Software

Infineon supports LTE-A LNA customers with band-specific application notes generated with NI AWR software

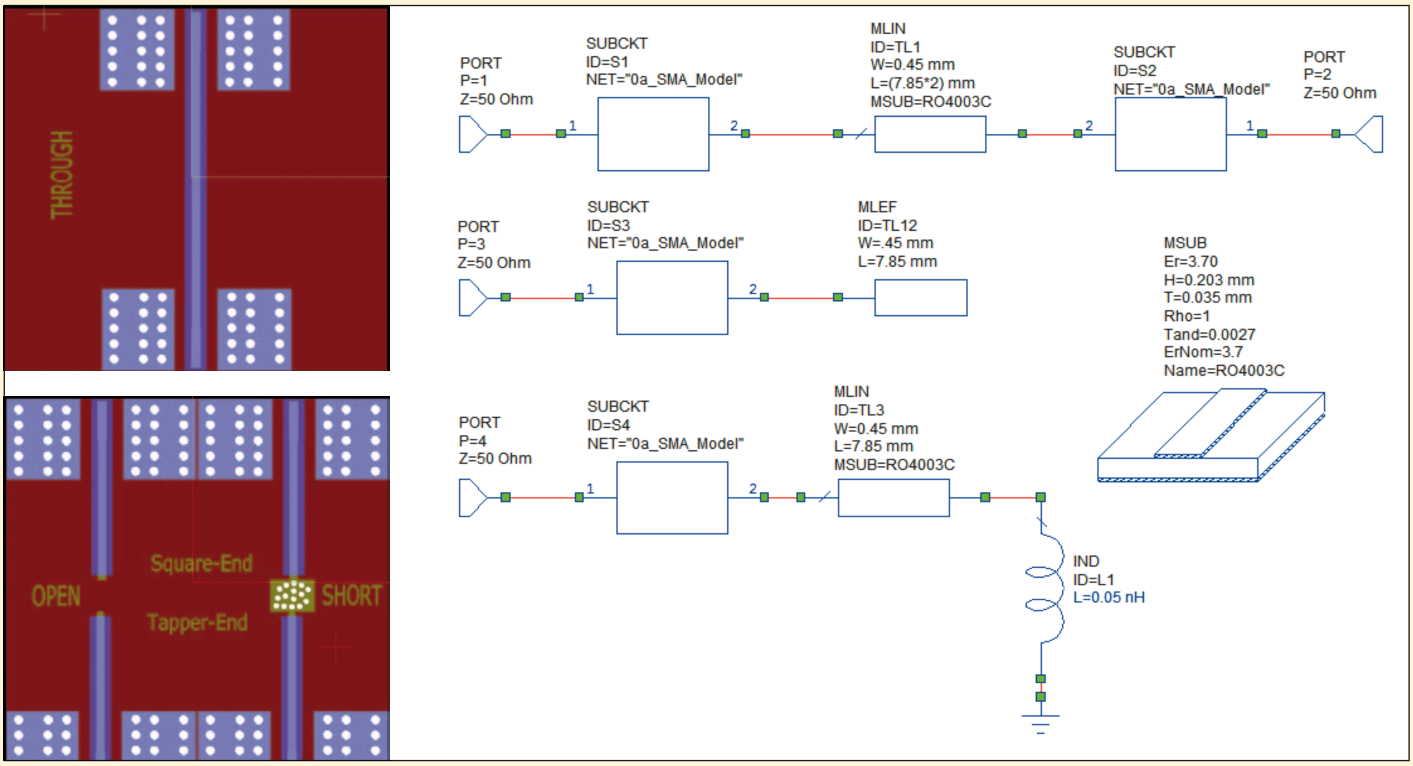


Figure 1: Actual layout of the PCB (left) and Microwave Office schematic diagram for PCB characterization (right)

Company Profile

Infineon Technologies AG is a German semiconductor manufacturer spin off of Siemens AG. The company has more than 50 years of experience in developing RF devices for a wide range of wireless applications, leading the market with high-performance, yet cost-effective products.

To support its customers, Infineon developed a solution finder tool that provides easy access to the application notes, datasheets, device models, and evaluation boards that help designers quickly and easily identify the right product for the right application.

The Design Challenge

The complexity of mobile phone design has increased significantly in order to support higher data rates and more functionality, while the window for bringing new devices to market has decreased from years to months. Consequently, phone manufacturers require microwave semiconductor vendors to offer highly integrated devices with linear performance.

Infineon is addressing this need with 3G/4G, LTE, and LTE-Advanced low-noise amplifier (LNA) microwave monolithic integrated circuits (MMICs) and multiplexer modules designed to optimize the sensitivity of mobile cellular devices and systems. These modules extend the coverage area for the highest data traffic and provide the greatest network efficiency through support of reduced transmission power and lower bit-error rates.

LNAs that are located in the antenna paths of the phone improve the system noise figure on the receive path, enabling increased data rates nearly double that of solutions without LNAs, especially under very weak signal strength. Infineon LNAs have high linearity, which assures optimal signal reception even with poorly isolated antennas and losses between antennas and transceivers. In addition, their extremely low noise figure enhances the sensitivity of the RF modem by about 3 dB, offering system layout flexibility by suppressing noise contribution from losses of signal lines and the surface acoustic wave filters, as well as the receiver.

To deliver best-in-class linearity and noise-figure performance, Infineon designers rely on the robust, accurate circuit simulation and precise modeling of all the components used in their MMIC and module designs, including printed-circuit board test boards. Precise linear models enable faster verification of system-level performance for the application circuits supporting different bands of 4G LTE-A, currently numbering more than 44 LTE bands worldwide. By using powerful scripting capabilities built into NI AWR Design Environment, the time for designing and documenting new application circuits has been reduced from days to hours.

The Solution

Infineon chose NI AWR software for its exacting device modeling needs, which at the application level begin with the characterization of the printed circuit board used for LNA/module measurements. The LNA and LNA/multiplexer PCB test structure include an RF input and output transmission line of predefined length and width. S-parameter and noise figure measurements of any device at the calibrated test equipment port will include

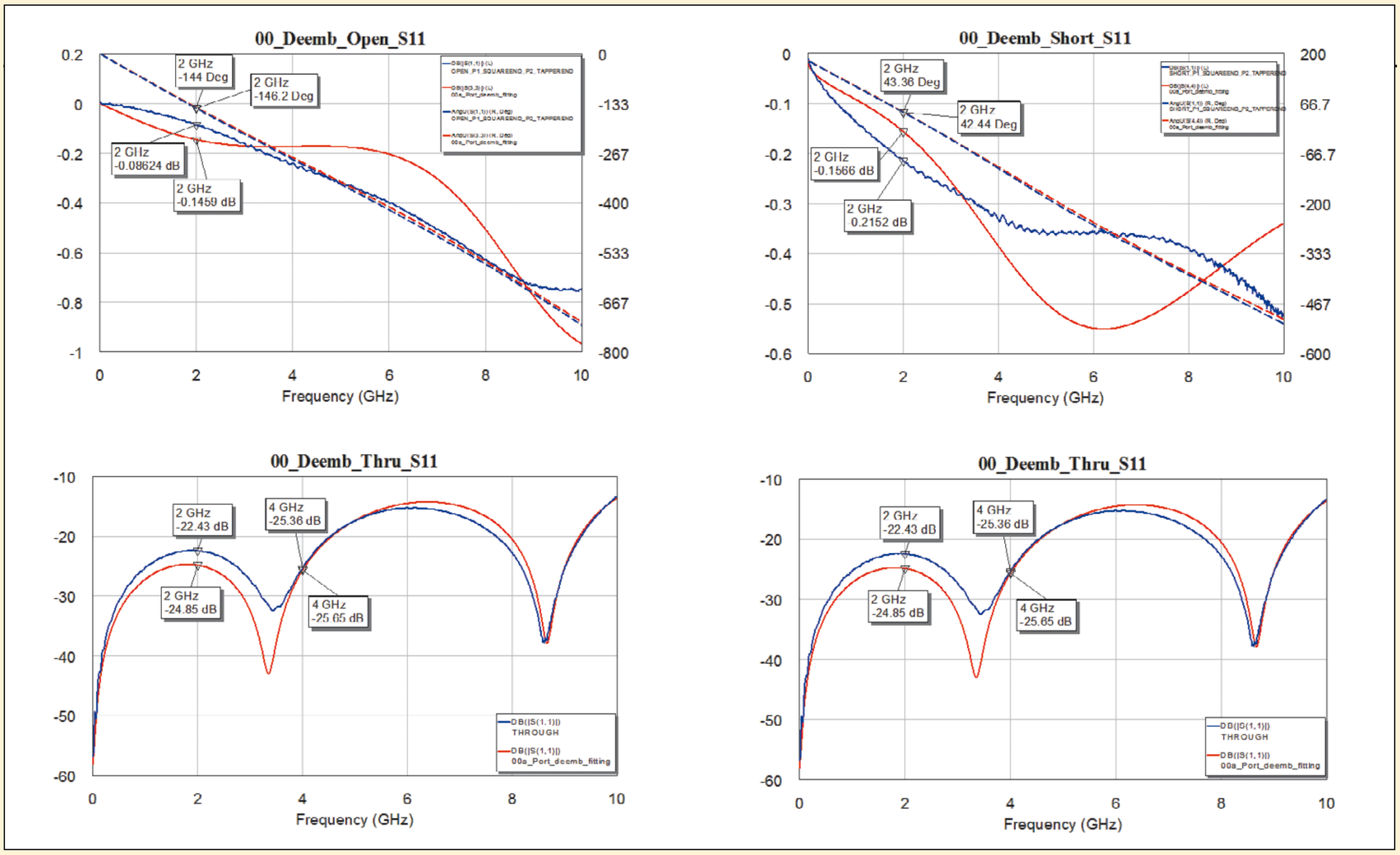


Figure 2: Simulation versus measured results for short, open and through PCB using Microwave Office software

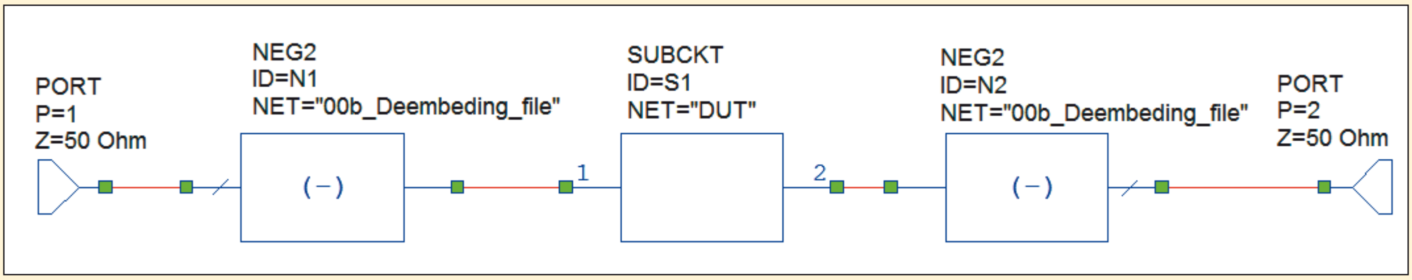
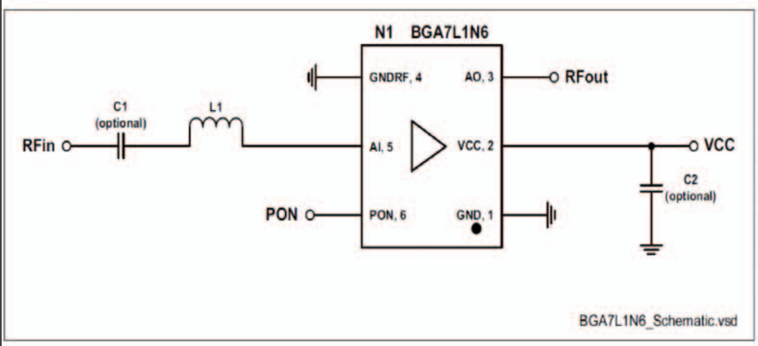
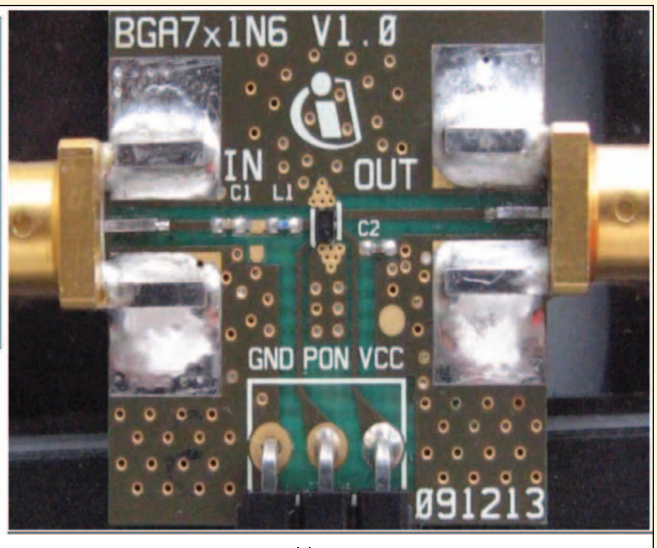


Figure 3: Microwave Office schematic diagram showing NEG blocks for de-embedding the measurement result



Symbol	Value	Unit	Size	Manufacturer	Comment
C1 (optional)	1	nF	0201	Various	DC block
C2	100	nF	0201	Various	RF to ground
L1	18	nH	0201	Murata LQP series	Input matching
N1	BGA7L1N6	TSNP-6-2		Infineon	SiGe LNA

a)



b)

Figure 4: a) Schematics and bill of materials (BOM) for the BGA7L1N6 LTE Band 5 application board. b) Photo of the BGA7L1N6

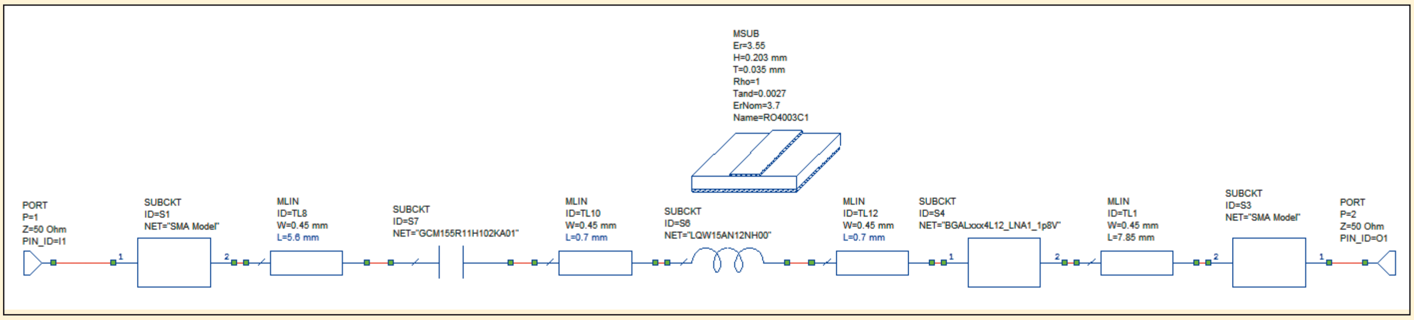


Figure 5: Schematic diagram for LTE application circuit used in simulations for generating application note data

this transmission line, as well as the Sub-Miniature Version A (SMA) connector launches on the test boards input/output. The response of the test structure can be removed from the measurement through de-embedding, resulting in a more accurate measurement of the isolated device response. The test structure can be characterized through a variety of measurement-based methods or rigorous electromagnetic (EM) simulation. In this case, engineers used the closed-form transmission line and SMA models in NI AWR Design Environment, specifically Microwave Office circuit design software, to compare to three different calibration standards: namely a short, open, and through transmission line, as shown in Figure 1.

A comparison of the measured response of these three structures to the closed-form models (Figure 2) shows reasonable agreement at the band of interest with the variation between the simulation and measurement results being less than five percent at 10 GHz, well above the carrier frequency.

These PCB and connector models were used later in the development of the application circuits to reconcile the device measurements on the evaluation board with the simulated results.

To de-embed the device under test (DUT) from the test fixture, designers used the NEG block from Microwave Office software to subtract the effects of the transmission line and SMA connectors from the raw measured data. The negative block contained a sub circuit comprising a serially connected SMA launch and microstrip transmission lines with PCB substrate definition that includes metal and dielectric stackup information (physical dimensions and electrical properties). The de-embedding

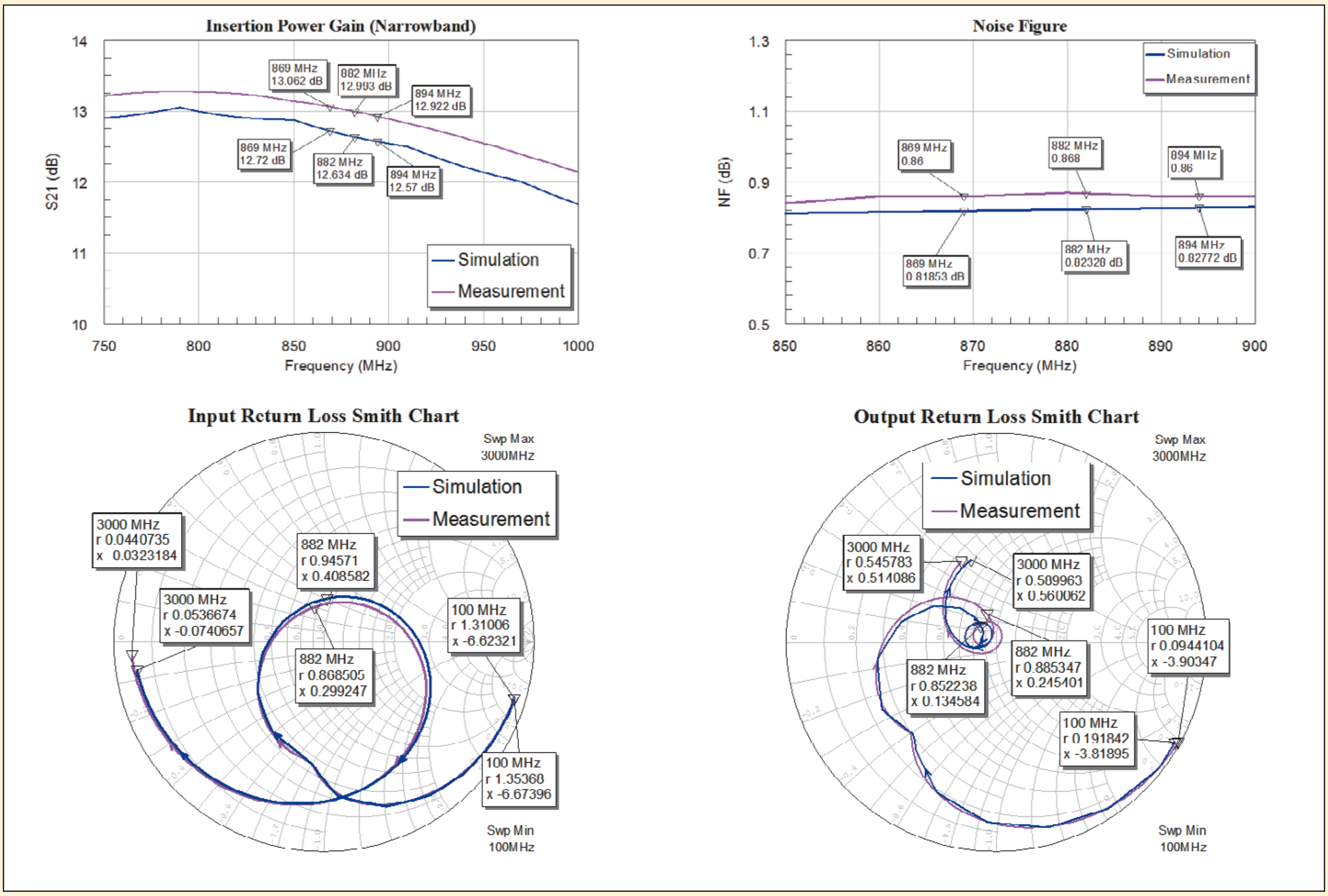


Figure 6: LNA simulation versus measured results for LTE Band 5 application circuit

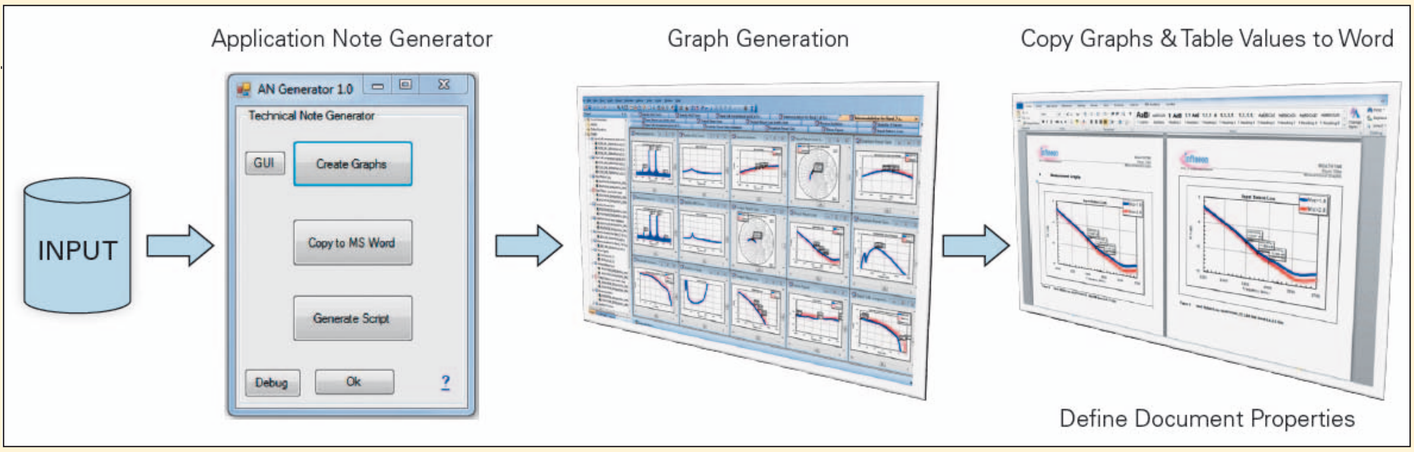


Figure 7: Automatic report generation process (illustrated)

blocks were added to the input and output of the measured data block, as shown in the schematic in Figure 3.

After generating a linear device model from de-embedded measurement data, the LNA data was incorporated into an application circuit for the various LTE bands. The application circuit schematic from Infineon Application Note AN351 [1] and test board for Infineon's BGA7L1N6, covering LTE Band-5, are shown in Figures 4a and 4b, respectively. Subsequent designs, including the LNA and application circuit, were simulated with the transmission lines, SMA connectors, and PCB information included.

Simulating the device, application circuit, and test fixture together enabled the engineers to make a direct comparison to the application circuit's measured results (in the test fixture). If the simulation and measurement results showed equivalent responses, then the model was accepted. Figure 5 shows the schematic diagram used for the simulation of an application circuit designed for LTE Band 5 and figure 6 shows the simulation results versus measurements.

As the simulation and measurement results of the application boards demonstrated an acceptable level of agreement, the LNA model was used in hundreds of simulation circuits for different wireless applications, especially for different LTE bands. Generating the documentation (datasheets and application notes) for the hundreds of application circuits is very time consuming, however, the Infineon RF & Sensors Business Unit was able to develop an application note generator add-on tool for Microwave Office software. Using this tool, the documentation for each application circuit was completed in a few minutes.

The generator tool is based on a custom script file that automates the entire operation, reducing the time and effort considerably. By running the script file first, all the necessary graphs were generated with proper annotations, axis definition, title, and markers. Then all the graphs were verified by the applications engineers. If the graphs were approved, the script was used again and all the graphs were copied from Microwave Office software to the appointed document file. The script was also used to complete the table in the document file by finding the proper values from the generated graphs.

The work flow for application note generation is shown in Figure 7, with the specific graphs generated for Infineon Application Note AN351 [1] shown in Figure 8.

Why NI AWR Design Environment

With proper device modeling that resulted in repeatable agreement between measured and simulated results, Infineon was able to develop new application circuits and associated documentation quickly and easily. NI AWR Design Environment enabled Infineon designers to develop accurate models that closely matched measurement results, generate the on-board RF design to address the application/LTE band performance requirements, and report all the data necessary to serve their customers' information needs.

References

[1] http://www.infineon.com/dgdl/AN351.pdf?fileId=db3a304344e406b50144e46e4b3802ef

■ *National Instruments AWR*
www.ni.com/awr

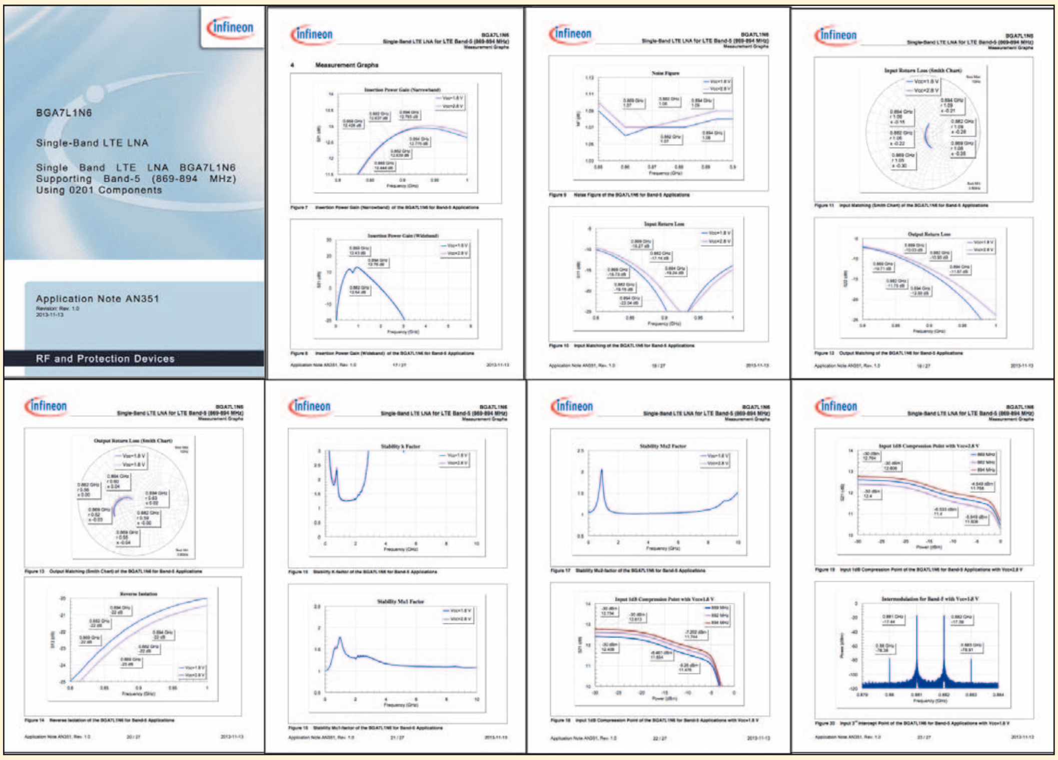


Figure 8: Application note generator tool created within NI AWR Design Environment through customized scripting by the Infineon applications team