Receiving spread spectrum signals with narrowband interference

A receiver 39 receives spread spectrum signals which also include unwanted narrowband signals, for example, radio signals which comprise a mixture of signals from signal sources using the Group Special Mobile (GSM) ETSI standard coding and from signal sources using Code Division Multiple access (CDMA) coding. The unwanted narrowband signals have been coded using a coding scheme with error correction capabilities.

In the invention, the narrowband signal is decoded 42, regenerated 44 and subtracted 46 prior to despreading 21 of the spread spectrum signal.

Figure 5
Figure 6
Description

[0001] This invention relates to receivers for receiving spread spectrum signals which also include unwanted narrowband signals, for example, radio signals which comprise a mixture of signals from signal sources using the Group Special Mobile (GSM) ETSI standard coding and from signal sources using Code Division Multiple Access (CDMA) coding.

[0002] Demand for systems and services which require the use of the radio spectrum has recently far outstripped the capacity of present systems. This means that future systems must provide significantly improved spectral efficiency. One technique which has been suggested is to allow wideband spread spectrum signals to share a common spectrum with conventional narrowband signals.

[0003] Spread spectrum signals use a bandwidth which is in excess of the minimum bandwidth required to transmit the information in the signal. One method of generating a spread spectrum signal is known as pseudo random noise modulation (or direct sequence modulation). The spectrum of a signal is spread using a spreading code at the transmitter. A corresponding receiver uses the same code to despread the spectrum. The technique used to despread the spectrum to regenerate the original data signal has the effect of spreading the spectrum of any other signals which are not correlated with the spreading code used by the transmitter. Where, as is usual, several wideband signals from different sources (using different codes) share the same frequency spectrum, this technique is known as Code Division Multiple Access (CDMA).

[0004] The transmitted narrowband signal generally has a high power spectral density compared with that of the transmitted wideband signal. In the narrowband signal receiver the wideband signal creates interference in the narrowband signal. Equally, once the combined received signal has been decoded by a spread spectrum receiver, the narrowband signal causes interference in the decoded spread spectrum signal.

[0005] One method which has been used to reduce the interference between the narrowband signal and the wideband signal is to use corresponding filters in the spread spectrum transmitter and receiver to attenuate those frequencies used by the narrowband signal.

[0006] A notch filter in the spread spectrum transmitter reduces the interference in the narrowband signal from the wideband signal. A corresponding notch filter in the spread spectrum receiver attenuates the frequencies used by the narrowband signal prior to despreading the spectrum to decode the spread spectrum signal.

[0007] There are problems with using such techniques to reduce the cross signal interference. To minimise the signal removed by the attenuation filters which is outside the band used by the narrowband signal, filters with very sharp cut-offs are required.

[0008] However, in a system such as the GSM cellular network adjacent cells have transmitters using different frequencies. Therefore the receiver is required to receive different frequency bands according to which transmitter is being used. Filters which are required to attenuate these narrowband frequencies need to be programmable. Programmable filters are most easily achieved with digital hardware which implies the use of high order finite impulse response (FIR) filters. Such filters currently only work on signals up to a maximum of a few tens of megahertz so it is most convenient to implement such filtering at baseband.


[0010] Any non-linear distortion to the signal prior to attenuating those frequencies used by the narrowband signal means that any signal in the narrowband frequency range introduces noise outside that range. The power spectral density of the narrowband signal is typically many tens of dB higher than the power spectral density of the wideband signal. Any components between the radio frequency receiver and the filter must have a very large dynamic range in order to minimise noise introduced into the remaining wideband signal by such non-linear distortions.

[0011] If a non-linear coding method is used to increase the dynamic range of such components then there are resolution problems for the low-level wideband signal.

[0012] Therefore the problem with known systems which utilise an attenuating filter, is that performing filtering at baseband requires components prior to the filtering step to have a very large dynamic range, but filtering at high frequency is not possible using currently available digital programmable filters.

[0013] According to the present invention, there is provided an apparatus for decoding a spread spectrum signal which has been transmitted via a transmission channel, said signal comprising a wanted spread spectrum signal component and an unwanted narrowband signal component, the narrowband signal having been coded using a coding scheme with error correction capabilities, said apparatus comprising a narrowband signal subtractor containing means for decoding and correcting the composite signal according to the narrowband signal coding scheme to provide a decoded version of the narrowband signal; means to estimate the amplitude and phase characteristics of the transmission channel; means to encode the decoded corrected signal according to the narrowband signal coding scheme to produce an estimated narrowband signal; means to adjust the phase and amplitude of the estimated narrowband signal according to the estimated amplitude and phase characteristics; and
means to subtract the adjusted signal from the received composite signal to provide an estimate of the spread spectrum signal component.

[0014] Preferably the narrowband coding scheme can also detect uncorrectable errors and in which the decoding means is arranged upon detection of an uncorrectable error to suppress the said subtraction.

[0015] In another embodiment there is also included means for attenuating the frequencies of the signal corresponding to the narrowband signal component wherein the decoding means is arranged upon detection of an uncorrectable error to cause the attenuating means to be used.

[0016] Corresponding methods for decoding spread spectrum signals are also provided.

[0017] Embodiments of the present invention will be described, by way of example only, with reference to the drawings where

Figure 1 shows the carrier to interference ratios for a high power spectral density narrowband signal and a low power spectral density wideband signal; Figure 2 shows a block diagram of a known composite transmitter using a notch filter to attenuate some frequencies in the transmitted wideband signal;

Figure 3a shows a block diagram of a conventional spread spectrum signal receiver;

Figure 3b shows a block diagram of a known spread spectrum signal receiver with a suppression filter to attenuate some frequencies in the received wideband signal;

Figure 4 shows a data signal encoded using a seven bit pseudo noise code;

Figure 5 shows a receiver which has a narrowband signal subtractor according to an embodiment of the present invention;

Figure 6 shows details of a narrowband signal subtractor;

Figure 7 shows a more sophisticated narrowband signal subtractor which does not subtract the estimated narrowband signal if uncorrectable errors are detected; and

Figure 8 shows an embodiment of the present invention in which the estimated narrowband signal is not subtracted if uncorrectable errors are detected, and in which a notch filter is used under those circumstances.

[0018] Figure 1 shows a narrowband signal transmitter 1 transmitting a narrowband signal 2 and a wideband transmitter 3 transmitting a wideband signal 4. The wideband transmitter and the narrowband transmitter are connected to an adder 5. The wideband signal and the narrowband signal are summed at the adder 5 to create a composite signal 6. Of course, different transmitters in different locations may be used, the effect as far as the present invention is concerned is identical. The composite signal 6 is received by a wideband signal decoder 8 where the signal is decoded producing a new composite signal 9. The spectrum of the original wideband signal 4 is despread by the decoder producing a decoded signal component 4' of the new composite signal 9 and the spectrum of the original narrowband signal 2 is spread to produce a new component 2' of the new composite signal 9. The new composite signal 9 has a carrier to interference ratio 7 for the wideband signal transmitter and the narrowband transmitter are connected to an adder 5. The wideband signal and the narrowband signal are summed at the adder 5 to create a composite signal 6. Of course, different transmitters in different locations may be used, the effect as far as the present invention is concerned is identical. The compos-
the narrowband signal coding scheme can detect uncorrectable errors if an uncorrectable error is detected by the demodulator 42 then an output 50 is used to control a switch 51 and the narrowband signal subtraction at 46 does not occur.

[0027] Figure 8 shows a block diagram of another embodiment of a narrowband signal subtractor 40 connected to a combined despreader and notch filter 24 which replaces the despreader 21 (Figure 5). Here a PN code generated by a PN code generator 27 is filtered at baseband by a digital programmable notch filter 26. The filtered PN code is then used to despread the incoming signal using a mixer 25, thus achieving the despread- and filtering of the incoming signal simultaneously, at the received frequency. After mixing by the mixer 25 the signal is filtered by a band-pass filter 35 and amplified by an amplifier 36. In this embodiment the output 50 is used to control both the switch 51 to bypass narrowband signal subtraction and to control a switch 52 to control whether the notch filter 26 is bypassed. When an uncorrectable error is detected the narrowband signal subtraction is bypassed and the notch filter 26 is used instead.

Claims

1. An apparatus for decoding a spread spectrum signal which has been transmitted via a transmission channel, said signal comprising a wanted spread spectrum component and an unwanted narrowband signal component, the narrowband signal having been coded using a coding scheme with error correction capabilities, said apparatus comprising a narrowband signal subtractor containing means for decoding and correcting the composite signal according to the narrowband signal coding scheme to provide a decoded version of the narrowband signal; means to estimate the amplitude and phase characteristics of the transmission channel; means to encode the decoded corrected signal according to the narrowband signal coding scheme to produce an estimated narrowband signal; means to adjust the phase and amplitude of the estimated narrowband signal according to the estimated characteristics of the transmission channel; and means to subtract the adjusted signal from the received composite signal to provide an estimate of the spread spectrum signal component.

2. An apparatus according to claim 1 wherein the narrowband coding scheme can also detect uncorrectable errors and in which the decoding means is arranged upon detection of an uncorrectable error to suppress the said subtraction.

3. An apparatus according to claim 2 further comprising means for attenuating the frequencies of the signal corresponding to the narrowband signal component.
wherein the decoding means is arranged upon detection of an uncorrectable error to cause the attenuating means to be used.

4. A method for decoding a spread spectrum signal which has been transmitted via a transmission channel, said signal comprising a wanted spread spectrum signal component and an unwanted narrowband signal component, the narrowband signal having been coded using a coding scheme with error correction capabilities, said method including narrowband signal subtraction comprising the steps of decoding and correcting the composite signal according to the narrowband signal coding scheme to provide a decoded version of the narrowband signal; estimating the amplitude and phase characteristics of the transmission channel; encoding the decoded corrected signal according to the narrowband signal coding scheme to produce an estimated narrowband signal; adjusting the phase and amplitude of the estimated narrowband signal according to the estimated amplitude and phase characteristics; and subtracting the adjusted signal from the received composite signal to provide an estimate of the spread spectrum signal component.

5. A method according to claim 4 wherein the narrowband coding scheme can also detect uncorrectable errors and in which upon detection of an uncorrectable error the step of subtracting the narrowband signal is omitted.

6. A method according to claim 5 including the optional step of attenuating the frequencies of the signal corresponding to the narrowband signal component wherein upon detection of an uncorrectable error the attenuation step is performed.