DESIGN FAQs

Frequently Asked Questions:

DATA CONVERTERS FOR CELL-PHONE BASESTATION DESIGN

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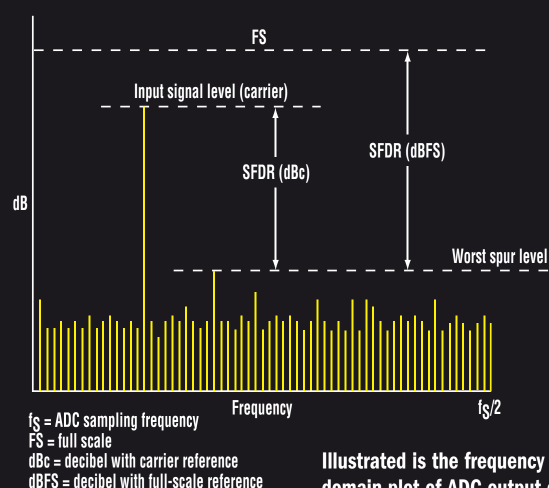
Cell-phone basestations are regularly updated to expand system capacity as well as implement new standards and data services. Complete replacement of equipment is too expensive, so most carriers look to vendors for system upgrades. Soon, many basestations will upgrade to systems that can support the new wideband 3G cell-phone systems. At the heart of the new and upgraded equipment are the data converters that translate between the analog wireless and digital processing worlds.



Illustrated is the frequency domain plot of ADC output derived from an FFT analysis to show and define SFDR.

What are the current trends in basestation design?

The newer equipment uses a broadband design that is essentially a software-defined radio (SDR). The receiver picks up the entire assigned multichannel band and digitizes at the earliest point in the receiver possible. Receivers with bandwidths to 30 MHz may receive part of the band or an entire 75-MHz band, which may include multiple types of cell-phone air standards. From there, all other receiver functions such as additional downconversion, filtering, demodulation, demulitplexing, and all baseband functions (decompression, etc.) are done digitally in a DSP. With such a design, fewer receivers are needed, reducing space and decreasing power consumption and heat.

What does the architecture of a basestation transceiver look like?

The receiver has an appropriate low-noise amplifier (LNA), input filters, and a mixer that downconverts the signal to the intermediate frequency (IF). Newer SDRs implement a single high-frequency IF. Typical values in the newer systems range from about 60 to 70 MHz to as high as 240 MHz. The IF is usually harmonically related to some baseband reference frequency. Some newer designs use zero-IF (ZIF) or direct-conversion designs. In the receiver, the signal is immediately downconverted to baseband by heterodyning the signal with a synthesizer on the same frequency. This greatly relaxes the ADC's conversion speed requirement. DSP takes over from there with filtering, demodulation, and other functions. In the transmitter, the baseband signal is sent to the DAC and immediately upconverted to the final output frequency before being sent to the PA.

What type of ADC should I look for to implement an SDR basestation receiver?

Most ADCs fast enough for this service use what is called a subranging or pipeline converter. This type of ADC uses low-bit-count (4 bits) flash converters connected in two or more pipeline stages to achieve the desired resolution and conversion speed.

What are the key specifications needed in an ADC for basestation service?

Sampling rate, resolution, spurious-free dynamic range (SFDR), and signal to noise ratio (SNR) are the main specifications. The maximum sampling rate dictates the Nyquist bandwidth. This bandwidth is essentially the sampling rate in megasamples per second divided by two. ADCs with sampling rates as high as 125 Msamples/s are available now, and that rate is expected to climb with future products. Resolution is given in number of bits. The minimum for this service is 12 bits, while 14 bits is better. SFDR is the most important ADC specification. It is defined as the ratio of the rms value of the received signal to the rms value of the peak spectral spur in the sampling region *(see the figure)*. It is usually expressed in terms of dBc. Values of 70 dBc and higher are necessary for good performance. Values of 80 to 90 dBc can be achieved in practice. SFDR is measured using discrete Fourier transform (DFT) techniques. SNR is another key spec. It is the ratio of the rms value of the signal to the rms noise level. Some ADC manufacturers include harmonics with all forms of noise in the spec. This is called signal-to-noise and distortion (SINAD) or S/N+D. High-speed 12- or 14-bit ADCs have an SNR in the 65- to 75-db range. The noise also affects the effective number of bits (ENOB) of resolution. Because noise degrades the least significant bits, the useable resolution is less than that of the design. For example, ENOB is calculated with the expression:

$$ENOB = (SINAD - 1.76\ dB)/6.02$$

Keep in mind that a high sampling rate also produces processing gain. If a narrow bandwidth signal is sampled at the Nyquist rate, the full noise of the converter will occur within the converter bandwidth. Doubling the sampling rate causes half the noise power to appear outside the convert bandwidth. This brings about a 3-db improvement in SNR. Even higher sampling frequencies further reduce the noise, increasing SNR by as much as 20 to 40 dB. This is called process gain.

What are some other important considerations?

Linearity and distortion are also critical design considerations. With multiple signals in a band, intermodulation products can be a problem.

What type of DACs are used in basestation designs for the transmitter?

The multiple weighted current-source DAC is the most common for these applications, though some designs actually use the older R2R network.

What are the key specs to look for in a DAC?

As with ADCs, resolution and conversion rate are important. Twelve- and 14-bit converters are available, and conversion speeds are as high 1.2 Gsamples/s. Noise and linearity specs are also critical.

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