

BIT SIGNAL STRUCTURE FOR DIFFERENTIALLY ENCODED BROADCASTS

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BACKGROUND

[0001] The subject matter described herein relates to electronic communication, and more particularly to signal encoding techniques which may be used in wireless communication systems such as satellite communication systems. In addition, the subject matter described herein relates to techniques to perform geolocation using low-earth orbit (LEO) satellite signals.

[0002] The Global Positioning System (GPS) is a space-based, world-wide navigation system which includes a space, ground, and user segment. The locations of the satellites are used as reference points to calculate positions of the GPS user receiver, which is usually accurate to within meters, and sometimes even within centimeters. Each of the satellites, the ground stations, and the GPS user receiver has preprogrammed timing signals that start at precise times. In order to lock on to the signals broadcasted by the satellites, the ground station and GPS user receiver slew their respective internal generated signals relative to time as predicted by their respective internal clocks. When the signals are locked, the GPS user receiver makes ranging measurements to each satellite called pseudoranges. These pseudorange measurements include the actual ranges to the satellites, in addition to an error associated with the receiver clock time offset relative to GPS time, plus other smaller errors. The ground stations included in the GPS control segment network provide ranging measurements which are used to generate

predictions for the satellites clocks and orbits. These predictions are periodically uploaded to the satellites and the satellites broadcast this data to the user receiver to support the user receiver positioning function.

[0003] Due in part to concerns about jamming of GPS signals and power
5 limitations on GPS signals, low Earth orbiting (LEO) satellite constellations, such as Iridium, have been suggested as a mechanism to allowing navigation without using GPS, or in conjunction with GPS systems. The Iridium satellite constellation is a constellation of low earth orbiting satellites at a height of approximately 485 mi (781 km), with six near polar orbits with an inclination of 86.4°, and maintains an orbital velocity of
10 approximately 17,000 mph (27,000 km/h). The constellation is used to provide global satellite communication services including voice and data coverage to satellite phones, pagers, and integrated transceivers around the globe. The constellation includes sixty-six active satellites in orbit which orbit from pole to pole at an orbital period of just over 100 minutes. The orbit design produces counter-rotating planes of satellites next to one
15 another traveling in opposite directions. In addition, the satellites use cross-linking technology to relay data across the constellation. Each Iridium satellite has 48 spot beams as part of the constellations uniquely-identifiable beam geometry that project onto the surface of the earth.

[0004] Various techniques for using the time standard from the LEO satellites to
20 augment the functionality of the GPS system include such patents as U.S. Pat. RE 37,256, issued to Cohen, et al. entitled, "System and Method For Generating Precise Position Determinations;" U.S. Pat. No. 5,812,961 issued to Enge, et al. entitled, "Method And

Receiver Using A Low Earth Orbiting Satellite Signal To Augment The Global Positioning System;" U.S. Pat. No. 5,944,770 issued to Enge, et al. entitled, "Method And Receiver Using A Low Earth Orbiting Satellite Signal To Augment The Global Positioning System;" and U.S. Pat. No. 6,373,432 issued to Rabinowitz, et al. entitled

5 "System Using LEO Satellites For Centimeter-Level Navigation." The disclosures of these patents are incorporated herein by reference in their respective entireties.

[0005] The Iridium system employs a signal processing scheme known as differential encoding to encode and transmit quadrature phase shift keyed (QPSK) modulated broadcasts. During the differential encoding process the In-Phase and

10 Quadrature modulated bits (Is and Qs) of a broadcast are re-coded as such that the output state of the differential encoder is a function of both the current (I,Q) input to the differential encoder and the previous (I,Q) state of the differential encoder. This differential encoding scheme raises issues when using pseudo-random code sequences and associated correlation detection methods because for every desired code that is

15 intended to transmit there are multiple possible broadcasts. This complicates the correlation processing in the user receiver. Instead of searching and correlating for a group of possible code messages the receiver instead must search through a multiple of the number of messages broadcast. This increases the memory, processing, and power requirements of the user receiver. Furthermore, it weakens the separation between the

20 codes and increases the likelihood that one code might be mistaken for another in the correlation process.

[0006] Accordingly, additional encoding techniques for use with LEO satellite systems such as Iridium may find utility.

SUMMARY

[0007] Described herein are methods to encode data for transmission using a differential encoder. Also described are transmitters adapted to implement such
5 transmissions and communication systems which utilize differential encoders.

[0008] In some embodiments a communication device comprises a differential encoder to receive data for transmission and encode the data for transmission using a set of codes that, when processed by the differential encoder, place the differential encoder in
10 a known state and generate uncorrelated output sequences.

[0009] In other embodiments a method to encode data for transmission using a differential encoder comprises receiving, in a differential encoder, data for transmission, and encoding the data for transmission using a set of codes that, when processed by the differential encoder, place the differential encoder in a known state and generate
15 uncorrelated output sequences.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The detailed description is described with reference to the accompanying figures.

[0011] Fig. 1 is a schematic illustration of a low Earth orbit (LEO) satellite
5 communication system, according to embodiments.

[0012] Fig. 2 is a schematic illustration of components of a transmitting device and a receiving device, according to embodiments

[0013] Fig. 3 is a flowchart illustrating operations in a method to implement a bit signal structure for differentially encoded broadcasts, according to embodiments.

10 **[0014]** Fig. 4 is a flowchart illustrating operations in a method to generate codes for differential encoding operations, according to embodiments.

DETAILED DESCRIPTION

[0015] In the following description, numerous specific details are set forth to provide a thorough understanding of various embodiments. However, it will be understood by those skilled in the art that the various embodiments may be practiced without the specific details. In other instances, well-known methods, procedures, components, and elements have not been illustrated or described in detail so as not to obscure the particular embodiments.

[0016] The subject matter of this application is described primarily in the context of differential encoding in QPSK modulation schemes implemented by Iridium satellites.

However, one skilled in the art will recognize that the techniques described here are readily applicable to other systems which utilize differential encoding in either QPSK modulation schemes or BPSK modulation schemes. Such systems may include other mobile communication systems, e.g., airborne communication systems or the like, as well as, stationary communication platforms including but not limited to a ship or a cell phone tower.

[0017] Described herein are differential encoding techniques which may be used in transmitters associated with low Earth orbit (LEO) satellite systems. In some embodiments the differential encoding techniques use preselected codes which exhibit the property of leaving the transmitter's differential encoder in a known logical state. For example, some preselected codes leave the transmitter in the same logical state as it was in prior to transmission. This results in a 1:1 mapping between input data and output data for the differential encoder, which facilitates signal correlation and selection at a receiver.

[0018] Fig. 1 is a schematic illustration of a low Earth orbit (LEO) satellite communication system 100, according to embodiments. Referring to Fig. 1, in some embodiments a system 100 comprises one or more LEO satellites 110 in communication with one or more receiving devices 120a, 120b, which may be referred to generally by
5 the reference numeral 120.

[0019] In some embodiments the LEO satellites 110 may be embodied as satellites in the Iridium satellite constellation. A typical satellite communication system such as Iridium is designed to work under conditions where the satellite signal has a received power above the ambient noise floor.

10 [0020] Receiving devices 120 may be implemented as communication devices such as satellite or cellular phones or as components of a communication or computing device, e.g., a personal computer, laptop computer, personal digital assistant or the like. Alternatively, receiving devices 120 may be implemented as position locating or navigation devices analogous to devices used in connection with the global positioning
15 system (GPS). The GPS system utilizes spread-spectrum access techniques which enables the receivers to pick up a signal even when the received broadcast is below the noise floor. In systems such as GPS, pseudo-random codes are broadcast by satellites, and correlation techniques are used to pull the signal out of the noise.

[0021] GPS systems have relatively poor performance within an attenuated (e.g.
20 indoor) environment 130 due to insufficient signal power which has created a need for other systems that can perform better in these environments. Iridium satellites broadcast with significantly more power than GPS transmissions. In an example, a receiver unit

configured to work with signals received from a LEO satellite, such as an Iridium satellite, may work with signal levels of less than about 45 dB of attenuation at the antenna of a receiving device 120. Thus, by leveraging the LEO based Iridium satellite, the Iridium-configured receiver unit may operate at about 15-20 dB below where a
5 typical GPS-configured receiver unit would stop working.

[0022] Various satellite communication systems, including Iridium, use a differential encoding signal processing scheme to encode and transmit quadrature phase shift keyed (QPSK) modulated broadcasts. During the differential encoding process the In-Phase (I) and Quadrature (Q) modulated bits of a broadcast are re-coded such that the
10 output of the differential encoder is a function of the current I/Q state and the previous I/Q state. Table I is a typical differential encoding scheme used for QPSK systems. Any given message (represented by a string of bits) is differentially encoded before it is broadcast.

	Current Input State		Previous Output State		Current Output State	
	I	Q	I	Q	I	Q
	0	0	0	0	0	0
	0	0	0	1	0	1
5	0	0	1	0	1	0
	0	0	1	1	1	1
10	0	1	0	0	1	0
	0	1	0	1	0	0
	0	1	1	0	1	1
15	0	1	1	1	0	1
	1	0	0	0	0	1
	1	0	0	1	1	1
	1	0	1	0	0	0
	1	0	1	1	1	0
20	1	1	0	0	1	1
	1	1	0	1	1	0
	1	1	1	0	0	1
	1	1	1	1	0	0

Table I Differential Encoding Scheme

[0023] The current output of the differential encoding process is a function of the current I/Q state and the previous I/Q state. By way of example, a bit coded message (A) input to a differential encoder will actually be broadcast in a form (B) which can have four different versions (B1, B2, B3, B4) depending on the previous state (C) of the differential encoder. The cases presented in Table II, below are exemplary:

Case 1:
 A= 00000000 Pre-encoded message
 C= 00
 B1= 00000000 Broadcast message

5	Case 2:	
	A= 00000000	Pre-encoded message
	C= 01	Previous state of the differential encoder
10	B2= 01010101	Broadcast message
	Case 3:	
	A= 00000000	Pre-encoded message
15	C= 10	Previous state of the differential encoder
	B3= 10101010	Broadcast message
	Case 4:	
	A= 00000000	Pre-encoded message
	C= 11	Previous state of the differential encoder
	B4= 11111111	Broadcast message

Table II: Encoder Transformations

[0024] Thus, for any subsequent given message A, there are four possible differentially encoded versions of the message B, which emerges from the differential encoder. The message B is dependent on the previous encoder state C, creating a 1:4 input code (A) to potential output (B) code ratio.

[0025] The differential encoding scheme used on Iridium and other communication satellites generates issues in using pseudo-random code sequences and associated correlation detection methods because every desired code, message A, that is inputted into the differential encoder can generate four possible broadcasts. This 1:4 ratio significantly complicates the correlation processing in the user receiver. Instead of searching and correlating for a single group of possible code messages, the receiver instead must search through 4X this number of messages. This increases the memory, processing, and power requirements of the user receiver. Furthermore, it weakens the separation between the codes and increases the likelihood that one code might be mistaken for another in the correlation process.

[0026] In one aspect there is described herein systems and methods for differential encoding in which a differential encoder uses a set of codes that, when processed by the differential encoder, places the differential encoder into a known state. The known state may be a predetermined logical state. For example, in various embodiments the differential encoder may reside in an initial logical state when the data for transmission is received and the set of codes used by the differential encoder to encode the data may reset the differential encoder to the initial logical state. In various embodiments the differential encoder may reside in an initial logical state when the data for transmission is received and the set of codes used by the differential encoder to encode the data may reset the differential encoder to a known logical state that differs from the initial logical state. In various embodiments the known state may be a known (I,Q) state after an input data stream has been processed. Placing the differential encoder into a known (I,Q) state eliminates the 1:4 ratio of inputs to outputs.

[0027] In some embodiments, methods of the present disclosure may be implemented in a transmitting device such as, e.g., a transmitter of a LEO satellite such as the satellite 110 depicted in Fig. 1. Fig. 2 is a schematic illustration of components of a transmitting device and a receiving device, according to embodiments. Referring to Fig. 2, in one embodiment a transmitting device 210 comprises a differential encoder 212, a modulator 214, and an amplifier 216. The transmitting device 210 is coupled to an antenna 218. A receiving device 230 comprises one or more signal processor(s) 232, a demodulator 234, and a band pass filter 236. The receiving device 230 is coupled to an antenna 238.

[0028] Operations of the transmitting device 210 and the receiving device 230 will be explained with reference to Fig. 2, and with reference to Fig. 3, which is a flowchart illustrating operations in a method to implement a bit signal structure for differentially encoded broadcasts, according to embodiments. Referring to Figs. 2 and 3, at operation
5 310 data for transmission is received in the differential encoder 212 of the transmitting device 210.

[0029] At operation 315 the data is differentially encoded using selected codes. In some embodiments the differential encoder 212 differentially encodes the data using a set of codes that have the property that when they are transmitted they always leave the
10 differential encoder 212 in a known (I,Q) state, such as (00). This ensures a 1:1 correlation between the input code (A) and the output code (B) of the differential encoder 212, which in turn ensures that the previous message does not present an ambiguity to the current message in spite of the system's differential encoder. Thus, the code word always rotates the differential encoder 212 back to its initial phase (00) in the above example.

15 **[0030]** At operation 320 the data signal output from the differential encoder is modulated by the modulator 214. The modulated signal is amplified (operation 325) by the amplifier 216 and passed to the antenna 218 for transmission (operation 330).

[0031] The broadcast signal is received (operation 335) at the antenna 238 coupled to the receiving device 230. The signal is passed from the antenna 238 to a band pass
20 filter, which filters (operation 340) out undesired frequency ranges, then is demodulated (operation 345) by demodulator 234 and then passed to a signal processor 232. In relevant part, the signal processor 232 may decode (operation 350) the signal to recover

the original message. The original message may then be used in a position location process.

[0032] In another aspect, the differential encoder 212 may implement a coding technique referred to herein as super bit encoding (SBE), which is designed to improve the signal detection of messages in noisy environments. In some embodiments the differential encoder 212 encodes messages with a processing gain equivalent to:

$$G=N/n; \quad \text{where } G = \text{processing gain,} \\ N = \# \text{ of bits in the code message,} \\ n = \# \text{ of information bits in the message.}$$

[0033] By way of example, if the 10 message bits are used to represent 1 information bit, the processing gain is equal to 10 (or 10dB). Where the dB conversion factor is: $10 \log_{10}(G)$. Super bit sequences may be constructed using a string of N pseudo-random bits, where each code has the correlation properties as previously described. N may be implemented as an integer, such that output sequences from the differential encoder 212 are uncorrelated with each other to the extent possible in order to preserve the differentiation amongst code words.

[0034] In various embodiments, the super bit encoding scheme may be used with the previously described methods in which a differential encoder uses a set of codes that, when processed by the differential encoder, places the differential encoder into a known state. In one embodiment, the super bit encoding scheme may append a multi-bit sequence to a string of N pseudo-random bits, where the multi-bit sequence resets the differential encoder to a known state. For example, two SBE bit sequences are set forth below. Each bit sequence uses a 10 bit sequences to represent a 0 or a 1, respectively. As

an example of this embodiment, the bit codes presented in Case 1 through Case 4 in Table III below illustrate a 20 bit input code after which four zeros (0000) are appended as a test sequence, A. The four zeros appended to the end of the 20 bit sequence help identify the state C of the differential encoder 212. In addition, D identifies the post-encoded state of the differential encoder 212. A preferred output code results in C=D, meaning that the post-encoded state of the differential encoder 212 includes four zeroes also at the end of the message showing that the state of the encoder has been reset to the initial state of the differential encoder 212. By contrast, the examples illustrated in Case 5 through Case 8 do not result in resetting the post-encoded state of the differential encoder 212 to the initial pre-encoded state of the differential encoder 212.

Case 1:

15 A = 101111001111011100110000 Pre-encoded message
 C = 0000 Previous state of the differential encoder
 B = 100110100110001111000000 Broadcast message
 D = 0000 Post-encoded state of the differential encode

Case 2:

20 A = 101011110001001010100000 Pre-encoded message
 C = 0000 Previous state of the differential encoder
 B = 101100111110101101000000 Broadcast message
 D = 0000 Post-encoded state of the differential encoder

Case 3:

25 A = 101010101110101101010000 Pre-encoded message
 C = 0000 Previous state of the differential encoder
 B = 101101001101001110000000 Broadcast message
 D = 0000 Post-encoded state of the differential encoder

Case 4:

35 A = 101110000110110011000000 Pre-encoded message
 C = 0000 Previous state of the differential encoder
 B = 100100000100111100000000 Broadcast message
 D = 0000 Post-encoded state of the differential encoder

Case 5:

40 A = 011101000011100000010000 Pre-encoded message
 C = 0000 Previous state of the differential encoder
 B = 011000000011010101111111 Broadcast message

	D = 1111	Post-encoded state of the differential encoder
	Case 6:	
5	A = 001101110101001001110000	Pre-encoded message
	C = 0000	Previous state of the differential encoder
	B = 001110011110101110010101	Broadcast message
	D = 0101	Post-encoded state of the differential encoder
10	Case 7:	
	A = 100110010110101110100000	Pre-encoded message
	C = 0000	Previous state of the differential encoder
	B = 011000000011010101111111	Broadcast message
15	D = 1111	Post-encoded state of the differential encoder
	Case 8:	
20	A = 110011111011100100000000	Pre-encoded message
	C = 0000	Previous state of the differential encoder
	B = 111100110110111010101010	Broadcast message
	D = 1010	Post-encoded state of the differential encoder

Table III: Example Bit Codes

[0035] In some embodiments, the super bit encoding concept can be extended to the idea of representing several Gray codes within a single communication satellite message burst such as an Iridium satellite message burst. The burst data structure includes information bits that provide identifying information as well as payload data, which is differentially encoded. In some embodiments there are 256 data bits (N) in a message burst in which multiple messages are to be transmitted, where $n=8$ or 256 possible messages. SBE sequences can be defined for a cases in which $n=1$ for use in a communications satellite differential decoder, using two 10 bit sequences to represent a 0 or a 1. In this case $N=10$ and $n=1$ and therefore the signal gain $G=10$.

[0036] Fig. 4 is a flowchart illustrating operations in a method to generate codes for differential encoding operations, according to embodiments. Referring to Fig. 4, at operation 410 candidate pseudo-random codes are generated. In some embodiments

pseudo-random codes may be generated using a random number generator to create candidate bit sequences of 0s and 1s.

[0037] At operation 415 it is determined whether the pseudo-random codes meet differential encoding criteria. For QPSK encoding the pseudo-random code the number of bits must be even and the sum of all bits having a value of 1 must be an even multiple of four. For BPSK encoding the number of bits must be even and the some of all bits having a value of 1 must be an even multiple of two.

[0038] The pseudo-random code(s) may be input into the differential encoder 212, which differentially encodes data (operation 420) and generates an output from the input pseudo-random code(s). Differentially encoding a long random sequence of 0s and 1s typically produces a new code with similar statistical properties as the input code. Thus there is a high probability that the output code generated by the differential encoder 212 has similar properties as the input code.

[0039] At operation 425 the correlation properties of the output codes generated by the differential encoder 212 are tested by correlating the input code with the output code. In general, a good set of code words will produce a low cross-correlation between code words in the set. The operations of Fig. 4 may be repeated until a suitable set of code words is determined. The set of codes may then be used in the differential encoding process depicted in Fig. 3.

[0040] In summary, the forced differential encoding scheme implemented by satellite communications systems presents a difficulty in using pseudo-random code sequences in message encoding because for every input code for transmission results in

four possible output code broadcasts. This significantly complicates the correlation processing in the user receiver by increasing the memory, processing, and power requirements. Furthermore, it weakens the separation between the codes and increases the likelihood that one code might be mistaken for another in the correlation process.

- 5 According to embodiments described herein, encoding data in the differential encoder 212 using codes which leave the differential encoder 212 in a known output state may be useful in delivering pseudo-random coded messages to users via a communication satellite. Using these techniques, timing and frequency information can be delivered to a user in attenuated environments (e.g., indoors) by sending pseudo-random messages from
- 10 a satellite such as Iridium to a user located inside a structure. The user receiving the message benefits because the broadcast from the communications satellite is more powerful than GPS, and the pseudo-random coding technique provides an additional gain that allows the signal to be pulled out of the noise. Once received, these messages can provide information suitable for the user to self-locate. However, without loss of
- 15 generality, the message delivered to the user code could be for any purpose.

- [0041] Reference in the specification to “one embodiment” or “some embodiments” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least an implementation. The appearances of the phrase “in one embodiment” in various places in the specification may
- 20 or may not be all referring to the same embodiment. For example, various embodiments may include:

- A1. A communication device comprising a differential encoder to:
receive data for transmission; and
encode the data for transmission using a set of codes that, when processed by the
differential encoder, place the differential encoder in a known state and generate
5 uncorrelated output sequences.
- A2. The communication device of A1, further comprising:
a modulator to modulate the encoded signal;
an amplifier to amplify the encoded signal; and
10 a transmitter to transmit the encoded signal.
- A3. The communication device of claim A1 further comprising a receiving device
remote from the communication device, the receiving device comprising:
a receiver to receive the encoded signal; and
15 a decoder to decode the encoded signal.
- A4. The communication device of A1, wherein the encoded signal comprises at least
one of a global positioning system (GPS) signal, a Gray code signal, or a satellite signal.
- 20 A5. The communication device of A3, wherein the receiving device comprises at least
one of a satellite phone, a cellular phone a personal computer, laptop computer, or a
personal digital assistant.
- A6. The communication device of A3, wherein the receiving device uses the encoded
25 signal in a positioning algorithm.
- B1. A method to encode data for transmission using a differential encoder, comprising:
receiving, in a differential encoder, data for transmission; and
encoding the data for transmission using a set of codes that, when processed by the
30 differential encoder, place the differential encoder in a known state and generate
uncorrelated output sequences.

B2. The method of B1, wherein the differential encoder utilizes QPSK modulation schemes.

5 B3. The method of B1, wherein the differential encoder utilizes BPSK modulation schemes.

B4. The method of B2, wherein the differential encoder is within a mobile communication system.

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B5. The method of B2, wherein the differential encoder is within a stationary communication system.

15 **[0042]** Although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that claimed subject matter may not be limited to the specific features or acts described. Rather, the specific features and acts are disclosed as sample forms of implementing the claimed subject matter.

CLAIMS

What is claimed is:

1. A method to encode data for transmission using a differential encoder, comprising:
receiving, in a differential encoder, data for transmission; and
5 encoding the data for transmission using a set of codes that, when processed by the differential encoder, place the differential encoder in a known state and generate uncorrelated output sequences.
2. The method of claim 1, wherein:
the differential encoder resides in an initial logical state when the data for
10 transmission is received; and
the set of codes used by the differential encoder to encode the data resets the differential encoder to the initial logical state.
3. The method of claim 1, wherein:
the differential encoder resides in an initial logical state when the data for
15 transmission is received; and
the set of codes used by the differential encoder to encode the data resets the differential encoder to a known logical state that differs from the initial logical state.
4. The method of claim 1, further comprising:
modulating the encoded signal;
20 amplifying the encoded signal; and
transmitting the encoded signal.
5. The method of claim 4, further comprising:
receiving the encoded signal; and
decoding the encoded signal.
- 25 6. The method of claim 5, further comprising using the encoded signal in a positioning algorithm.

7. The method of claim 6, wherein the encoded signal comprises at least one of a global positioning system (GPS) signal, a Gray code signal, or a satellite signal.
8. The method of claim 1, wherein encoding the data for transmission comprises using a super bit encoding scheme in which each bit of information transmitted is
5 represented by a string of N pseudo-random bits.
9. The method of claim 8, wherein the super bit encoding scheme is utilized to increase the signal to noise ratio to allow a user indoors to acquire robust timing information.
10. The method of claim 8, wherein the super bit encoding scheme appends a multi-bit
10 sequence to the string of N pseudo-random bits, wherein the multi-bit sequence resets the differential encoder to a predetermined logical state.
11. The method of claim 1, wherein the differential encoder is located within a communication system that is leveraged as a positioning system.
12. The method of claim 5, wherein receiving the encoded signal comprises allowing
15 a user in an attenuated environment to receive a signal acquire robust timing information.
13. A communication device comprising a differential encoder to:
receive data for transmission; and
encode the data for transmission using a set of codes that, when processed by the differential encoder, place the differential encoder in a known state and generate
20 uncorrelated output sequences.
14. The communication device of claim 13, wherein:
the differential coder resides in an initial logical state when the data for transmission is received; and
the set of codes used by the differential encoder to encode the data resets the
25 differential encoder to the initial logical state.

15. The communication device of claim 13, wherein:
the differential coder resides in an initial logical state when the data for
transmission is received; and
the set of codes used by the differential encoder to encode the data resets the
5 differential encoder to a known logical state that differs from the initial logical state.
16. The communication device of claim 13, wherein the differential encoder
implements a super bit encoding scheme in which each bit of information transmitted is
represented by a string of N pseudo-random bits.
17. The communication device of claim 16, wherein the super bit encoding scheme
10 appends a multi-bit sequence to the string of N pseudo-random bits, wherein the multi-bit
sequence resets the differential encoder to a predetermined logical state.