

Method For Error Correction of Program-Related Data

Prior Art

5 For data transmission, the DAB (Digital Audio Broadcasting) Standard, for example, specifies a process for transmitting data in groups of variable length within an MPEG frame, said groups being associated with audio programs based on their content. These are referred to as "program-associated data (PAD)". The additional data, in particular those of variable lengths, are referred to as "X-
10 PAD" (X for extended). This process does not provide any method for error detection to detect incorrectly transmitted data. For some uses, these data are combined into data groups for which an error detection process (CRC process) is used. Since the individual data are combined into data groups and then into data files, a single incorrect bit can ruin the transmission of large quantities of
15 data. The error protection in DAB is achieved by means of a convolution code. The objective of this code was to achieve a bit error rate of 10^{-4} .

DE 10 2004 014 594.6 has described a process for packet data error correction in which redundancy information for error correction is added while
20 maintaining the original packet data structure.

With the DVB-T method, a concatenated code is used, which is comprised of a convolution code and a block code. This makes it possible to achieve very low bit error rates on the order of 10^{-8} .

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Advantages of the Invention

With the steps taken in claim 1 – in which code words are used over several frames, redundancy information for error correction is added while
30 maintaining the original data structure and in fact, for program-associated data of

variable lengths, the information regarding the length of the program-associated data is additionally protected by means of a code – it is possible to correct errors without, for example, requiring a DAB receiver to have knowledge of this method; the data, however, are recognized as valid DAB PAD data and can be processed with a conventional error detection method (CRC). High-quality receivers that control the error correction method according to the present invention can make use of the novel method and thus deliver correct data files more often and more quickly.

10 If the information regarding the length of the program-associated data (X-PAD fields) is additionally protected from transmission errors, then it is not possible for the new structure to completely break down in the event of incorrect length indicators.

15 The present invention is based on the knowledge that although the bit error rate is sufficiently low for audio data, it is too high for the transmission of program-associated data.

Other advantageous embodiments are disclosed in the dependent claims.

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Drawings

Exemplary embodiments of the present invention will be explained in greater detail below in conjunction with the drawings.

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- Fig. 1 shows a contiguous data stream of audio data and program-associated data,
- Fig. 2 shows an FEC-PAD structure,
- Fig. 3 shows an FEC-PAD structure with 192 rows and 12 columns,

Fig. 4 shows an FEC-PAD structure with protection of the length of the program-associated data,

Fig. 5 shows the structure of the content indicator field,

Fig. 6 shows the protection of the length information of the program-associated data,

Fig. 7 shows a 3-bit grouping for the data from Fig. 6,

Fig. 8 shows the F-PAD structure with additional PAD error correction,

Fig. 9 shows the overall data structure.

10 Description of the Exemplary Embodiments

Before the actual invention is described, prior art structures with error correction will be demonstrated for the sake of better comprehension.

Fig. 1 shows a prior art frame structure of audio data to which program-associated data fields in the form of X-PAD subfields 2 of variable lengths have been assigned. These X-PAD subfields 2 are followed by a 4-byte field, which is in turn followed by two 2-byte fields. The 4-byte field is filled with 1-byte content indicators CI and an END marker to terminate the CI list. Depending on the length and/or number of X-PAD subfields, zero to four CI indicators are provided. The CI indicator describes what the X-PAD subfield contains. If X-PAD subfields 2 are present, then this is indicated by a "10" in the F-PAD field. If there are no X-PAD subfields, then the indication "00" appears in the F-PAD field (F = fixed). UEP (unequal error protection) means better protection.

The constraints of the method are as follows:

- the bit error rate should be less than 10^{-8} if the entire audio channel has a BER of 10^{-4} ,
- existing services should not be influenced, including simple ones such as "dynamic label" (level 2 backward compatibility),

- X-PAD applications with variable lengths should be supported,
- sudden termination of the data should be supported, with a variable end of the FEC-frame (FEC = forward error correction).

5 Fig. 2 shows the FEC-PAD structure, with 16-byte FEC fields for error correction arranged in 12 columns with fixed lengths. The signaling occurs within the F-PAD field (byte L indicator/L-byte data field). In addition, a counter is provided for identification of frames in the F-PAD field in order to definitely ascertain the position of the code words.

10 Fig. 3 shows the FEC-PAD structure in a matrix with 192 columns and 12 rows. Only relevant data are protected. Padding zeroes are not transmitted. The matrix contains additional parity data that are inserted in the form of new X-PAD-FEC data. All other data with PAD are not influenced. Consequently, all X-PAD applications are available and can be used for conventional receivers. A robust synchronization and signaling of the FEC data is provided in the F-PAD field. The data are arranged in an application data table in the same way as in the packet mode method. The same frame structure and encoding are used in order to limit receiver complexity. The FEC frame can be terminated at any time in order to support interruption of the X-PAD transmission. But there is one main problem: only a single bit error in the length indicators (CI indicators) of the X-PAD subfields can corrupt the entire FEC frame, despite the higher degree of protection afforded by UEP.

25 In order to prevent this, according to the present invention, the information regarding the length of the program-associated data (CI indicators) is protected by means of an additional code.

The items of length information (CI indicators), which are circled in Fig. 4, are shown on an enlarged scale in Fig. 5. There are four groups of 3-bit length information (a total of 12 bits), which are protected according to Fig. 6.

5 To that end, 6 data bits are added as parity bits to the F-PAD byte L field. A simple block code (18, 12) is only able to correct 1 bit. This is insufficient when a Viterbi codec generates an error burst. It is more advantageous to encode the length information by means of a Reed-Solomon code (RS code), which is calculated by means of the Galois field 2^3 . This means that the 3-bit
10 length information is grouped into four information symbols, which, together with 2 parity symbols, are encoded by means of an RS code by means of the Galois field (2^3). An RS (6, 4) code is not possible. But an RS (7, 5) code can be used, which is shortened (by one) to the packet length being used. This code can be used to correct a symbol (a 3-bit group) so that the code is robust with regard to
15 burst fields.

Fig. 7 shows the groupings of the CI data. An RS (7, 5, 3) code is provided. The first symbol is set equal to 0 and is not transmitted. This is followed by 4 information symbols and 2 parity symbols. It is advantageous to
20 correct all 4-bit groups, regardless of whether or not they contain length information.

Fig. 8 shows the identification/signaling in the F-PAD field, with redefined L-byte indicators, e.g. for protected CI data:
25 byte L ind = 'b 1111,
e.g. for FEC frames:
byte L ind = 'b 1010

For FEC frames, a counter Z is provided for synchronization in the L-byte data field. For data frames, parity bits that are required for correct detection of PAD bits are inserted into the L-byte data field.

5 Fig. 9 shows the overall data structure.

What is claimed is:

1. A method for error correction of data in frames, in which code words are used over several frames, including the following steps:
 - 5 – redundancy information for error correction is added while maintaining the original data structure and in fact, for program-associated data of variable lengths,
 - the information regarding the length of the program-associated data is additionally protected by means of a code.
- 10 2. The method as recited in claim 1, wherein DAB X-PAD data packets are used as program-associated data.
3. The method as recited in claim 2,
 - 15 wherein the redundancy information for protecting the length information of the X-PAD data is placed in the F-PAD field, in particular in the "L-byte data field".
4. The method as recited in claims 2 through 3, wherein the existence of redundancy information for the length information is
20 identified.
5. The method as recited in claim 4, wherein the identification is provided in the F-PAD field.
- 25 6. The method as recited in claims 1 through 5, wherein for the error correction of the length information, a Reed-Solomon code is used, which is in particular calculated by means of the Galois field 2^3 .
7. The method as recited in claims 1 through 6,

wherein for the error correction of the length information, in particular in the content indicator/CI field, all 4-bit groups are corrected, regardless of whether or not they contain length information.

- 5 8. The method as recited in claims 1 through 7,
wherein for detecting whether a frame contains redundancy information for error
correction and/or for ascertaining the position of the code word in the data
stream, a corresponding identification is provided in the frame, e.g. in the F-PAD
field.
- 10 9. The method as recited in claim 8,
wherein for identification of the frame, a counter is provided, e.g. in the F-PAD
field, in order to definitely ascertain the position of code words.
- 15 10. The method as recited in claims 1 through 7,
wherein for error correction, a Reed-Solomon code is used, which is in particular
shortened to the packet length used.
- 20 11. The method as recited in claims 1 through 10,
wherein for the redundancy information, a separate data packet is used, which is
attached to the data packets that contain useful information.
- 25 12. The method as recited in claims 1 through 11,
wherein the transmission of useful data can be interrupted at any time in order to
send redundancy data.