Frequency Planning and Evaluating Tool

This application note describes the Excel spreadsheet used for radio frequency planning. The spreadsheet is offered for download, and supports cellular and PCS handset design. Example given is for an IS-136 TDMA radio design. Frequency difference between receive IF and transmit IF is found to be 45MHz. This allows a single RX IF and single TX IF to serve both cellular and PCS operation. Screen shots of the software in operation are used to explain the software's use.

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One of the most important steps in any radio frequency (RF) transceiver design is a properly chosen frequency plan. The basis of any frequency planning exercise is the well-known formula for mixer action:

$$f_{sp} = m \cdot f_{rf} \pm n \cdot flo^{1}$$

f_{sp} is the spurious output frequency.
f_{rf} is the RF signal.
f_{lo} is the LO, or local oscillator frequency.

Simple things become quite complicated for modern multi-band cellular phones. The designer has to find an optimum solution to resolve the following issues:

• Define proper intermediate frequency (IF) to eliminate in-band spurious signals, especially those which may cause receiver self muting - a performance issue.

• Minimize the number of IF filters - a cost issue.

• Mitigate the half IF (offset) problem - a performance issue for TDMA systems.

• Determine the main voltage controlled oscillator (VCO) frequency swing - a design feasibility and cost issue.

Much software exists to aid the designer, and the cost is only the time to download it from the Internet. Some programs make tabulated output listings which are tedious to read. Some programs provide a graphical output that looks impressive for high-level design presentation, but are difficult to use for understanding details.

The Excel spreadsheet featured here provides an easy to understand and useful tool. It is used for frequency planning of single and multiband transceivers. Initially this spreadsheet was designed for cellular and PCS telephone applications. Thus, when the cellular or/and PCS

channel number is entered, the spreadsheet will automatically calculate the transmitter output, the receiver input, the main local oscillator frequency, and the transmitter IF, based upon the entered receiver IF. At the same time, it is possible to have any number of scenarios under consideration. For the example in the default spreadsheet, three recevier IFs are to be evaluated. Another target for this spreadsheet was to design an IS-136 TDMA radio. This is why in the PCS band the difference between RX and TX IF is chosen as 45MHz. This solution dramatically reduces the cost of the hardware, using a single RX IF and a single TX IF for both cellular and PCS band.

Here are a few notes on how to use the spreadsheet: (See Figure 1)

1. Entering 1 or 2 in the purple cell selects High or Low side for LO injection.
2. Entering 1, 2, or 3 in the yellow cell selects RX IF frequency from the cells below. Those frequencies can be changed manually as desired.
3. Use blue cells to enter the frequency channel to be evaluated.
4. If there any spurious response within the RX or TX band, the frequency of the spur will be automatically highlighted in red.
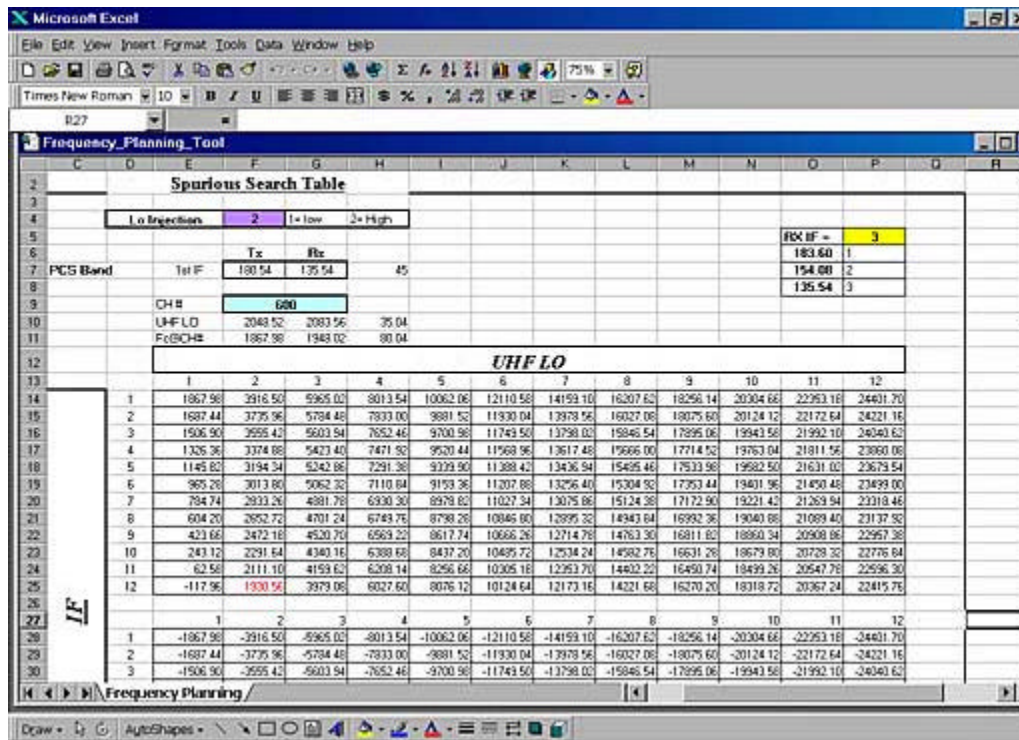5. If an illegal channel number is entered, "Ch# Error" will be displayed.

Figure 1. The frequency planning spreadsheet is controlled by entering appropriate values in the yellow, purple and blue cells.

The second table, "VCO Plan", is to see how much frequency range is required for the VCO with the evaluated frequency plan. Figure 2 shows a sample of this. Please note that the table is based on using a divide-by-2 on the VCO output when operating in the cellular band.

Figure 2. The maximum tuning range of VCO is calculated

References

1 Bullock, Scott, *Transceiver System Design for Digital Communications*, Tucker, GA.: Noble Publishing, 1995, section 3.16.1, pp. 124-128.

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