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A Few Common Design Tradeoffs

There are many, many tradeoffs in any high frequency design. Here are a few of the most common areas where decisions must be made. Of course, this list is only a fraction of the possibilities, but perhaps it will stimulate your thinking the next time you need to make some of these decisions.

Dynamic Range

Amplifier Current/Dynamic Range—Strong signals add a varying voltage to transistor bias. The easiest way to minimize the effect is to keep the bias well into the turn-on range and allow significant collector-emitter or drain-source current. Feedback helps, too, but generally, increased current and higher dynamic range go hand-in-hand.

Drive Power/Dynamic Range—This applies to passive mixers, using the local oscillator to provide power to switch the mixer diodes (or BJTs or FETs). Mixers are most linear with the shortest possible turn-on/turn-off times. For AC-coupled LO drive, that means high enough amplitude to use the most vertical portion of the sine wave. Square wave drive is possible, but must provide the necessary current or voltage.

Noise Figure/Dynamic Range—The higher current required for higher dynamic range increases the internal noise of the active device. Some feedback techniques also increase the noise figure. So-called "noiseless feedback" is fine for noise figure, but reduces input-output isolation, which can result in instability.

Operating Voltage/Dynamic Range—This applies mainly to IC process, where low operating voltage reduces the difference between the maximum signal voltage swing and the noise floor.

Bandwidth

Bandwidth/Efficiency—In amplifiers, it is relatively easy to obtain an optimum impedance match in a narrow bandwidth. Gain and/or efficiency, including matching network losses, are degraded with most broadband matching techniques.

Bandwidth/Noise—When feedback is used to improve amplifier bandwidth, most techniques increase the noise figure.

Bandwidth/Interference—Obviously, wide bandwidth systems have more potential interfering signals at the input. In severe cases, a choice may be necessary between a wideband design and a tunable narrowband system.

Bandwidth/Group Delay—Complex modulation schemes are more sensitive to time domain errors than simpler modulation types. Narrowband circuits actually increase the time domain variations, especially at the transitions from filter passband to stopband. Wider bandwidths place these transition zones away from the frequency occupied by the signal and its modulation components. (See Bandwidth/Inteference above, however.)

Power Consumption

Power/Dynamic Range—Higher currents for high dynamic range add to power consumption. Power-critical applications may need to address this with feedback, filtering or dynamic adjustments.

Power/PA Linearity—A very important area of development, especially with the high peak-to-average power ratios of complex modulations. The objective is to achieve high linearity without the very high power consumption of Class A bias to support the maximum peak power. Many types of device characteristics, circuit designs, and corrective signal processing schemes have been developed and are still being explored for even greater improvements.

Power/Semiconductor Process—CMOS is lowest power, GaAs is highest power of typical RF/microwave processes, with bipolar, BiCMOS and SiGe somewhere in between. The choice of process for a particular RFIC can become complicated when attempting to balance performance and cost.

Power/Control Complexity—System-level power consumption can be reduced with intelligent management routines, but these require processing power and control circuitry that adds to a system's complexity.

Analog or Digital

The decision of which parts of a system are analog and which are digital is a relatively recent development for low cost, consumer-level devices. This is a different type of tradeoff than a circuit design choice, since it is done at the initial conception of the design rather than for individual functions.

The key factors for an analog/digital include the obvious cost vs. performance factors, which involves such things as the need to achieve system simplicity to meet size or power consumption requirements, or to permit increased system complexity to support a larger number of features and higher performance. High volume manufacturing and the required engineering development time are also part of the tradeoff equation that must be balanced.

Cost

Sorry, no notes here. This topic is much too big for a one-page Design Note!