Automated characterisation of a super low noise InGaAs HEMT at X and Ku band.

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Abstract

This paper describes a process developed at Cardiff University for extracting the noise figure and gain contours for packaged low noise devices. Specially developed software is used to control an automated source tuner and record the results over a user defined area of the Smith chart.

Full 3D EM simulation is used to de-embed the device from the measurement fixture.

Introduction

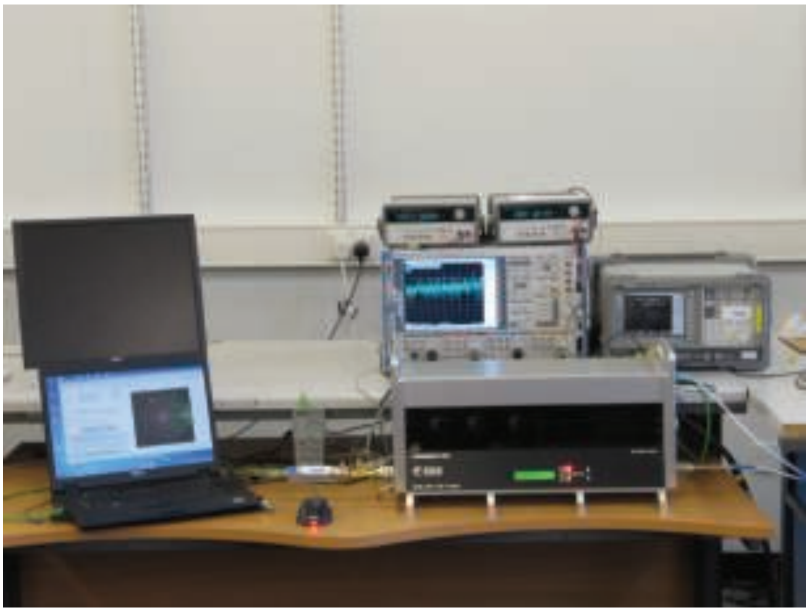
In order to design low noise amplifiers the relationship between the impedance used to drive the gate and the resulting noise figure must be known. Discovering this relationship becomes more problematical as the operating frequency increases, precise manual tuning of a circuit at Ku band is scarcely practical, and still leaves the task of somehow extracting the data if the design is to be repeated. Automated tuners are available, but these have a significant insertion loss which changes for different impedances, masking the noise figure performance. A substantial amount of processing needs to be done to each point to uncover the actual data so tuning to find an optimum point is not possible.

The only practical way to find the information is to map a substantial area of the Smith chart and post process the results, a very time consuming activity, especially if multiple frequency points are required. In order to meet this challenge software has been developed to automate the task, and has been successfully used to characterise a super low noise InGaAs HEMT.

The Measurement Method

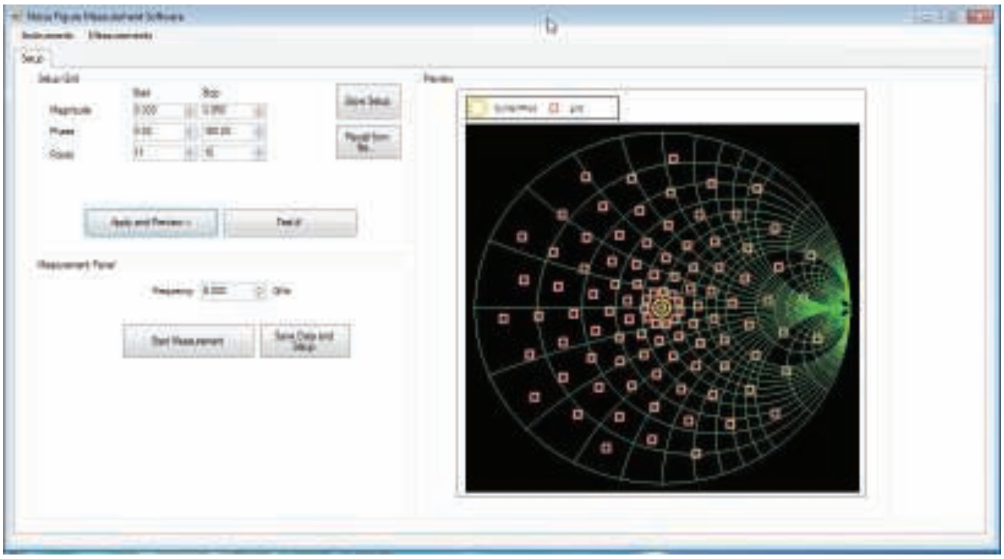
To capture the data the equipment is set up as shown below, a Focus passive tuner is connected to the input of the device, and an Agilent NF8975A noise figure analyser is connected from the tuner input to the device output, with high frequency bias tees to power the device.

The device is mounted in a custom made fixture, with 50 Ohm lines leading up to the tabs, with field replaceable connectors to connect to the test equipment.



The R&S ZVA network analyser seen in the background is used to calibrate the tuner before commencing the actual measurement phase, the tuner is driven through its range of positions and a table generated of S-parameters against position number. The input bias Tee was included in this measurement. Once this has been done the NFA is calibrated by connecting its noise source to its RF input through the output cables to be used, the output bias Tee is included in this.

Once the calibration is finished the custom software is opened and a range of impedance targets chosen.



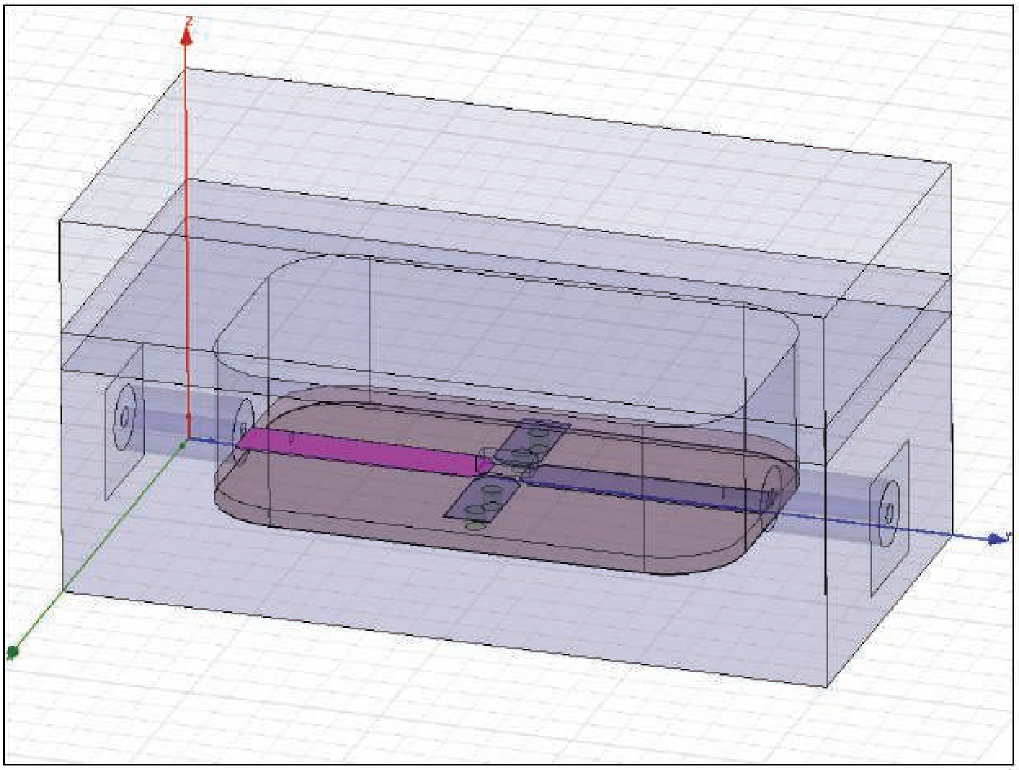
The program steps through the target list, moving the tuner to the closest matching position and creating a table of the S-parameters and the corresponding noise figure and gain measurements.

Fifty measurements were taken at each point, rising to eighty at the higher frequencies, with one hundred and ten locations, either five thousand five hundred or eight thousand eight hundred in all for each frequency.

Separating the Device and Fixture coefficients

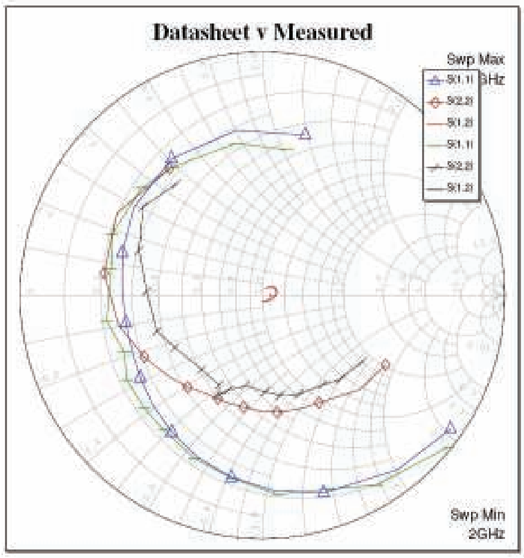
Once all the data has been collected it is necessary to calculate the actual impedance seen at the device reference plane, and to compensate for the insertion loss of the tuner and input circuit.

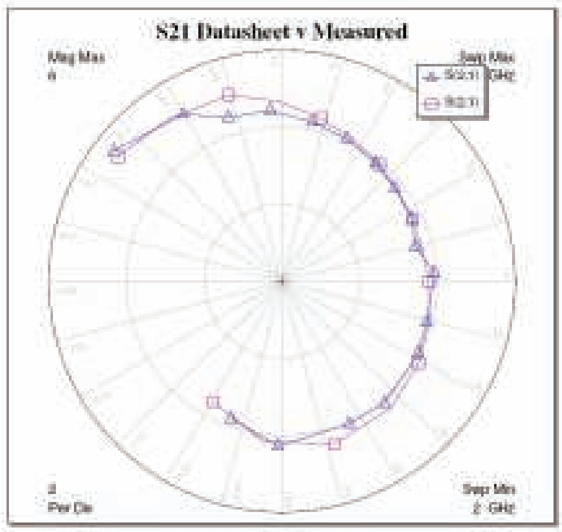
The effect of the test fixture was determined by 3D EM simulation using Ansoft HFSS, this technique is used because of the difficulty in fabricating microstrip calibration standards at these frequencies.



The substrate used was Rogers 5880, 0.015" thick. The mounting and earth arrangements were as suggested by the device manufacturer. Southwest Microwave launches take the connections from microstrip to connector interface.

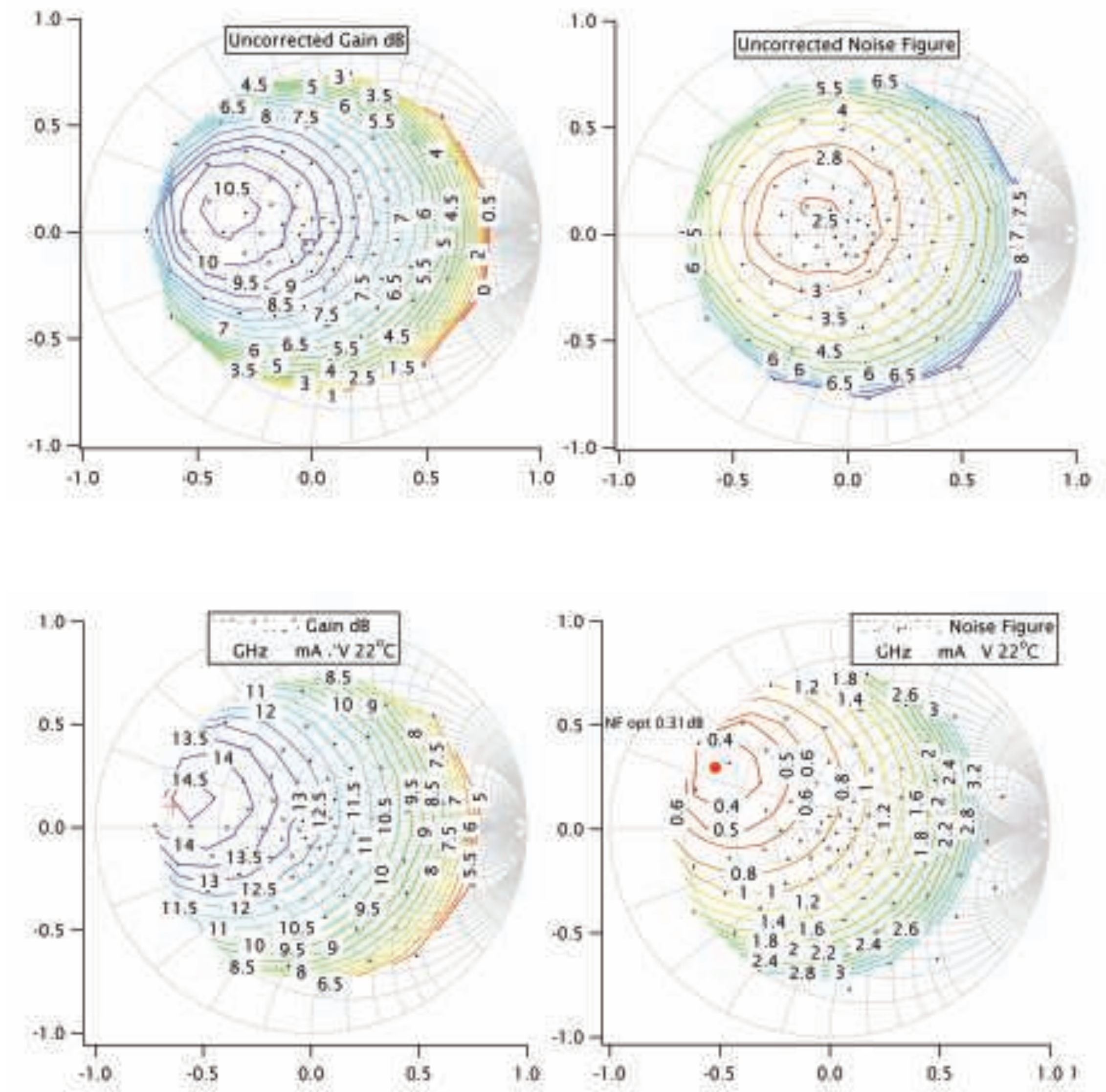
At this point it is now possible to de-embed the S-parameters of the mounted device from a measurement taken port to port and compare them with the manufactures data sheet values.





The correlation seen here confirms that our work is accurate, and we can proceed to the next step.

Analysing the Results



The earlier comment regarding the impossibility of locating the optimums from the raw data is clearly illustrated here, not only does the absolute value change, the position of the optimums is camouflaged by the tuner loss.

The final extracted value for Noise Figure of 0.31dB tallies closely with the datasheet value of 0.34dB, so we have a high degree of confidence in the result at this frequency, and therefore also at the other measured frequencies where data is not provided by the manufacturer.

The red cross seen on the gain plot indicates the position of the maximum available gain conjugate match for the device, calculated from the S-parameters, again the close coincidence of this with the measured gain optimum supports the accuracy of the results.

The contour approach used to analyse the results assists in designing practical wideband circuits, where the performance may need to be compromised.

Conclusion

The technique illustrated here is a practical and accurate method for extracting the optimum impedance values required to yield best performance from a low noise device

Acknowledgements

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