

Comparing Narrowband and Wideband Channels

Narrowband and wideband communications channels make use of available bandwidth in different ways—so employ them according to the requirements of a particular application.

Bandwidth is limited at all frequencies. This holds true whether we're discussing those in the kilohertz range used for amplitude-modulated (AM) radio broadcasting; microwaves and millimeter waves for commercial and military radar systems; or those frequencies bands with the shortest-wavelength electromagnetic (EM) signals, including infrared (IR), ultraviolet (UV), x-rays, and gamma rays.

No single component, such as a filter or amplifier, has enough bandwidth to handle them all. But some components are designed for more narrowband use while some are wideband and can process (for example) a number of different communications frequency bands at the same time. It might make economic sense to use a single amplifier or filter rather than two of each to tackle two different frequency bands in a system. But just what are the tradeoffs (other than cost) in using wideband rather than narrowband components in an RF/microwave system?

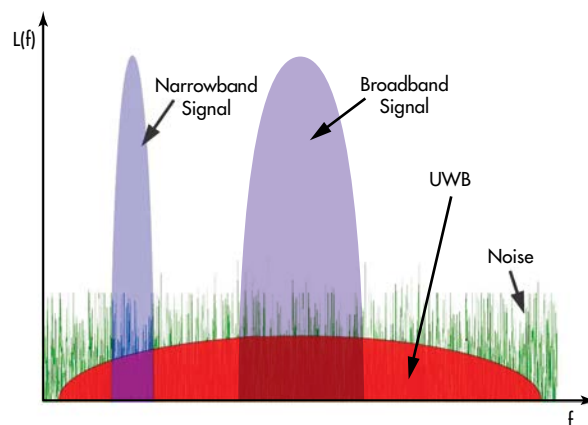
Narrowband communications channels have long been used in many applications that have depended upon achieving reliable links in different operating environments, such as in tactical military radios and industrial monitoring purposes. But as more information must be conveyed between two points by wireless means, such as for video streaming and advanced surveillance systems, wideband communications channels with their greater

data capacities become more attractive.

In terms of transmitted and received signal information, more bandwidth translates into higher data rates. For instance, depending upon the speed of available analog-to-digital converters (ADCs) and digital-to-analog converters (DACs), achieving a data rate of 1 Gb/s with a wireless communications system will require at least 100 MHz of contiguous bandwidth. However, finding that much contiguous bandwidth in today's crowded spectral environment can be quite difficult, especially at lower frequencies.

This is one of the several reasons why planners of the emerging 5G wireless communications network are looking to millimeter-wave frequencies and their available bandwidths in support of high-speed data communications links, both for terrestrial links and those incorporating low-earth-orbit (LEO) satellites. Transmitting and receiving more voice, video, and data over wider-bandwidth frequency channels comes at a cost, however, since wider sections of frequency spectrum also contain greater numbers of noise sources and higher levels of noise (see figure).

In contrast to narrowband channels, where the amount of noise within the channel is limited by effective filtering to suppress any noise and interference outside of the frequency band in use, wideband channels can limit the noise appearing at frequencies outside of the channel.



Narrowband signals occupy much less frequency spectrum and require less transmit power for a given application than wideband signals, while UWB signals are short pulses that send information while briefly occupying a large portion of the traditional communications frequency spectrum.

WHAT ABOUT USING UWB COMMUNICATIONS?

TRADITIONAL ELECTRONIC COMMUNICATIONS SYSTEMS

have employed wideband channels, narrowband channels, and sometimes a combination of both, with different types of signal modulation typically based on changes in amplitude, frequency, or phase. But pulses have also been used in a form of communications system known as ultrawideband (UWB) communications.

In UWB communications systems, information is transmitted and received over wide bandwidths, typically greater than 500 MHz or 20% of the arithmetic center frequency (such as 200 MHz of 1 GHz), in a way that will not interfere with conventional narrowband and wideband communications systems, sharing the same spectrum among many users. Once known as pulse radios, UWB radios transmit short pulses at low power levels which occupy a wide designated bandwidth. They may operate at low or high pulse repetition rates (PRRs).

In contrast to conventional communications systems which transmit information by varying a sinusoidal signal's amplitude (in amplitude modulation), frequency (frequency modulation), or phase (phase modulation), UWB pulses occupy a wide band-

width by use the timing of the pulses to transfer large amounts of information, although by also occupying a large bandwidth for those short durations.

Some UWB communications systems are designed to transfer information by encoding the polarity of a pulse, by changing its amplitude, or even by using orthogonal pulses. Other UWB systems are designed to send pulses sporadically, while still others transmit pulses continuously, at pulse rates exceeding 1 Gpulses/s for high-capacity (high-data-rate) transmissions.

UWB communications technology has never become widespread, in part because of availability of building-block components (such as wideband mixers and amplifiers) and concerns about interference with existing narrowband systems where a short pulsed signal at sufficient energy level could block the reception of a low-level narrowband signal. Although UWB communications technology provides the means for relatively long-distance communications, its most practical use may develop as a short-range solution for wireless applications requiring transmission of large, high-speed data rates. ■

However, any signals that are transmitted within the band must compete with the noise floor of that section of spectrum.

As a result, typically higher transmit signal power is needed in a wideband channel to overcome the noise level—as well as other factors, such as signal propagation losses—so that a significant signal level will appear at the receiver and meet the receiver's minimum signal-to-noise-ratio (SNR) performance requirements for reception and processing.

In short, wideband channels can carry more information than narrowband channels, but they typically require more power to do so. Narrowband channels typically carry much less information than wideband channels and operate over shorter distances between transmitter and receiver. But because narrowband channels have less noise and typically lower noise floors (depending upon the channel bandwidth) than wideband channels, they require less transmit power levels than communications systems with wideband channels and can typically operate with lower transmitter and receiver power supplies than communications equipment with wideband channels at nearby frequencies.

In fact, the lower operating-power requirements of narrowband communications equipment often makes it the preferred solution for applications that require transmission of limited information over relatively short distances, but may require operation by means of battery power, such as in a portable and/or mobile electronic device.

The frequencies intended for different communications (and other) systems are tightly orchestrated and allocated by federal organizations within a country, such as the U.S. Federal Communications Commission (FCC) and the Interna-

tional Telecommunications Union (ITU). Without this control, it would be possible for multiple signals from different applications to occupy the same segment of bandwidth, such as tuning to a frequency channel on an AM or FM radio and receiving two broadcast stations at the same time (and not being able to make sense of either station).

Similarly, two different radio communications systems with different center frequencies, but with overlapping bandwidth, will serve as interference sources for each other, depending upon such factors as transmit power and receiver selectivity and sensitivity. If the sensitivity of one radio is high enough to detect a signal that falls within its bandwidth, that outside signal will act as interference. For this reason, both center frequencies and their bandwidths must be monitored and controlled.

In terms of practical applications, if given an available portion of spectrum (such as 100 MHz), does it make more sense to use the entire radio bandwidth in one application or to break it into multiple applications? In some cases, such as in pulsed ultrawideband (UWB) communications systems, most of the available bandwidth may be used at extremely low power levels to send a great deal of information, albeit transmitting for very short pulse periods (see sidebar).

Different wireless applications have different electrical performance requirements. Narrowband communications channels are limited in the amounts of instantaneous voice, video, and data they can carry compared to wideband channels. The movement of a receiver and/or transmitter, as in a mobile wireless radio application, can also impact the capability of a narrowband receiver compared to a wideband receiver

attempting to detect higher broadband signal levels. Narrowband radio channels are typically used for shorter-range, fixed-location wireless applications, such as radio-frequency identification (RFID) and commercial vehicle remote keyless entry (RKE) devices.

MAKING ENDS MEET

In cellular communications networks (e.g., the 4G LTE systems currently in service), a variety of relatively narrow bands are employed to support different service applications, including emergency service functions. While this use of narrow bands within the available spectrum helps to minimize interference, it poses challenges to infrastructure and mobile device manufacturers to specify suitable components for devices in each band without having to acquire an enormous volume of inventory in components—such as receiver and transmitter components—to support a different block diagram for each cellular service band.

A number of component and integrated-circuit (IC) suppliers for modern wireless communications systems that employ any number of multiple narrowband channels, including Skyworks Solutions (www.skyworksinc.com), have turned to integrating the functionality for multiple frequency bands within a single IC or module. As an example, the SKY13713-21 from Skyworks is a low-noise-amplifier (LNA) diversity module capable of supporting multiple wireless standards and narrower frequency bands using a single device.

It is supplied in a compact surface-mount package for ease of installation in a portable, mobile device, such as a manpack radio or cellular telephone, and allows switching among different operating frequencies and cellular service bands (in-

cluding 3G and 4G cellular bands), so that one part can be used for many different block diagrams. The integration of front-end components, such as amplifiers and filters, within a single component for these different narrowband designs eases inventory issues for system integrators and manufacturers. It also provides a practical solution for designing communications systems with dedicated or multiple narrowband frequency ranges.

Both narrowband and wideband communications channels have their purposes, and components and modules are needed for both approaches, since they will support different applications. As noted, the multiple-function promises of 5G wireless communications networks with their “instant data and video” assurances will require wideband channels—and for many of them, so much so that 5G system planners are reaching into millimeter-wave frequencies with their wide bandwidths for the capacity to carry all the information expected to be carried through 5G wireless networks.

But 5G is only one of a number of emerging global wireless applications expected to change the world, with such applications as “connected cars” and Internet of things (IoT) sensors sending data to the Internet wherever they can provide information. The potentially billions of IoT sensors that will require wireless connectivity for access to the internet will, for the most part, be sending their data by means of narrowband channels, at whatever frequencies those channels can be formed. The need for front-end components and integrated front-end modules will only grow during the next few years, as the applications for both wideband and narrowband channels continue to expand, and this truly starts to become “a wireless world.”