Select mixer frequencies painlessly.

With a simple, graphical method, you can sidestep long trial-and-error sessions and determine bandwidth, too.

If you've ever become bogged down in the calculation of mixer frequencies, you'll appreciate a simple, graphical selection technique that avoids the voluminous printouts of computer aided iterations and trial solutions.

With this procedure, you can visually select the appropriate mixer frequencies to meet your spurious requirements. Only those spurs whose levels exceed the given spec are plotted on the chart. As an added benefit, you can map the output bandwidth onto the spur chart as a function of the bandwidths of the two input signals. The region thus described is an irregular hexagon with sides defined by the relative bandwidths and ratios of the mixing tones.

This definition of the locus of output frequencies mapped on the spur-chart plane lets you select mixer frequencies rapidly and lends further usefulness to the chart. (The spur chart has been available since 1966 but has not been widely used because of a poor understanding of bandwidth effects.)[1]

Derivation of equations

Typical spurs of high and low-level mixers are shown in Figs. 1 to 4. The ordinate is the frequency ratio f_1/f_2, and the abscissa is the percentage bandwidth with respect to the desired output frequency, f_0, where $f_0 = f_1 + f_2$ for the sum charts, and $f_0 = f_2 - f_1$ for the difference charts ($f_2 > f_1$).

To derive the equations that generate the graphs, note that the spurs, or cross-modulation products, have the general form

$$P = Mf_1 + Nf_2, \qquad (1)$$

where M and N are positive or negative integers. The frequency ratio, $n = f_1/f_2$, is always less than 1. Percentage separation is given by:

$$S = \frac{P - f_0}{f_0} \times 100 \qquad (2)$$

or

$$P = \frac{f_0 S}{100} + f_0. \qquad (3)$$

Eq. 1 and 2 can be rewritten for the case $f_0 = f_1 + f_2$:

$$f_2 = \frac{P - Mf_0}{N - M}. \qquad (4)$$

Then the frequency ratio, n, can be expressed, with use of Eq. 4, as

$$n = \frac{f_1}{f_2} = \frac{f_0 - f_2}{f_2} = \frac{Nf_0 - P}{P - Mf_0}. \qquad (5)$$

Eq. 4 and 5 are both undefined for the case N = M. To simplify calculations, such spurs are deleted from this computation. It can be shown, however, that the N = M spur lines are vertical and appear on the summing mixer chart at $S = (N - 1) \times 100$. Similarly, the analysis of difference mixing does not consider spurs where $N = -M$. These, too, are vertical lines on the chart, with $S = (N - 1) \times 100$.

Now, with use of Eq. 3, Eq. 5 becomes

$$n = \frac{-S + 100\,(N - 1)}{S - 100\,(M - 1)}. \qquad (6)$$

This equation relates n, the frequency ratio, to S, the percentage separation, for $f_0 = f_1 + f_2$ and is used to plot the sum charts.

Similarly, for $f_0 = f_2 - f_1$, Eq. 1 can be rewritten

$$f_2 = \frac{P + Mf_0}{N + M}. \qquad (7)$$

Again, the frequency ratio, n, can be expressed, with use of Eq. 7, as

$$n = \frac{f_1}{f_2} = \frac{f_2 - f_0}{f_2} = \frac{P - Nf_0}{P + Mf_0}. \qquad (8)$$

Now, using Eq. 3, we see that Eq. 8 becomes

$$n = \frac{S + 100\,(1 - N)}{S + 100\,(1 + M)}. \qquad (9)$$

Eq. 9 relates n and S for $f_0 = f_2 - f_1$ and is used to plot the difference charts.

Calculator does the plotting

A program written for the HP 9810 calculator uses Eqs. 6 and 9 to plot spurs for any M and N. If all the spurs to the seventh order are plotted, the graphs are seen to be identical to those in reference 1. However, many of the spurs that are plotted with this procedure are very small in

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