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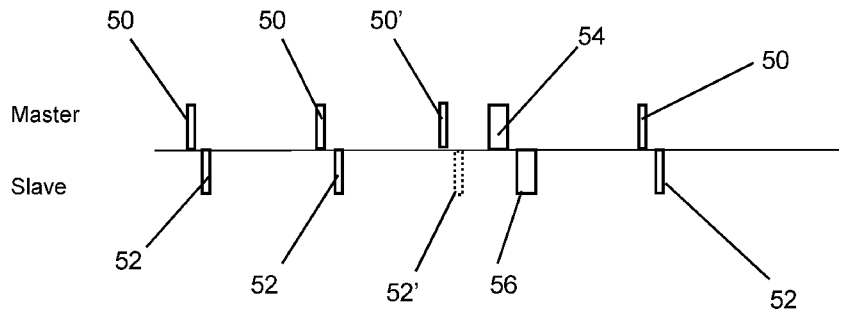


FIG 6

(57) Abstract: A method of digital radio communication between a first device (2) and a second device (8), where each device comprises a radio transmitter (4) and a radio receiver (6), the method comprising: a) said first and second devices (2, 8) establishing a connection at a first data rate using a predetermined protocol having at least one predefined message format; b) said first device (2) transmitting a poll message to said second device (8); c) if said first device (2) does not receive a reply from said second device (8), said first device (2) transmitting a further poll message at a second data rate, lower than the first data rate.

WO 2014/195704 A1

Digital Radio Communication

This application relates to short range radio communication. It relates particularly, although not exclusively, to ad hoc short range radio communication protocols such as Bluetooth (TM), or the more recent Bluetooth Low Energy (TM) protocol.

The Bluetooth Low Energy (BLE) core specification version 4.0 specifies a fixed data rate of 1 MBps as well as a maximum transmitter output power of 10 mW and a minimum receiver sensitivity of -70dB at a bit error rate (BER) of 0.1%. The combined effect of these is that there is a maximum effective range between which BLE-enabled devices can communicate. The actual range which can be achieved is dependent on environmental factors such as noise and obstacles but may be of the order of 10-100 metres.

When viewed from a first aspect the invention provides a method of digital radio communication between a first device and a second device, each comprising a radio transmitter and a radio receiver, the method comprising:
a) said first and second devices establishing a connection at a first data rate using a predetermined protocol having at least one predefined message format;
b) said first device making a quantitative determination of a quality of said connection;
c) performing a comparison between said quality and a threshold; and
d) based on said comparison, the first device initiating a control protocol to change from the first data rate to a second, different data rate to communicate with the second device.

The invention extends to a digital radio communication system comprising a first device and a second device, each comprising a radio transmitter and a radio receiver, wherein:
a) said first and second devices are arranged to establish a connection at a first data rate using a predetermined protocol having at least one predefined message format;
b) said first device is arranged to make a quantitative determination of a quality of said connection;

c) said first device is arranged to perform a comparison between said quality and a threshold; and

d) based on said comparison, the first device is arranged to initiate a control protocol to change from the first data rate to a second, different data rate to communicate with the second device.

The invention extends further to a first digital radio device comprising a radio transmitter and a radio receiver, the device being arranged:

a) to establish a connection with a second digital radio device using a predetermined protocol having at least one predefined message format;

b) to make a quantitative determination of a quality of said connection;

c) to perform a comparison between said quality and a threshold; and

d) based on said comparison, to initiate a control protocol to change from the first data rate to a second, different data rate to communicate with the second device.

Thus it will be seen by those skilled in the art that in accordance with the invention two devices may be able to change the data rate at which they communicate in response to the quality of the connection. This may allow the devices, say, to communicate over a longer range by using a lower data rate and then taking advantage of the stronger signals available when they are closer together to use a higher data rate.

The first data rate may be lower than the second data rate. In this case the change to the second data rate may occur if the connection quality is above a threshold. Similarly the first data rate may be higher than the second data rate. In this case the change to the second data rate may occur if the connection quality is below a threshold. The data rate may be changed again to the first data rate if the connection quality falls below or rises above the threshold respectively, or a different threshold may be defined for a change from the second to the first rate (e.g. to introduce hysteresis). Further thresholds may be defined for other changes in the data rate. These too may depend on the direction of change.

The connection quality could comprise one or more of many different measures. It could, for example, comprise the physical separation of the devices, the number of

dropped packets, bit errors, etc. In a set of embodiments the connection quality comprises a strength of signal from one device to the other.

In a set of embodiments a lower data rate results from transmitting a message in a message format predefined in said protocol wherein at least part of said message is encoded using a coding scheme in which at least some bits specified in said predefined message format are represented by a plurality of bits transmitted. The advantage of this is that it is easier to recover the represented bit even if some of the actual bits transmitted are not received or recovered reliably. This means that a BER specified in the protocol can be achieved for represented bits whilst the error for transmitted bits (referred to hereinafter as "chips") - i.e. the Chip Error Rate is much higher. In practical terms this means that for a given transmission power and receiver gain, a reconnection that is otherwise in accordance with the protocol may be achieved over a greater distance than without the coding scheme being applied. Such operation can therefore be considered part of a long range mode of the protocol.

In the context of Bluetooth Low Energy, the arrangements described above represent an extension to the core specification which support the introduction of a long range mode. This has the potential to extend the usefulness of BLE.

As will be appreciated by those skilled in the art representing each data bit by a plurality of chips reduces the effective data rate which can be achieved. More specifically where each data bit is represented by a fixed length sequence, the effective data rate is the chip rate divided by the sequence length. There is thus a trade-off between sequence length and data rate. On the other hand the longer the sequence used, the greater the range which can be achieved for a given data BER as longer sequences give greater tolerance to dropped chips,

The higher data rate may be achieved by applying a reduced coding gain, or no coding gain. Additionally or alternatively it may be based on a higher base rate - i.e. a higher over-the-air data rate.

In a set of embodiments the first device comprises a master device and the second device comprises a slave device.

Where employed, the coding scheme could take one of a number of different forms. In a set of embodiments it may, for example, comprise simply repeating each bit in a message or part of a message a predetermined number of times. It may comprise repeating a string forming part of a message a predetermined number of times. In a set of preferred embodiments a respective fixed sequence of chips is used to represent each data bit, which may be known as direct sequence spread spectrum (DSSS) coding. Any combination of the above approaches (and others) could also be used.

In set of embodiments the first and second devices agree during a connection that they will operate in accordance with the invention. Such agreement may, for example, be predicated on the first and second devices both supporting the second data rate. The first and second devices may agree during a negotiation what the second data rate should be. The second data rate could, for example, be set during a Bonding phase as defined in the Bluetooth core specification v4.0.

The first data rate could be set in a number of ways. It may be a standard data rate for the protocol - e.g. 1 MBps for conventional BLE. It could be set as a default initial date rate for establishing a reconnection after an initial connection is broken or it could be a rate determined by the coding gain applied to a successfully received Advertising packet to establish the connection.

The second data rate could be predetermined either by being specified in the protocol or by being previously agreed during the connection or a prior connection.

The second device may also be arranged to determine the connection quality - e.g. the signal strength received from the first device - to determine whether to initiate a change in the data rate; or the first device may be the only one arranged to do this.

The Applicant has recognised that as well as persistent changes in conditions which may indicate a need to change the data rate through a change in the connection quality (such as received signal strength), more transient conditions may lead to packets being lost, particularly if the devices are close to their maximum effective range.

According to a further aspect of the invention there is provided a method of digital radio communication between a first device and a second device, each comprising a radio transmitter and a radio receiver, the method comprising:

a) said first and second devices establishing a connection at a first data rate using a predetermined protocol having at least one predefined message format;

b) said first device transmitting a poll message to said second device;

c) if said first device does not receive a reply from said second device, said first device transmitting a further poll message at a second data rate, lower than the first data rate.

This aspect of the invention extends to a digital radio communication system comprising a first device and a second device, each comprising a radio transmitter and a radio receiver, wherein:

a) said first and second devices are arranged to establish a connection at a first data rate using a predetermined protocol having at least one predefined message format;

b) said first device is arranged to transmit a poll message to said second device; and

c) if said first device does not receive a reply from said second device, said first device is arranged to transmit a further poll message at a second data rate, lower than the first data rate.

This aspect of the invention extends further to a first digital radio device comprising a radio transmitter and a radio receiver, the device being arranged:

a) to establish a connection with a second digital radio device using a predetermined protocol having at least one predefined message format;

b) to transmit a poll message to said second device; and

c) if said first device does not receive a reply from said second device, to transmit a further poll message at a second data rate, lower than the first data rate.

Thus in accordance with this aspect of the invention if a poll message such as a standard poll packet is not received or the reply thereto is not received, the first device transmits a further message with a lower data that should have a greater

chance of being received. This can help to prevent a connection being broken in the event of transient conditions such as temporary noise or interference.

In a preferred set of embodiment the lower data rate results from transmitting the further poll message in a message format predefined in said protocol wherein at least part of said message is encoded using a coding scheme in which at least some bits specified in said predefined message format are represented by a plurality of bits transmitted. As previously explained this gives rise to a coding gain which increases the probability of the message being received.

Although not essential, it is preferred that the second device transmits a reply to the further message at the second data rate. Thereafter the first device could revert to the first data rate for the next message it sends or it could continue at the second data rate. It may continue at the second data rate for a fixed time, for a fixed number of transmissions or until a further change is initiated - e.g. if a criterion is met such as the received signal strength crossing a threshold.

In a set of embodiments, the first device transmits the further poll message at the second data rate after no reply is received for a predetermined number of poll messages. The predetermined number may be chosen unilaterally by the first device, but in a set of embodiments it is pre-agreed during a connection process between the two devices, for example during a Bonding phase as defined in the Bluetooth core specification v4.0. In a set of embodiments, the first device transmits the further poll message at the lower data rate without sending any separate messages to say the data rate is changing. It is not necessary to effect a control procedure between the devices. This is because the predetermined number was pre-agreed during the connection process, so when the predetermined number of transmissions have not been carried out correctly (e.g. a certain amount of time has passed without a complete transmission and response), both devices know what the protocol is for continuing transmissions. This prevents the need for a real-time negotiation in order to change the rate, which may be beneficial when there is a high latency and a short time interval for changing the data rate to avoid the signal simply being lost.

In a particular example, two devices may agree during bonding that if three consecutive packets are lost, then the fourth packet shall use a lower data rate to re-establish a connection. When three packets have been lost, both devices therefore expect the fourth packet to be transmitted at a lower data rate, for example by using a coding gain, and therefore are prepared to transmit and/or receive in this state.

In a set of embodiments of any aspect of the invention the predetermined protocol is compatible with the Bluetooth (TM) protocol as issued by the Bluetooth Special Interest Group, e.g. as defined in the Bluetooth Low Energy core specification v4.0. For example the protocol may be a modification of the Bluetooth Low Energy core specification v4.0 to accommodate, *inter alia,* the features described herein. In a set of such embodiments of the second aspect of the invention, the first device preferably transmits the further packet within the same Event as the first packet.

Certain embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a generalised illustration showing a first and second device communicating with one another;

Fig. 2 is a schematic illustration of a Bonding/re-connection procedure;

Fig. 3 is a more detailed schematic illustration of the Bonding process;

Fig. 4 is a schematic illustration of a process in accordance with an embodiment of the invention to change the data rate during a connection;

Fig. 5 is a representation of a packet structure and possible coding schemes which may be applied; and

Fig. 6 is a diagrammatic representation of the operation of an embodiment of another aspect of the invention.

Fig. 1 shows a master device 2 (also known as a Central device) having a radio transmitter section 4 and a radio receiver section 6; and a slave device 8 (also known as a Peripheral device) also having a radio transmitter section 10 and a radio receiver section 12. Apart from where specified to the contrary hereinbelow the Master and Slave devices 2, 8 are configured to operate according to the Bluetooth Low Energy (BLE) core specification version 4.0.

Fig. 2 gives a broad overview of a possible operation of two devices. In the first step 14 the master 2 and slave 8 undergo a conventional Bonding procedure. which is described below with reference to Fig. 3. The procedure commences with the master 2 setting the Bonding_Flags to Bonding. It is assumed that the slave 8 is also in Bonding mode.

With reference to Fig. 3, the master device 2 sends a Pairing request 16 to the slave device 8 comprising various capability and security information including, for example, input/output (IO) capability and a Short Term Key (STK) which is used for encrypting the transmissions during the negotiation process. The slave device 8 issues a Pairing response 18 indicating its compatibility with the capabilities specified by the master device 2. This comprises phase one of a standard Pairing operation.

In phase two of the Pairing operation, data can be exchanged between the two devices using the STK. The paired connection between the two devices 2, 8 at this point is a one-off one so that if the connection were to be broken it would be necessary to repeat the procedure anew.

In a further round of communication representing phase three in which the Pairing connection is transformed to a Bonding connection, the master device 2 sends further identity and security information 20, encrypted using the STK. The further information includes a Long Term Key (LTK) to use for encryption of subsequent communication between the master and the slave. More significantly the additional information includes an indication that the master device 2 supports a Long Range mode. This could, for example, include a specification of a data rate or coding gain to be applied between the devices when attempting to establish a re-connection if the connection between them is broken. This information is stored in a memory by

both the master 2 and slave 8 so that they 'recognise' one another if subsequently re-connecting.

In one possible example the Master could specify a coding gain of say 6 dB which corresponds to a data rate of 25% of the original value - i.e. 250 kBps in a Bluetooth Low Energy system. This can be achieved by representing each bit of the packet, or part-packet, to which the coding gain is applied by four chips, i.e. using a sequence length of four. This may be seen in greater detail with reference to Fig. 5 described below.

The slave device 8 then sends an acknowledgement 22 back to the master device 2 confirming that it can support the requested coding gain. If the slave device is unable to support the requested coding gain the acknowledgement message 22 may include a proposed alternative coding gain.

Thereafter at step 24 the master and slave devices 2, 8 may communicate with one another at the standard 1 MBps data rate, encrypted using the LTK. Alternatively they may communicate at the lower data rate agreed for re-establishing connection - e.g. 250 kbps. This could be determined by the master measuring the signal strength it receives from the slave and determining this to be below a predetermined threshold as explained below with reference to Fig. 4.

Returning to Fig. 2 it is now assumed that at a later point the connection between the master 2 and slave 8 is broken at step 26 - e.g. because one of the devices does not receive an expected message within a specified time-out period.
The slave device 8 transmits Advertisement packets 28 to the master device 2 seeking to establish a re-connection. However rather than the Advertisement packet being transmitted at the standard 1MBps data rate, part of it is transmitted at a lower data rate to give a coding gain, as previously agreed during phase three of the Bonding process.

The Master device 2 receives one of the Advertisement packets 28 and because of the prior negotiation and agreement of data rate during the Bonding process, it applies the correct coding sequence to its demodulator to extract packets containing the correct address and data rate. If it had not applied the correct data

rate the packet would have been automatically rejected. As a result of the coding gain / reduced data rate applied to the Advertisement packet 28, the master 2 has a greater opportunity to receive it reliably at a greater distance than if a standard data rate packet had been transmitted.

A further connection 30 is then established to allow continued communication between the master 2 and slave 8. This communication initially takes place at the lower data rate used for the Advertisement packet since the coding gain is applied to the packets exchanged. However in accordance with an embodiment of the invention if the master device 2 detects a received signal strength from the slave device above a threshold, a criterion is met for reducing the coding gain using the protocol illustrated in Fig. 4.

As shown in Fig. 4 the master 2 and slave 8 begin in a connected state 32. Following a regular check carried out by the master 2, it determines that the received signal strength of the signal from the slave 8 is above a threshold, typically because the distance between the master and slave devices has been reduced. In order to take advantage of the increased signal strength, the master 2 sends a special packet 34 to initiate an increase of the data rate. The packet 34 initiates a control procedure to bring this about and includes a field which specifies the new data rate to be applied. For example it may specify a shorter sequence length corresponding to a lower coding gain and so a higher data rate. The master 2 will be aware of which data rates the slave 8 can support from the exchange of capability information during the third phase of the Bonding procedure previously carried out and thus further negotiation is not necessary.

After a certain number of events 38 (which number may be specified in the initiating packet 34) the master 2 and slave 8 begin at step 40 to communicate at the new data rate. This means that the devices each apply the new sequence length to all or part of their transmitted packets and configure their receive demodulators to be responsive to the new sequence length for received packets.

The procedure set out above may be repeated any number of times during the connection - either to further relax the coding gain if the signal strength continues to

increase or to increase it again if the devices move apart and the signal strength drops.

Although the procedure described above is based on received signal strength, this is not essential. It could, for example, be based on a threshold bit error rate, separation of the devices or other parameter related to the quality of the connection.

Fig. 5 shows a typical packet construction. The packet is divided into four separate fields of differing lengths. The first is the Preamble 42. This is made up of a single octet of alternating bits which may be used by the receiver for frequency recovery, timing recovery etc. Below the table are some examples of how a four times coding gain could be applied to the preamble '10101010'. In the top example the original sequence is simply repeated four times. Thus a bit at position n in the original string is represented by four bits (or 'chips') in the extended sequence - namely those at positions n, n+8, n+16 and n+24 of the extended string. .

In the centre example each bit is repeated four times. Again, clearly each bit in the original string is represented by four chips in the extended string.

In the bottom example a direct-sequence spread spectrum is used. In this example each '1' bit is represented by the sequence '1101' and each '0' bit is represented by '0010'. Of course different sequences could be used, particularly different length sequences could be used depending on the required coding gain. The actual sequence to be used for each bit could be agreed during phase three of the Bonding process.

Although the preamble is used in Fig. 5 as a simple example of how coding gain might be applied, in an exemplary embodiment no coding gain is applied to the preamble in order that it can still be used for initialisation at the receiver.

The fields in the packet are the Access Address 44 which specifies the address of the device to which the packet is directed, the Protocol Data Unit (PDU) 46 which is the actual content of the message carried by the packet and the Cyclic Redundancy

Check (CRC) 48 which is a field generated by a predetermined formula from the PDU 46 for use in error checking.

In an example implementation the Access Address 44, PDU 46 and CRC 48 are all encoded using DSSS. The CRC 38 is calculated from the PDU 46 before the DSSS coding is applied.

With reference now to Fig. 6, there may be seen a timing diagram illustrating the operation of an embodiment of another aspect of the invention. In this embodiment a master device and a slave device are operating according to a standard Bluetooth protocol except for the feature described below. As may be seen Fig. 6 shows, above the line, the master transmitting standard Bluetooth Poll packets 50 and the subsequent responses 52 from a slave to which it is paired.

Now assuming that the third Poll packet 50' is lost and not received by the slave, it will of course not transmit the corresponding response packet 52'. When the master does not receive the expected response packet it transmits a further packet 54 known as a recovery packet, in the same Event as the lost packet 50'. The recovery packet 54 is encoded using DSSS as described above and thus is at a lower data rate than the Poll packets 52. This allows a much greater chance of it being received, Indeed the slave does receive it and issues a response 56 which also has a coding gain from its use of DSSS. Thereafter the master device continues as normal, transmitting an ordinary Poll packet 50 and receiving a corresponding response packet 52. In other embodiments however the coding gain could be applied to subsequent packets too. In this embodiment, the data rate is changed after the first device does not receive a response from a single poll message. However, in alternative embodiments, the first device may not receive responses from a plurality of poll messages before the data rate is changed. By adopting this feature communication between the master and slave recovers from the lost Poll packet 50' more quickly than would have been the case under the standard Bluetooth (TM) protocol.

Claims:

1. A method of digital radio communication between a first device and a second device, each comprising a radio transmitter and a radio receiver, the method comprising:
a) said first and second devices establishing a connection at a first data rate using a predetermined protocol having at least one predefined message format;
b) said first device transmitting a poll message to said second device;
c) if said first device does not receive a reply from said second device, said first device transmitting a further poll message at a second data rate, lower than the first data rate.

2. A method as claimed in claim 1 comprising transmitting the further poll message in a message format predefined in said protocol wherein at least part of said message is encoded using a coding scheme in which at least some bits specified in said predefined message format are represented by a plurality of bits transmitted.

3. A method as claimed in claim 2 wherein said coding scheme comprises a respective fixed sequence of chips to represent each data bit.

4. A method as claimed in any preceding claim comprising the second device transmitting a reply to the further poll message at the second data rate.

5. A method as claimed in any preceding claim wherein the first device comprises a master device and the second device comprises a slave device.

6. A method comprising the first and second devices agreeing during a connection that they will operate as claimed in any preceding claim.

7. A method as claimed in any preceding claim comprising the first device transmitting the further poll message at the second data rate after no reply is received for a predetermined number of poll messages.

8. A method as claimed in claim 7 wherein the predetermined number is pre-agreed during a connection process between the two devices.

9. A method as claimed in any preceding claim comprising the first device transmitting the further poll message at the second data rate without sending any separate messages to say that the data rate is changing.

10. A method as claimed in any preceding claim wherein the predetermined protocol is compatible with a Bluetooth (TM) or Bluetooth Low Energy (TM) protocol.

11. A method as claimed in claim 10 comprising the first device transmitting the further poll message within the same Event as the first poll message.

12. A digital radio device comprising a radio transmitter and a radio receiver, the device being arranged:
a) to establish a connection with another digital radio device using a predetermined protocol having at least one predefined message format;
b) to transmit a poll message to said other device; and
c) if the device does not receive a reply from said other device, to transmit a further poll message at a second data rate, lower than the first data rate.

13. A device as claimed in claim 12 arranged to transmit said poll message in a message format predefined in said protocol wherein at least part of said poll message is encoded using a coding scheme in which at least some bits specified in said predefined message format are represented by a plurality of bits transmitted.

14. A device as claimed in claim 13 wherein said coding scheme comprises a respective fixed sequence of chips to represent each data bit.

15. A device as claimed in any of claims 12 to 14 arranged to agree with the second device during a connection that they will operate as claimed in any of claims 1 to 11.

16. A device as claimed in any of claims 12 to 15 arranged to transmit the further poll message at the second data rate after no reply is received for a predetermined number of poll messages.

17. A device as claimed in claim 16 wherein the predetermined number is pre-agreed during a connection process.

18. A device as claimed in any of claims 12 to 17 arranged to transmit the further poll message at the second data rate without sending any separate messages to say that the data rate is changing.

19. A device as claimed in any of claims 12 to 18 wherein the predetermined protocol is compatible with a Bluetooth (TM) or Bluetooth Low Energy (TM) protocol.

20. A device as claimed in claim 19 arranged to transmit the further poll message within the same Event as the first poll message.

21. A digital radio communication system comprising a first device and a second device, each comprising a radio transmitter and a radio receiver, wherein:
a) said first and second devices are arranged to establish a connection at a first data rate using a predetermined protocol having at least one predefined message format;
b) said first device is arranged to transmit a poll message to said second device; and
c) if said first device does not receive a reply from said second device, said first device is arranged to transmit a further poll message at a second data rate, lower than the first data rate.

22. A digital radio communication system as claimed in claim 21wherein one or both of said first and second devices comprise a device as claimed in any of claims 9 to 15.

23. A system as claimed in claim 21 or 22 wherein the first device comprises a master device and the second device comprises a slave device.

24. A system as claimed in any preceding claim wherein the first device is arranged to transmit the further poll message at the second data rate after no reply is received for a predetermined number of poll messages.

25. A system as claimed in claim 24 wherein the predetermined number is pre-agreed during a connection process between the two devices.

26. A system as claimed in any preceding claim wherein the first device is arranged to transmit the further poll message at the second data rate without sending any separate messages to say that the data rate is changing.

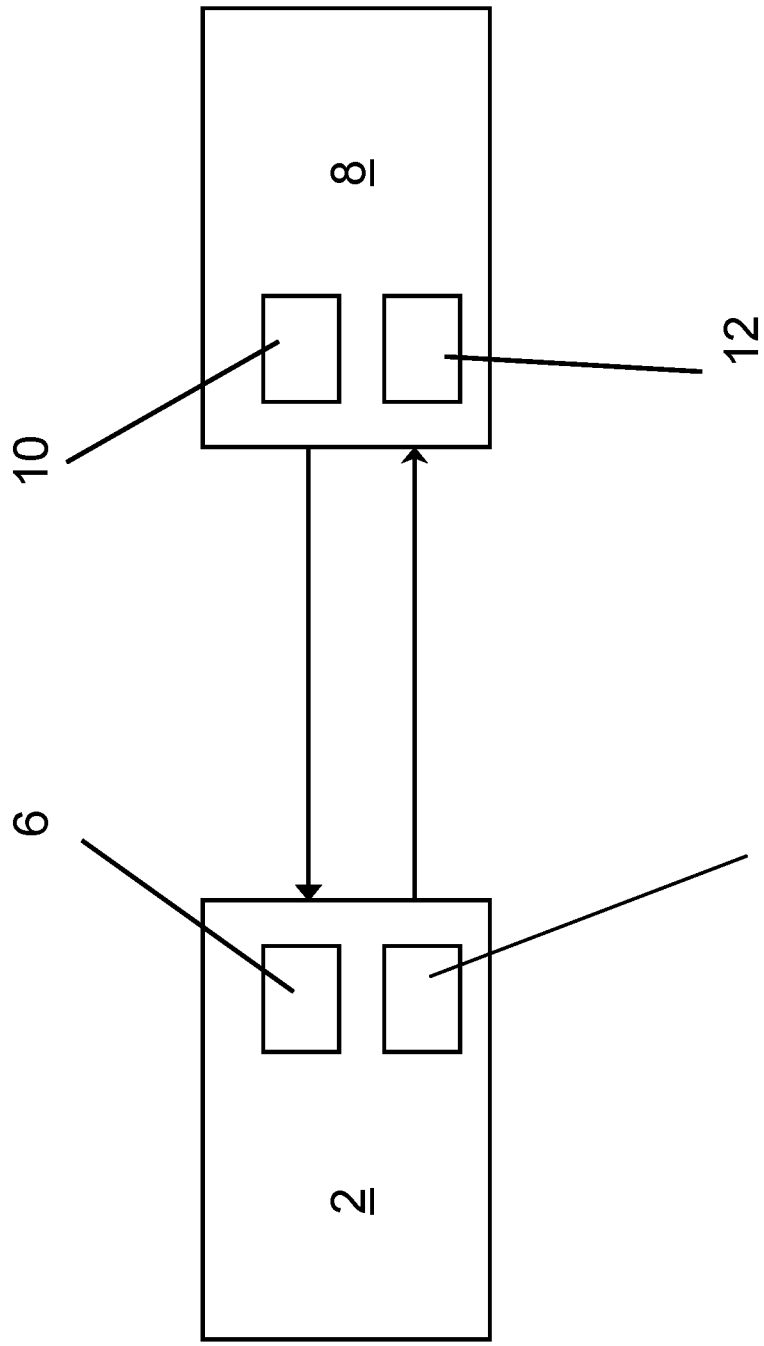


FIG 1

FIG 2

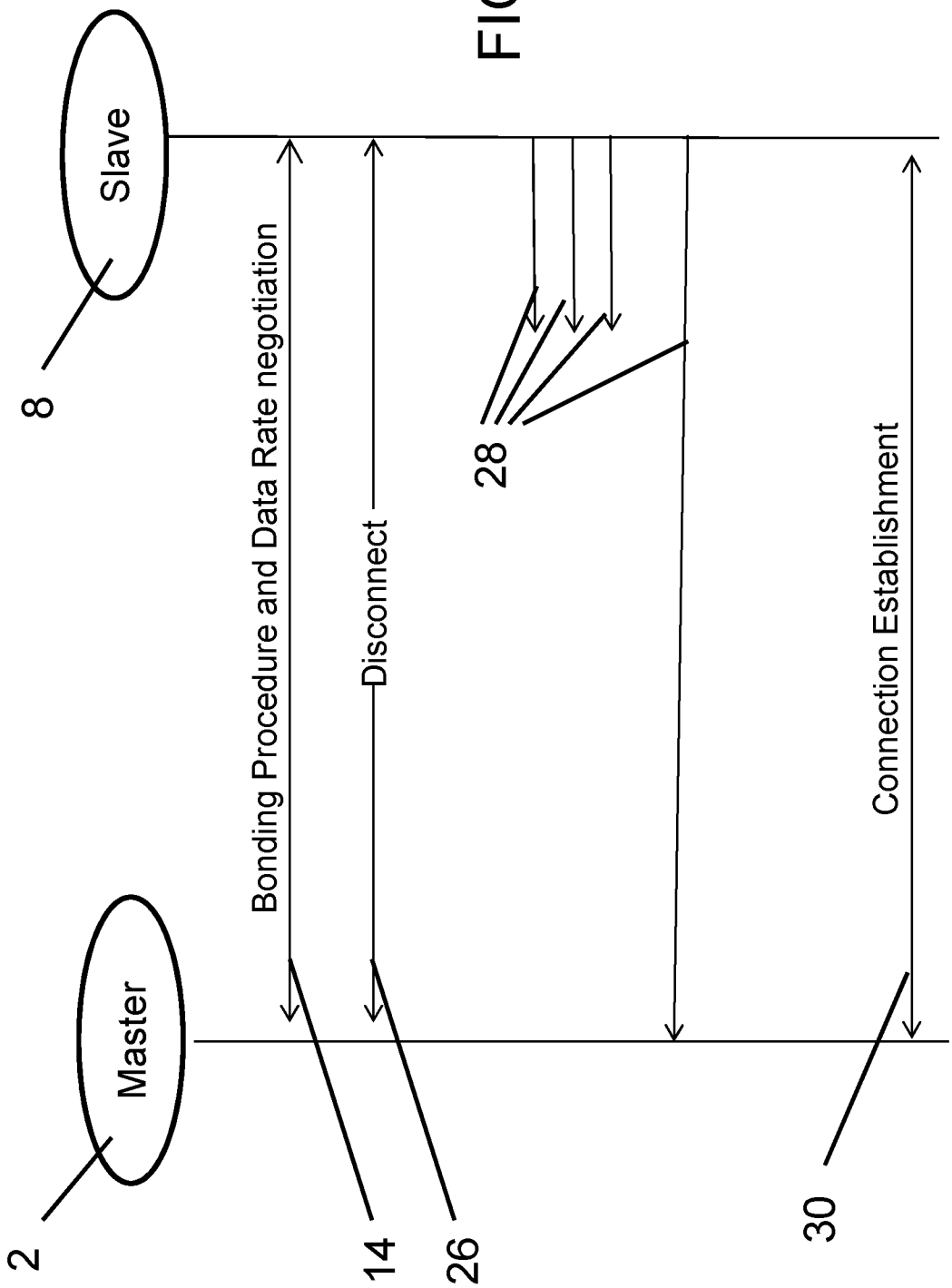

Slave
8
Master
2
Bonding Procedure and Data Rate negotiation
Disconnect
28
Connection Establishment
14
26
30

FIG 3

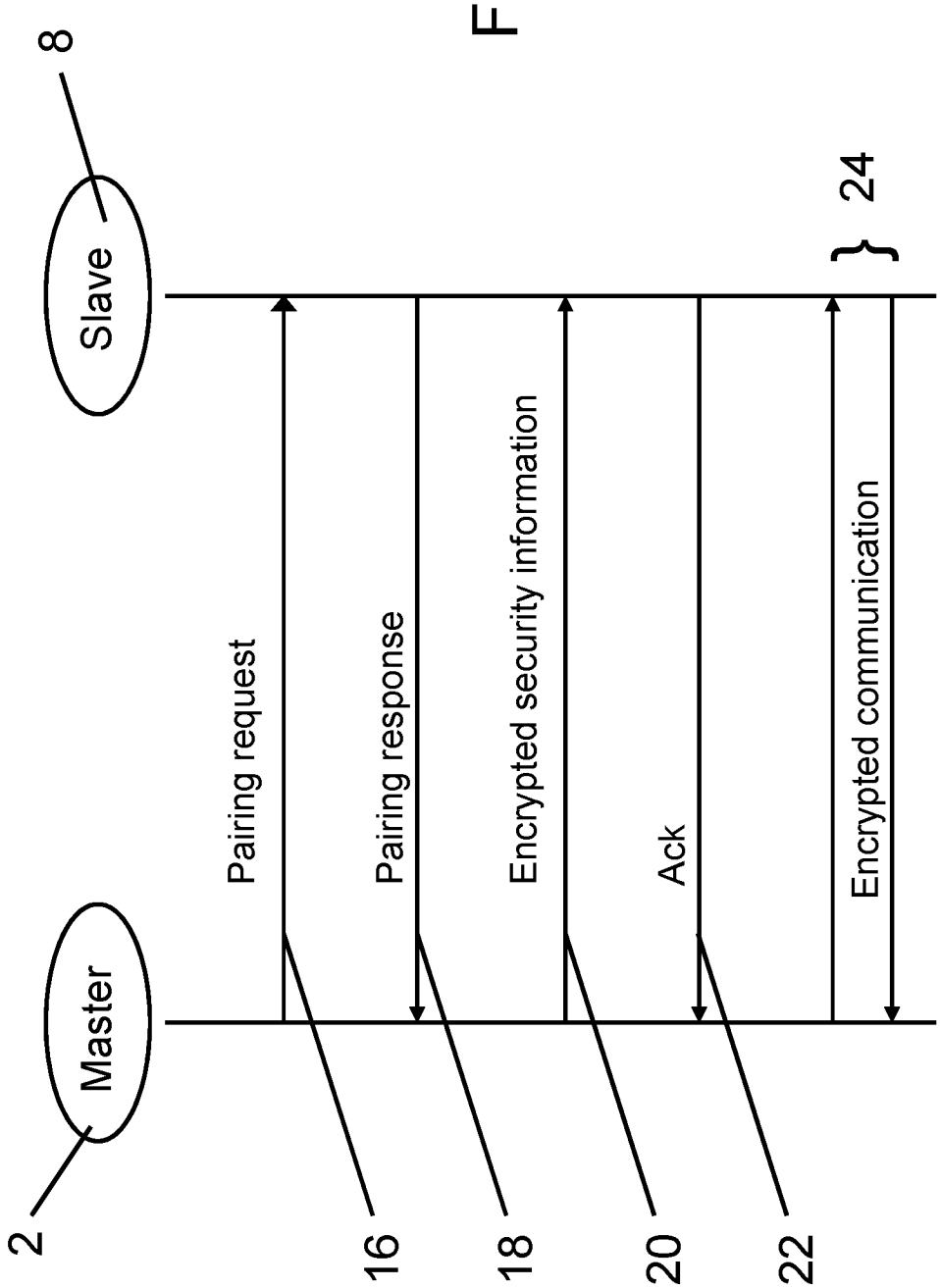
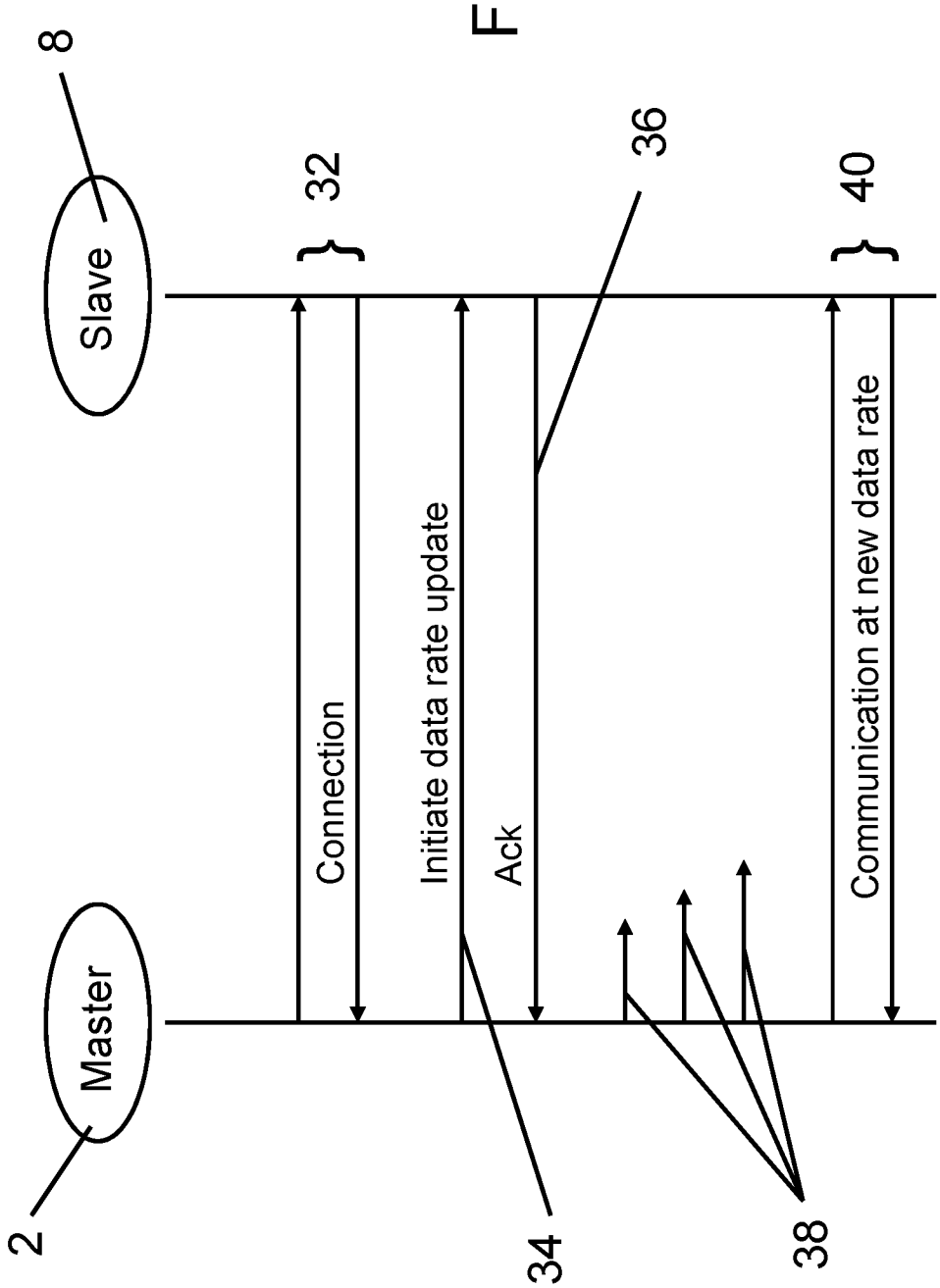

Master
2
Slave
8
Pairing request
Pairing response
Encrypted security information
Ack
Encrypted communication
16
18
20
22
24

FIG 4


8
Slave
32
36
40
Connection
Initiate data rate update
Ack
Communication at new data rate
Master
2
34
38

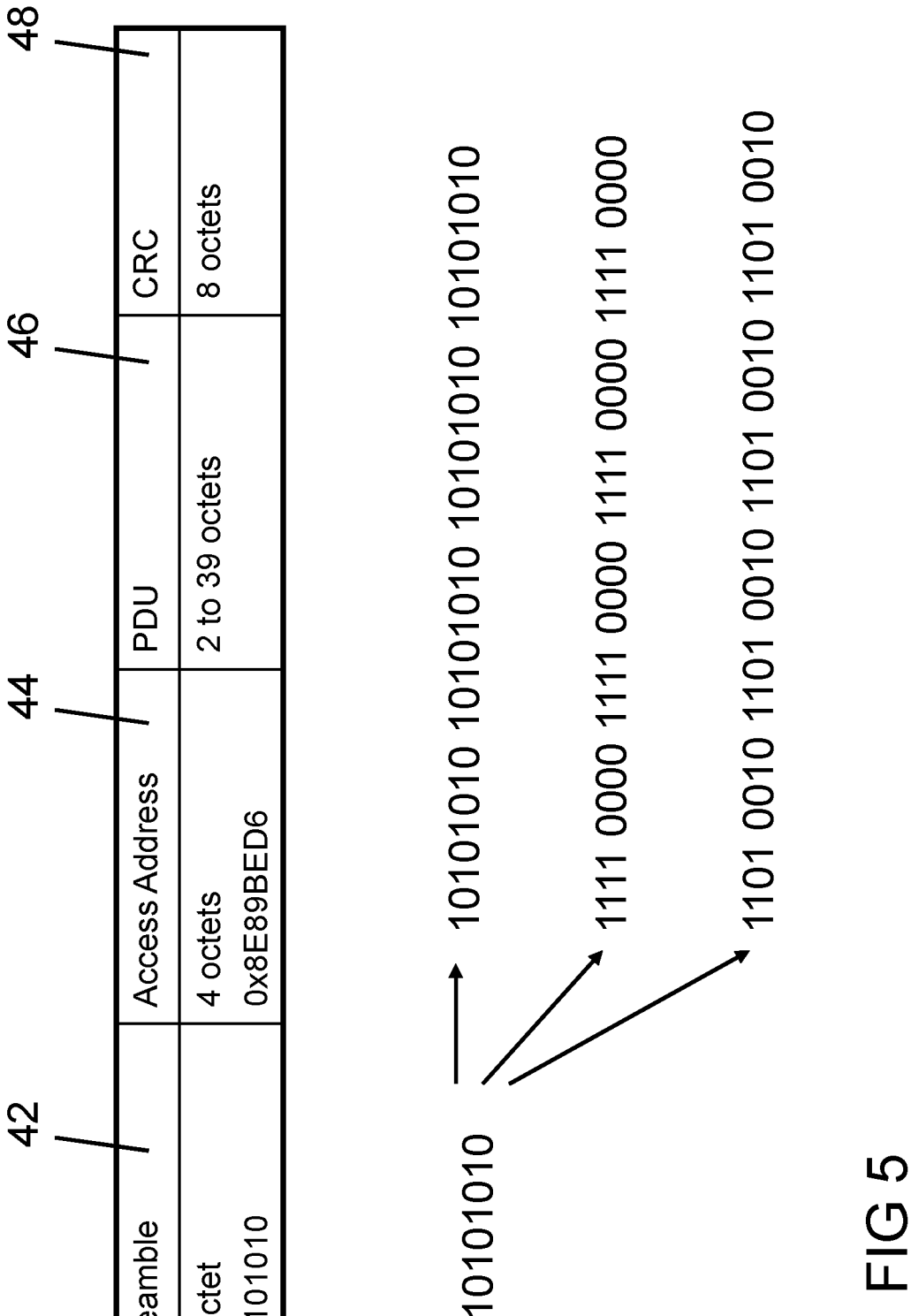

42
44
46
48
Preamble
Access Address
PDU
CRC
1 octet
10101010
4 octets
0x8E89BED6
2 to 39 octets
8 octets
10101010
10101010 10101010 10101010 10101010
1111 0000 1111 0000 1111 0000 1111 0000
1101 0010 1101 0010 1101 0010 1101 0010

FIG 5

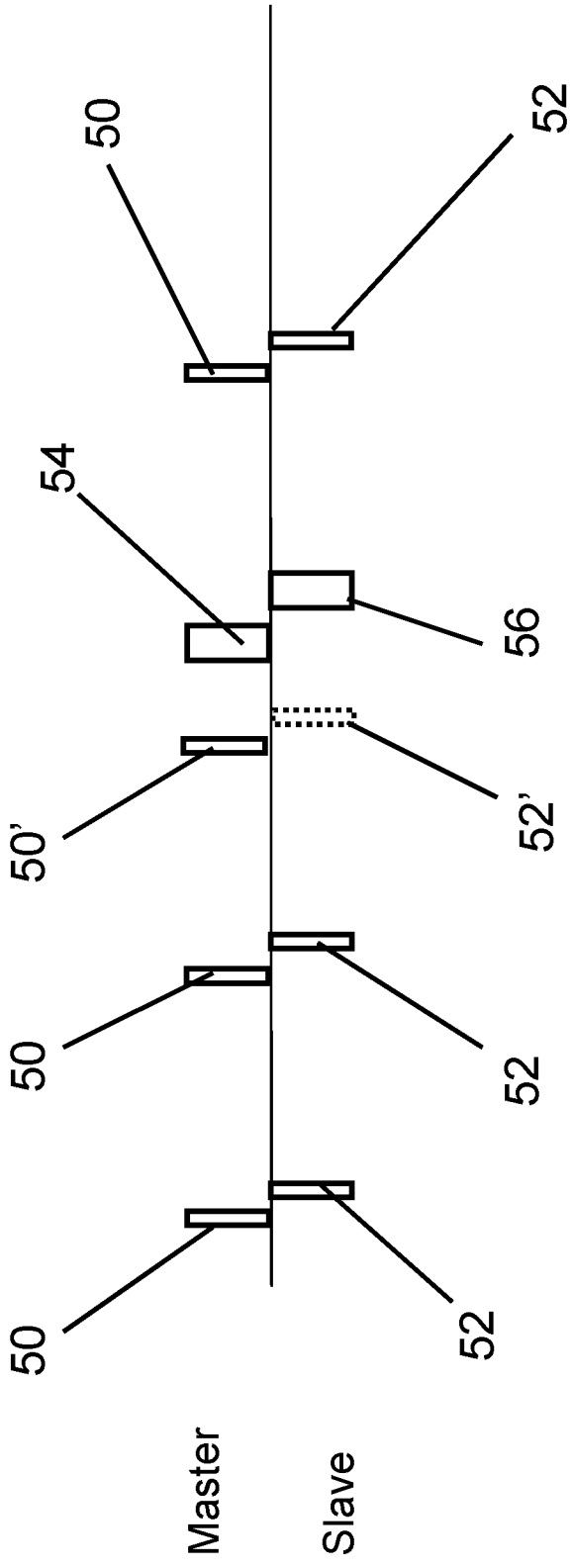


FIG 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/051727

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/00
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)
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 practicable, search terms used)

EPO-Internal, 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 2012/218979 A1 (YEH CHIH-HAO [TW] ET AL) 30 August 2012 (2012-08-30)	1,4-9, 11,12, 15-18, 20-26
Y	paragraphs [0007] - [0009] paragraphs [0038] - [0042]; figures 5,7 paragraphs [0048], [0049]	2,3,10, 13,14,19

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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 application or patent but published on or after the international filing date

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"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
24 July 2014	01/08/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kreppel, Jan

2

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	VALENTI M C ET AL: "Improving the QoS of bluetooth through turbo coding", MILITARY COMMUNICATIONS CONFERENCE. MILCOM 2002. PROCEEDINGS.ANAHEIM, CA, OCT. 7 - 10, 2002; [IEEE MILITARY COMMUNICATIONS CONFERENCE], NEW YORK, NY : IEEE.; US, vol. 2, 7 October 2002 (2002-10-07), pages 1057-1061, XP010631924, DOI: 10.1109/MILCOM.2002.1179623 ISBN: 978-0-7803-7625-0 page 1057 - page 1058	2,3,10, 13,14,19
X	US 2003/043930 A1 (MORRIS MARTIN [US]) 6 March 2003 (2003-03-06) paragraphs [0026] - [0033] paragraphs [0042], [0043]; figure 5	1-26
X	US 2004/125753 A1 (MAHANY RONALD L [US] ET AL) 1 July 2004 (2004-07-01) paragraphs [0119] - [0207]; figure 2	1,4-9, 11,12, 15-18, 20-26

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2014/051727

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2011007724 A1	13-01-2011