Linear RF Mixers

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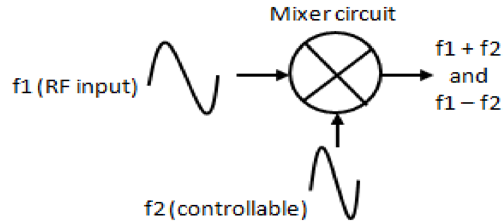

Virtually all of today's RF technologies depend upon the mixing function, by which two frequencies are combined to produce sum-and-difference signals, which are then filtered to select the desired output.

Even Software Defined Radio (SDR) designs require mixing to get microwave signals into the range of analog-to-digital converters. However, all known mixers introduce spurious signals and noise, which limit the capability of the overall circuit. Those undesired signal components are due to inherent nonlinearity-in-the-amplitude-domain of accepted mixer technologies.

Wikipedia (and engineering reference books and publications) describe the mixing function as follows ***"…a mixer, or frequency mixer, is a nonlinear electrical circuit that creates new frequencies from two signals applied to it."*** (emphasis is added) Note that the RF industry assumes that the mixing function is inherently nonlinear, which is the source of undesired noise in the output of the circuit.

In RF circuits such as radios, system performance is dependent upon – and limited by – mixer performance. Developments in amplifiers, filters, and other circuit components have made the mixer the limiting factor in RF circuits. Many attempts have been made to compensate for the natural nonlinearity of the mixing function to improve system performance, but accepted technologies are not capable of a fundamentally linear mixing function. Such a technical achievement can improve virtually every aspect of many RF industries. As examples:

In **broadcast television** (including satellite), linear mixing can reduce required transmission power, and reduce the cost of both transmitter and receivers.

In **radar** systems, linear mixing can permit optimal performance, virtually independent of range. This would improve sensitivity for a given level of cost, or reduce cost for a given level of performance.

In **electronic warfare**, linear mixing can reduce energy of undesired signal components while increasing system sensitivity and selectivity.

In **cellular** telephony, linear mixing will reduce the required number of cell towers for a given level of system range and performance, permitting less costly handsets and transmitters, a lower error rate, and better reception.

In **instrumentation**, linear mixing will enable cost-effective instruments with levels of sensitivity and performance that are not currently possible.

The Belkin Mixer is the first RF mixing circuit that is inherently linear in the amplitude domain. Conceived and developed by Sam Belkin (MSEE, JD), the newly patented design has been validated by simulations in which results met predictions, and has been demonstrated by measured operation of functional proof-of-concept circuits. Mixers are generally defined by the specification called the 3rd intercept point (IP3), and conventional mixers achieve an IP3 level at about 20 dBm. This single specification defines mixer performance and therefore limits system capabilities. The Belkin Mixer can improve the IP3 figure by orders of magnitude; the project cost-effectively achieves IP3 measurements better than 100 dBm, and 130dBm is deemed possible. Specific advantages of the Belkin mixer:

1. Low noise (IP3 > 100dBm).
2. Low insertion loss (about half a dB).
3. LO does not appear in the signal path (lower noise).
4. Such linear mixers support development of fast/agile tunable filters. (US/PCT patent pending)
5. Such dynamic filters support development of an adaptive front end for all radio designs, including software-defined. (US patent pending)