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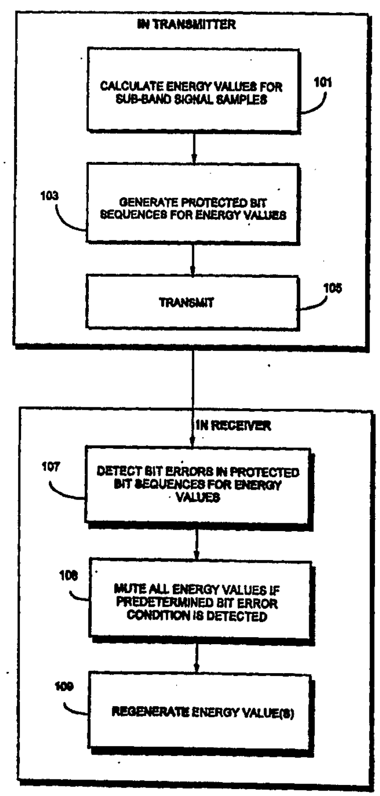
(54) Title: ERROR PROTECTION IN DYNAMIC BIT ALLOCATION SUB-BAND CODING

(57) Abstract

A method for correcting random errors, and detecting and replacing fading errors in radio frequency (RF) digital transmissions, such as voice transmission. In a Dynamic Bit Allocation Sub-Band Coder (DBASBC), bits corresponding to sub-band energy levels are protected before transmission. If the bit error rate detected for a current speech frame is sufficiently high for a sufficient period of time, the band energies for the speech frame are zeroed thereby effectively muting the speech coder output for that frame. If muting is not required but there still exists a bit error condition detected as a fade, the speech frame is deemed corrupted. As a result, the energies for the bands in the current speech frame are replaced with the band energies from the previous frame (assuming the previous frame band energies are reasonable values). Otherwise, the individual band energies are examined one by one. If the individual band energy requires correction, the band energies are replaced individually. In addition, the energy replacement values are checked for reasonableness.



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ERROR PROTECTION IN DYNAMIC BIT ALLOCATION SUBBAND CODING.

FIELD OF THE INVENTION

This invention relates to coding, transmitting and detecting errors in a digital signal. In particular, the invention relates to bit error detection and correction in radio frequency (RF) transmissions of digital signals.

SUMMARY AND BACKGROUND OF THE INVENTION

Dynamic Bit Allocation Sub Band Coders (DBASBCs) are typically used for coding and digital transmission of speech signals. In portable/mobile radio environments, such digitally coded speech signals are subject to a variety of impairments. For example, fading pattern errors are induced as the radio moves through direct and reflected wave patterns. Fading errors are manifested as quasi-periodic bursts of dense bit errors (10-50% of the received bits may be in error). In addition, random pattern errors resulting from an overall weak received signal level are manifested as static occurrences of occasional errors (0-10% of the received bits in error).

Sub-band coders operate by dividing the incoming digital signal, e.g., digitized speech samples, into separate frequency bands. These bands are usually identical in bandwidth, such as for a dynamic bit allocation coder, but may be of different widths. Splitting digital input signals into bands is accomplished using digital filters, either arranged in parallel (1 filter per band) or in a tree structure (a cascaded, binary tree of half-band split filters). The outputs of these filters are digitally decimated to permit reduction of their effective sampling rate to the required Nyquist bandwidth before transmission, e.g., two times the filter bandwidth. The decimated sub-band signals are then individually coded for transmission. This coding usually takes the form of a scalar (1-dimensional) quantizer.

Sub-band coders achieve positive coding gains by allocating a variable number of quantization bits to the individual frequency bands according to the energy level of the signal presently in that band. Coding gain is the gain in signal-to-noise ratio of a coding algorithm over the signal-to-noise ratio of a scalar quantizer operating at the same transmission (bit) rate. Since the spectrum of speech signals varies significantly over time, the allocation of quantization bits needs to be periodically updated. The combination of variable bit allocation used together with a sub-band coder is DBASBC.

The energy level of each sub-band is also used in computing the correct scaling for the individual band quantizers' step sizes. Because both bit allocation and quantizer scaling information is contained in the energy level for each frequency band, energy levels are transmitted to the receiver as "side" information. The receiver and transmitter use the same algorithms to extract the bit allocation information and quantizer scaling information from the energy levels.

The bits used to code the sub-band energies are sensitive to error. In fact, a single, well-placed bit error in a sub-band energy level can cause the bit allocation algorithm in the receiver to mistrack resulting in incorrect decoding of all the sub-band samples in a frame. Accordingly, energy bits are usually heavily protected to guard against such errors.

Previous protection methods for digital transmissions treat the entire set of energy values as a single entity. For example, U.S. Patent No. 4,831,624 discloses a single cyclic redundancy code (CRC) checksum to detect differences in the bit allocation from transmitter to receiver. If the CRC detects a mismatch, the entire set of energy values from the previous frame is used in place of the values producing the erroneous bit allocation. While this algorithm works adequately for fading errors, it has a serious failing when subjected to random pattern errors. Because a single error in the significant energy bits causes the single CRC check to indicate a failure, the probability that a frame will need to be replaced is many times greater than the probability of any one bit in the frame being in error. For example, if there are 20 "sensitive" bits and the probability of a single bit error is 0.05 (i.e., 5% random pattern BER), then the probability of replacing the entire set of energies is about 0.64 or 64%. This produces unintelligible garble at the sub-band coder output, since only 36% of the receiver bit allocations will be correct. Accordingly, a more powerful algorithm is required to handle both random and fading pattern errors.

A novel strategy of protection of the DBASBC-encoded speech from bit errors is disclosed in commonly owned U.S. Patent No. 5,384,793. Only the most perceptually significant bits corresponding to the sub-band energy levels are protected. The significant bits corresponding to each energy value are protected individually using a

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