



(51) International Patent Classification:
G06F 13/37 (2006.01)

(21) International Application Number:
PCT/US2018/053281

(22) International Filing Date:
28 September 2018 (28.09.2018)

(25) Filing Language: English

(26) Publication Language: English

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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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: REGENERATION AND PROPAGATION OF A SIGNAL BETWEEN COMMUNICATION UNITS

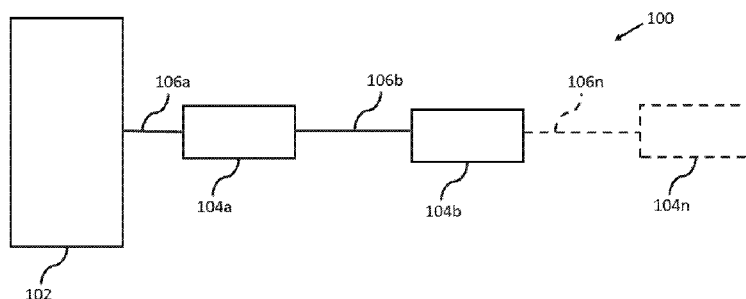


FIG. 1A

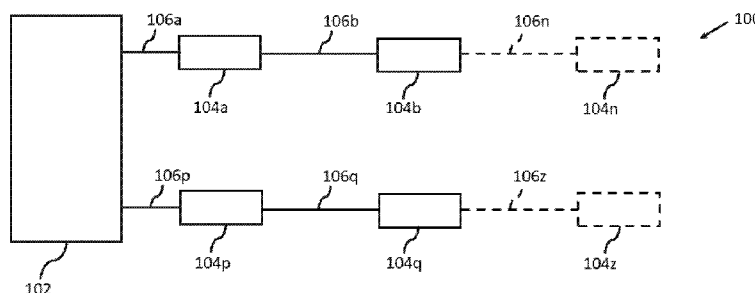


FIG. 1B

(57) Abstract: A method is provided, comprising transmitting a signal between a plurality of communication units which are connected to each other by a communication line. The method further comprises receiving the transmitted signal at one of the communication units. According to the method, the received signal is electrically regenerated and propagated to another one of the communication units.

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

Published:

— *with international search report (Art. 21(3))*

REGENERATION AND PROPAGATION OF A SIGNAL BETWEEN COMMUNICATION UNITS

BACKGROUND

[0001] Data is often transmitted in using signals between a plurality of communication units, such as, for example, electronic devices or components of electronic devices, which are connected by a communication line. Increased data transmission rates are handled by variety of communication systems, such as, for example, bus systems. Such bus systems may include, for example, a master and a number of slave devices which are connected by a communication line. The master may transmit the signals to the slave devices. However, data may also be transmitted in systems including multiple masters, that is, where the role of the master may be taken by different devices.

[0002] In synchronous communication systems, the master has a master clock and transmits a master clock signal to the slave devices, such that all communication units which are connected to each other by the communication line have the same clock signal. Other communication systems use asynchronous transmission, which means that each communication unit has its own clock which is synchronized upon reception of the transmitted data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Features of examples will be described, by way of example only, in the following detailed description with reference to the accompanying drawings in which similar reference numerals correspond to similar, though perhaps not identical, components. For the sake of brevity, reference numerals or features

having a previously described function may or may not be described in connection with other drawings in which they appear.

[0004] Figure 1A is a schematic view of an example communication system, according to one example;

[0005] Figure 1B is a schematic view of a further example communication system, according to one example;

[0006] Figure 2A illustrates an example communication unit which is to act as a master unit, according to one example;

[0007] Figure 2B illustrates a further example communication unit which is to act as a master unit, according to one example;

[0008] Figure 3A illustrates an example communication unit which is to act as a slave unit, according to one example;

[0009] Figure 3B illustrates a further example communication unit which is to act as a slave unit, according to one example;

[0010] Figure 4 illustrates a further example of a slave unit with a controller, according to one example;

[0011] Figure 5 is a block diagram of an example method for transmitting a signal, according to one example;

[0012] Figure 6 shows a program product having computer readable code stored thereon, according to one example, and

[0013] Figure 7 is a schematic view of an example system comprising multiple communication units which are connected by a communication line, according to one example.

DETAILED DESCRIPTION

[0014] Examples provided herein include methods and systems for transmitting signals between communication units. Systems for transmitting signals between communication units may be referred to as communication systems. Example communication systems described herein may correspond to bus systems or network systems. Example signals described herein may correspond, but are not limited, to any of electrical signals, optical signals, electromagnetic waves, radio signals, or any combination thereof. As used herein, the term signal may correspond to both the raw data, i.e. bits, which are transmitted on the physical layer (layer 1) according to the Open Systems Interconnection model (OSI model), and the electrical, radio, or optical signals into which these bits are converted.

[0015] Example communication systems may comprise a plurality of communicating units which are connected to each other by a communication line. Example communication lines described herein may correspond, but are not limited, to any of copper wire (e.g. unshielded or shielded twisted pair), coaxial cables, phone lines, optical fibers or the like. Example communication units described herein may correspond, but are not limited, to any of microcontrollers, peripheral devices, such as, e.g. sensor and actuator devices, printer circuits, I/O (Input/Output) units, or the like.

[0016] In general, a plurality of communication units may be connected to each other by a communication line. For example, the communication units may be connected in a daisy chain manner. That is, each communication unit is serially connected to a previous communication unit in the chain and to a next communication unit in the chain. Of course, the first communication unit in the chain may not have a connection to a previous communication unit, and the last communication unit in the chain may not have a connection to the next communication unit. In some examples, the communication units may be connected to each other in a serial manner in a ring topology.

[0017] However, the communication units may be connected to each other by a communication line in a number of different topologies. For example, a number of daisy chains, each including a plurality of communication units which are serially connected to each other, may arise from one particular communication unit. In other examples, the communication units may further be interconnected to each other, for example, in a mesh-like topology. In some examples, some of the communication units may be serially connected to each other and form a tree-like topology.

[0018] In some examples, one of the communication units is a master unit and the remaining other communication units are slave units. The master unit transmits a signal via the communication line to the slave units. In some examples, the system comprises multiple master units. Each of these master units may then initiate transmission of signals to the slave units. In some examples, all communication units have the same configuration, such that each unit may be used either as a master unit or as a slave unit.

[0019] Each of the communication units comprise a receiving element to receive a signal from another communication unit. For example, each slave unit may comprise a receiving element to receive the signal transmitted from the master unit across the communication line. In some examples, the slave unit may receive a signal from the previous slave unit in the chain. In some examples, the slave unit may comprise a receiving element to receive a signal from the next slave unit in the chain. For example, a response signal may be sent back to the master unit from one of the slave units in the chain via the previous slave units in the chain.

[0020] Each communication unit further comprises a transmitting element to transmit a signal to another communication unit. For example, each slave unit may comprise a transmitting element to transmit the signal received from the master unit or from the previous slave unit in the chain to the next slave unit in the chain. In some examples, the slave unit may comprise a transmitting element to transmit a signal received from the next slave unit in the chain to the previous slave unit in the chain or to the master unit.

[0021] The master unit may comprise a transmitting element to transmit the signal to the slave units. In some examples, the master unit may comprise a receiving element to receive a signal from the slave units via the communication line. For example, one of the slave units may transmit a response signal to the master unit via the communication line and the previous slave units in the communication line.

[0022] The slave units further comprise a regenerating element to electrically regenerate the received signal. That is, the signal which is transmitted by the master unit to the slave units is received by a first slave unit in the chain. The first slave unit in the chain comprises a regenerating element which electrically regenerates the signal upon reception. The regenerating element further propagates the regenerated signal to another communication unit. For example, after electrically regenerating the received signal, the first slave unit in the chain may propagate the regenerated signal to the second slave unit in the chain. The second slave unit in the chain may receive the signal from the first slave unit in the chain by its receiving element. The second slave unit in the chain also comprises a regenerating element. The signal may then be electrically regenerated and propagated to the next communication unit by the regenerating element of the second slave unit in the chain.

[0023] In some examples, the regenerating element may be controlled by controller. For example, the controller may enable/disable the regeneration and/or the propagation of the signal. In some examples, the controller may control the power or shape of the regenerated signal.

[0024] The controller may be included in the slave unit. In some examples, however, the controller may be an external controller. For example, the controller may be a separate unit which could be programmed or controlled by, for example, a user. In some examples, the controller may be included in the master unit and the master unit may transmit configuration signals to control the regeneration and propagation of the signal at the slave units.

[0025] In general, the transmission of the signals serves the transmission of data from the master unit to the slave units. That is, the signals transmitted by the master unit correspond to data. In some examples, the signals may correspond to data frames. That is, the data may be transmitted in data frames. However, the actual received signals, i.e. the bits, are electrically regenerated and propagated to the next communication unit by the regenerating element. That is, the slave unit does not wait until it has received a full data frame before the electrical regeneration of the received signal.

[0026] In some examples, each data frame comprises an address field. That is, the data frames which are transmitted in terms of signals comprise an address field in which, for example, one of the slave units is addressed. For example, the master unit may initiate transmission of a data frame to slave unit X. In this case, the identifying address of slave unit X is written into the address field of the corresponding data frame. In some examples, each slave unit may check whether its internal identifying address matches the address in the address field of the data frame and will disregard the remaining data in the data frame if the addresses do not match.

[0027] In some examples, the slave unit which is addressed in the address field may transmit a response signal to the master unit. That is, the addressed slave unit may transmit a response signal via its transmitting element across the communication line either directly to the master unit or to the previous slave unit in the chain. The previous slave unit in the chain may then receive the response signal from the addressed slave unit via its receiving element. In some examples, the previous slave unit may electrically regenerate the received response signal and propagate the regenerated response signal to a further previous slave unit in the chain or the master unit. The master unit will receive the corresponding response signal via its receiving element.

[0028] In some examples, the communication units are connected to each other by a plurality of signal lines. That is, the communication line may comprise a plurality of signal lines. For example, the communication line may comprise a signal line for transmitting the signal from the master unit to the slave units in the

chain. The communication line may further comprise a signal line for transmitting the response signals from the slave units to the master unit. In some examples, the communication line may comprise a third signal line. For example, configuration signals from the master unit to the slave units may be transmitted along the third signal line. In further examples, the communication line may also comprise power and ground. In this case the communication line comprises five signal lines. However, in some examples, the communication line may comprise further signal lines for transmitting further configuration or control signals between the master unit and the slave units.

[0029] Accordingly, in one example, a signal is transmitted between a plurality of communication units which are connected to each other by a communication line. The transmitted signal is received at one of the communication units, wherein the received signal is electrically regenerated and propagated to another one of the communication units.

[0030] In a further example, a non-transitory program product may have computer-readable codes stored thereon that, when executed by a computing device, may cause the computing device to transmit a signal from a communication unit which acts as a master unit to a plurality of communication units which act as slave units across a communication line by which the communication units are connected to each other. Transmitted signals may be received by one of the slave units and the computer-readable code stored on the program product may cause the computing device to control the electrical regeneration of the received signal and the propagation of the regenerated signal to another one of the communication units.

[0031] In **Figure 1A**, a system 100 comprising a plurality of communication units 102, 104a, 104b, ... is shown. The communication units are connected to each other by separate communication lines 106a, 106b, In the example shown in Figure 1A, one communication unit 102 acts as a master unit whereas the other communication units 104a, 104b, ... act as slave units. In the example of Figure 1A, the communication units are connected to each other in a daisy chain manner.

[0032] Similar to the system 100 shown in Figure 1A, **Figure 1B** shows an example system 100 comprising a plurality of communication units 102, 104a, 104b, ..., wherein one communication unit 102 acts as a master unit and the other communication units 104a, 104b, ... act as slave units. However, the system shown in Figure 1B comprises two separate parallel daisy chains of slave units 104a, 104b, ... and 104p, 104q, ..., which are both connected to the master unit 102.

[0033] **Figure 2A** shows an example master unit 202 comprising a transmitting element 208 and a receiving element 210. The transmitting element 208 is to transmit a signal across the transmitting signal line 207a to another communication unit, such as, for example, a slave unit. The receiving element 210 is to receive a signal via the receiving signal line 207b from another communication unit, such as, for example, another slave unit. For example, the master unit 202 may transmit a data frame which is addressed to slave unit 104b by its transmitting element 208. Upon reception, the slave unit 104b may transmit a response signal to the master unit 202. The master unit 202 may then receive the response signal by its receiving element 210.

[0034] **Figure 2B** shows a further example master unit 202 similar to that in Figure 2A, but further comprising a controller 212. The master unit 202 may transmit a configuration signal by its controller 212 across the configuration signal line 207c to the slave units in the chain. The configuration signal may, for example, be a reset signal, such as, for example, a HW trigger. Such a HW trigger signal may be used, for example, for resetting a slave unit in the chain to an initial state. In some examples, all or at least a number of slave units in the chain may be reset by the HW trigger signal. The controller may further control the regeneration and propagation of the received signal in the slave units. For example, the controller may send a command to enable or disable the regeneration or propagation of the received signal at a particular slave unit or at a number of particular slave units across the transmitting line 207a.

[0035] **Figure 3A** shows an example slave unit 304, comprising a receiving element 310, a transmitting element 308 and a regenerating element

314. A signal transmitted from the master unit or propagated from the previous slave unit may be received by the receiving element 310. Upon reception, the regenerating element 314 may electrically regenerate the received signal and propagate the regenerated signal to the next slave unit in the chain. In some examples, the slave unit 304 may be the slave unit which is addressed in the addressed field of the data frame which has been transmitted from the master unit to the slave unit 304. In this case, the slave unit 304 may transmit a response signal across the communication line to the master unit or to the previous slave unit in the chain by its transmitting element 308. In some examples, one of the slave units further along the chain may be the slave unit addressed in the address field. In this case, the response signal from the addressed slave unit may be transmitted across the communication line to the master unit through the slave unit 304.

[0036] **Figure 3B** shows a similar example slave unit 304, further comprising a controller 312. The controller 312 may receive a configuration signal from the master unit. In some examples, however, the controller may receive a configuration signal from another entity than the master unit. In some examples, the controller 312 may control the regeneration element 314. In some examples, the controlling of the regenerating element 314 may be predetermined, that is, for example, the controller may be programmed a priori how to control the regeneration element 314. In some examples, controlling the regenerating element 314 may include enabling or disabling the regeneration of the received signal. In some examples, controlling the regeneration element 314 may further include enabling or disabling the propagation of the regenerated signal to the next slave unit.

[0037] **Figure 4** shows a further example slave unit 404. The slave unit 404 comprises a receiving element 410, a transmitting element 408, a controller 412 and a regenerating element 414. The signal transmitted by the master unit is received by the receiving element 410 via an incoming signal line MOSI_IN. The controller 412 receives a configuration signal via an incoming signal line CONFIG_IN. The signal received at the receiving element 410 may be electrically regenerated by the regenerating element 414 and propagated to the next slave

unit via an outgoing signal line MOSI_OUT. As is illustrated in the example shown in Figure 4, the controller 412 may control the regenerating element 414. For example, the controller 412 may enable or disable the regeneration of the received signal. The controller may also enable or disable the propagation of the signal by the regenerating element 414 via the outgoing signal line MOSI_OUT. In some examples, the configuration signals may further be transmitted to the next slave unit via an outgoing signal line CONFIG_OUT. The example slave unit 404 shown in Figure 4 further receives a signal from the next slave unit in the chain via an incoming signal line MISO_IN. In some examples, this signal may be a response signal from a slave unit which has been addressed in the address field of the transmitted data frame. In this case, the signal is passed through the slave unit 404 and transmitted to the previous slave unit in the chain via an outgoing signal line MISO_OUT. In some examples, however, the example slave unit 404 may be the slave unit which has been addressed in the address field of the data frame. In this case, the slave unit 404 may transmit a response signal by its transmitting element 408 via the outgoing signal line MISO_OUT.

[0038] **Figure 5** is a block diagram of an example method according to one example. At box 502, a signal is transmitted between a plurality of communication units which are connected to each other by communication lines. At box 504, the transmitted signal is received at one of the communication units. At box 506, the received signal is electrically regenerated, and at box 508 the regenerated signal is propagated to another one of the communication units.

[0039] The signal may be transmitted by one of the communication units which acts as master unit to the other communication units which act as slave units. In some examples, the master unit may transmit a signal across the communication line to the slave units, and the slave unit may electrically regenerate the received signal and propagate the regenerated signal to another communication unit.

[0040] In **Figure 6**, an example non-transitory program product is illustrated. The example program product 600 may have computer readable code stored thereon. The computer readable code may, when executed by a

computing device, cause the computing device to transmit a signal 602 from a communication unit which acts as a master unit to a plurality of communication units which act as slave units across a communication line. For example, the communication units, that is, at least one master unit and a number of slave units, are connected to each other by a communication line. The computer readable code may further cause the computing device to receive the transmitted signal at one of the slave units 604. The computer readable code may further cause the computing device to control the electrical regeneration of the received signal and the propagation 608 of the regenerated signal to another one of the communication units.

[0041] An example system 700 is shown in **Figure 7**. The system 700 comprises a communication unit 702, which is to act as a master unit, and a plurality of communication unit 704a, 704b... which are to act as slave units. The communication units are connected to each other by a communication line, which may comprise, for example, three signal lines, power and ground (not shown). In the example shown in Figure 7, the communication units are connected in a daisy chain manner. Each communication unit 702, 704 comprises a receiving element, a transmitting element and a controller. In the example master unit 702, the receiving element, the transmitting element and the controller are combined in a transceiving element 716. In the example slave units 704a, 704b the receiving element, the transmitting element and the controller are combined in transceiving elements 718.

[0042] The master unit 702 transmits a MOSI signal to the slave units 704 across the MOSI signal line by its transceiving element 716. The transmitted signal is received by the transceiving element 718 of the first slave unit 704a in the chain. According to the instructions included in the MOSI signal, the transceiving element 718 either enables or disables the electrical regeneration of the MOSI signal. The master unit 702 further transmits a configuration signal across the CONFIG signal line to the first slave unit 704a in the chain. In some examples, the CONFIG signal may be used as a HW trigger for resetting the device.

[0043] If the regeneration is enabled, an enable signal and the MOSI signal may be ORed, such that the MOSI signal is electrically regenerated to its original power. Power for electrically regenerating the MOSI signal may be provided by the transceiving element or by a separate power element (not shown). In some examples, power for regenerating the signals may be provided externally, e.g. from the master unit or from an external power source. In some examples, the slave units 704 may comprise an internal power source (not shown). The regenerated MOSI signal may then be propagated to the next slave unit 704b.

[0044] If the regeneration is disabled, a disable signal and the MOSI signal may be ORed, such that the MOSI signal is not regenerated. The MOSI signal may then be propagated to the next slave unit 704b without being regenerated. However, based on the instructions included in the MOSI signal, the propagation of the MOSI signal may also be disabled. In this case, no signal may then be propagated or transmitted to the next slave unit 704b.

[0045] In some examples, the signals transmitted by the master unit 702 to one of the slave units 704a, 704b, ... across the MOSI signal line may comprise instructions or commands. The slave unit 704 to which the signals were addressed may execute the instructions and send a response to the master unit 702, if appropriate. For example, the slave unit 704 may acknowledge receipt of the signal or confirm that the instructions have been executed. In some examples, the instructions may cause the slave unit 704 to block the further propagation of the signals, that is, to disable the further propagation of the signal. In that case, slave units 704 further down the chain, to which the signals were not addressed, may not receive the signal.

CLAIMS:

What is claimed is:

1. A system, comprising:
 - a plurality of communication units connected to each other by communication lines, wherein each communication unit comprises
 - at least one receiving element to receive a signal from another communication unit, and
 - at least one transmitting element to transmit a signal to another communication unit, and wherein
 - at least one of the communication units is to act as a master unit and the other communication units are to act as slave units, wherein the slave units further comprise
 - a regenerating element to electrically regenerate the received signal and propagate the regenerated signal to another communication unit.
2. The system of claim 1, wherein the communication units are connected in a daisy chain manner.
3. The system of claim 1, wherein the regenerating element is controlled by a controller.
4. The system of claim 1, wherein the signals transmitted by the master unit correspond to data frames.
5. The system of claim 4, wherein each data frame comprises an address field.
6. The system of claim 5, wherein the slave unit which is addressed in the address field is to transmit a response to the master unit, and the master unit is to receive the response.

7. The system of claim 1, wherein the communication units are connected to each other by a plurality of signal lines.
8. A method, comprising:
 - transmitting a signal between a plurality of communication units connected to each other by communication lines,
 - receiving the transmitted signal at one of the communication units;
 - electrically regenerating the received signal and propagating it to another one of the communication units.
9. The method of claim 8, wherein
 - at least one of the communication units acts as a master unit and the other communication units act as slave units,
 - the method further comprising: transmitting from the master unit a signal across the communication line to the slave units, and
 - electrically regenerating, by the slave unit, the received signal and propagating it to another communication unit.
10. The method of claim 9, further comprising:
 - transmitting from the master unit a configuration signal across the communication line to one of the slave units, and
 - receiving the configuration signal at the one of the slave units.
11. The method of claim 8, further comprising
 - controlling the regenerating of the received signal by a controller.
12. The method of claim 8, wherein the transmitted signals correspond to data frames and each data frame comprises an address field, the method further comprising:
 - transmitting, by the slave unit which is addressed in the address field, a response to the master unit, and
 - receiving, by the master unit, the response.

13. The method of claim 10, further comprising:
causing the one slave unit, by the received configuration signal, to reset to an initial state.
14. The method of claim 8, further comprising:
transmitting, with the transmitted signal, a command which, upon reception of the signal, causes the receiving communication unit to enable or disable at least one of the electrical regenerating of the signal and the propagating of the signal.
15. A non-transitory program product having computer readable code stored thereon that, when executed by a computing device, causes the computing device to:
transmit a signal from a communication unit which acts as a master unit to a plurality of communication units which act as slave units across communication lines by which the communication units are connected to each other,
receiving the transmitted signal at one of the slave units, and
controlling the electrical regeneration of the received signal and the propagation of the regenerated signal to another one of the communication units.

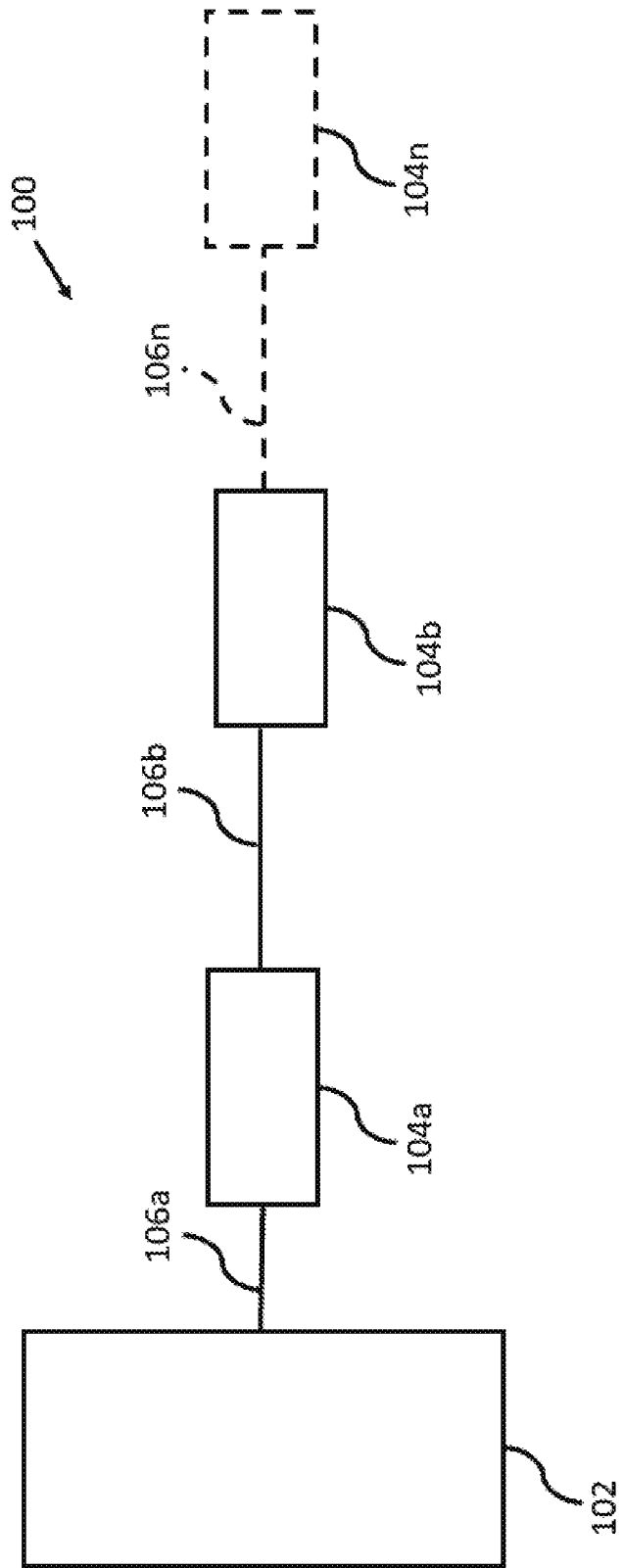


FIG. 1A

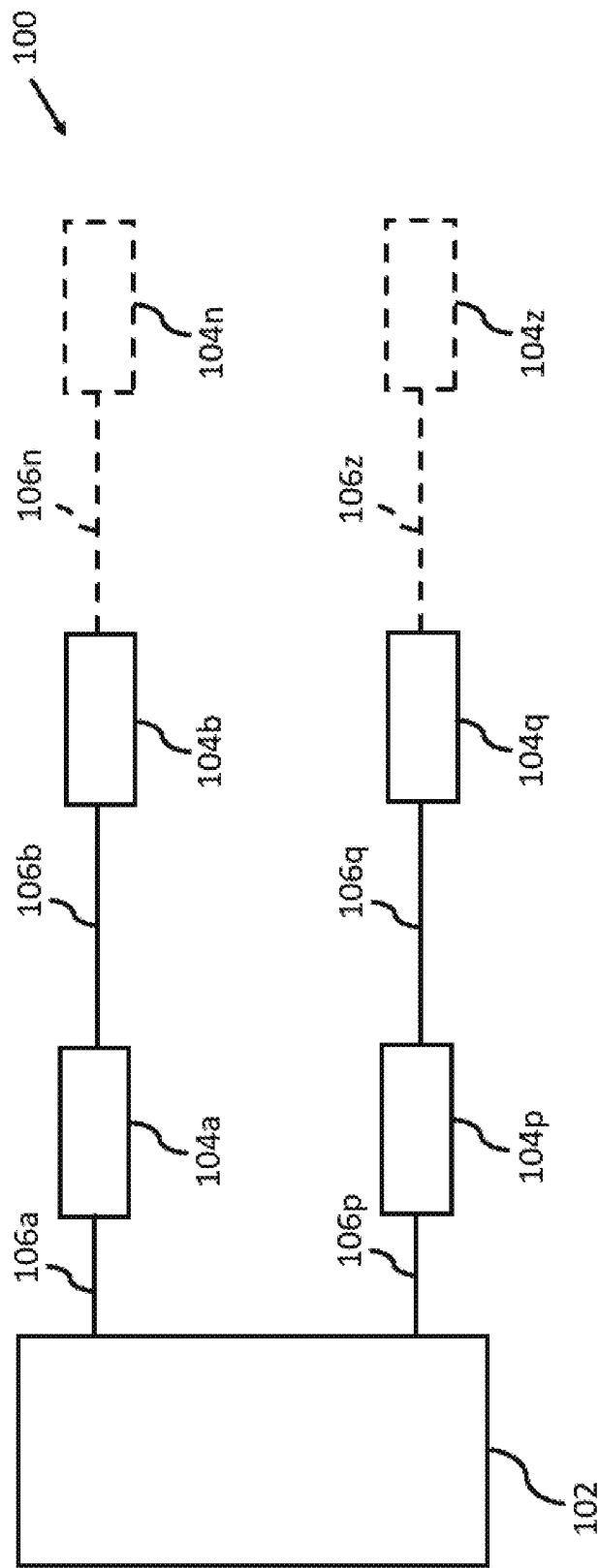
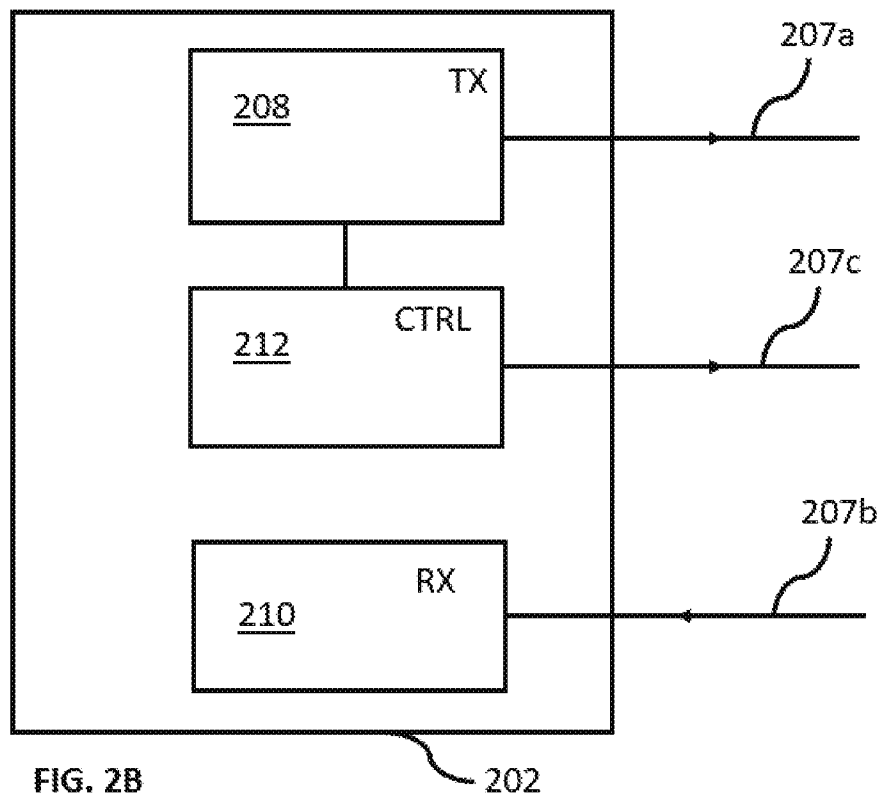
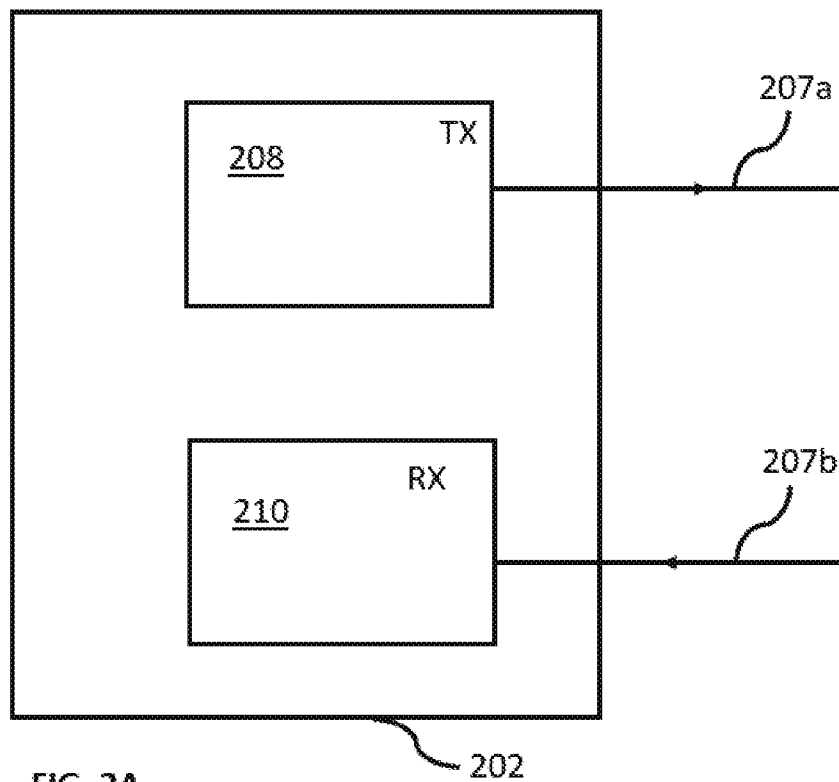


FIG. 1B



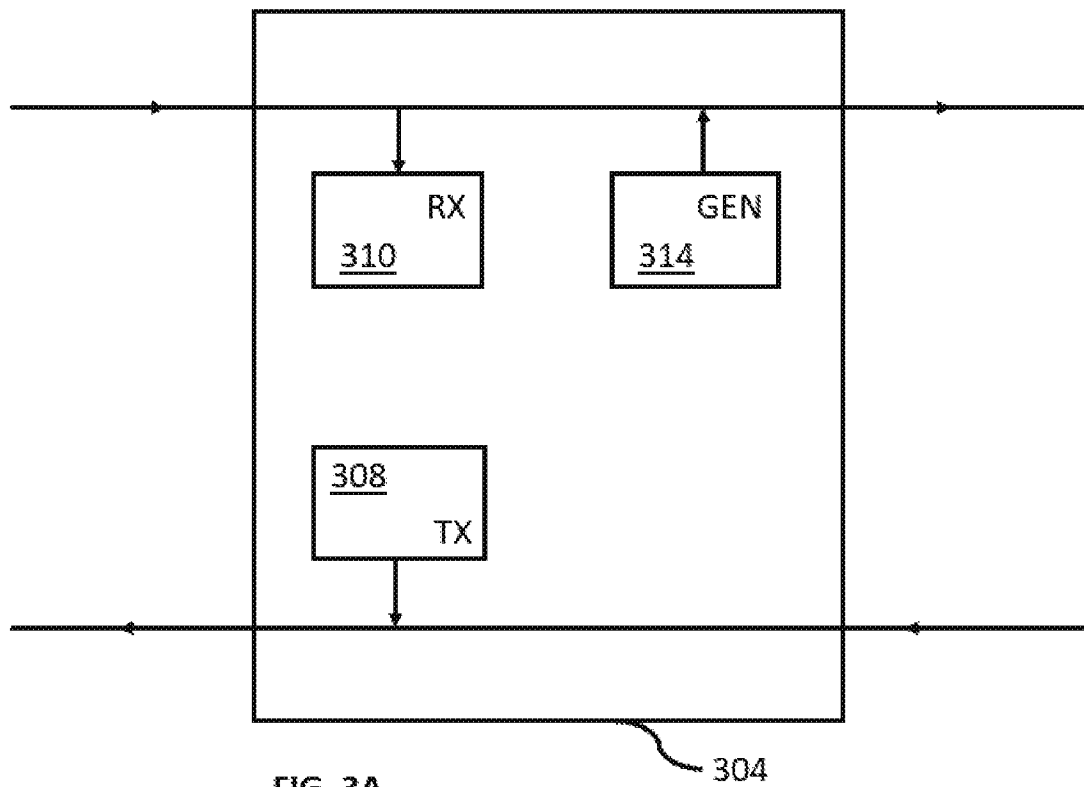


FIG. 3A

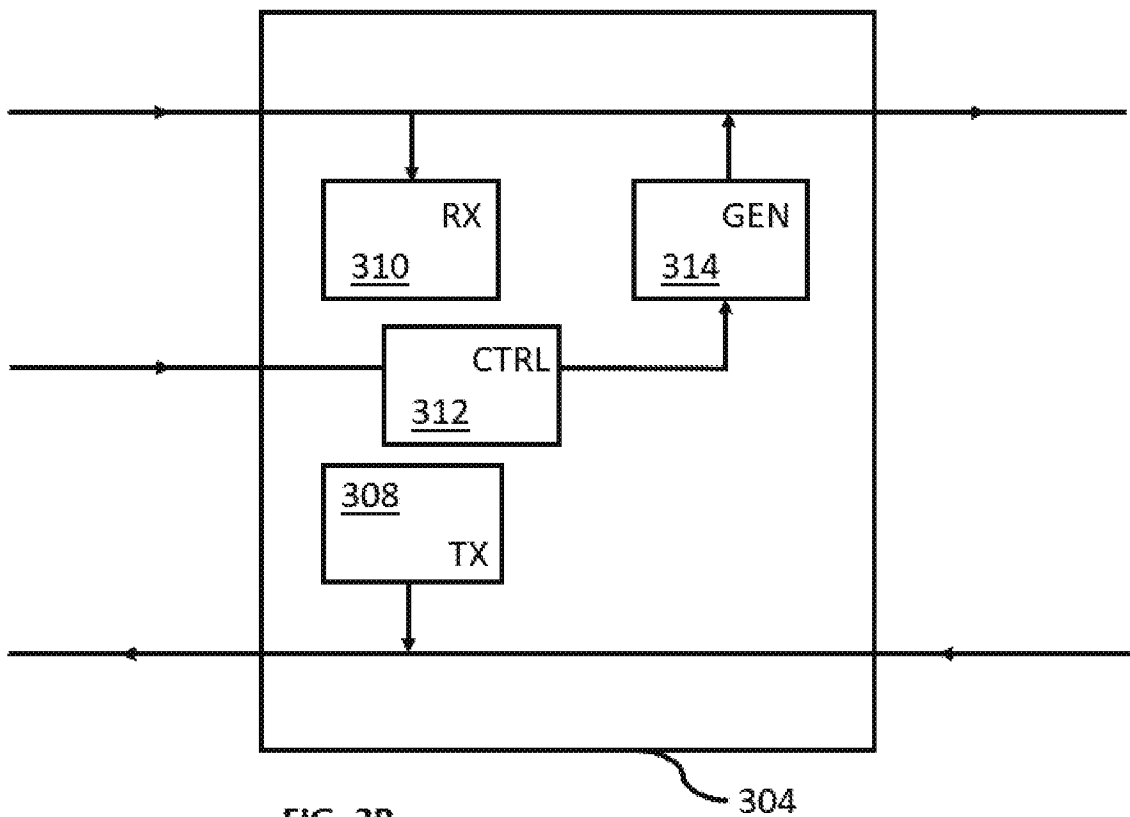


FIG. 3B

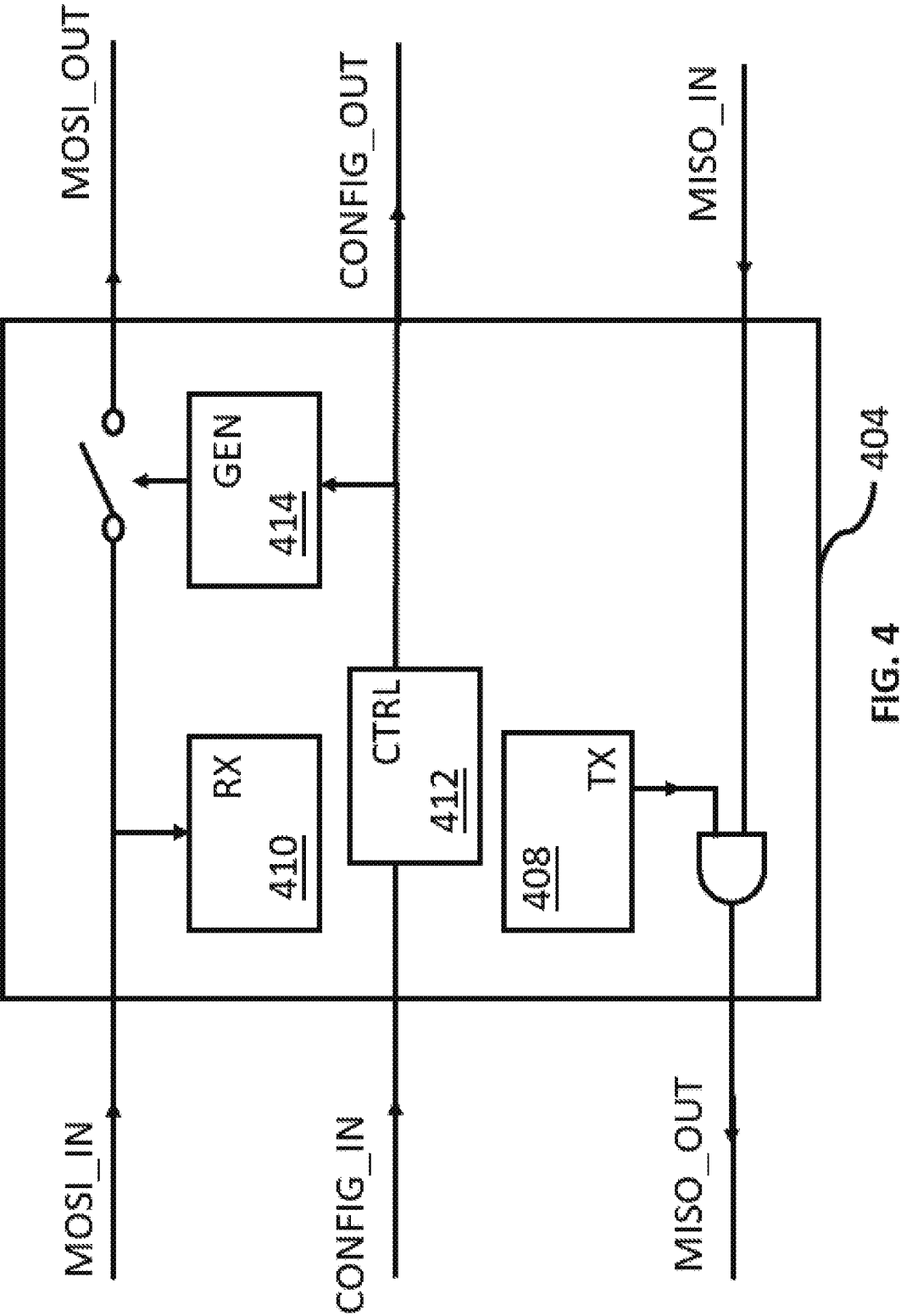


FIG. 4

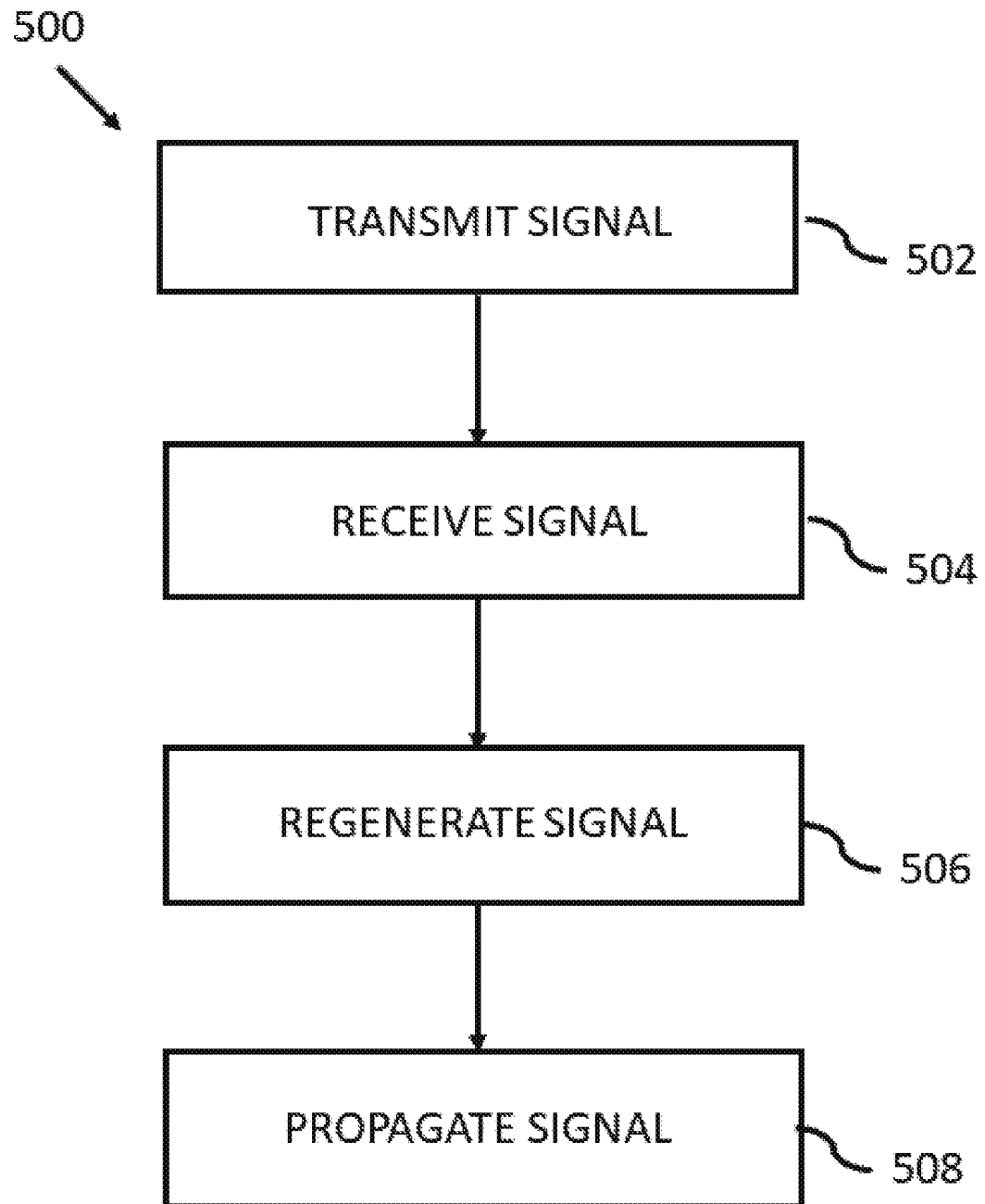


FIG. 5

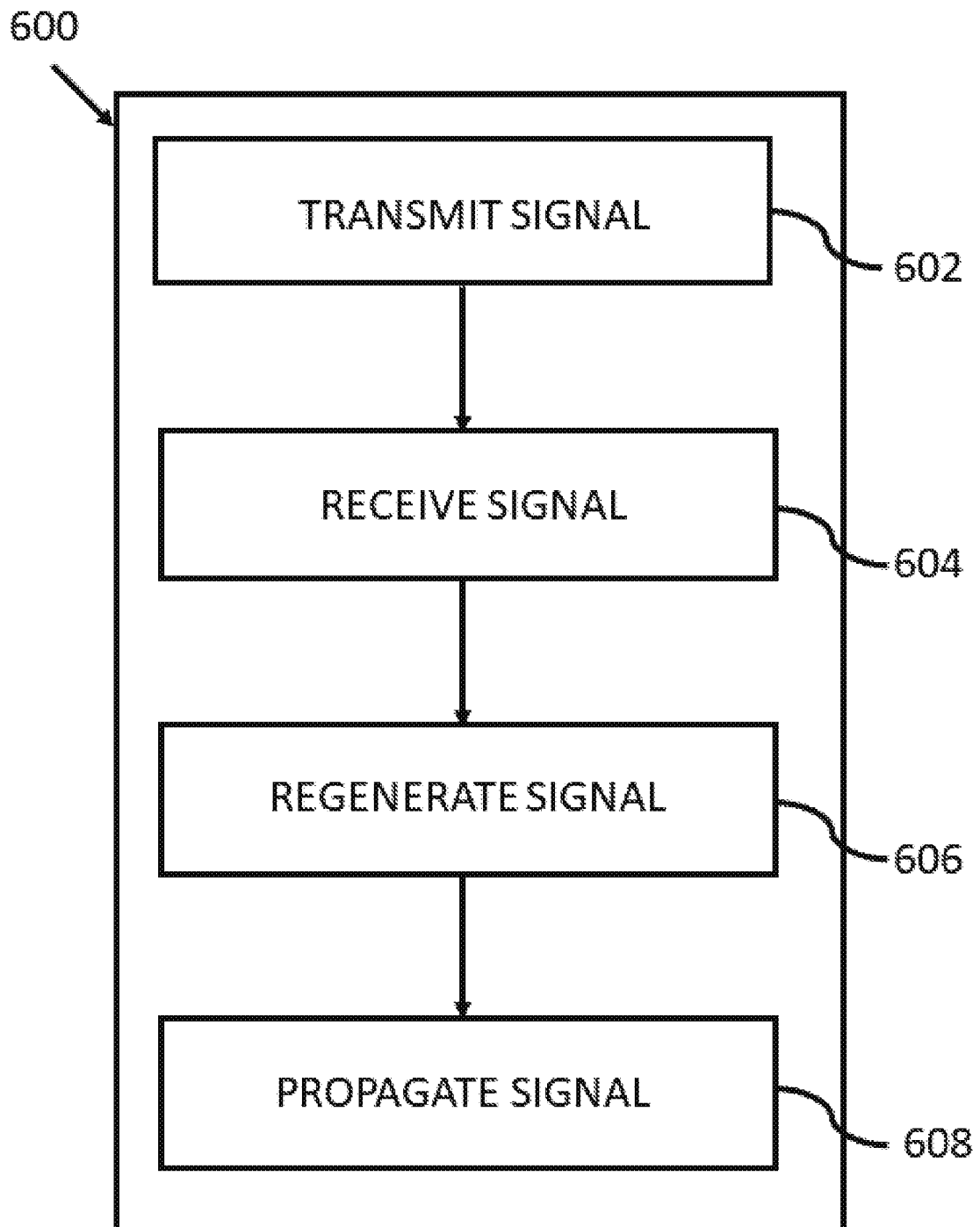


FIG. 6

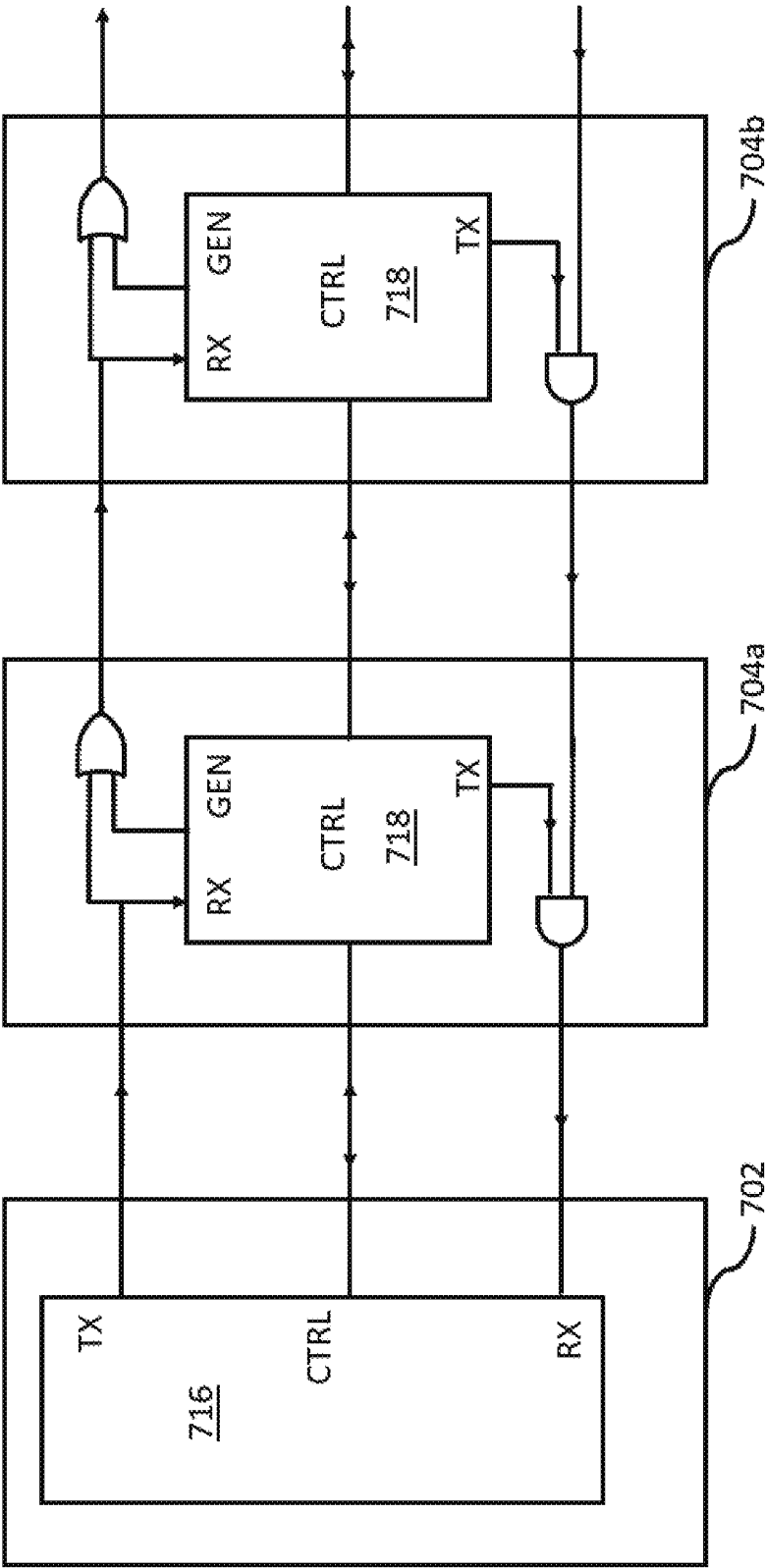


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/053281

A. CLASSIFICATION OF SUBJECT MATTER

G06F 13/37 (2006.01)

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)

G06F 9/00-9/54, 11/00-11/30, 13/00-13/42, 15/00-15/82, H04L 1/00-1/24, 12/00-12/955, 29/00-29/14, H04B 1/00-1/76

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7809873 B2 (SANDISK IL LTD.) 05.10.2010, column 8, line 58 - column 10, line 21, fig. 4	1-15
Y	EP 1867082 B1 (TELLABS OY) 22.01.2014, paragraphs [0003], [0028]-[0033]	1-15
Y	US 6792337 B2 (POWER MEASUREMENT LTD.) 14.09.2004	4-6, 12
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A	US 6519302 B1 (NORTEL NETWORKS LIMITED) 11.02.2003	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

29 May 2019 (29.05.2019)

Date of mailing of the international search report

13 June 2019 (13.06.2019)

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