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## Notes on Switching Mixers

An area of interest for high performance receiver designers is switch-mode mixers. Mixers are usually the circuit element that determines the upper limit of intermodulation-free dynamic range, and switching type mixers have the potential for the highest performance.

Mixers are considered to be inherently non-linear devices, but a mixer is more accurately described as a circuit that switches between two linear states. Those linear states are the transmission of the normal and inverted polarities of the signal. The rate of transition between the two states takes place at the offset frequency or "local oscillator" frequency. If the transition between the two states is instantaneous, there is only one non-linear transition. Of course, all switches have finite transition times, but as those times get smaller, the non-linear region—and its resulting distortion—is reduced.

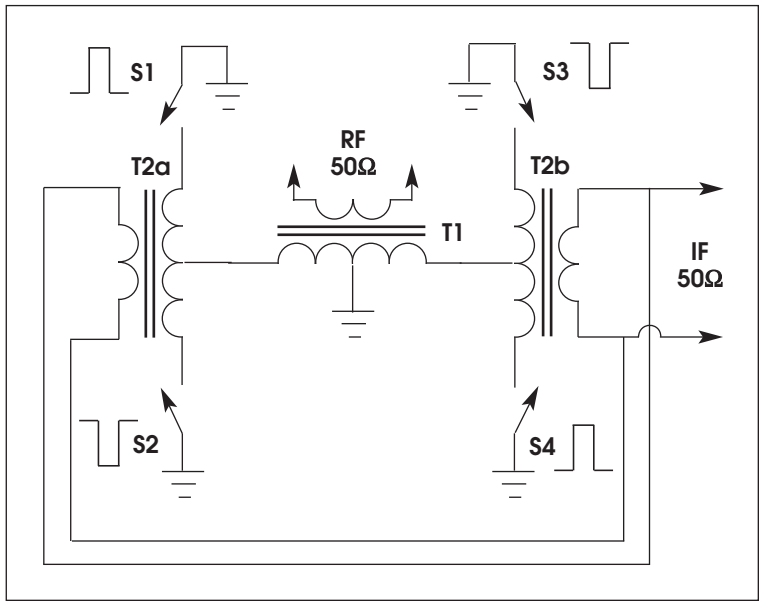


**Figure 1 · The high dynamic range H-mode switching mixer developed by Horrabin.**

Using this description, a conventional high LO level diode double balanced mixer can be considered a "switching" mixer. After all, it achieves its low distortion by driving the diodes with a high amplitude sine wave. The time between zero crossing and diode turn-on threshold is very short, since it occurs during the near-vertical portion of the sine waveform. Regardless, common usage of the term typically refers to active devices used as the switching elements.

The fastest switches are only "fast" at low frequencies, where their switching time is a small fraction of a cycle. Thus, the greatest interest in switching mixers is in the HF and VHF range. These frequencies are also the range where maximum dynamic range is most important. High power broadcast transmitters are common in this range: medium wave, shortwave, FM and television. There are also hundred- to kilowatt-level transmitters for military communications, mobile and fixed "bush" or "outback" radios, as well as amateur radio. With the possibility of efficient ionospheric propagation, signal strengths can easily represent a range in excess of 120 dB between strong signals and desired weak signals on adjacent frequencies. It is not a surprise that much experimental work is carried out by amateur radio operators in Europe, where these conditions are the most difficult.

One interesting topology that has gotten much recent attention is the "H-mode" mixer, developed by Colin Horrabin in the UK. A simplified diagram is shown in Figure 1, which has the "H" shape that gives this design its name, which is best for showing the signal paths at the input. The switches are driven with symmetrical, complementary square waves. As alternate pairs of switches open and close, the input is coupled to opposite halves of T2a and T2b. This provides the commutation between normal and inverted signal polarity. The complementary outputs from the two pairs of switches are summed at the IF port, which can be connected as a balanced or single-ended connection. In essence, there are two push-pull switched assemblies (S1/S2 and S3/S4) that are also fed in push-pull (doubly balanced).

The principle advantage of this configuration is that the switches are connected to ground. This stabilizes one end (typically the source of a FET switch) at zero volts, minimizing the possibility of the input signal modulating the ON resistance. That type of cross-modulation can be a problem when the FETs are floated above ground, as they would be if they replaced diodes in a conventional double balanced mixer.

Rather than list the numerous references available for the H-mode mixer, we simply suggest that interested readers do a Web search on "H-mode mixer" — which will return many articles and technical notes by various investigators of this design.