Cell Phone RFI Desense Example

Introduction:

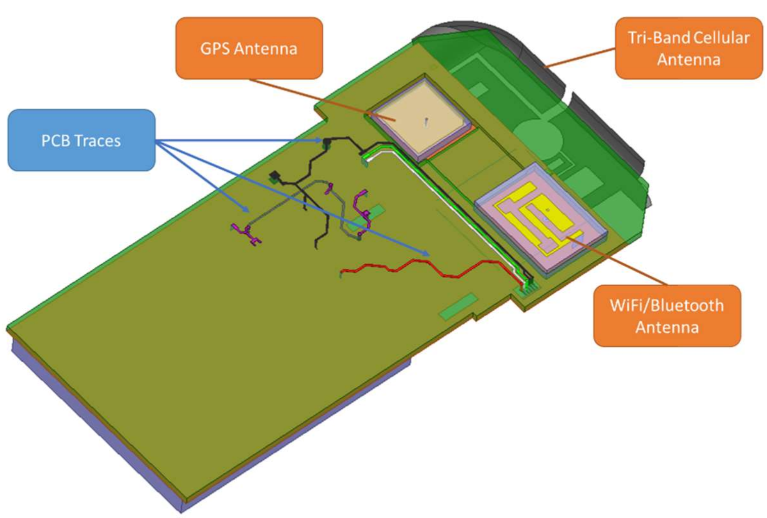
A rapidly increasing number of modern electronic devices incorporate integrated wireless capabilities and often contain multiple radio systems for communication, data, and navigation. When designing these products, engineers must ensure that all these wireless functions can operate properly in close proximity to each other, as well as close to high-speed digital signals that can be sources of radio frequency (RF) interference that can interfere with the wireless radio modules, leading to receiver interference, or *desense*. The cost of fixing desense issues after a product is built is cost-prohibitive and so reliable simulation methodologies are required to address this type of RF interference (RFI) during the product design.

In this example a desense simulation is performed in ANSYS Electronics Desktop (AEDT) using HFSS and EMIT design types to model the electromagnetic coupling and RF system interactions.

Coupling:

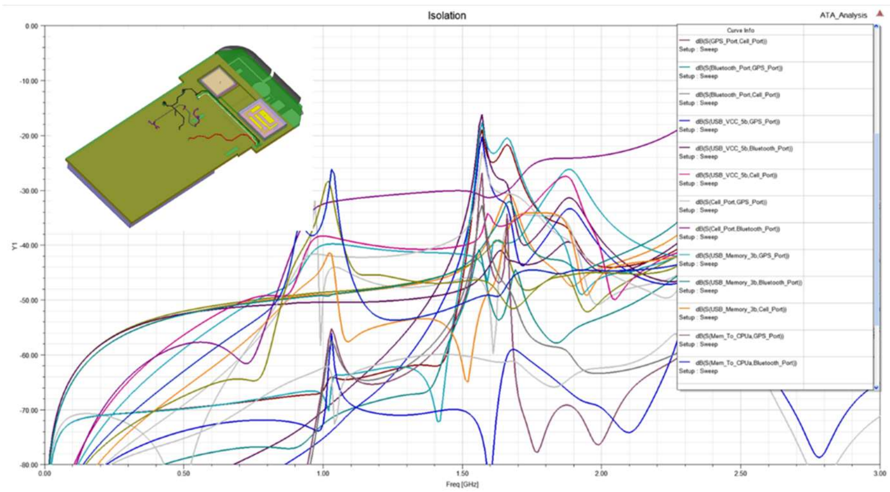
An important part of analyzing desense in electronic devices is the availability of accurate wideband electromagnetic coupling data that characterizes the coupling between all antennas and between radiating circuit traces on the printed circuit boards (PCB's) and antennas. This is best obtained from a full-wave simulation performed in ANSYS HFSS that includes antennas, PCB's and the physical construction of the device itself. The HFSS model can then be linked to the EMIT design and the HFSS antenna and trace ports attached to the EMIT RF systems and emitters for use in the EMIT simulation.

The HFSS model of the simplified cell phone used for this example is shown below. The phone includes three different antennas and several PCB traces as shown in the figure below. In practice, an actual PCB would be much more complex than the simplified version shown here for demonstration purposes. Note also that the phone case and other physical structure are not shown in the figure.



3D ANSYS HFSS model of the cell phone showing antennas and PCB traces.

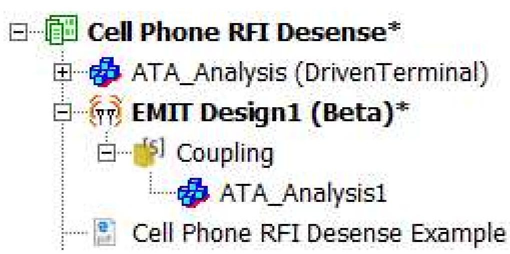
Simulating this model in HFSS provides wideband coupling data between all antenna and PCB ports and an example of this coupling data is shown below.



Results for wideband antenna-to-antenna and PCB-to-antenna coupling computed using ANSYS HFSS.

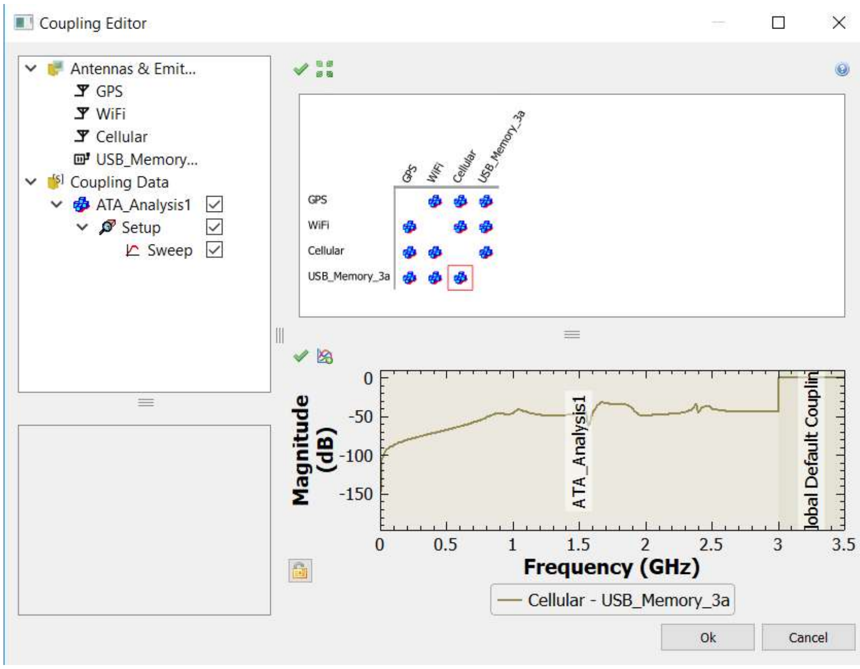
In the EMIT design, a link to the HFSS model is used to include the HFSS coupling data and add the antenna and trace ports into the EMIT model. The linked HFSS model appears in the EMIT design's *Coupling* folder in the Project Manager tree.

Emitters in EMIT represent unintentional RF sources and are used to model the driving signals on the traces that can couple to the antennas and desense the receivers. In the figure below, we see the HFSS model added to the EMIT design as a link.



Linked HFSS designs are shown in the Coupling *folder within the EMIT design in the* Project Manager.

The *Coupling Editor* (available via right-click on the *Coupling* folder) provides a comprehensive window to setup and view all of the coupling models used in an EMIT design. It displays all the ports defined in linked HFSS designs and allows these ports to be mapped, or connected, to antennas or emitters in the EMIT model. Note that the EMIT antennas for the HFSS ports can be created automatically if desired. Antennas, Emitters and coupling models not contained in the linked HFSS model(s) can also be added and configured. By selecting the appropriate entry in the *Coupling Matrix* the wideband coupling for that antenna (or emitter) pair can be viewed in the plot *Coupling Editor*'s plot window.



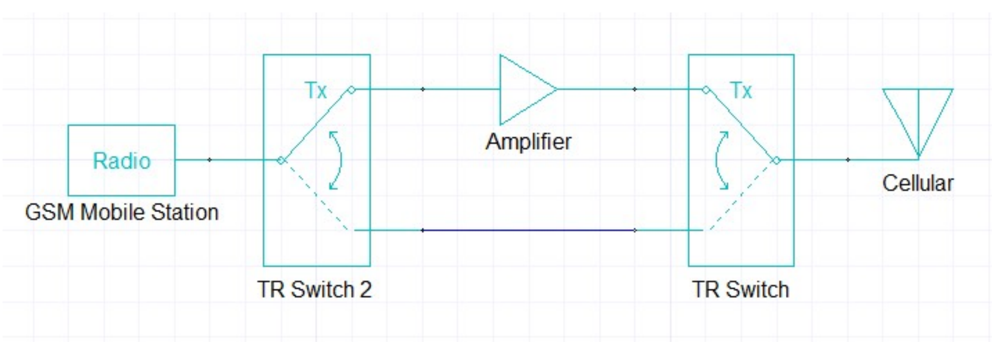
The HFSS design is added to the EMIT design and configured in the Coupling Editor *where the EMIT antennas are "connected" to the HFSS ports to use the antenna-to-antenna coupling results from HFSS for the interference analysis in EMIT.*

With this setup, EMIT will use the coupling data computed by HFSS when performing the RF system analysis to predict the desense.

Systems & Emitters:

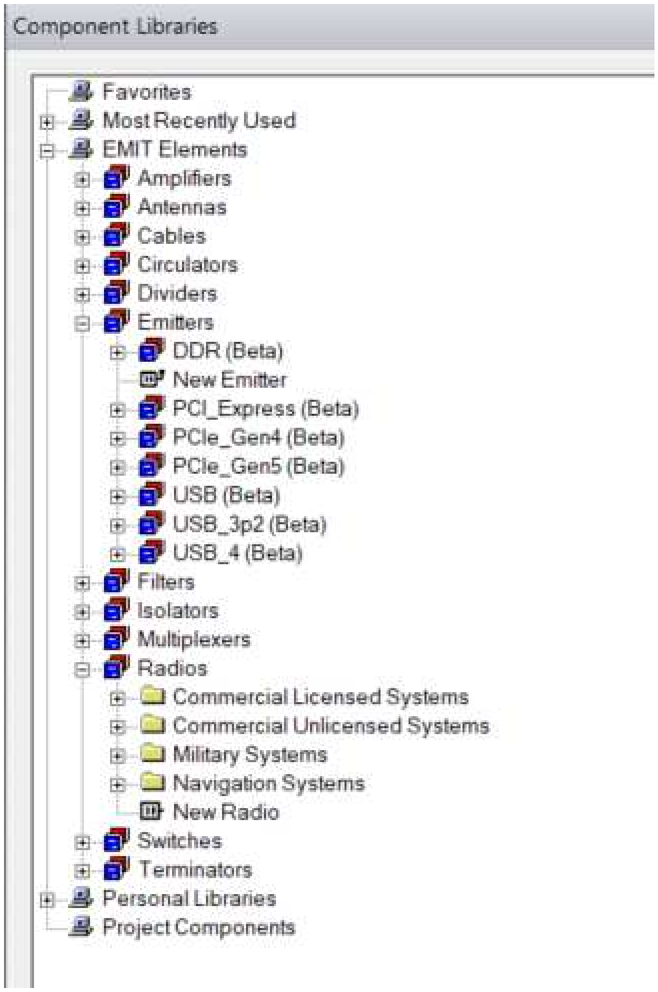
The RF systems and Emitters are added and configured in the EMIT design's schematic editor using models from the *EMIT Elements* library.

As an example, the figure below shows the schematic editor for the *GSM Mobile Station* system:



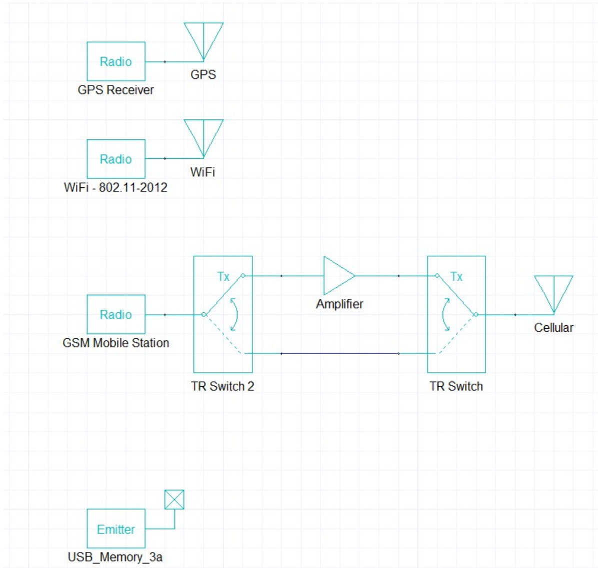
RF Systems are configured and edited in the schematic editor using radios and components from the System Elements library.

The radio, emitter and RF component models are all available from the *EMIT Elements* component library:



The EMIT Elements library provides a selection of many radios and RF components.

The complete EMIT design is shown below in the EMIT schematic editor where all the systems for this design have been configured. The position of each system in this schematic view controls the position of the systems in the *Scenario Matrix* window when viewing the results.



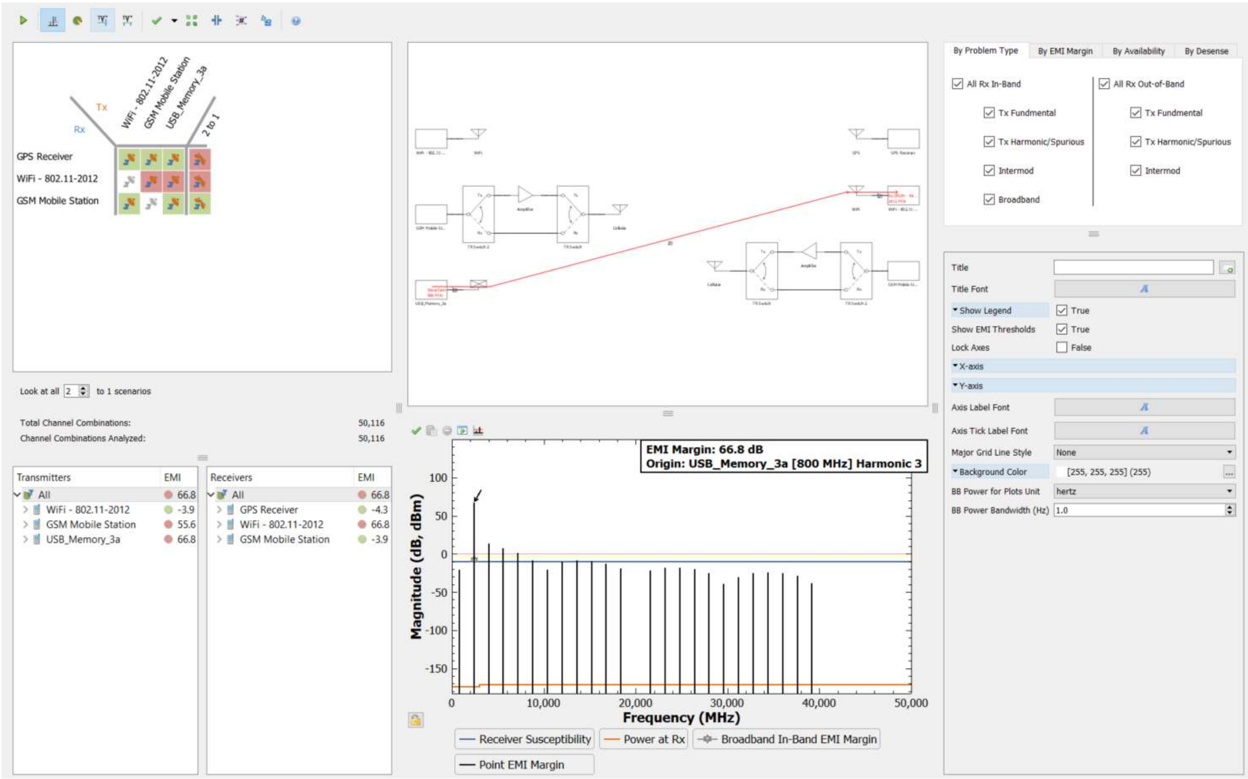
The complete EMIT design is viewed and edited in the top-level schematic editor where all systems and emitters are represented by component blocks and their connections to antennas shown.

Emitters:

Emitters are intended to model unintentional sources of interference, such as a high-speed digital signals that can radiate from PCB traces. In this example, the Emitter models a clock signal connected to one of the PCB traces. The HFSS model provides the coupling from this emitter driving the trace to all the antenna ports so that the interference to the radios can be simulated in the EMIT simulation.

Analysis and Results:

The simulation is performed, and the results are viewed in the integrated *Analysis & Results* window. This view provides a single view for controlling the simulation as well as viewing & interacting with the results in order to troubleshoot interference issues to determine the root-cause of the problem.



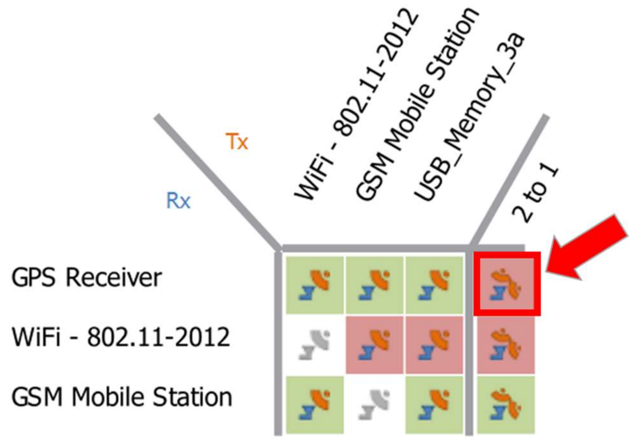
The EMIT design's integrated Analysis and Results window provides a single view for running EMIT simulations and diagnosing interference problems using a number of results views.

The *Scenario Matrix*, in the upper left of the window provides a system-level overview in an easy-to-see matrix view of what systems are interfering with each other. While the view rapidly identifies problematic system pairs, it does not reveal the specific frequencies or underlying cause of the interference. The color coding (which can be specified by the user) indicates whether the interference threshold is exceeded for each receiver in the scenario. In this example green indicates no interference, while red indicates that the interference threshold is exceeded, and so interference is an issue. The yellow square indicates a marginal case that may not be a problem but warrants further investigation.

The *Scenario Details* in the lower left offers complete access to all channel (frequency) combinations which can be selected. When selected in either the *Scenario Matrix* or *Scenario Details* views, the *Interaction Diagram* (upper center) and the *Results Plot* (lower center) respond to show the worst case interference for the current selection. The *Interaction Diagram* shows the signal path that the interference takes to the victim receiver. The *Results Plot* shows the wideband frequency spectrum of the interference at the receiver and provides an information box that identifies the exact cause of the interference that it selected.

The panes on the right provide for further customization to set interference thresholds, plot appearance, etc. Complete details are provided in the online documentation for the EMIT design.

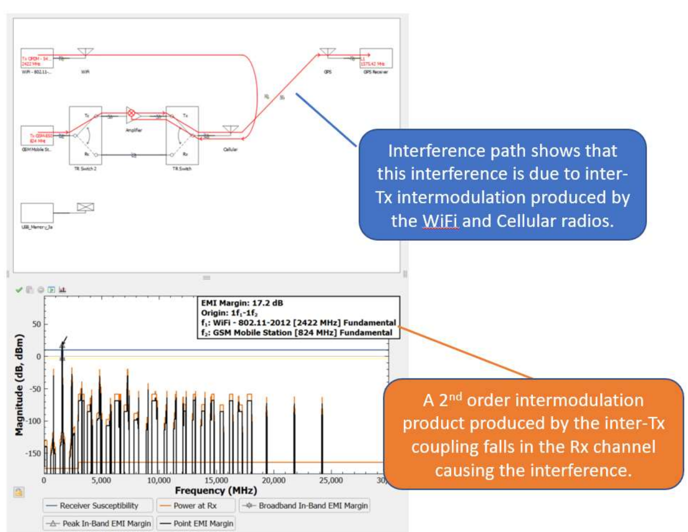
As an example of how powerful the results views are for diagnosing interference, consider one of the interference issues identified by EMIT. Specifically, the red square highlighted in the figure below is the result for interference to the "GPS" receiver when the other two systems and emitter are operating. This is the so-called “N-to-1” interference case that is particularly difficult to diagnose due to the very large number of ways that multiple transmitters can interfere with a receiver (50,116 in this example).



The Scenario Matrix shows a high-level system interaction view to quickly identify which systems are problematic for interference. The highlighted square shows that there is an interference problem to the GPS receiver when multiple transmitters operate simultaneously, even though no single transmitter alone causes interference.

Clicking on this square in the *Scenario Matrix* shows specific details in the *Interaction Diagram* and *Results Plots* that allows us to see the cause of the problem and the path of the interference.

The interference is identified to be caused by interactions between two of the transmitting systems. The unwanted coupling between two of the active transmitters results in a 2nd order intermodulation product being produced at the receiver frequency that couples into the receiver. Identifying this root-cause of interference among the 50,116 possible channel combinations would be extremely difficult without EMIT’s comprehensive diagnostic results views in AEDT.



The Interaction Diagram (top) and Results Plot (bottom) provide key information for diagnosing the root-cause of interference.