



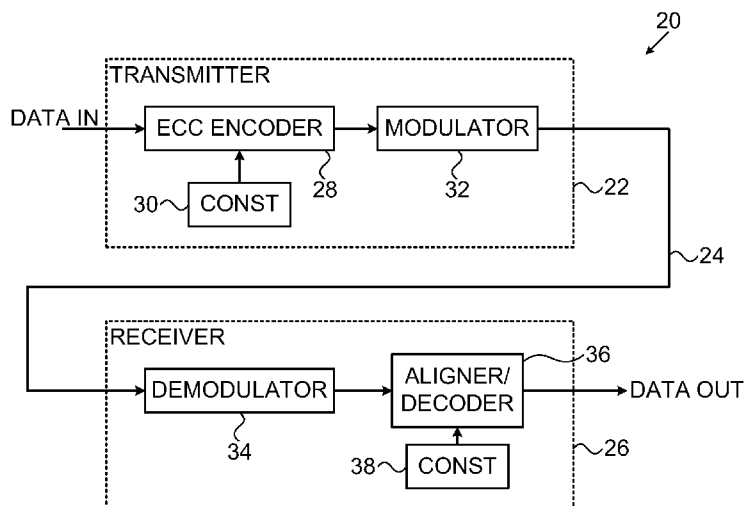
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(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) **Title:** ERROR CORRECTION CODING WITH BLOCK SYNCHRONIZATION**FIG. 1**

(57) **Abstract:** A method for data protection includes computing a codeword over an input string of data in accordance with a pre-defined error detection code. A predetermined constant string is added to the codeword so as to generate an output string. A signal is modulated with a sequence of symbols representing the output string. Related systems and methods are also included.

ERROR CORRECTION CODING WITH BLOCK SYNCHRONIZATION**FIELD OF THE INVENTION**

The present invention relates generally to processing of data signals, and specifically to detection and correction of data errors.

BACKGROUND OF THE INVENTION

Error detection schemes are widely used in data transmission and storage. In many of these schemes, an error detection codeword is computed, using a predefined algorithm, over each block of data. The codeword contains the data along with additional redundancy bits. The codeword may subsequently be decoded in order to recover the data and verify that no errors have occurred. Some types of error detection codes, referred to as error correction codes, enable the receiver of a codeword not only to detect errors, but also to correct them. (In the context of the present patent application and in the claims, the term "error detection code" includes both error correction codes and other code types, such as cyclic redundancy check [CRC] codes, which detect but may not be able to correct errors.) Typically, the type of error correction code and its level of redundancy determine the number of errors that can be detected and the number of errors that can be corrected in any give data block.

Reed-Solomon (RS) codes are error-correcting codes that can be used to detect and correct multiple random symbol errors. By adding d check symbols to the data, a RS code can detect any combination of up to d symbol errors, and correct up to $\#d/2$ errors. A message comprising m data symbols is encoded by viewing the

symbols as coefficients of a polynomial $p(x)$ of maximum degree $m-1$ over a finite field F of order n . The message polynomial $p(x)$ is multiplied by a generator polynomial (or base polynomial) $f(x)$ of degree d to give an output polynomial $c(x)$ of degree $L = m + d$. The coefficients of the output polynomial are the codeword. The receiver can divide the received polynomial by $f(x)$ (using polynomial division) to determine whether the message is in error: A non-zero remainder means that an error has occurred.

SUMMARY

Embodiments of the present invention that are described hereinbelow provide methods, systems and software for improving the performance of error detection codes.

There is therefore provided, in accordance with an embodiment of the invention, a method for data protection, which includes computing a codeword over an input string of data in accordance with a predefined error detection code. A predetermined constant string is added to the codeword so as to generate an output string. A signal is modulated with a sequence of symbols representing the output string.

In some embodiments, the constant string is selected so as to resolve an ambiguity with respect to a start point of the sequence in decoding the signal. Typically, the constant string is selected so that within a range of possible start points extending over a predetermined number of the symbols in the series, only one of the start points will give a codeword satisfying the error correcting code following subtraction of the constant string from the data. Additionally or alternatively, the error detection code uses a base polynomial of a given degree, and the constant string is chosen so as to resolve the ambiguity up to a maximal shift of the start point that is determined by the degree of the base polynomial.

In a disclosed embodiment, adding the predetermined constant string includes selecting a given constant string after verifying that the given constant string is not a member of a predetermined set of one or more linear subspaces. The constant string may be a balanced string

of ones and zeros, and adding the predetermined constant string may include computing an exclusive disjunction between the codeword and the constant string.

There is also provided, in accordance with an embodiment of the invention, a method for data protection, which includes receiving and demodulating a signal to recover a sequence of symbols. A start point in the recovered sequence is selected, and a predetermined constant string is subtracted from the data beginning at the selected start point. An error detection code is checked over the data remaining after subtracting the constant string.

When an error is detected in decoding the error detection code, a new start point may be selected in the recovered sequence from which to subtract the constant string and to check the error detection code until an acceptable codeword is found.

There is additionally provided, in accordance with an embodiment of the invention, apparatus for data protection, including an encoder, which is configured to compute a codeword over an input string of data in accordance with a predefined error detection code, and to add a predetermined constant string to the codeword so as to generate an output string. A modulator is configured to modulate a signal with a sequence of symbols representing the output string.

There is further provided, in accordance with an embodiment of the invention, apparatus for data protection, including a demodulator, which is configured to receive and demodulate a signal to recover a sequence of symbols. A decoder is configured to select a start point in the recovered sequence, to subtract a

predetermined constant string from the data beginning at the selected start point, and to check an error detection code over the data remaining after subtracting the constant string.

There is moreover provided, in accordance with an embodiment of the present invention, a computer software product, including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a processor, cause the processor to compute a codeword over an input string of data in accordance with a predefined error detection code, and to add a predetermined constant string to the codeword so as to generate an output string, for application in modulating a signal with a sequence of symbols representing the output string. The present invention will be more fully understood from the following detailed description of the embodiments thereof, taken together with the drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram that schematically illustrates a data communication system, in accordance with an embodiment of the present invention;

Fig. 2 is a plot that schematically shows received signals over time, in accordance with an embodiment of the present invention; and

Fig. 3 is a flow chart that schematically illustrates a method for error detection coding and decoding, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

OVERVIEW

In order to decode a given error detection codeword within a stream of symbols, the receiver must generally be able to identify the symbol at which the codeword begins. Some communication protocols require the transmission of a particular preamble in order to signal the beginning of a data packet, and thus indicate the beginning of the next codeword unambiguously. In other systems, however, it may not be practical or desirable to use such a preamble, or the preamble may be blurred due to poor signal quality. In such situations, the start point of a codeword within a symbol stream may be uncertain.

If the receiver chooses the wrong starting point for a given codeword, it would normally be expected that decoding the resulting shifted sequence of symbols will lead to detection of an error. The inventor has found, however, that in certain cases this shifted sequence of symbols may, by coincidence, also be a valid codeword. For example, in the case of RS coding, as described above, the shifted symbol sequence may be divisible by the base polynomial $f(x)$. In consequence, the receiver may decode and output an erroneous data result.

In order to resolve this potential problem, in embodiments of the present invention, after computing a codeword over an input string of data in accordance with a certain error detection code, a predetermined constant string is added to the codeword. In the context of binary data, "addition," as well as "subtraction," is performed by exclusive disjunction (XOR) of the codeword

with the constant string (although these arithmetic operations will be expressed differently in non-binary fields, as is known in the art). The resulting output string is transmitted by modulating a signal with a sequence of symbols representing the output string.

A receiver of the signal chooses the apparent start point of the codeword and subtracts out the constant string. By appropriate choice of the constant string, as explained below, ambiguity with respect to the start point of the output string in the received symbol sequence can be resolved. In other words, decoding of the error detection code after subtraction of the constant string will give a correct result only if the correct start point has been chosen. Any shift of the start point - up to a certain maximum shift, which is a function of the degree of the error detection code - will yield an error upon decoding.

MATHEMATICAL FOUNDATIONS

To explain how the constant string is chosen, we first define the following terms:

- **F** is a fixed Galois field.
- A **Block** is an element of F . If $F = G(2, n)$, wherein n is a constant, each block is identified with a corresponding sequence of n bits.
- A **String** is a sequence of blocks.
- L_c is the length of the string c (in blocks).
- A **Full string** is sequence of L blocks (for the given codeword length L).
- $a||b$ is the concatenation of the strings a and b .

- A **Base polynomial** f is a fixed polynomial on the field F , which is used in generating and decoding RS codewords.
- d is the degree of f , also referred to as the "redundancy" of the code.

For each string $c = \{c_0 \ c_1 \ \dots \ c_{L-1}\}$ in a received signal, an error correction decoder computes the corresponding polynomial $P_c(x) = c_0 + c_1x + \dots + c_{L-1}x^{L-1}$. A string $c = \{c_0 \ c_1 \ \dots \ c_{L-1}\}$ is **acceptable** if its polynomial $P_c = 0 \bmod f$. In cyclic Reed-Solomon coding (and CRC for the field $\mathbb{Z}_2$), the base polynomial is chosen so that $x^{L-1} = 0 \bmod f$.

As noted earlier, uncertainties in the received signal, particularly at the beginning and end of the codeword, may lead to situations in which the start point of the string is uncertain, and therefore the error correction code itself gives uncertain results. To illustrate this situation, we use the following terms:

- k is small natural number (in many practical cases $k=1$, although it may have any value satisfying $k < d/2$ and in the best case may have any value up to $k = d-1$).
- a and b are short strings, $L_a = L_b = k$.
- m is an "almost full" string, $L_m = L - k$.

An ambiguous situation arises when $a||m$ and $m||b$ both are acceptable results of error detection decoding. This sort of situation can occur, for example, when $P_a = P_b = 0$.

To avoid such situations, in embodiments of the present invention, the polynomial codeword c is modified before transmission by adding it (as an element of the field F) to a constant string $r = \{r_0 \ r_1 \ \dots \ r_{L-1}\}$. As noted

earlier, for the case of $F = G(2, n)$, the addition is carried out by exclusive disjunction (XOR). It can be shown that ambiguity of the start point of the codeword will be eliminated if the string r is chosen such that its polynomial P_r , of degree d , is not a member of any of the linear subspaces $V_i = \{G_i P_a + H_i P_b \mid \text{for all } a, b \text{ such that } \deg(P_a) < k, \deg(P_b) < k\}$ for $i=1\dots k$, wherein G_i and H_i are polynomials meeting the respective requirements that $(x^i - 1)G_i = 1 \bmod f$ and $(x^i - 1)H_i = x^L \bmod f$. (For the existence of G_i and H_i , it is sufficient to require that f is co-prime with $(x^i - 1)$ for all $i = 1\dots k$.) It can be shown that in general, for a code of redundancy d , P_r satisfying the above criterion exists for any $k = \lfloor d/2 \rfloor$; and in the case of cyclic coding (in which $x^L - 1 = 0 \bmod f$, as noted above), such P_r exists even for $k = d-1$.

Performing the above-mentioned XOR operation with r will prevent the occurrence of ambiguity in determining the starting point of the codeword upon decoding.

SYSTEM OPERATION

Fig. 1 is a block diagram that schematically illustrates a communication system 20, in accordance with an embodiment of the present invention. A transmitter 22 transmits data in the form of modulated signals over a communication link 24 to a receiver 26. Link 24 may comprise a wired or wireless link of any suitable type that is known in the art. Although only a single link is shown in the figure, the techniques of error correction coding and decoding that are described herein are equally effective over multiple successive links, and can be applied, as well, to data that are stored and later recalled.

Transmitter 22 comprises an error correction code (ECC) encoder 28, which encodes blocks of input data into codewords using an appropriate encoding algorithm. Encoder 28 applies any suitable ECC algorithm known in the art, such as RS encoding, as described above. It then reads a constant string from a memory 30 and adds the string to the codeword in order to generate an output string for transmission. Criteria for selection of the constant string were presented in detail hereinabove. Typically, the codeword and constant string are binary strings of equal length, and the addition is performed by a XOR operation, as explained above. The constant string may be selected in advance and pre-stored in memory 30, or it may alternatively be computed and/or selected by encoder 28 as needed at the time of data encoding.

A modulator 32 converts the data bits of the codeword into symbols of an appropriate alphabet and modulates the signals transmitted over link 24 with the symbols. Such modulation may comprise time- and/or frequency-domain modulation of an electrical or optical carrier, as is known in the art. Alternatively, the modulation may be applied to an image or sequence of images, as described, for example, in the above-mentioned provisional patent application.

A demodulator 34 in receiver 26 extracts the symbols from the modulated signals on link 24 and passes the results to an ECC decoder 36. Before decoding each incoming codeword, the decoder aligns the received string, i.e., it finds the presumed start point of the codeword in the incoming symbol sequence. It then reads from a memory 38 the same constant string that was added by encoder 28 and subtracts the constant string (by XOR)

from the received string, starting from the presumed start point. Decoder 36 applies error detection decoding to the result of the subtraction. If the decoder has chosen a shifted start point, decoding at this stage will give an error, and the decoder may try again with a different start point. When the correct start point has been found, decoder 36 will be able to successfully decode the codeword and output the recovered data.

Encoder 28 and decoder 36 typically comprise suitable hardware logic circuits, which may be implemented, for example, in application-specific integrated circuits (ASIC) or in programmable gate arrays. Alternatively, some or all of the functions of the encoder and/or decoder may be implemented in software, for execution by a suitable processor. The software may be downloaded to the processor in electronic form, over a network, for example, or it may, alternatively or additionally, be stored in tangible, computer-readable media, such as optical, magnetic, or electronic memory media.

Fig. 2 is a plot that schematically shows signals 40 received by receiver 26 over time, in accordance with an embodiment of the present invention. In this example, signals 40 are shown as comprising in-phase (I) and quadrature (Q) components, as are known in the art. Alternatively, the signals may comprise U and V chrominance components, as described in the above-mentioned provisional patent application, or any other number (one or more) and/or type of signal components. Signals 40 comprise peaks 42 corresponding to symbols that were transmitted by modulator 32, with a symbol

period indicated by the ticks on the horizontal (time) axis in the figure.

Peaks 42 in signals 40, however, are masked by noise, and the peaks cannot be clearly distinguished in at least some of the symbol periods. As a result, demodulator 34 may output ambiguous results, and decoder 36 may be unable to determine with certainty where to place the start point of a given codeword. In Fig. 2, for example, two possible codewords C_1 and C_2 start at two different symbols, which are offset by a single symbol period. This ambiguity is overcome using the addition and subtraction of an appropriate constant string, as noted above.

Fig. 3 is a flow chart that schematically illustrates a method for error detection coding and decoding, in accordance with an embodiment of the present invention. The method is described, for the sake of clarity, with reference to the components of system 20 (Fig. 1) and signals 40 (Fig. 2), but it may similarly be implemented in substantially any system that uses error detection coding and any type of signals. The initial steps of the method (through step 56) are performed by transmitter 22, while the remaining steps are performed by receiver 26.

To begin the process, encoder 28 reads the constant string r from memory 30, at a constant selection step 50. The string r is chosen such that its polynomial P_r is not a member of any of the linear subspaces V_i , as defined above. For reliable reception of the signal in some symbol constellations, it is desirable that r be "balanced," containing approximately equal numbers of ones and zeros. To choose the appropriate value of r ,

balanced strings can be tested at random until a string is found satisfying $P_r \notin V_i$ for all $I = 1 \dots k$. For instance, for codewords of length $L = 30$ over the field $F = GF(2,2)$, with redundancy $d = 8$ and cyclic coding, there are several polynomials that satisfy these criteria, and their use makes it possible to identify the start of the strings up to $k = 7$. As one example, the polynomial $P(x) = x^8 + x^7 + x^6 + x^5 + 3x^4 + 2x^3 + x^2 + 2$ may be used, with $r = 01101010100101110111000110110111100000000110001010011001010110011$.

Encoder 28 computes an error correction code (ECC), or other error detection code, over the string of input data, at an encoding step 52. The encoder adds the resulting codeword (by XOR) to the constant string, at an addition step 54. The encoder passes the resulting output stream to modulator 32, which modulates a signal with a sequence of symbols representing the output stream, and transmits the signal over link 24, at a modulation step 56.

Demodulator 34 receives and demodulates the signal, at a demodulation step 60. The demodulator recovers and outputs a sequence of symbols to decoder 36, which attempts to locate the start point of the codeword in the sequence, at a start point identification step 62. If the start point is uncertain (because of noise in the signal, for example), the decoder may initially take the most likely start point, such as the beginning of the sequence C_2 in Fig. 2. (Typically, the decoder will choose the start point at which the ECC, when checked, gives the smallest number of flipped bits.) Decoder 36 reads the constant string r from memory 38 and subtracts it (by XOR) from the data beginning at the chosen start

point, at a constant string removal step 64. The decoder then checks the ECC of the presumed codeword remaining after subtraction of the constant string, at an error checking step 66. If the codeword is acceptable (i.e., its remainder mod f is zero), decoder 36 outputs the recovered data, at a data output step 68. Otherwise, the decoder returns to step 62 in order to try a different start point, and steps 62-66 are repeated until an acceptable codeword is found.

It will be appreciated that the embodiments described above are cited by way of example, and that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove, as well as variations and modifications thereof which would occur to persons skilled in the art upon reading the foregoing description and which are not disclosed in the prior art.

CLAIMS

1. A method for data protection, comprising:
 computing a codeword over an input string of data in accordance with a predefined error detection code;
 adding a predetermined constant string to the codeword so as to generate an output string; and
 modulating a signal with a sequence of symbols representing the output string.
2. The method according to claim 1, wherein the constant string is selected so as to resolve an ambiguity with respect to a start point of the sequence in decoding the signal.
3. The method according to claim 2, wherein the constant string is selected so that within a range of possible start points extending over a predetermined number of the symbols in the series, only one of the start points will give a codeword satisfying the error correcting code following subtraction of the constant string from the data.
4. The method according to claim 2 or claim 3, wherein the error detection code uses a base polynomial of a given degree, and wherein the constant string is chosen so as to resolve the ambiguity up to a maximal shift of the start point that is determined by the degree of the base polynomial.
5. The method according to any of claims 1-4, wherein adding the predetermined constant string comprises selecting a given constant string after verifying that the given constant string is not a member of a predetermined set of one or more linear subspaces.

6. The method according to any of claims 1-5, wherein the constant string is a balanced string of ones and zeros.
7. The method according to any of claims 1-6, wherein adding the predetermined constant string comprises computing an exclusive disjunction between the codeword and the constant string.
8. The method according to claim 1, and comprising:
 - receiving and demodulating the signal to recover the sequence of the symbols;
 - selecting a start point in the recovered sequence;
 - subtracting the constant string from the data beginning at the selected start point; and
 - checking the error detection code over the data remaining after subtracting the constant string.
9. A method for data protection, comprising:
 - receiving and demodulating a signal to recover a sequence of symbols;
 - selecting a start point in the recovered sequence;
 - subtracting a predetermined constant string from the data beginning at the selected start point; and
 - checking an error detection code over the data remaining after subtracting the constant string.
10. The method according to claim 9, wherein checking the error correction code comprises:
 - detecting an error in decoding the error detection code; and
 - responsively to the error, selecting a new start point in the recovered sequence from which to subtract the constant string and to check the error detection code until an acceptable codeword is found.

11. Apparatus for data protection, comprising:

an encoder, which is configured to compute a codeword over an input string of data in accordance with a predefined error detection code, and to add a predetermined constant string to the codeword so as to generate an output string; and

a modulator, which is configured to modulate a signal with a sequence of symbols representing the output string.

12. The apparatus according to claim 11, wherein the constant string is selected so as to resolve an ambiguity with respect to a start point of the sequence in decoding the signal.

13. The apparatus according to claim 12, wherein the constant string is selected so that within a range of possible start points extending over a predetermined number of the symbols in the series, only one of the start points will give a codeword satisfying the error correcting code following subtraction of the constant string from the data.

14. The apparatus according to claim 12 or claim 13, wherein the error detection code uses a base polynomial of a given degree, and wherein the constant string is chosen so as to resolve the ambiguity up to a maximal shift of the start point that is determined by the degree of the base polynomial.

15. The apparatus according to any of claims 11-14, wherein the constant string is selected after verifying that the constant string is not a member of a predetermined set of one or more linear subspaces.

16. The apparatus according to any of claims 11-15, wherein the constant string is a balanced string of ones and zeros.

17. The apparatus according to any of claims 11-16, wherein the encoder is configured to add the predetermined constant string to the codeword by computing an exclusive disjunction between the codeword and the constant string.

18. The apparatus according to claim 11, and comprising a receiver, which is configured to receive and demodulate the signal to recover the sequence of the symbols, to select a start point in the recovered sequence, to subtract the constant string from the data beginning at the selected start point, and to check the error detection code over the data remaining after subtracting the constant string.

19. Apparatus for data protection, comprising:

a demodulator, which is configured to receive and demodulate a signal to recover a sequence of symbols; and

a decoder, which is configured to select a start point in the recovered sequence, to subtract a predetermined constant string from the data beginning at the selected start point, and to check an error detection code over the data remaining after subtracting the constant string.

20. The apparatus according to claim 19, wherein the decoder is configured, upon detecting an error in decoding the error detection code, to select a new start point in the recovered sequence from which to subtract the constant string and to check the error detection code until an acceptable codeword is found.

21. A computer software product, comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a processor, cause the processor to compute a codeword over an input string of data in accordance with a predefined error detection code, and to add a predetermined constant string to the codeword so as to generate an output string, for application in modulating a signal with a sequence of symbols representing the output string.

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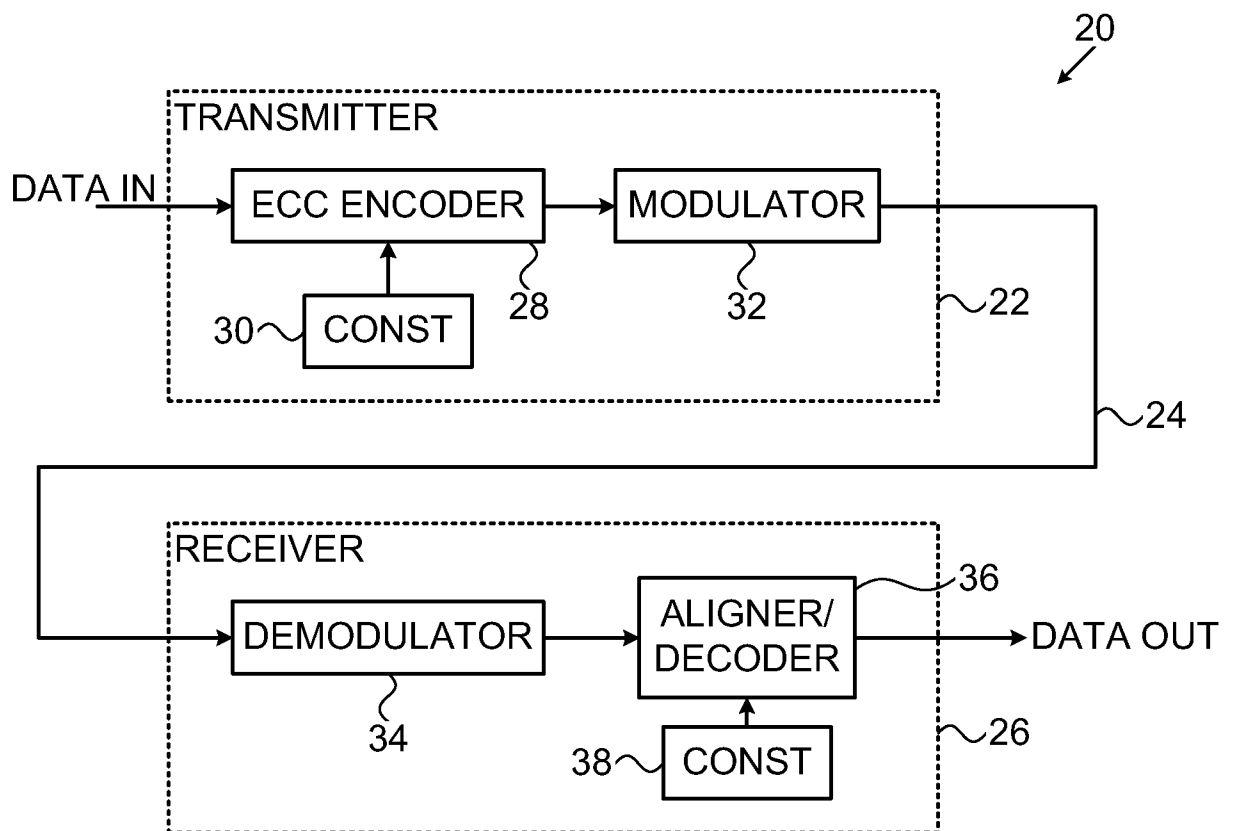


FIG. 1

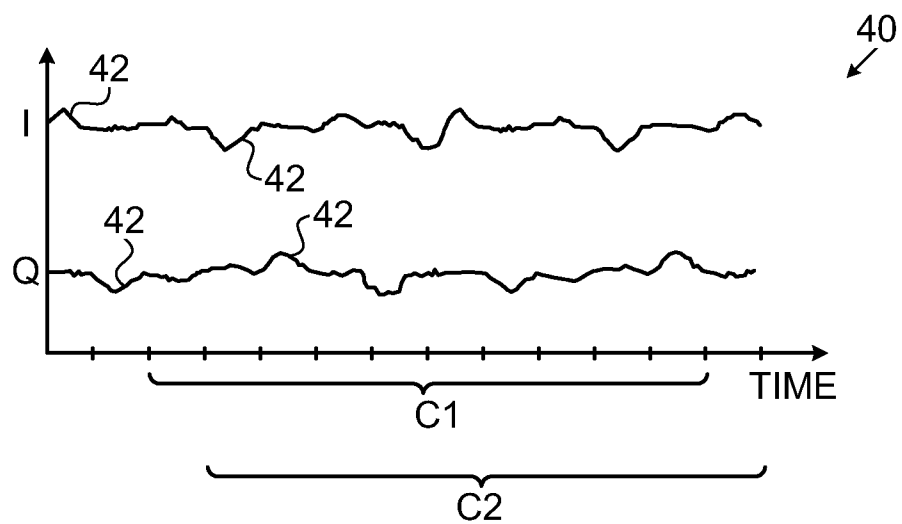


FIG. 2

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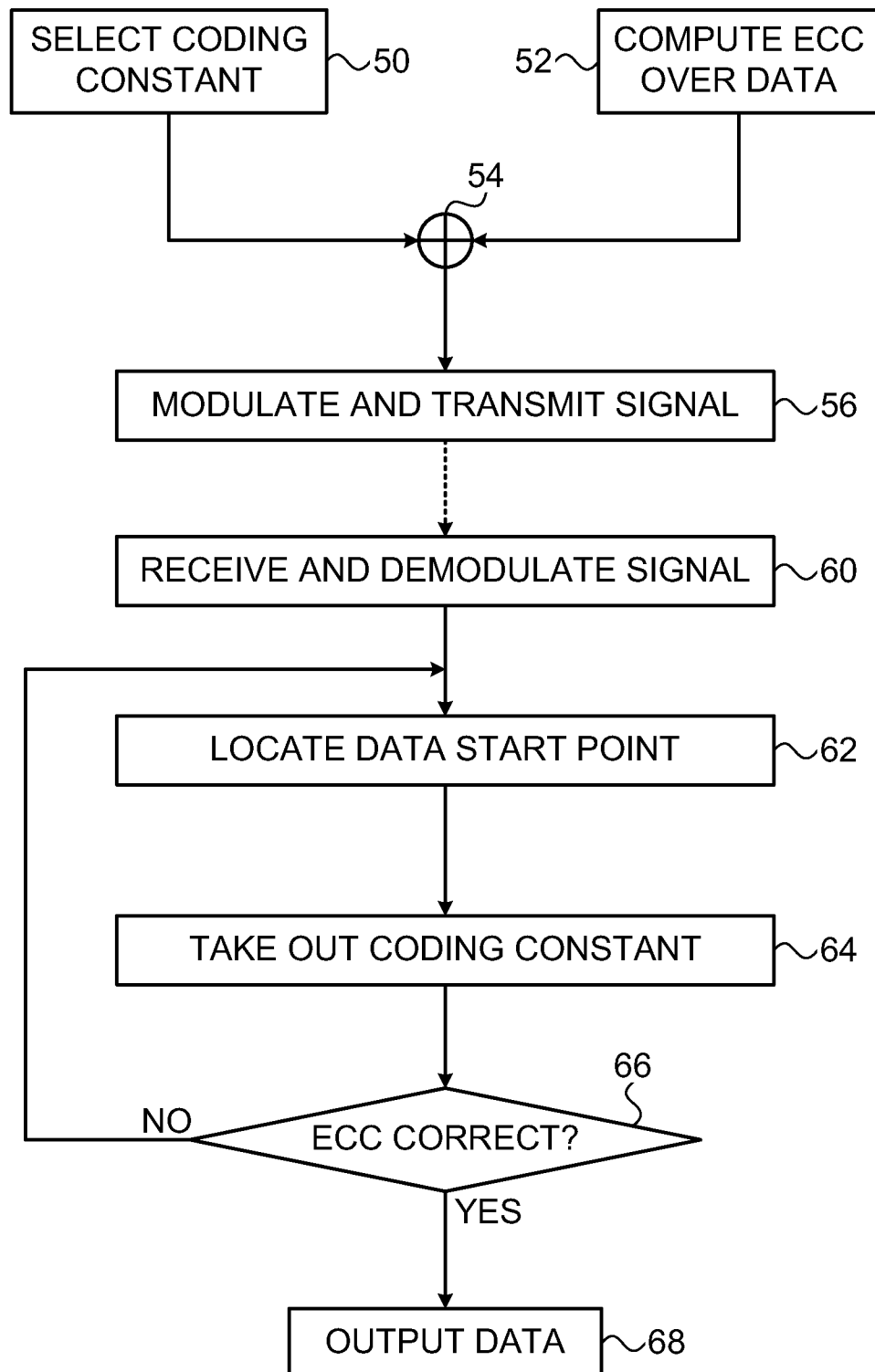


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/050003

A. CLASSIFICATION OF SUBJECT MATTER INV. H03M13/33 H04L7/04 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H03M H04L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, COMPENDEX, INSPEC, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/157060 A1 (GANGA ILANGO S [US] ET AL) 5 July 2007 (2007-07-05)	1-3, 5-13, 15-21
A	abstract paragraph [0050] - paragraph [0064] figures 2,5,6,7	4,14
X	----- PETERSON W W ET AL: "12 SYNCHRONIZATION OF BLOCK CODES", 1 January 1978 (1978-01-01), ERROR CORRECTING CODES, LONDON, MIT PRESS, GB, PAGE(S) 374 - 391, XP000808350, page 377 - page 380	1-5,7,8, 11-15, 17,18,21
A	----- -/-	6,9,10, 16,19,20
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
Date of the actual completion of the international search	Date of mailing of the international search report	
6 March 2012	19/03/2012	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Burkert, Frank	

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2012/050003

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 550 082 A (TONG SHIH Y) 22 December 1970 (1970-12-22)	1,2,5,9, 11,12, 15,19,21
A	column 2, line 51 - column 3, line 2 column 3, line 61 - column 5, line 26 column 12, line 72 - column 13, line 19 figure 1	3,4,6-8, 10,13, 14, 16-18,20
X	----- CHANG L F ET AL: "Performance of a TDMA portable radio system using a block code for burst synchronization and error detection", PROC. IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE, 27 November 1989 (1989-11-27), pages 1371-1376, XP010083678, page 1371 - page 1372	1,8-11, 18-21
A	----- page 1371 - page 1372	2-7, 12-17
X	----- HAMMONS A R JR: "CRC-based techniques for combined burst synchronization and error detection in TDMA PCS systems", PROC. IEEE 46TH VEHICULAR TECHNOLOGY CONFERENCE 1996 (VTC 1996), ATLANTA, GA, USA, 28 APRIL-1 MAY 1996, NEW YORK, NY, USA, IEEE, US, vol. 1, 28 April 1996 (1996-04-28), pages 472-476, XP010162432, DOI: 10.1109/VETEC.1996.503492 ISBN: 978-0-7803-3157-0	1,2,11, 12,21
A	page 472, right-hand column - page 474, right-hand column	3-10, 13-20
X	----- US 6 463 564 B1 (WENG LIH-JYH [US]) 8 October 2002 (2002-10-08)	1,2,7, 11,12, 17,21
A	abstract column 3, line 56 - column 4, line 3 column 5, line 21 - line 28 figure 1	3-6, 8-10, 13-16, 18-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2012/050003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007157060 A1	05-07-2007	US 2007157060 A1	05-07-2007
		US 2010095185 A1	15-04-2010
		US 2011138250 A1	09-06-2011

US 3550082 A	22-12-1970	NONE	

US 6463564 B1	08-10-2002	JP 4527255 B2	18-08-2010
		JP 2001160760 A	12-06-2001
		US 6463564 B1	08-10-2002
