

# New RF System Simulator Enhances RF Architectural Planning, Design and Analysis

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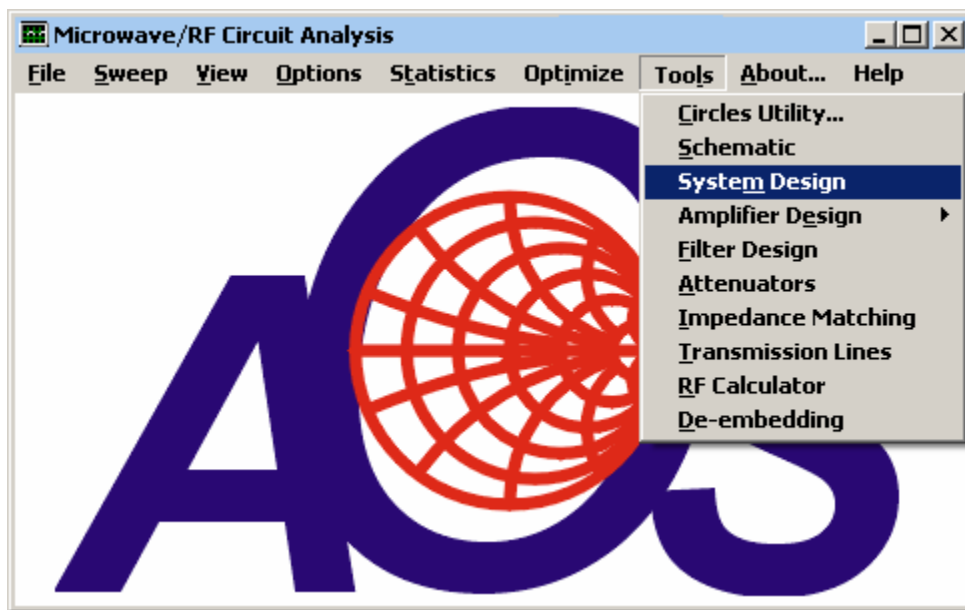


Figure 1, Selecting the Visual System Architect from the LINC2 Tools Menu

For more than a decade Applied Computational Sciences (ACS) has provided powerful computer-aided engineering (CAE) software for designing at the circuit level with the LINC2 RF and microwave design suite. LINC2 Pro continues to offer affordable design automation in the form of circuit synthesis, simulation, optimization and yield analysis - all bundled together in an easy to use design environment.

With the success of the advanced LINC2 Pro circuit simulator, it soon became evident that designers wanted a tool just as powerful and easy to use for designing at the system level. The need for capable, full-featured system simulation software has also been fueled by the content of most RF and wireless products shifting from systems of circuits made up of discrete components to systems made up of RF integrated circuits (RFICs) or other integrated modular components. The growth in the complexity of products and systems in recent years further created the need for software that is easy to use and yet takes the complexity out of the analysis. Thus, ACS developed the Visual System Architect (VSA) program to automate the design and analysis of these kinds of systems.

There is also the need for software that encompasses the overall product design flow, from high level product specifications to detailed circuit design. Now, with the Visual System Architect addressing product design at the system level and LINC2 Pro automating design at the circuit level, RF and microwave product development can be assured of success by being appropriately driven by system design that connects product specifications to circuit level specifications. Figure 1 shows the LINC2 Tools menu from which both LINC2 Pro and LINC2 VSA are launched.

The LINC2 VSA offers a large variety of new design and analysis capability for designing at the system level. The program renders obsolete many of the traditional spreadsheet and system

cascade calculators once used to analyze system performance. Instead of having to create and maintain a spreadsheet of calculations, the VSA employs the flexibility and ease of use of schematic based system simulation as shown in Figure 2.

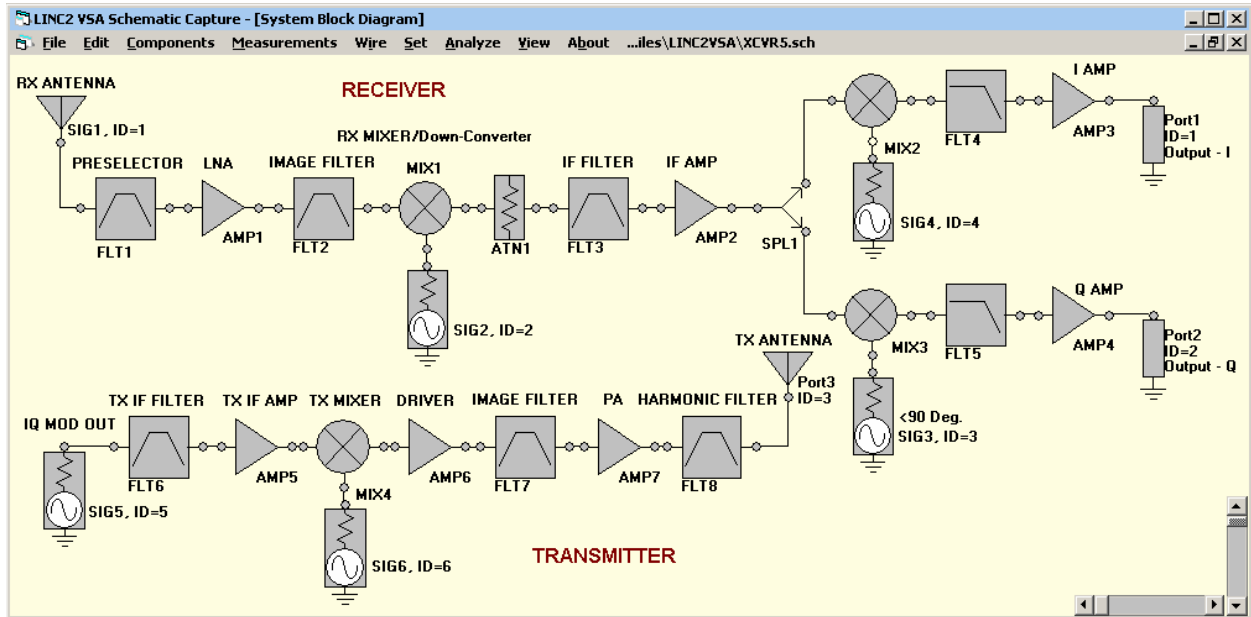


Figure 2, The Visual System Architect's System Schematic

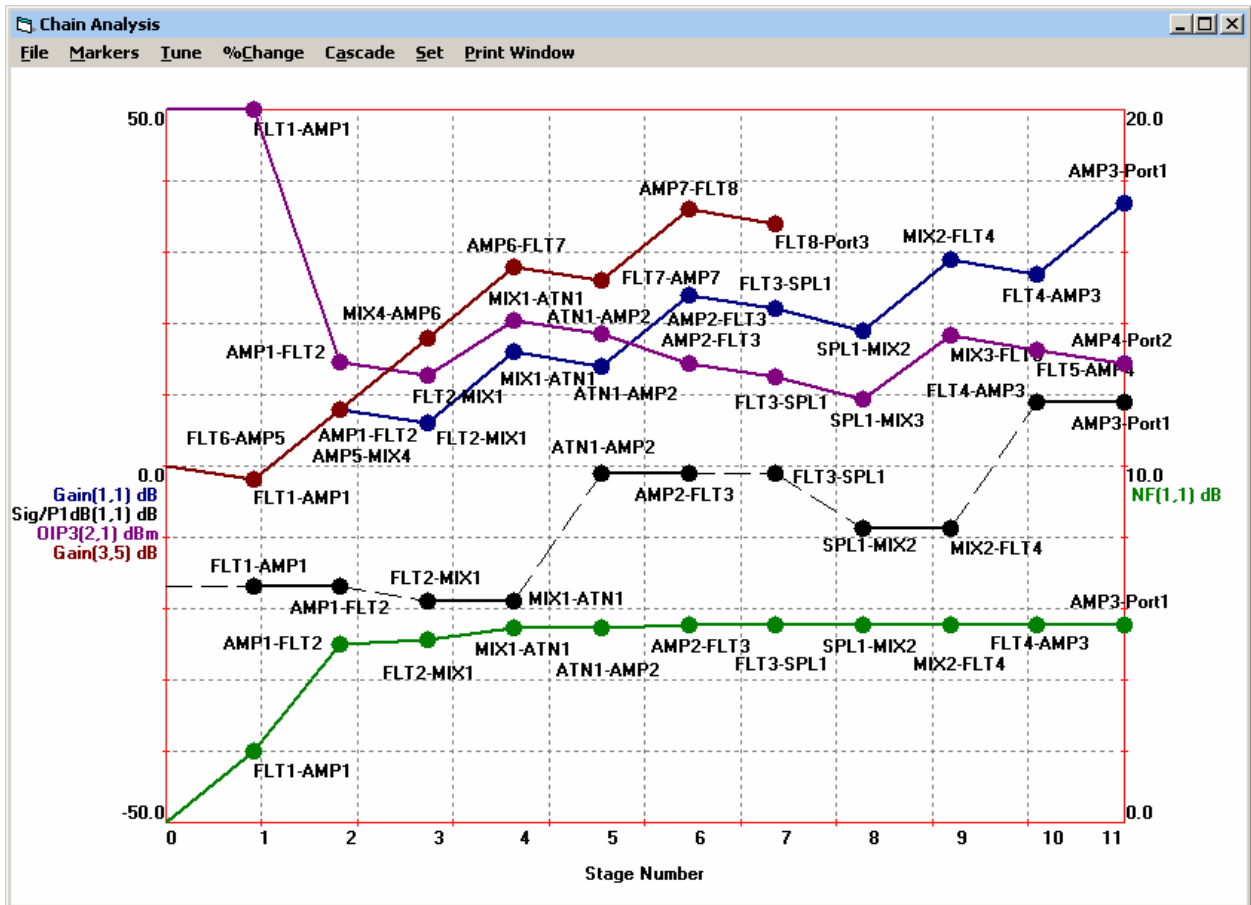


Figure 3, The VSA's Cascade Budget Analysis Plots

Schematics or system level block diagrams are quickly and easily created from a comprehensive menu of system component behavioral models such as amplifiers, filters, mixers, splitters and attenuators etc. Verifying performance is as simple as clicking the **Analyze** button.

The system schematic allows the user to construct systems of arbitrary topology. Thus, the program is not limited to a single chain of cascaded components. The system simulator can analyze schematics with multiple cascades driven by an equal number of signal power sources. For example, the Visual System Architect can analyze a transmitter and receiver chain simultaneously, each with different signal sources and separate local oscillators for the up-converter and down-converter stages respectively.

Plots of power budget, efficiency, gain, IP3 (intercept point) and NF (noise figure) are just a sampling of the many system performance indicators that are provided on a cumulative stage-by-stage basis. All simulation outputs can be saved to a file or displayed numerically in a table summarizing total system performance (Figure 4). Figure 3 shows a typical cascade budget plot for a transceiver system. Each data point represents a system performance parameter at a circuit node or interface point between stages.

The screenshot shows a window titled 'System Performance Analysis - Reports' with a menu bar containing 'File', 'Tune', '%Change', 'Cascade', 'Set', and 'Print Window'. Below the menu is a section titled 'System Performance Reports' containing a table with the following data:

System Parameters	Source Port	Termination Port	Parameter Value	Units
Gain	1	1	33.924	dB
Tot PWR	1	1	-14.23851	dBm
NF	1	1	2.88207	dB
Noise PWR	1	1	-87.16946	dBm
SNR	1	1	72.93094	dB
SFDROut	1	1	69.92532	dB
OIP3	1	1	17.71852	dBm

Figure 4, The VSA Reports Table with Overall Performance Summary

Furthermore, the Visual System Architect goes beyond the traditional budget plots to offer a much wider array of performance measurement methods and analysis tools. For example, Figure 5 shows a power sweep that graphically displays the linear range as well as the P1dB point and compression curve characteristics for the entire system cascade. The **Tune** menu allows the user to vary any component parameter to immediately see its effect on system linearity including changes to the compression point. The bold curve in Figure 5 represents the initial power sweep while the light curve shows the changes after tuning. The Power Sweep **Set > Options** menu allows the user to select the range over which input power will sweep.

The ability to display an input-output power sweep curve extends to any point in the system, not just to the output port. Thus, the user can probe any internal system node to view the linear range and compression curve characteristics of the system up to and including the selected component.

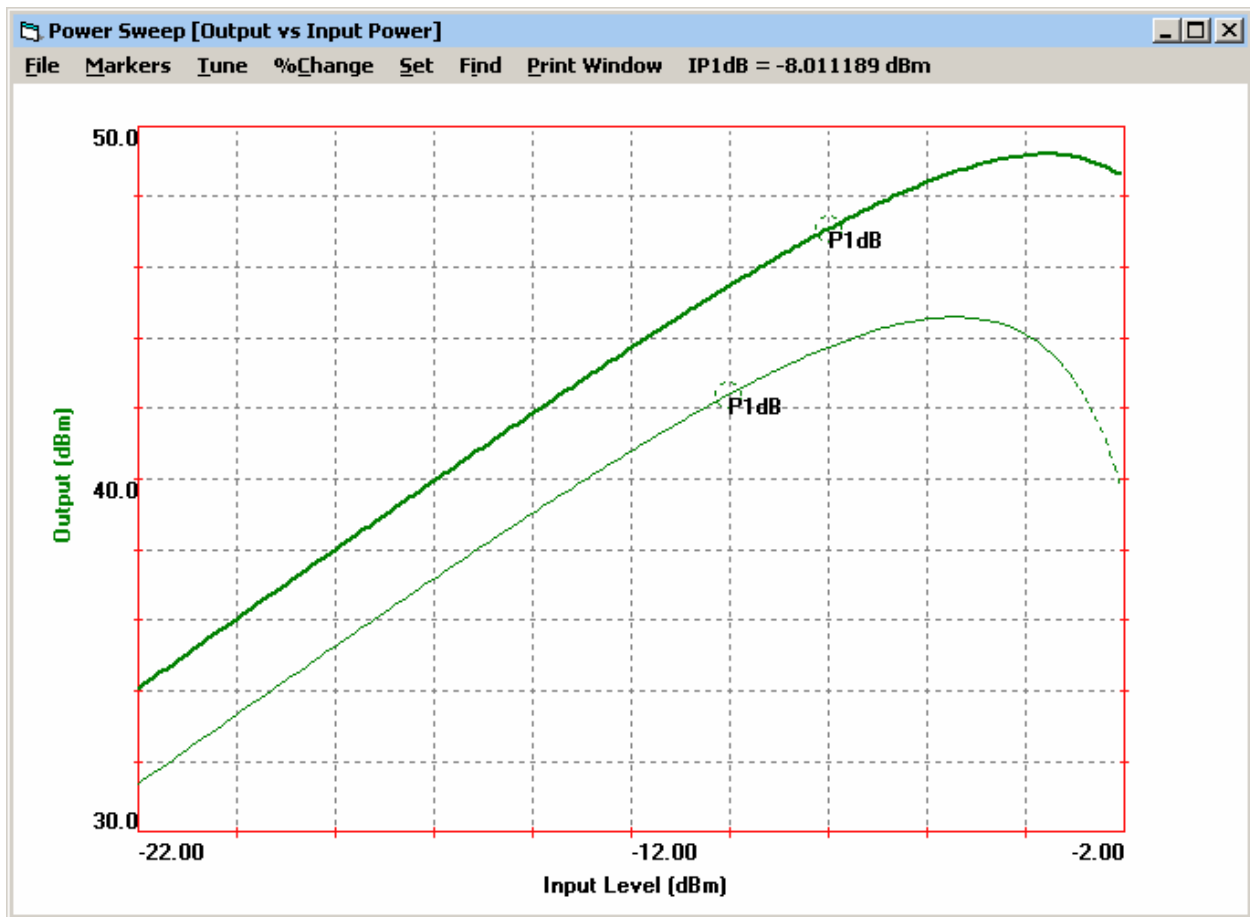


Figure 5, The Visual System Architect's Power Sweep Plots

## VSA Spectral Domain Analysis

One of the most challenging tasks an RF designer is faced with is to ensure that spurious signals are not generated and propagated through the system to places where they may degrade circuit or system performance. Undesired spurious signal products (or spurs) can degrade the sensitivity of a receiver or put a stage into compression and prevent the modulation on a desired signal from passing through the system properly. Spurious signals can mix with other spurs or they can mix with desired signals to create even more undesired spurs that are harmful to system performance, often to the extent of causing the product to fail to meet a number of key specifications.

To address the serious issue of spurs, ACS developed the Visual System Architect software with two very powerful analysis tools. One, the **Spectrum Analysis** display, for viewing the spectral content at any node in the system and the other, the **Signal and Spur Viewer Tree**, to track the creation and propagation of all spurs throughout the system.

The VSA's spectral domain analysis can plot all the signals and spurs in the system in the form of spectrum analyzer type graphs. To help isolate the cause and path of any unknown spurs, the VSA **Spectrum Analyzer Graph** can turn any signal source on or off to see which signals or spurs are related to a given source.

### Like a spectrum analyzer, only better!

At first glance the Visual System Architect's Spectrum Analyzer graph window looks a lot like the screen of a typical spectrum analyzer bench instrument. The spectrum plot displays the

entire power spectrum content at any point in the circuit. However, unlike any physical spectrum analyzer *instrument*, the user can select any component parameter from the Tune menu and adjust its value to see its effect on the production of spectral content. For example, the user could interactively adjust the third order intercept point on a power amplifier to see the effect on the level of 3<sup>rd</sup> order inter-modulation products at the output. All the signal sources driving the system are listed in the **Set** menu as well. This allows the user to adjust the input power to the system from any signal source while viewing the resulting change in the levels of all affected signals and spurs.

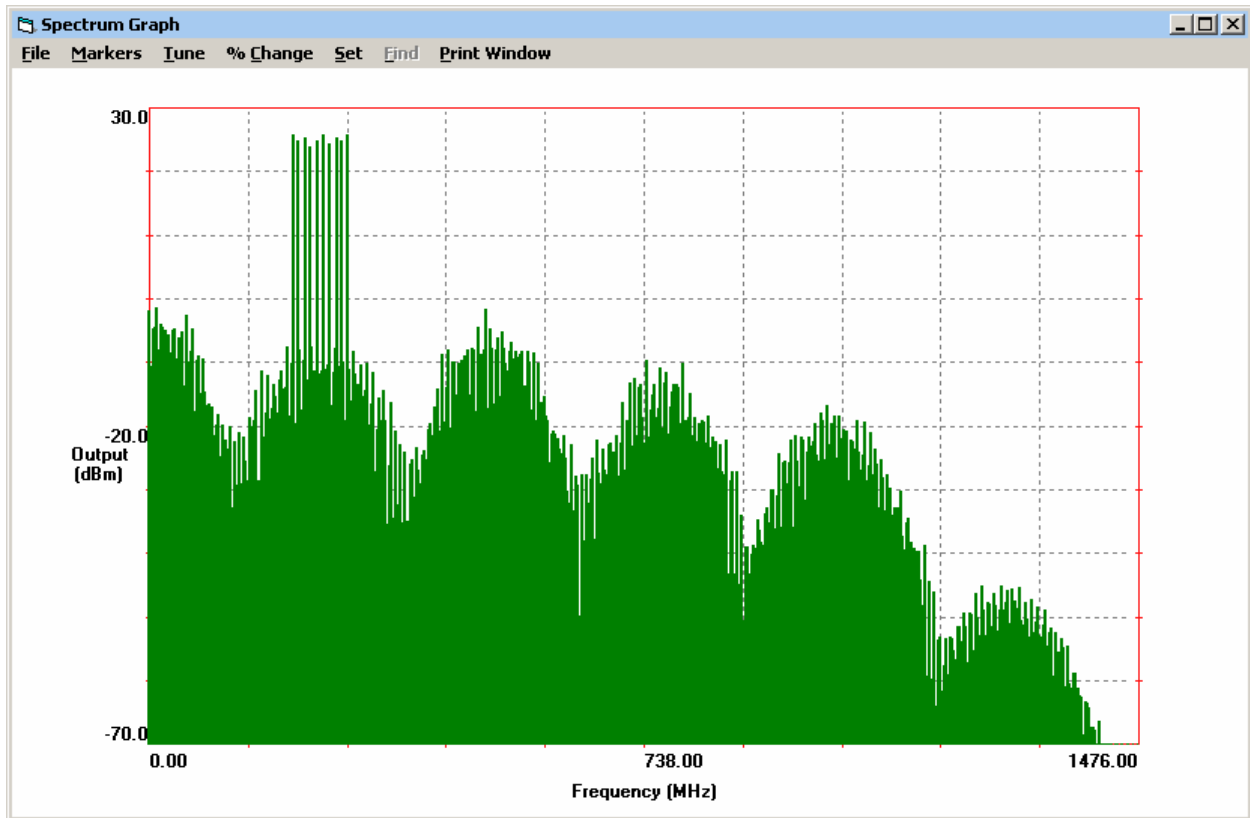


Figure 6, Power Spectrum Output Plot from the ACS Visual System Architect

Figure 6 shows the **LINC2 VSA's Spectrum Analyzer** view for an amplifier with multi-tone inputs. The number of input signals is limited by the (RAM) memory available for the computer used. However, there are no restrictions on the relative amplitudes of the tones or their spacing. (Note the different amplitudes and spacing for the ten fundamental signals in Figure 6). Thus, one or multiple signals can be input to the system with complete freedom to independently specify the amplitude, frequency and phase of each input signal. The signals input to the system can be represented on the system schematic by signal generators producing up to 3 simultaneous tones per generator. Additionally, a signal generator can be file based so that an entire spectrum of signals can be loaded into the system at once.

## All New Spectral Noise Simulations!

The VSA's powerful noise simulation capability lets you see signals and spurs rise above a simulation of the noise floor in a spectrum display that rivals the displays found in actual spectrum analyzer instruments (Figure 7). The VSA also reveals signals or spurs below the noise floor (Figure 8)! Now you can catch impending spurs before they rise above the noise floor - a feature that not even a real spectrum analyzer can do!

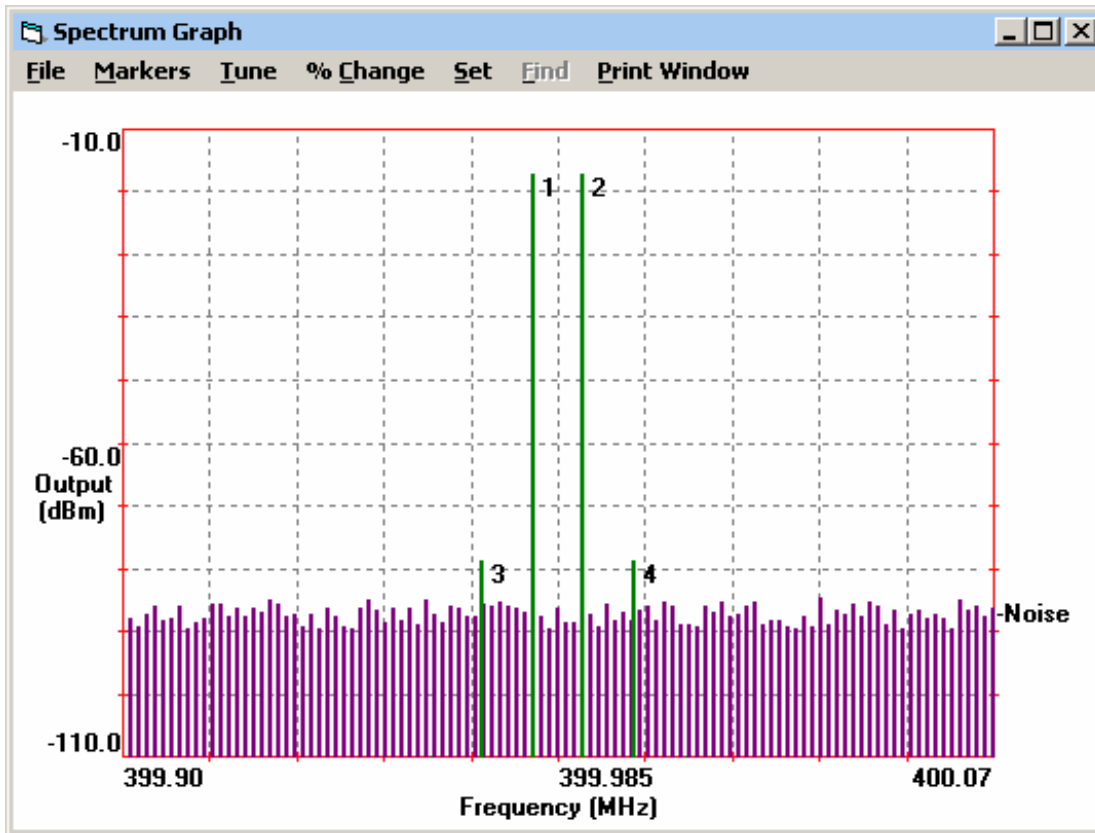


Figure 7, VSA Spectrum Graph Showing Signals and Spurs Above the Noise Floor

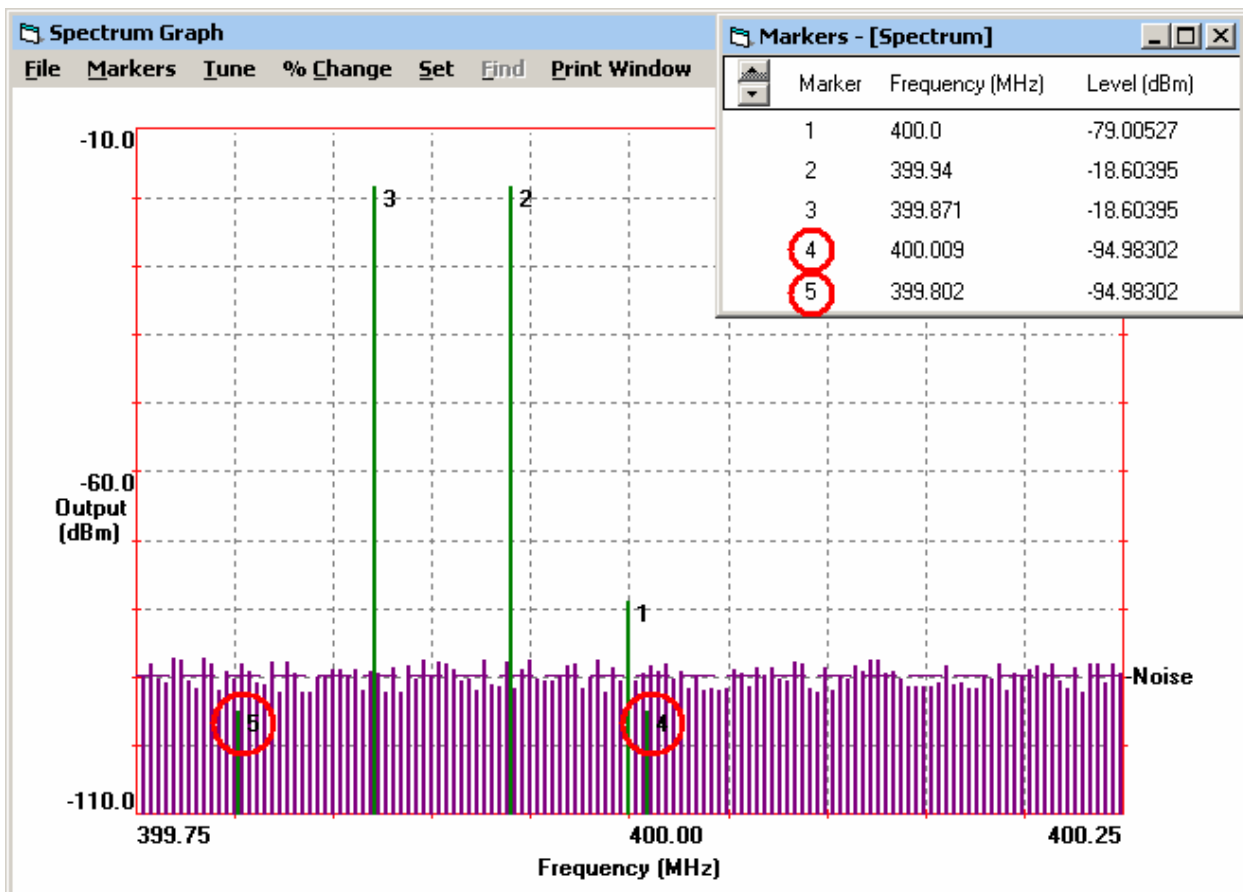


Figure 8, The VSA Spectrum Graph Showing Spurs Below the Noise Floor

LINC2 VSA noise simulation provides the ability to...

- Specify the system noise temperature.
- Specify the optional system noise bandwidth (or use filters to define the NBW).
- Simulations automatically find the proper system noise bandwidth by analyzing all the filters used in the system schematic!
- See spectrally how filtering can lower the noise floor and reduce adjacent channel interferers.
- See signals and spurs rise above a simulation of the noise floor in a spectrum display that appears just as it would in a real spectrum analyzer instrument.
- Visually compare signal-to-interferer levels and signal-to-noise levels on the same spectrum analysis display.

In addition to plots of noise figure (NF), the following noise related simulated output measurements are available:

### Noise Bandwidth Calculations

- The noise bandwidth is automatically calculated at every stage in the system
- The noise bandwidth (NBW) is adjusted according to the filters used
- If filters are not present in the schematic then a detector (or global) NBW can be specified

### Noise Power Measurement

- Total noise power can be plotted (or numerically displayed) for every stage/node

### SNR (Signal-to-Noise Ratio) Measurement

- The Signal-to-Noise Ratio can be plotted (or numerically displayed) for each node

### SFDR (Spur-free Dynamic Range) Measurement

- The SFDR can be plotted (or numerically displayed) for each system stage/node

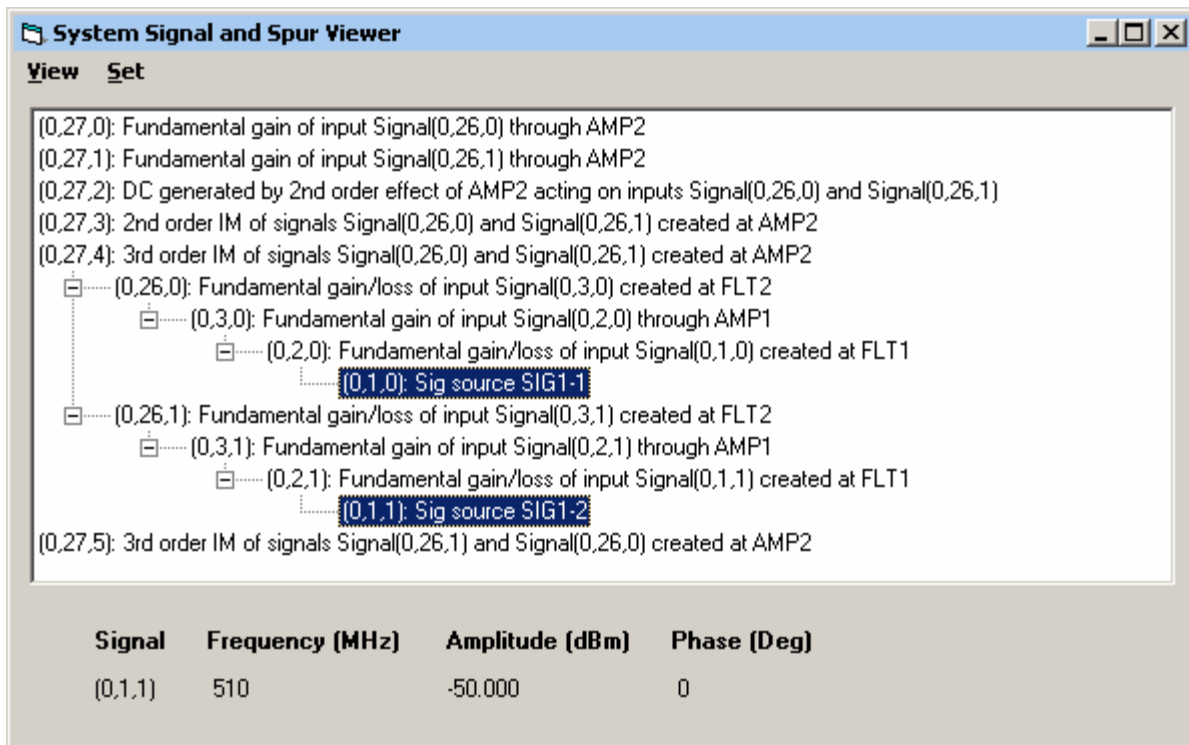


Figure 9, The Visual System Architect's Signal and Spur Viewer

## The VSA Signal Tree- Unique System Signal and Spur Viewer

The Visual System Architect provides unique user access to a detailed analysis of every signal and spur in the entire system. The **System Signal and Spur Viewer** window automatically organizes all these signals and spurs into a tree structure that provides nearly instant access to detailed information on any signal anywhere in the system (as shown in Figure 9). At the highest level in the signal tree is a list of all the signals present at a given node (the output node, for example). Click on any one of these signals and the next level in the tree opens for that signal. A list of all the signals involved in the creation of the selected signal are displayed at this next lower level in the tree. Clicking the “+” symbol in front these “ancestor” signals displays the next level of signals - all the signals involved in creating the selected ancestor. This process continues down to the end (or lowest level) of the branch where the origin of the signal is located. The process of navigating the VSA Signal Tree is similar to the familiar file and folder navigation tree found in the Windows Explorer/File Browser.

### Each Signal Uniquely Identified

Preceding every signal in the list is a numerical tag that uniquely identifies the signal. The signal identifier tag is comprised of three numbers of the form (**Source, Node, Index**) that uniquely identifies each signal according to the **Source** that was the ultimate origin of the signal, the **Node** at which the signal exists and the **Index** that identifies this signal among the array of signals that are present at this node. Moreover, any signal at any node along the path can be right clicked to reveal its amplitude, frequency and phase (as displayed directly below the signal tree). Expansion of the signal tree (clicking through a branch in the tree) yields the path a particular component of the signal travels from its source to arrive at the point of observation.

### Summary and Conclusions

The Visual System Architect from ACS includes the stage-by-stage cumulative system budget analyses that are essential to successful system design, analysis, system performance verification and report generation. Full spectral domain analysis provides a spectrum analyzer view of all signals and spurs at any point in the system. With the System Signal and Spur Viewer the user can trace any signal or spur through the system back to its source.

System design and analysis productivity is enhanced by the flexibility and ease of use of schematic based system simulation. The ability to drag and drop circuit or system components onto the schematic page from an inclusive menu of component models allows the user to quickly construct system diagrams of arbitrary topology. “What if” scenarios can quickly and easily be tested by simply dragging components into new configuration lineups.

Documenting system performance and report generation is easy since the VSA software can export the tabular data from the Reports page as well as all data from Cascade Budget Analysis, Power Sweeps, and Spectrum Analysis Graphs to standard CSV files that can be immediately imported into spreadsheets such as Excel. The data is also compatible with a wide variety of other programs through the common CSV format.

The VSA maintains a common user interface between system level and circuit level schematics making it easy to transition from system design to detailed circuit design and back without having to learn or become reacquainted with a different operational behavior. LINC2 system simulation and circuit simulation is also operationally similar and both have the same easy to use



operator interface- simply enter schematic, set output options, click **Analyze** and **View Results/Reports**.

## **The LINC2 Software Suite**

With the addition of the LINC2 Pro circuit design and simulation software suite (also from ACS), system level designs created with the Visual System Architect can proceed to the detailed circuit design level, all within a common integrated user interface.

LINC2 is a high performance RF and microwave design and simulation program from ACS. In addition to schematic based circuit simulation, optimization and statistical yield analysis, LINC2 Pro includes many value-added features for automating design tasks, including circuit synthesis.

LINC2 offers exact circuit synthesis, schematic capture, circuit simulation, circuit optimization and yield analysis in a single affordable design environment. Now, with the Visual System Architect, RF and microwave circuit design can be suitably driven by system design that connects product specifications to circuit level specifications. The Visual System Architect software provides interactive (real time) tuning at the system level to help ensure that a product will comply with required specifications before valuable resources are committed to detailed circuit design and prototyping.

More information about the ACS Visual System Architect and LINC2 Pro can be found on the ACS web site at [www.appliedmicrowave.com](http://www.appliedmicrowave.com).