



INTEGRATED SOFTWARE FOR ELECTROMAGNETIC SIMULATION

In the past, most electromagnetic (EM) simulation software has been slow, difficult to use and expensive. =empower= Plus EM software addresses these issues by providing fast, accurate EM simulation. This simulation is completely integrated with traditional circuit simulation, allowing lumped elements such as transistors to be included automatically. The =empower= software operates on Windows™ '95, '98 and NT systems.

In this article, a 2.3 to 2.5 GHz bipolar amplifier is examined. This example illustrates a powerful feature of =empower=: the ability to effortlessly and automatically incorporate lumped elements into EM simulations.

DESIGN AND LAYOUT

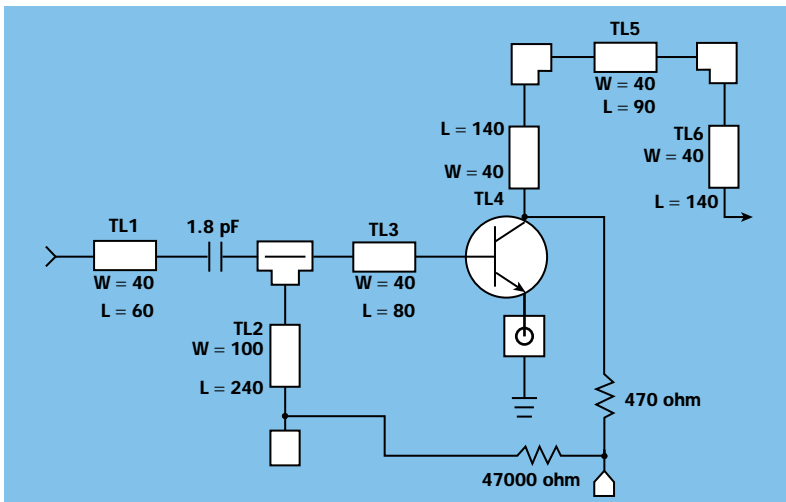
=empower= Plus includes =SuperStar=, =SCHEMAX=, =LAYOUT= and =empower= programs.¹ **Figure 1** shows the schematic of the 2.3 to 2.5 GHz bipolar amplifier, which uses a combination of lumped and distributed

elements as it was drawn in =SCHEMAX=. The performance was optimized using =SuperStar= and the layout was finalized in =LAYOUT=, as shown in **Figure 2**.

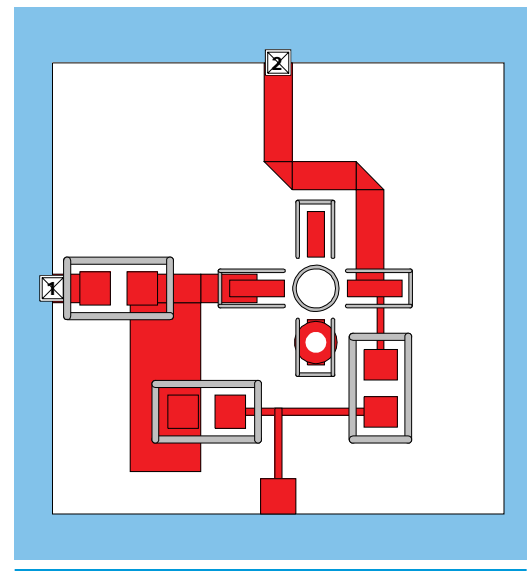
EM SIMULATION

For an EM analysis, it is only necessary to add =empower= ports, verify layering descriptions and start an =empower= run. On the circuit board layout, the input and output ports are located on the left and top walls, respectively. DC power is applied to the pad on the bottom wall. This pad contacts the wall and is assumed to be at RF ground. In practice, power would be applied through a feedthru capacitor. The meandering output line con-

Fig. 1 The amplifier as drawn in =SCHEMAX=. ▼

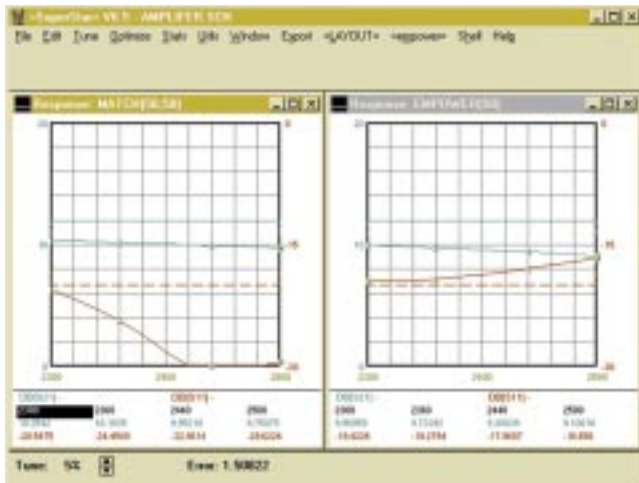


▼ Fig. 2 The circuit board from =LAYOUT=.



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PRODUCT FEATURE



▲ Fig. 3 Results of the original = SuperStar= and EM/lumped element analyses.

necting to the top wall has an impedance slightly higher than 50Ω and provides some impedance matching. It had been assumed (but not yet confirmed) that only one via hole was needed at 2.4 GHz.

The =empower= run was launched to perform an EM analysis. =empower= Plus then prepared the results using several completely automatic steps: =LAYOUT= creates the topology description file AMPLIFIER.TPL for =empower=. This file is stripped of lumped elements but includes the distributed elements (for example, the low impedance stub and the meandering output line) with metal and ports included for lumped element footprints.

The software performs an EM analysis on the circuit with two external and nine internal ports (the input and output ports plus automatically generated internal ports for the lumped elements). =empower= creates and writes an 11-port S-parameter data file called AMPLIFIER.SS. The analysis requires just 38 seconds per frequency for this circuit. Only three frequencies are required since lumped elements are not yet included and, therefore, the circuit has no resonances. The total analysis time is less than two minutes on a 200 MHz Pentium Pro system.

=empower= then adds an invisible section to the =SCHEMAX= file with the 11-port S-parameter data file and copies of the lumped elements reinserted. The final network is viewed in =SuperStar=.

The results of the original =SuperStar= circuit theory analysis

and the combined EM/lumped element analysis are shown on the =SuperStar= screen in **Figure 3**. The circuit theory simulation was optimized for good return loss, which produced the maximum and flat gain shown on the left graph; the =empower= analysis is shown on the right. Note that the gain S_{21} is in good agreement while the return loss S_{11} is sub-

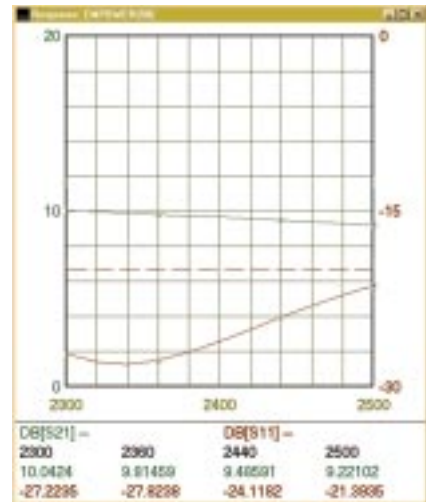
stantially different.

EM simulations are typically more accurate than circuit theory simulations. EM simulation includes discontinuity coupling, pad location effect, radiation, cover effects and other geometry-related issues. Between the simulations, the gain agrees within approximately 1 dB while the return loss error in decibels is much larger. Poorer return loss correlation is common in circuit theory simulation due to the high sensitivity of return losses better than 15 dB.

UPDATING THE DESIGN

Since it was determined from EM simulation that the original circuit would not have good return loss, the immediate question becomes how to fix it. While the circuit theory simulation is less accurate than the =empower= simulation, it is a fast and useful tool for estimating design changes prior to rerunning in =empower=. With its real-time tuning capabilities, =SuperStar= is especially strong in this area. A possible first step in updating the design is to change component values to make the =SuperStar= run match the =empower= run.

In adjusting component values for the circuit theory simulation, it was discovered that increasing the length of the low impedance stub TL2 and decreasing the input capacitor degrades the circuit theory return loss prediction and makes the =SuperStar= simulation appear more like the =empower= simulation. Logic dictates that doing the opposite will improve the =empower= simulation, making it



▲ Fig. 4 Results from =empower= after updating the design.

match the original =SuperStar= simulation with good return loss. The next step is to shorten TL2 and increase the capacitor value. The prediction is verified as shown **Figure 4**, which displays the response from an =empower= run with TL2 shortened to 160 mils and the capacitor increased to 2 pF.

CONCLUSION

While circuit simulation is an appropriate tool for many types of designs, other poorly modeled or very sensitive circuits require EM simulation. As mentioned previously, the traditional drawbacks have been speed, difficult interfaces and price. =empower= software can simulate circuits very quickly as was shown in this example. Much larger circuits are practical in =empower= due to advanced techniques such as thinning out and symmetry procedures. Since the interface is integrated with circuit simulation and lumped elements are handled automatically, =empower= is much easier to use. =empower= Plus' price is \$4999 and includes =SuperStar=, =SCHEMAX=, =LAYOUT= and =empower=.

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Reference

1. Eagleware Corp., "Integrated Software for RF/Microwave Design," *Microwave Journal*, January 1996, Vol. 39, No. 1, pp. 188-189.