Leveraging the Use of a Radio Frequency Planning (RFP) Design Tool for Modern System Design

RF planning ensures sufficient coverage and capacity for the services required by the end product.

By Malcolm Edwards

Introduction

RF planning, the process of assigning the frequencies, transmitter locations and parameters of a wireless communications system, is an important element of system design as it ensures sufficient coverage and capacity for the services required by the end product. Traditionally, system designers have relied on the use of spreadsheets for RF planning purposes rather than digging deeper into the problem(s) at hand: establishing the best frequency plan and system architecture to meet the system specification.

The task of frequency planning takes as the initial system definition the input signal frequency/power specification and the output frequency/power specification. Because today's communications devices must be small and lightweight, yet provide superior performance at a low cost, the goal of the systems engineer is to design a system that transports the signal from the input port to the output port using the minimum number of frequency translations (along with the simplest synthesizer architecture) and using the lowest cost filter technology. This means using filters that have realistic circuit Q, a reasonable number of resonators, and, most importantly, filters that meet the environmental specification of the equipment. Failure to meet these specifications can result in a system that has marginal performance or one that requires special attention when being used.

RF Planning

There are two aspects of frequency planning. The first, which is similar to a design tool, commonly uses so-called spur charts and related algorithms. The second, which is closer to a verification process, is commonly known as spur searching. With emphasis on the first, AWR has introduced an innovative new design methodology called RFP™. This RF frequency-planning software utility automates and streamlines the design process while retaining the spreadsheet concept so that the designer is comfortable with a familiar paradigm.

RFP is seamlessly integrated as a wizard within AWR's Visual System Simulator™ (VSS) communications system design environment for the design of radio communications systems, cellular, or military radio links. RFP enables designers to effortlessly and efficiently determine spurious free bandwidths in RF/microwave designs and gives engineers a greater insight into unwanted signals or spurs generated in a specified bandwidth.

RFP is not limited to simply analyzing spurs generated by a lineup of mixers. The RFP RF link lineup can include most common components found in radio communication links such as amplifiers, mixers, and filters, and can be built up from a selection of commercially available parts or behavioral models. In addition, the number of conversions in the RF link is not limited to two, as is often the case with other RF planning tools.

Figure 1 • RFP graphic interface with views of the system architecture and access to setup and utilities.

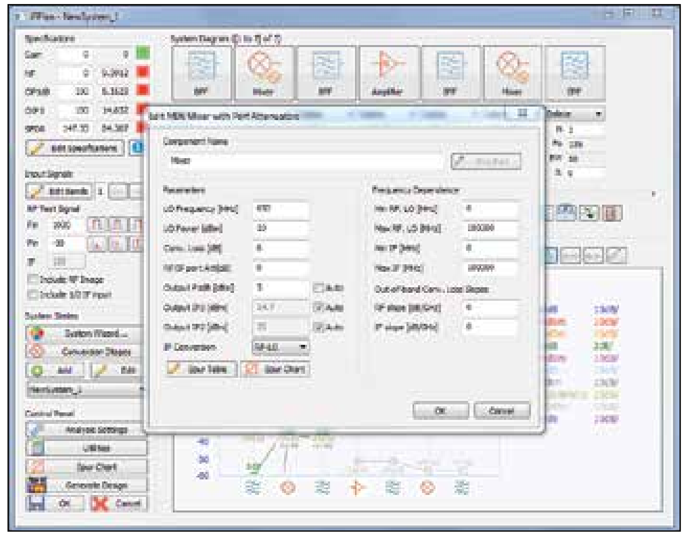

Figure 2 • The System Diagram view shows the details of the selected element's performance, in this case a mixer.

Using Spur Charts in RFP

The RFP graphical interface provides several views of the system architecture and access to the setup and utilities. The main sections of the interface, as shown in Figure 1, are the System Diagram and the System Response.

The System Diagram consists of a cascade of system blocks (elements) such as mixers, filters, and amplifiers. Beneath these blocks the major parameters of the elements can be seen. These parameters can be locked, linked, or user edited.

The System Response window can display the budget, the spur levels, and spot or wideband spectral plots. These will be expanded upon later in this paper.

By clicking on one of the mixers in the System Diagram view, the mixer performance can be examined in detail.

Clicking on the Spur Chart button displays a classic spur chart plot for the specific mixer and signal combination.

This display in Figure 3 will be familiar to designers who make use of the spreadsheet approach to mixer spur analysis. It uses the classic mixer equation

$$\omega_{mix} = \pm n * \omega_{lo} \ \pm m * \omega_{rf} \qquad (1)$$

This equation defines both wanted and unwanted mixing products that are generated by the process of frequency translation using a mixer driven by a local oscillator. Colors are used to assist in understanding the spur levels in relationship to the specification. The mixer model can either be the classical model based on the Henderson tables or imported from a mixer vendor's specification. These spur tables can also be user defined,

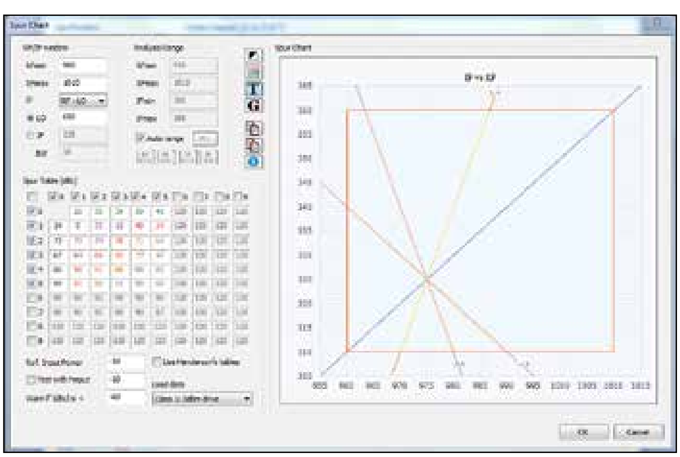

Figure 3 • The Spur Chart displays a classic spur chart plot for the specific mixer and signal combination.

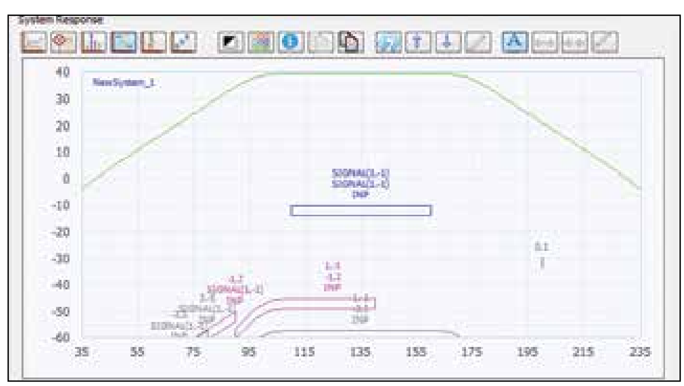

Figure 4 • The spur equations are enhanced to add the loss and filtering action of the input and output filters.

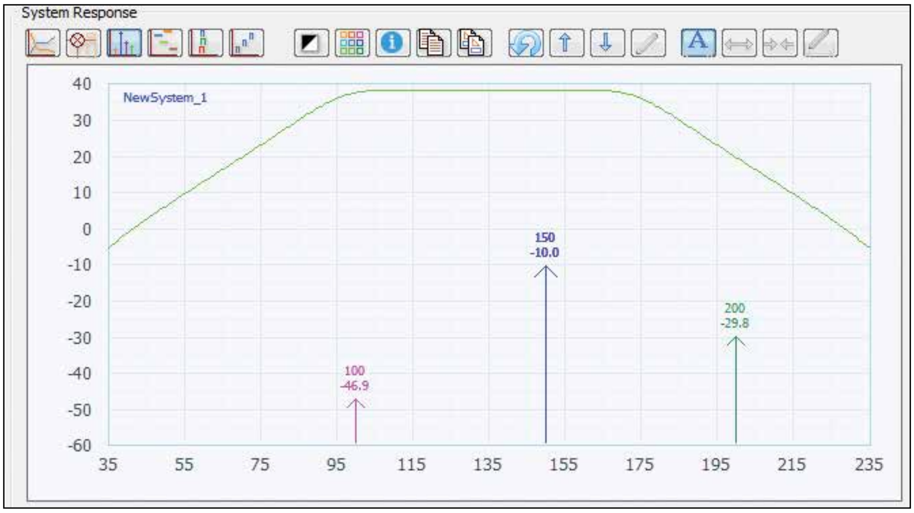

Figure 5 • The wanted and unwanted responses can be defined by the rectangles.

perhaps based on measurement or derived from a complete circuit-based model.

While spur charts of the form described above demonstrate the existence of spurs, some designers prefer to display the results using a spectral plot. In Figure 4 the spur equations are enhanced by accounting for the loss and filtering action of the input and output filters.

The rectangles visible in Figure 4 define the wanted and unwanted responses (Figure 5). The annotation provides the heritage of the signal.

A spot frequency spectrum is also provided. There are buttons available in the interface that allow quick changes to the signals to move them between band edges or place them at band center.

RFP enables complex signal environments to be constructed. Signals are classified as wanted and threats. Threat signals (friendly and unfriendly), a term often used by electronic countermeasure (ECM) designers, are color coded as red, while wanted signals are color coded as blue. The Input Signal Bands tool enables simple signal scenarios (a few signals) to complex signal scenarios (many signals) to be built. Figure 6 shows a system where the designer needs to select one of eight potential signals.

RFP allows local oscillators to track signals at a fixed offset. This permits a rapid assessment of spur creation at all LO states. For some systems, like ECM and surveillance receivers, a block converter is used, followed by a scanning LO. RFP also supports this architectural mode.

To complement the spur analysis, RFP provides an LO/IF Search utility, which reports spur-free regions to assist with LO planning.

Another key utility that RFP provides is the ability to create a system solution with just the click of a few buttons! Systems can be designed by manually adding blocks or by using the Up/Downconverter Wizard (Figure 7) opened using the System Wizard button in the main window.

Using this utility, a single, double, or triple converter can be defined. If required, the first filter in the RF chain can be a group filter that passes all the signals set up using the Input Signals window.

The choice of up or down conversion at each stage can be selected, as well as LO high side or LO Low side,

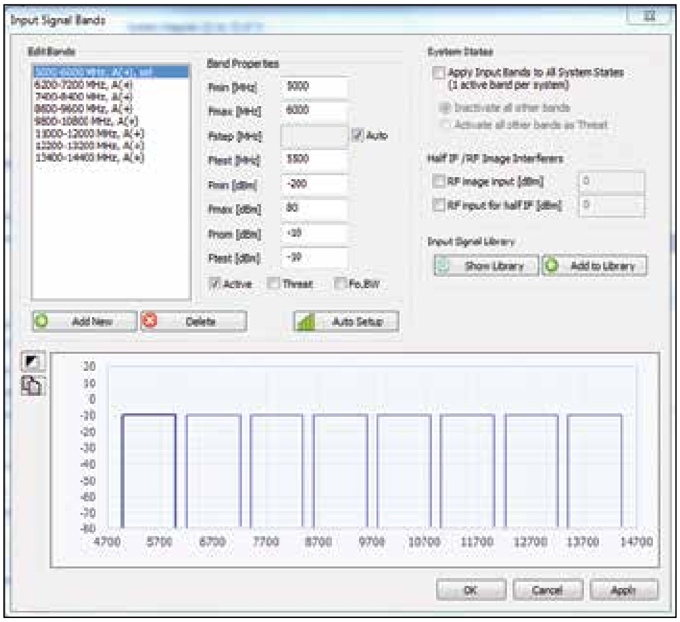

Figure 6 • In this system the designer needs to select one of eight potential signals.

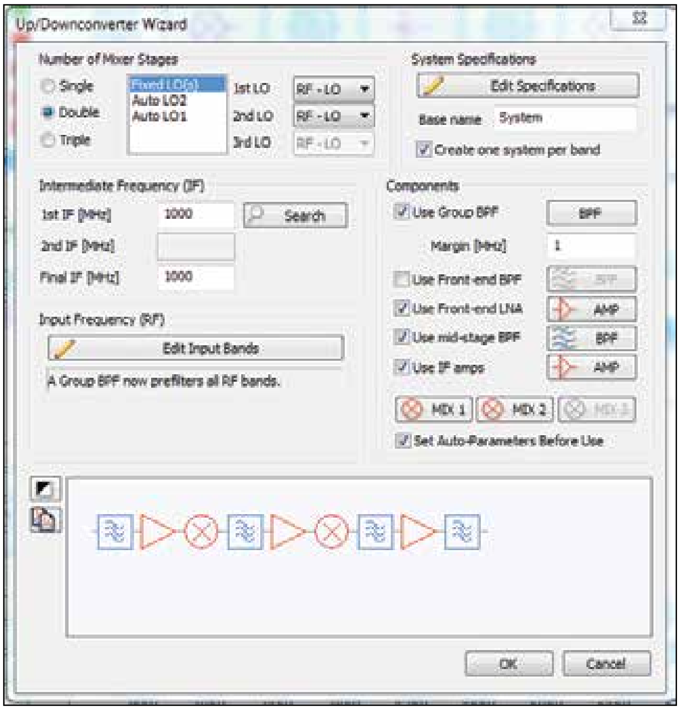

Figure 7 • Systems can be designed by manually adding blocks or by using the Up/Downconverter Wizard.

which avoids spectral inversion if that is important in the system. When the provisional system design is complete, the system can be exported to VSS for a more detailed budget and spur analysis. VSS can then be used to account for mismatch between components, account for noise at image frequency, and run yield analysis and optimization.

Designers have a choice of signals and can perform error vector magnitude (EVM), adjacent channel power ratio (ACPR), and bit error rate (BER) measurements, among others.

Conclusions

The art of system design entails frequency planning, budget planning, and spur searching. RFP provides the system designer with a solution for frequency planning that's also tightly integrated into the entire AWR Design Environment™ flow and specifically into VSS for complete system design, inclusive of budget planning and spur searching. In addition, RFP provides content that is familiar to expert spreadsheet users, enabling them to migrate over to a more comprehensive tool set. By using RFP as the initial design tool the designer can be confident that the downstream tools have a quality starting point.

About the Author:

Malcolm Edwards is European Technical Manager at AWR Corp.