



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.12.2022 Bulletin 2022/51

(51) International Patent Classification (IPC):
B61L 3/12 (2006.01) B61L 27/00 (2022.01)

(21) Application number: **21179687.5**

(52) Cooperative Patent Classification (CPC):
B61L 3/12; B61L 27/53; B61L 2027/202

(22) Date of filing: **16.06.2021**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Ertms Solutions**
1000 Bruxelles (BE)

(72) Inventor: **FERNANDES, Emmanuel**
Bruxelles (BE)

(74) Representative: **Gevers Patents**
Intellectual Property House
Holidaystraat 5
1831 Diegem (BE)

(54) **MONITORING THE ELECTRICAL SIGNAL BETWEEN AN ETCS LINESIDE ELECTRICAL UNIT AND ITS TRACKSIDE BALISE IN A RAILWAY ENVIRONMENT**

(57) Monitoring the Electrical Signal between an ETCS Lineside Electrical Unit and its trackside balise in a railway environment

The present invention relates the monitoring an electrical signal (10) in a cable (90) between an electric unit (91) and a balise (92) in a railway installation (9). The forward signal (11) and the reverse signal (12) of the electrical signal (10) are copied, and their copies (21, 22) are analyzed to determine a process output (55) based on the telegram signal (111) of the forward signal (11), and/or the sinusoidal signal (116) of the forward signal (11), and/or, the telegram signal (121) of the reverse signal (12), and/or the sinusoidal signal (126) of the reverse signal (12).

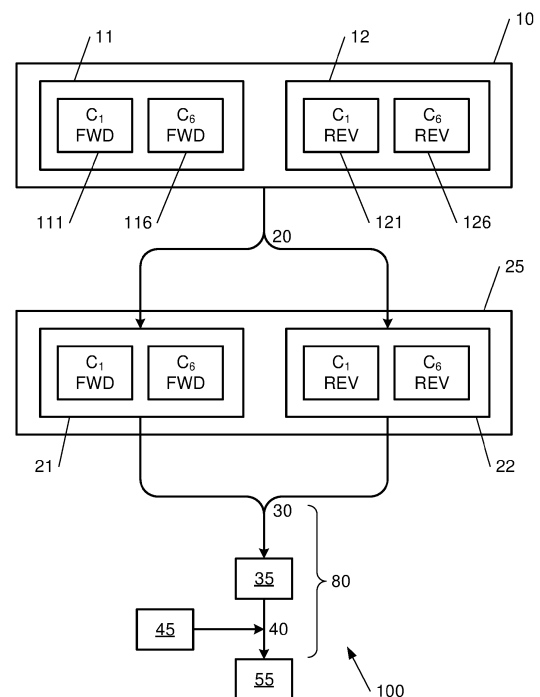


Fig. 3

Description**Field of the invention**

5 **[0001]** The invention relates to the monitoring of an electrical signal in a cable between an electric unit and a balise in a railway installation, within the framework of the ETCS.

Background of the invention

10 **[0002]** The European Train Control System (ETCS) in level 1 involves a cable connection between an electrical unit, called a LEU for Lineside Electrical Unit, and a balise. This connection is used to transmit from track to train the status of the lateral signals like the traffic lights. This is part of an automatic track-to-train information transmission which is received by the on-board vital computer (EVC).

15 **[0003]** The electrical unit is connected to the traffic light. Each active light is detected by the electrical unit which sends to the balise thru a cable a telegram signal. This telegram is retransmitted by the balise to the train using an inductive coupling RF channel, called the interface 'A1'.

20 **[0004]** The cable interface between the LEU and the balise is generally called the interface 'C' and denoted by I/F C. The electrical signal transmitted by the C interface comprises two additively mixed signals called signal C6 and signal C1. Signal C6 is a sinusoidal signal at $f=8.82$ kHz. Signal C1 is a telegram signal. More specifically, signal C1 is a Manchester-like encoded differential data signal. Signal C1 comprises digital information. Signal C1 typically conveys 341 or 1023 bits that repeat cyclically without interruption at a data rate of 564.48 kbits/s. The signal C(t) in the cable is the additive mixing of both C1(t) and C6(t): $C(t) = C1(t) + C6(t)$.

25 **[0005]** Document EP3067246 relates to a device and a method for monitoring the operability of a signal connection between the LEU and the balise. A problem of this known method is that it requires to inject a monitoring signal in the cable.

Summary of the invention

30 **[0006]** An object of the present invention is to monitor and help for the maintenance of a railway installation.

30 **[0007]** Accordingly, the invention relates to a process for monitoring an electrical signal in a cable between an electric unit and a balise in a railway installation; the electrical signal comprising a forward signal and a reverse signal, the forward signal comprising a telegram signal and a sinusoidal signal, the reverse signal comprising a telegram signal and a sinusoidal signal; the process comprising the following steps:

- a bidirectional coupler extracts a copy of the forward signal and a copy of the reverse signal;
- 35 • a signal processing unit analyzes the copy of the forward signal and the copy of the reverse signal to determine a process output related to the railway installation, based on at least one of:
 - the telegram signal of the forward signal,
 - the sinusoidal signal of the forward signal,
 - 40 ◦ the telegram signal of the reverse signal, or
 - the sinusoidal signal of the reverse signal.

45 **[0008]** The invention copies of the telegram signal (C1) and the sinusoidal signal (C6) in forward and in reverse and uses any of them, or a combination of several of them, to generate a process output, which relates to the railway installation and thus indicates a possible problem in the railway installation. An alarm can be triggered if the process output is above a threshold or is different from reference data. There is thus no need of injecting any signal in the cable.

50 **[0009]** Using information from both the telegram signal (in forward and/or in reverse) and the sinusoidal signal (in forward and/or in reverse) is not necessary within the frame of the invention, but it is preferred since it improves the monitoring.

50 **[0010]** Using information from both the forward signal (telegram and/or in sinusoidal) and the reverse signal (telegram and/or in sinusoidal) is not necessary within the frame of the invention, but it is preferred since it improves the monitoring.

55 **[0011]** The process according to the invention is made to be run continuously. It can for example run continuously during one week.

55 **[0012]** One bidirectional coupler at a fixed location along the cable is sufficient to obtain the copies. There is no need of multiple probes on a cable. The bidirectional coupler is preferably not powered.

55 **[0013]** The electric unit may be called a "Lineside Electronic Unit" or LEU. It is generally part of the European Train Control System (ETCS).

55 **[0014]** The cable may be called an "Interface C". It preferably comprises a pair of conductors (for example copper)

for the transmission of a differential electrical signal. The cable may have a constant characteristic impedance and behaves like a transmission line.

[0015] In some embodiments, the computer unit may include logic carry out by a processor, a central processing unit (CPU), a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or the like, or any combinations thereof, and can include discrete digital or analog circuit elements or electronics, or combinations thereof.

[0016] In an embodiment of the invention, the process output is based on a detection of an absence of at least one of:

- the telegram signal of the forward signal,
- the sinusoidal signal of the forward signal,
- the telegram signal of the reverse signal, or
- the sinusoidal signal of the reverse signal.

[0017] In practice, if the telegram signal is absent in forward, it is also absent in reverse (and the same for the sinusoidal signal). Anyway, the absence of any of these four signals in the cable indicates a problem in the railway installation. The process output preferably indicates said absence(s).

[0018] In an embodiment of the invention, the process output is based on a phase difference between the telegram signal of the reverse signal and the telegram signal of the forward signal, and/or a phase difference between the sinusoidal signal of the reverse signal and the sinusoidal signal of the forward signal. The phase difference of telegram signal or the sinusoidal signal provides information about the state of the cable, the electric unit and/or the balise.

[0019] In an embodiment of the invention, the process output is based on at least one of:

- an amplitude of the telegram signal of the forward signal,
- an amplitude of the sinusoidal signal of the forward signal,
- an amplitude of the telegram signal of the reverse signal, or
- an amplitude the sinusoidal signal of the reverse signal.

[0020] The amplitude provides information about the state of the cable, the electric unit and/or the balise. For example, an amplitude in forward at least ten times higher the amplitude in reverse for the telegram and/or the sinusoidal signal typically indicates a normal state of the railway installation. An amplitude in reverse higher than a tenth of the amplitude in forward for the telegram and/or the sinusoidal signal is an indication of a possible problem in the railway installation (an open or short for example). An increase in the reverse amplitude for the telegram and/or the sinusoidal signal is an indication of a possible problem in the railway installation.

[0021] In an embodiment of the invention, the process output is based on at least one of:

- a data rate of bits of the telegram signal of the forward signal,
- a frequency of the sinusoidal signal of the forward signal,
- a data rate of bits of the telegram signal of the reverse signal, or
- a frequency of the sinusoidal signal of the reverse signal.

[0022] The reference value the data rate of the telegram signal of both the forward and the reverse signal is 564.48 kbits/s. The reference value the frequency of the sinusoidal signal of both the forward and the reverse signal is 8.82 kHz. A deviation of more than a threshold (for example 5%) with respect to the reference value an indication of a possible problem in the railway installation.

[0023] In an embodiment of the invention, the process output is based on a digital content of the telegram signal of the forward signal, and/or a digital content of the telegram signal of the reverse signal. The digital content means the sequence of bits (0 or 1) in the telegram signal in the forward and/or the reverse signal.

[0024] In an embodiment of the invention, the process output is based on a comparison with reference data to identify a problem in the railway installation.

[0025] In an embodiment of the invention, the process comprises a timestamping of the process output and a storage of the process output in a memory.

[0026] In an embodiment of the invention, the process comprises a transmission of the process output from an equipment located along the railway installation, and comprising the bidirectional coupler, and the signal processing unit to a remote receiver. The transmission can be done through Internet and/or can be wireless. The receiver can for example be in a portable device of a security operator, in a server, and/or in a facility of a railway company.

[0027] The invention also relates to a system for monitoring for monitoring an electrical signal in a cable between an electric unit and a balise in a railway installation; the electrical signal comprising a forward signal and a reverse signal, the forward signal comprising a telegram signal and a sinusoidal signal, the reverse signal comprising a telegram signal

and a sinusoidal signal; the system comprising:

- a bidirectional coupler configured to extract a copy of the forward signal and a copy of the reverse signal;
- a signal processing unit configured to analyze the copy of the forward signal and the copy of the reverse signal to determine a process output related to the railway installation, using at least one of:
 - the telegram signal of the forward signal,
 - the sinusoidal signal of the forward signal,
 - the telegram signal of the reverse signal, or
 - the sinusoidal signal of the reverse signal.

[0028] The system is preferably installed at a fixed location.

[0029] In an embodiment of the invention, the bidirectional coupler provides a galvanic isolation between the cable and the analyzer.

[0030] In an embodiment of the invention, the bidirectional coupler is unable to inject any signal in the cable.

[0031] In an embodiment of the invention, all the components of the bidirectional coupler are passive. The bidirectional coupler may comprise capacitors, resistors, inductors, transformers. The bidirectional coupler does not comprise any transistor or active device for example.

[0032] In an embodiment of the invention, the signal processing unit comprises at least one of the following:

- a combination of a low-pass filter configured to determine the sinusoidal signal of the forward signal from the copy of the forward signal, and a signal slicer configured to slice the sinusoidal signal of the forward signal;
- a combination of a high-pass filter configured to determine the telegram signal of the forward signal from the copy of the forward signal, and a signal slicer configured to slice the telegram signal of the forward signal;
- a combination of a low-pass filter configured to determine the sinusoidal signal of the reverse signal from the copy of the reverse signal, and a signal slicer configured to slice the sinusoidal signal of the reverse signal; or
- a combination of a high-pass filter configured to determine the telegram signal of the reverse signal from the copy of the reverse signal, and a signal slicer configured to slice the telegram signal of the reverse signal.

[0033] Each filter selects the desired part of the electrical signal and the subsequent slicer cleans it.

[0034] The invention also relates to an equipment located along a railway, comprising a system according to any embodiment, and the electric unit, the equipment being configured to be located along the railway installation

Brief description of the figures

[0035] For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings in which:

- Figure 1 is a schematic representation of a railway installation,
- Figure 2 is a schematic representation of a system according to an embodiment of the invention,
- Figure 3 is a flowchart of a process according to an embodiment of the invention,
- Figure 4 is a schematic representation of a bidirectional coupler that might be used in embodiments of the invention, and
- Figure 5 is a schematic representation of an analyzer that might be used in embodiments of the invention.

Description of the invention

[0036] The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto. The described functions are not limited by the described structures. The drawings described are only schematic and are nonlimiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

[0037] Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. The terms are interchangeable under appropriate circumstances and the embodiments of the invention can operate in other sequences than described or illustrated herein.

[0038] On the figures, identical or analogous elements may be referred by a same number.

[0039] Figure 1 illustrates a railway installation 9 comprising a railway 93, a lineside signaling device 98, a cable 90,

an electric unit 91, and a balise 92. The cable 90 is located along the railway 93 and connects the electric unit 91 and the balise 92. The cable 90 is intended to be used, for example, in a European Train Control System (ETCS) level 1. The electric unit 91 is connected to the lineside signaling device 98, for example a traffic light. The balise 92 is able to transmit information to a train computer 95 (usually called EVC for European Vital Computer) in a train 94 on the railway 93.

[0040] A system 1 according to the invention is preferably located in an equipment 99 located along the railway installation 9, in a same housing as the electric unit 91.

[0041] Figure 2 illustrates a system 1 according to an embodiment of the invention. The system 1 comprises at least one bidirectional coupler 20, each bidirectional coupler 20 being electrically and mechanically coupled one cable 90. In the embodiment of Figure 2, each bidirectional coupler 20 is part of a probe 200 electrically and mechanically coupled to two cables 90. The bidirectional coupler 20 may be called "Passive and Isolated Probe". The bidirectional coupler 20 is a pass thru device, and is intended not to disturb the transmission of the signal in the cable 90.

[0042] The system 1 also comprises a signal processing unit 80 comprising at least one analyzer 30, preferably connected to at least one bidirectional coupler 20 through a connection 29. In the embodiment of Figure 2, each analyzer 30 is connected to two probes 200. If the analyzer 30 is connected to several bidirectional couplers 20, the analysis performed by the analyzer 30 may be done using a cyclic multiplexing method.

[0043] The data transfer between the bidirectional coupler 20 and the analyzer 30 is preferably unidirectional: there is no data transferred from the analyzer 30 to the bidirectional coupler 20. The analyzer 30 is preferably an analog and digital electronic device.

[0044] The signal processing unit 80 also comprises at least one processing unit 40, preferably connected to at least one analyzer 30 through a connection (USB, serial connection or LAN/Ethernet). The processing unit 40 preferably comprises a computing unit 41 and a memory 42.

[0045] The system 1 may also comprise a transmission device 50, like a modem, connecting wirelessly the processing unit 40 to the Internet 60.

[0046] Figure 3 is a flowchart of a process 100 according to an embodiment of the invention. An electrical signal 10 is present in the cable 90 between the electric unit 91 and the balise 92. The electrical signal 10 comprises a forward signal 11 and a reverse signal 12, the forward signal 11 comprising a telegram signal 111 and a sinusoidal signal 116, the reverse signal 12 comprising a telegram signal 121 and a sinusoidal signal 126.

[0047] The bidirectional coupler 20 connected to the cable 90 extracts a copy 21 of the forward signal 11 and a copy 22 of the reverse signal 12 and transfers them, as a bidirectional coupler output 25, to the analyzer 30.

[0048] Figure 4 illustrates an exemplary embodiment of the bidirectional coupler 20 coupled to a cable 90 comprising two conductors 90a, 90b. The signal 10 flows in the two conductors 90a, 90b between the electrical unit 91 and the balise 92. The exemplary embodiment of the bidirectional coupler 20 comprises four transformers and two resistors:

- Tr1 is a N:1 transformer;
- Tr2 is a 1:N transformer;
- Tr3 and Tr4 are 1:1 transformers;
- R1 and R2 are resistors of equal value. The value of these resistors is preferably equal to the characteristic impedance of the cable 90 seen as a transmission line. Usually this value is set to 120 Ω .

[0049] N may be equal to 10 for example. Tr3 and Tr4 provide galvanic isolation between the cable 90 and the analyzer 30. Preferably, the bidirectional coupler 20 only comprises passive electric components. Preferably, the bidirectional coupler 20 is not powered, except through the cable 90.

[0050] The connection 29 between the bidirectional coupler 20 and the analyzer 30 preferably comprises four conductors: two conductors 29a, 29b for the forward signal 21, and two conductors 29c, 29d for the reverse signal 22. The bidirectional coupler 20 sends to the analyzer 30 the forward signal 21 $C_{FWD}(t)$ and the reverse signal 22 $C_{REV}(t)$, which are voltages as a function of the time.

[0051] Many other embodiments of the bidirectional coupler 20 are possible within the frame of the invention.

[0052] Referring back to the process of Figure 3, the signal processing unit 80 receives the copy 21 of the forward signal 11 and the copy 22 of the reverse signal 12 and the analyzer 30 analyzes them to determine a measurement output 35. The analysis by the analyzer 30 preferably comprises the determination of at least one of:

- the telegram signal 111 of the forward signal 11,
- the sinusoidal signal 116 of the forward signal 11,
- the telegram signal 121 of the reverse signal 12, or
- the sinusoidal signal 126 of the reverse signal 12.

[0053] The measurement output 35 is based on one or several of these signals 111, 116, 121, 126. Preferably, one or several of these signals 111, 116, 121, 126 may be included or may form the measurement output 35.

[0054] Figure 5 shows a possible architecture of the analyzer 30. If the analyzer 30 is connected to several bidirectional couplers 20, the blocks (except blocks 230, 240) can be replicated. The analysis may comprise data analog filtering, signal reconditioning, analog envelope detection, digital decoding and data recording.

[0055] To determine the signals 111, 116, 121, 126:

- a low-pass filter 211 is applied on the copy 21 of the forward signal 11 to determine the sinusoidal signal 116 of the forward signal 11,
- a high-pass filter 212 is applied on the copy 21 of the forward signal 11 to determine the telegram signal 111 of the forward signal 11,
- a low-pass filter 221 is applied on the copy 22 of the reverse signal 12 to determine the sinusoidal signal 126 of the reverse signal 12, and
- a high-pass filter 222 is applied on the copy 22 of the reverse signal 12 to determine the telegram signal 121 of the reverse signal 12.

[0056] The low-pass filter 211 extracts the sinusoidal signal 116 of the forward signal 11 which is expected to be a pure sine wave at 8.82 kHz. The same holds for the reverse signal 126. The low-pass filters 211, 221 can be of any type. Their purpose is to reject the C1 signal which starts at 564.48 kHz. An example is a Butterworth low pass filter of order $n=8$ with 3dB cut-off frequency at 10 kHz.

[0057] The high-pass filter 212 removes the C6 and just extracts the telegram signal 111 of the forward signal 11. The same holds for the reverse signal 121. Preferably the C6 rejection is more than 60 dB. An example is a Butterworth of order $n=8$ with 3dB cut-off frequency of 100 kHz.

[0058] The analyzer 30 may comprise four envelop detectors 213, 216, 223, 226. The envelop detectors 213, 223 are AC signal envelop detector configured to determine the amplitude of the C6 extracted component, i.e., the amplitude $|V_{fwd6}|$ of the sinusoidal signal 116 of the forward signal 11 for 213 and the amplitude $|V_{rev6}|$ the sinusoidal signal 126 of the reverse signal 12 for 223. The envelop detectors 216, 226 are AC signal envelop detector configured to determine the amplitude of the C1 extracted component, i.e., the amplitude $|V_{fwd1}|$ of the telegram signal 111 of the forward signal 11 for 216 and the amplitude $|V_{rev1}|$ the telegram signal 121 of the reverse signal 12 for 226. The envelop detectors 213, 216, 223, 226 are preferably linear with respect to the input signal amplitude.

[0059] The analyzer 30 may comprise four signal slicers 214, 215, 224, 225. They are analog comparator-based signal resaper. They are configured to convert an analog AC signal to a square signal at TTL/CMOS levels with rising/falling edges corresponding to the negative-to-positive and positive-to-negative transitions of the signal respectively. The signal slicers 214, 215, 224, 225 make possible to remove a possible DC offset and/or possible deformation of the signal. The output of the signal slicers 215, 225 (i.e. for C1) is Differential Bi-Phase Level (DBPL) coding.

[0060] The analyzer 30 may comprise four analog-to-digital converters 217, 218, 227, 228, which convert the analog signal between 0 and V_{max} provided by the envelop detectors into a digital quantized representation to be processed by the FPGA 230 and the CPU 240. The four analog-to-digital converters 217, 218, 227, 228 have preferably a vertical resolution of at least 12 bits.

[0061] The analyzer 30 may comprise an FPGA 230.

[0062] The FPGA 230 may determine the frequency of the sinusoidal signal 116 of the forward signal 11 by measuring the frequency of the signal provided by the signal slicer 214. The FPGA 230 may determine the frequency of the sinusoidal signal 126 of the reverse signal 12 by measuring the frequency of the signal provided by the signal slicer 224.

[0063] The FPGA 230 may determine, from the output of the signal slicers 214, 224 a phase difference ϕ_6 between the sinusoidal signal 126 of the reverse signal 12 and the sinusoidal signal 116 of the forward signal 11. The FPGA 230 may determine, from the output of the signal slicers 215, 225 a phase difference ϕ_1 between the telegram signal 121 of the reverse signal 12 and the telegram signal 111 of the forward signal 11.

[0064] The FPGA 230 may decode the output of the signal slicer 215 to extract the digital content of the telegram signal 111 of the forward signal 11. The FPGA 230 may decode the output of the signal slicer 225 to extract the digital content of the telegram signal 121 of the reverse signal 11.

[0065] The FPGA 230 may determine, from the output of the signal slicers 215, the data rate of bits of the telegram signal 111 of the forward signal 11. The FPGA 230 may determine, from the output of the signal slicers 225, the data rate of bits of the telegram signal 121 of the reverse signal 12.

[0066] The FPGA 230 may determine the analog level of any of the four signals 111, 116, 121, 126 after analog-to-digital conversion.

[0067] The analyzer 30 may comprise a central processing unit (CPU) 240, which collects the data outputted by the FPGA 230 and prepare them for recording and transmission.

[0068] The analyzer 30 sends, preferably continuously, the measurement output 35 (both analog and digital) to the processing unit 40. A process output 55 may be determined by the processing unit 40 or may be formed by at least part of the measurement output 35.

[0069] The processing unit 40 may store in its memory 42 the measurement output 35 and/or process it further to determine the process output 55. The processing unit 40 may provide the process output 55 to the transmission device 50 (figure 2) for a transmission outside the equipment 99 (figure 22), to a remote receiver, for example to a server including a database.

[0070] The analyzer 30 and/or the processing unit 40 may also assess the actual presence, and thus the absence of at least one of the four signals 111, 116, 121, 126.

[0071] The signal processing unit 80 may determine phasor quantities for the four signals 111, 116, 121, 126 as follows:

$$V_{fwd6} = |V_{fwd6}|$$

$$V_{rev6} = |V_{rev6}| e^{j\varphi6}$$

$$V_{fwd1} = |V_{fwd1}|$$

$$V_{rev1} = |V_{rev1}| e^{j\varphi1}$$

[0072] The input voltages of the bidirectional coupler 20 illustrated at Figure 4 (between 90a and 90b on the side towards the electric unit 91) may be determined as:

$$V_{input6} = -N V_{fwd6} + \frac{N^2 - 1}{N} V_{rev6}$$

$$V_{input1} = -N V_{fwd1} + \frac{N^2 - 1}{N} V_{rev1}$$

[0073] The relationship between the phasors $V_{fwd6,1}$ and $V_{rev6,1}$ reflects the condition of the circuit between the bidirectional coupler 20 and the balise 92:

- if the circuit is open:

$$V_{rev6} = -\frac{N^2-1}{N^2} V_{fwd6} \text{ and } V_{rev1} = -\frac{N^2-1}{N^2} V_{fwd1}$$

- if the circuit is short:

$$V_{rev6} = V_{fwd6} \text{ and } V_{rev1} = V_{fwd1}$$

- if the circuit is matched:

$$V_{rev6} = \frac{1}{2N^2} V_{fwd6} \text{ and } V_{rev1} = \frac{1}{2N^2} V_{fwd1}$$

[0074] When circuit is matched, REV voltage is very small and almost zero (since N is considered as large usually greater than 10). In the terminology of bi-directional coupler, this corresponds to a circuit where all energy is transmitted to the load with no reflection (REV voltage is zero). When the circuit is open, the REV voltage is high and almost equal in magnitude, but reversed in phase (since N is usually larger than 10). When the circuit is shorted, the REV voltage is high and equal in magnitude and in phase with the FWD voltage. In other word, high REV voltages correspond to energy reflection and to open/short circuit conditions. Low and almost zero REV voltages correspond to well-matched circuits.

[0075] It is clear from these formulas how the amplitudes and/or phases can be used to measure voltages and currents

at the output on the side of the electric unit 92, to detect open/short cable failures, and use this information to generate the process output 55 related to the railway installation 9.

[0076] The processing unit 40 may compare measured data (preferably the measurement output 35 or data extracted from it) with reference data 45 to detect deviation with expected nominal range or value and thus identify a problem in the railway installation 9. The reference data 45 comprise an expected value or an expected sequence, and for example if the comparison indicates a difference above a threshold, the process output 55 indicates which measured data may be problematic, preferably with the measured data and its expected value. For example, if the measured data is a sequence of bits provided by the digital content of the telegram signal 111 of the forward signal 11, it may be compared with an expected sequence (the reference data), and the process output 55 may indicate that the sequence is as expected or may indicate the measured sequence and the expected sequence.

[0077] The processing unit 40 may also determine a drift in at least one of the measured data of the measurement output 35.

[0078] The processing unit 40 may analyze the digital content of the telegram signal 111 of the forward signal 11 and/or the digital content of the telegram signal 121 of the reverse signal 11 to detect, for example, the following problems:

- (a) a no fleeting release of a zone,
- (b) a non-permanent zone release,
- (c) a problem in a lineside signaling device (for example a faulty lamp in a traffic light),
- (d) a traffic light extinction,
- (e) a non-working switch (forgotten after work on the railway for example),
- (f) a problem in the control of the interlocking by the lineside signaling device,
- (g) a problem in the detection of the train by the track circuits and/or the axle counters.

[0079] The process output 55 relates to the railway installation 99. The process output 55 may comprise a timestamp corresponding to the time when it was determined. The process output 55 may be a message, displayed on the equipment 99 and/or send by the transmission device 50 and/or stored in the memory 42. It can be an alarm message and/or a warning message for example. It may be sent only if the comparison with the reference data 45 indicates a deviation with respect to a nominal range.

[0080] The process output 55 contain information, for example explicit information, about at least one of the following:

- the absence of at least one of the four signals 111, 116, 121, 126,
- the phase difference φ_1 and/or φ_6 ,
- the amplitude of at least one of the four signals 111, 116, 121, 126,
- the data rate of bits of the telegram signal 111 (or 121) of the forward signal 11 (or reverse signal 12),
- the frequency of the sinusoidal signal 116 (or 126) of the forward signal 11 (or reverse signal 12),
- the digital content of the telegram signal 111 (or 121) of the forward signal 11 (or reverse signal 12),
- an open, short or matched condition, or
- one or several of the problems (a) to (g) indicated above.

[0081] In other words, the invention relates to the monitoring an electrical signal 10 in a cable 90 between an electric unit 91 and a balise 92 in a railway installation 9. The forward signal 11 and the reverse signal 12 of the electrical signal 10 are copied, and their copies 21, 22 are analyzed to determine a process output 55 based on the telegram signal 111 of the forward signal 11, and/or the sinusoidal signal 116 of the forward signal 11, and/or, the telegram signal 121 of the reverse signal 12, and/or the sinusoidal signal 126 of the reverse signal 12.

[0082] Although the present invention has been described above with respect to particular embodiments, it will readily be appreciated that other embodiments are also possible.

Claims

1. Process (100) for monitoring an electrical signal (10) in a cable (90) between an electric unit (91) and a balise (92) in a railway installation (9); the electrical signal (10) comprising a forward signal (11) and a reverse signal (12), the forward signal (11) comprising a telegram signal (111) and a sinusoidal signal (116), the reverse signal (12) comprising a telegram signal (121) and a sinusoidal signal (126); the process (100) comprising the following steps:

- a bidirectional coupler (20) extracts a copy (21) of the forward signal (11) and a copy (22) of the reverse signal (12);
- a signal processing unit (80) analyzes the copy (21) of the forward signal (11) and the copy (22) of the reverse

signal (12) to determine a process output (55) related to the railway installation (9), based on at least one of :

- the telegram signal (111) of the forward signal (11),
- the sinusoidal signal (116) of the forward signal (11),
- the telegram signal (121) of the reverse signal (12), or
- the sinusoidal signal (126) of the reverse signal (12).

2. Process according to claim 1, wherein the process output (55) is based on a detection of an absence of at least one of:

- the telegram signal (111) of the forward signal (11),
- the sinusoidal signal (116) of the forward signal (11),
- the telegram signal (121) of the reverse signal (12), or
- the sinusoidal signal (126) of the reverse signal (12).

3. Process according to any of the preceding claims, wherein the process output (55) is based on:

- a phase difference (ϕ_1) between the telegram signal (121) of the reverse signal (12) and the telegram signal (111) of the forward signal (11), and/or
- a phase difference (ϕ_6) between the sinusoidal signal (126) of the reverse signal (12) and the sinusoidal signal (116) of the forward signal (11).

4. Process according to any of the preceding claims, wherein the process output (55) is based on at least one of :

- an amplitude ($|V_{fwd1}|$) of the telegram signal (111) of the forward signal (11),
- an amplitude ($|V_{fwd6}|$) of the sinusoidal signal (116) of the forward signal (11),
- an amplitude ($|V_{rev1}|$) of the telegram signal (121) of the reverse signal (12), or
- an amplitude ($|V_{rev6}|$) the sinusoidal signal (126) of the reverse signal (12).

5. Process according to any of the preceding claims, wherein the process output (55) is based on at least one of:

- a data rate of bits of the telegram signal (111) of the forward signal (11),
- a frequency of the sinusoidal signal (116) of the forward signal (11),
- a data rate of bits of the telegram signal (121) of the reverse signal (12), or
- a frequency of the sinusoidal signal (126) of the reverse signal (12).

6. Process according to any of the preceding claims, wherein the process output (55) is based on:

- a digital content of the telegram signal (111) of the forward signal (11), and/or
- a digital content of the telegram signal (121) of the reverse signal (11).

7. Process according to any of the preceding claims, wherein the process output (55) is based on a comparison with reference data (45) to identify a problem in the railway installation (9).

8. Process according to any of the preceding claims, comprising a timestamping of the process output (55) and a storage of the process output (55) in a memory (42).

9. Process according to any of the preceding claims, comprising a transmission of the process output (55) from an equipment (99) located along the railway installation (9) and comprising the bidirectional coupler (20), and the signal processing unit (80) to a remote receiver.

10. System (1) for monitoring for monitoring an electrical signal (10) in a cable (90) between an electric unit (91) and a balise (92) in a railway installation (9); the electrical signal (10) comprising a forward signal (11) and a reverse signal (12), the forward signal (11) comprising a telegram signal (111) and a sinusoidal signal (116), the reverse signal (12) comprising a telegram signal (121) and a sinusoidal signal (126); the system (1) comprising:

- a bidirectional coupler (20) configured to extract a copy (21) of the forward signal (11) and a copy (22) of the reverse signal (12);
- a signal processing unit (80) configured to analyze the copy (21) of the forward signal (11) and the copy (22)

of the reverse signal (12) to determine a process output (55) related to the railway installation (9), using at least one of :

- the telegram signal (111) of the forward signal (11),
- the sinusoidal signal (116) of the forward signal (11),
- the telegram signal (121) of the reverse signal (12), or
- the sinusoidal signal (126) of the reverse signal (12).

11. System according to claim 10, wherein the bidirectional coupler (20) provides a galvanic isolation between the cable (90) and the analyzer (30).

12. System according to any of claims 10 to 11, wherein the bidirectional coupler (20) is unable to inject any signal in the cable (90).

13. System according to any of claims 10 to 12, wherein all the components of the bidirectional coupler (20) are passive.

14. System according to any of claims 10 to 13, wherein the signal processing unit (80) comprises at least one of the following:

- a combination of:

- a low-pass filter (211) configured to determine the sinusoidal signal (116) of the forward signal (11) from the copy (21) of the forward signal (11), and
- a signal slicer (214) configured to slice the sinusoidal signal (116) of the forward signal (11);

- a combination of:

- a high-pass filter (212) configured to determine the telegram signal (111) of the forward signal (11) from the copy (21) of the forward signal (11), and
- a signal slicer (215) configured to slice the telegram signal (111) of the forward signal (11);

- a combination of:

- a low-pass filter (221) configured to determine the sinusoidal signal (126) of the reverse signal (12) from the copy (22) of the reverse signal (12), and
- a signal slicer (224) configured to slice the sinusoidal signal (126) of the reverse signal (12); or

- a combination of:

- a high-pass filter (222) configured to determine the telegram signal (121) of the reverse signal (12) from the copy (22) of the reverse signal (12), and
- a signal slicer (225) configured to slice the telegram signal (121) of the reverse signal (12).

15. Equipment (99) located along a railway (93), comprising a system according to any of claims 10 to 14, and the electric unit (91), the equipment (99) being configured to be located along the railway installation (9).

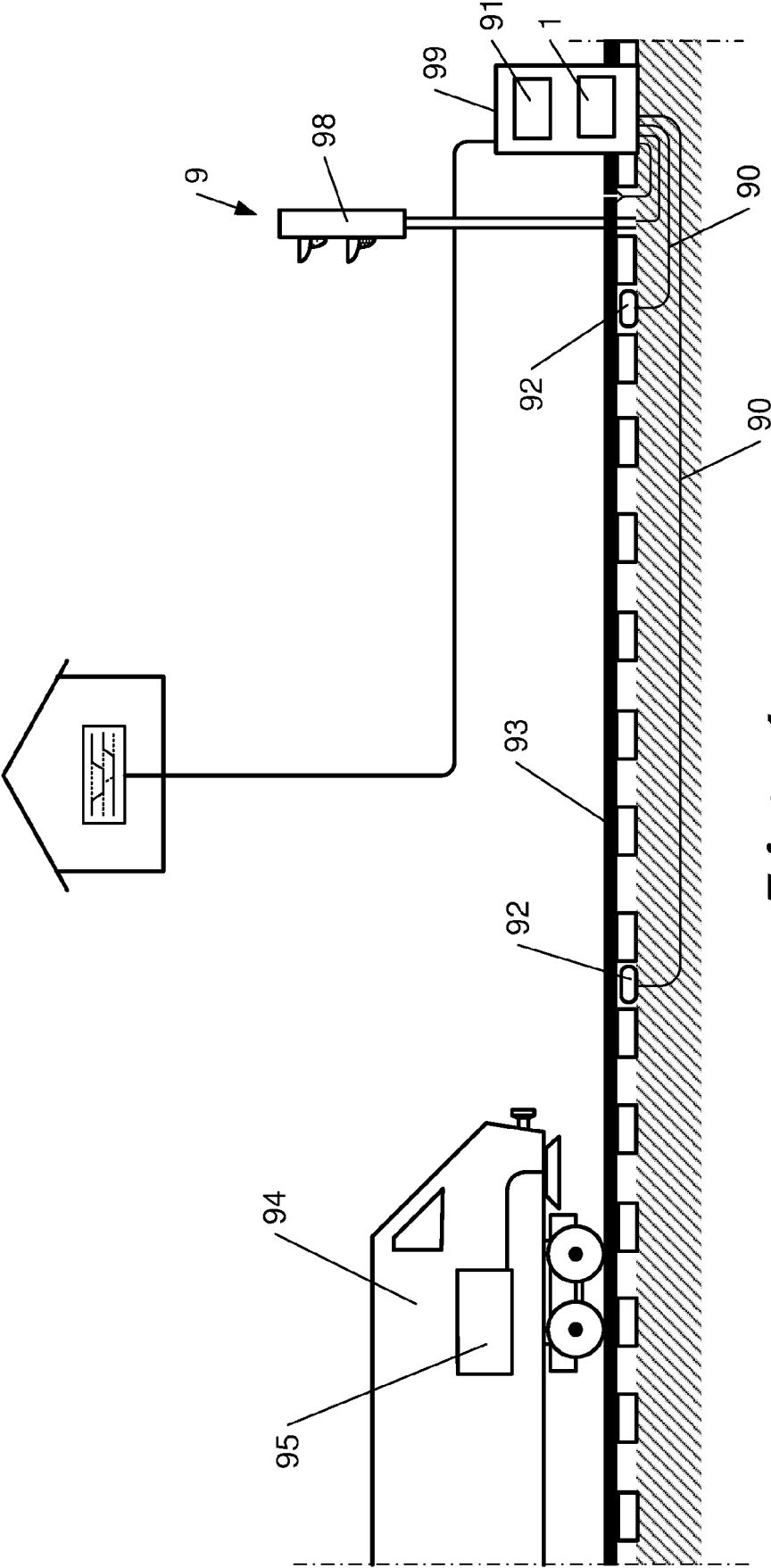


Fig. 1

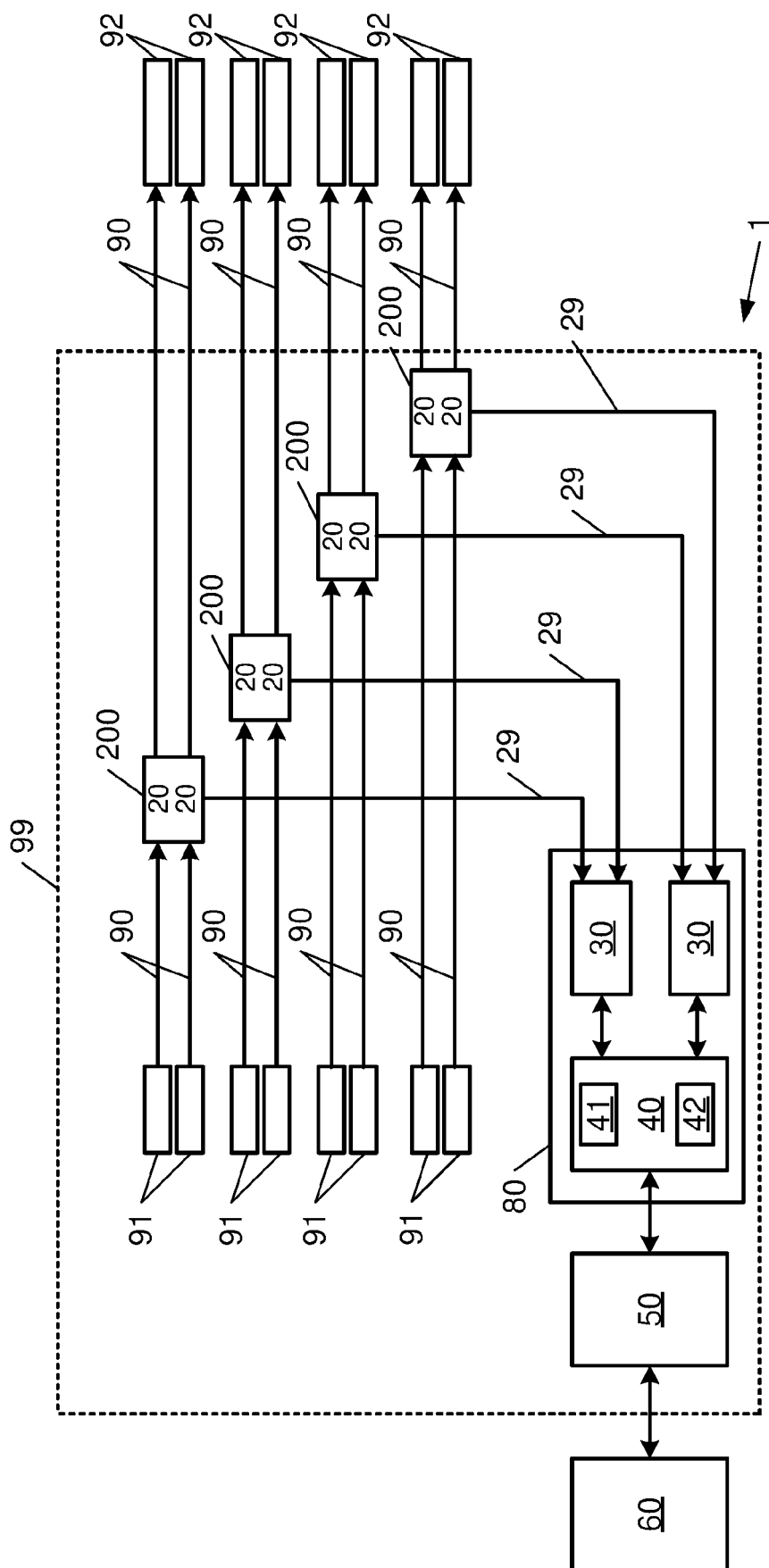


Fig. 2

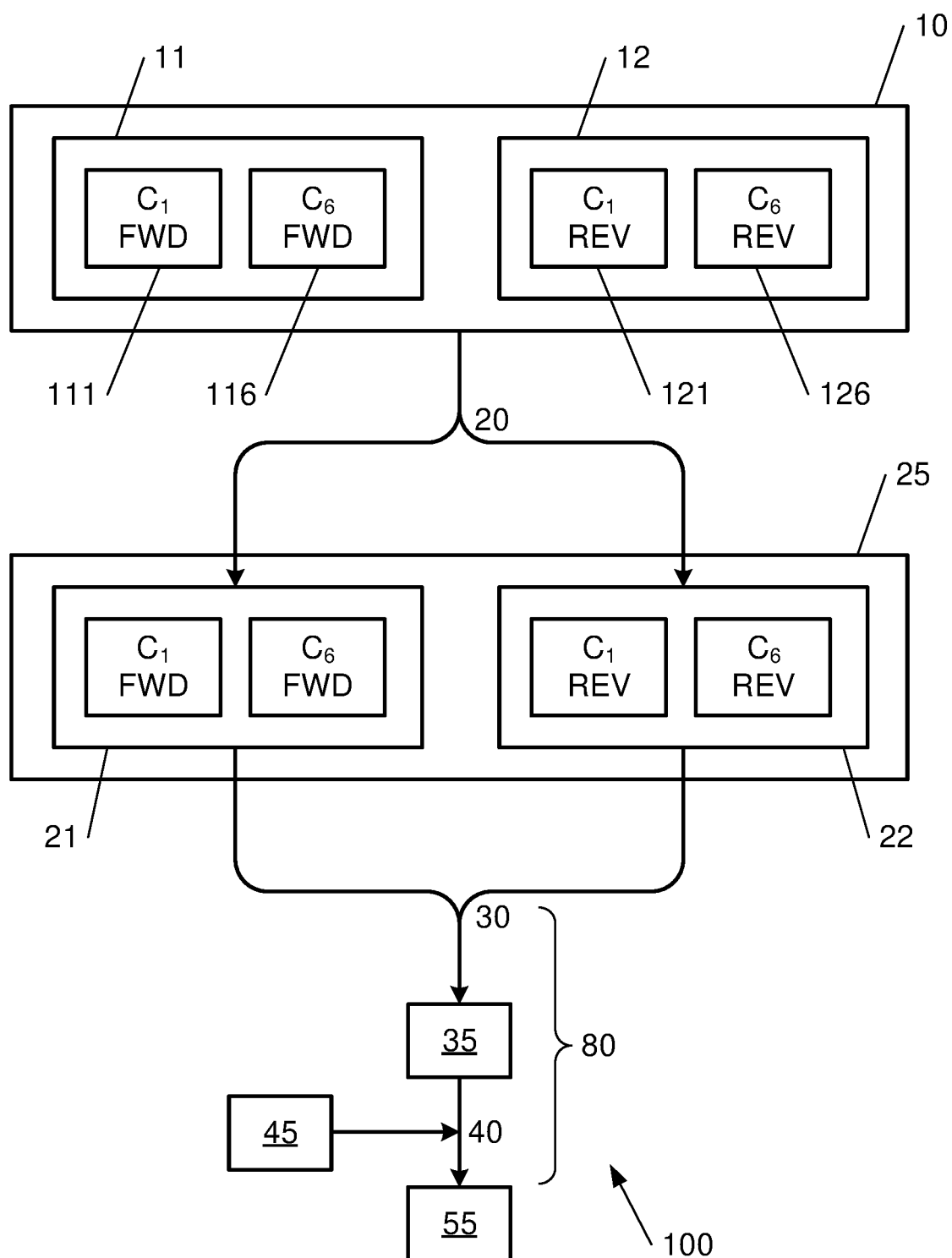


Fig. 3

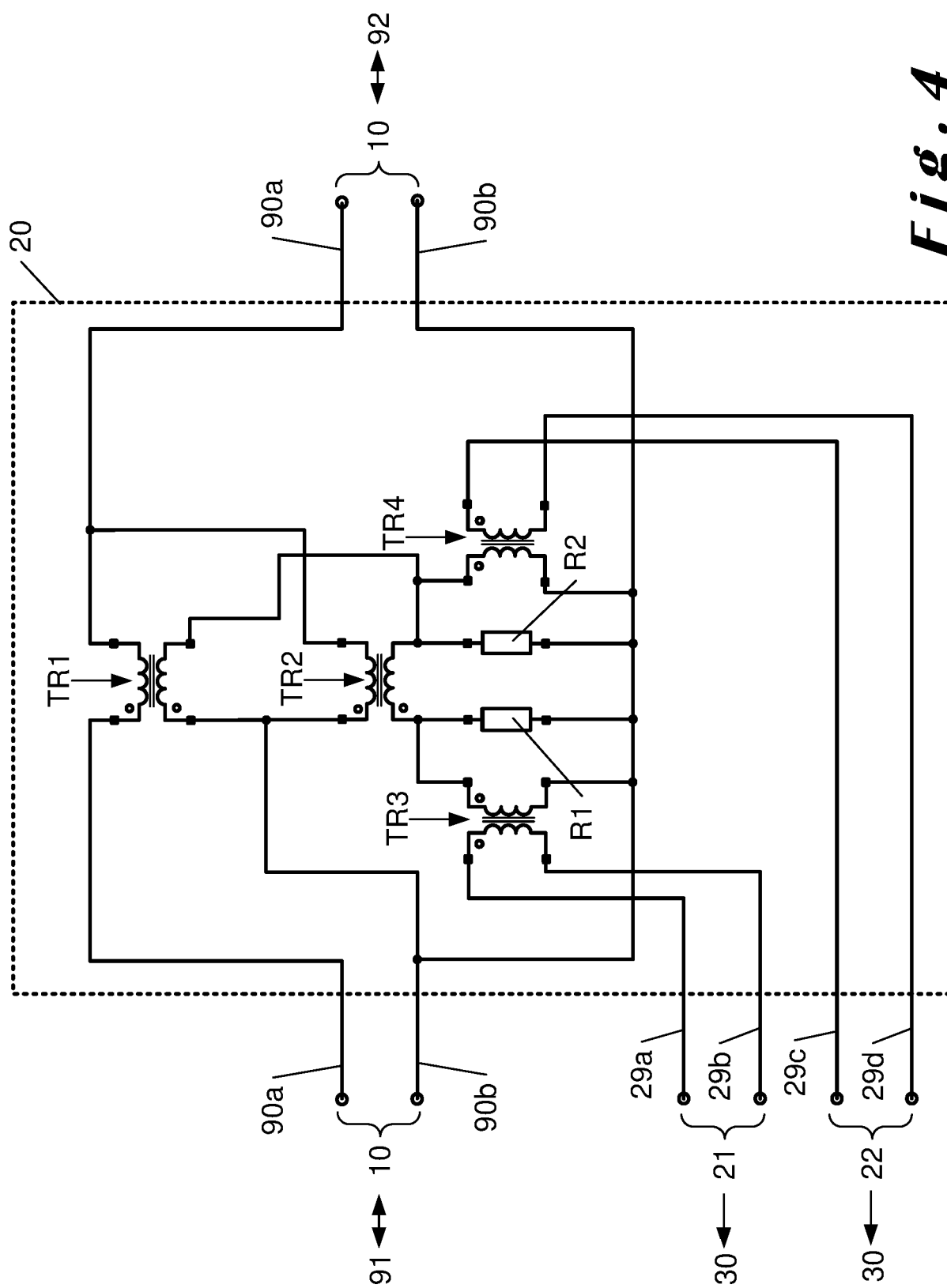


Fig. 4

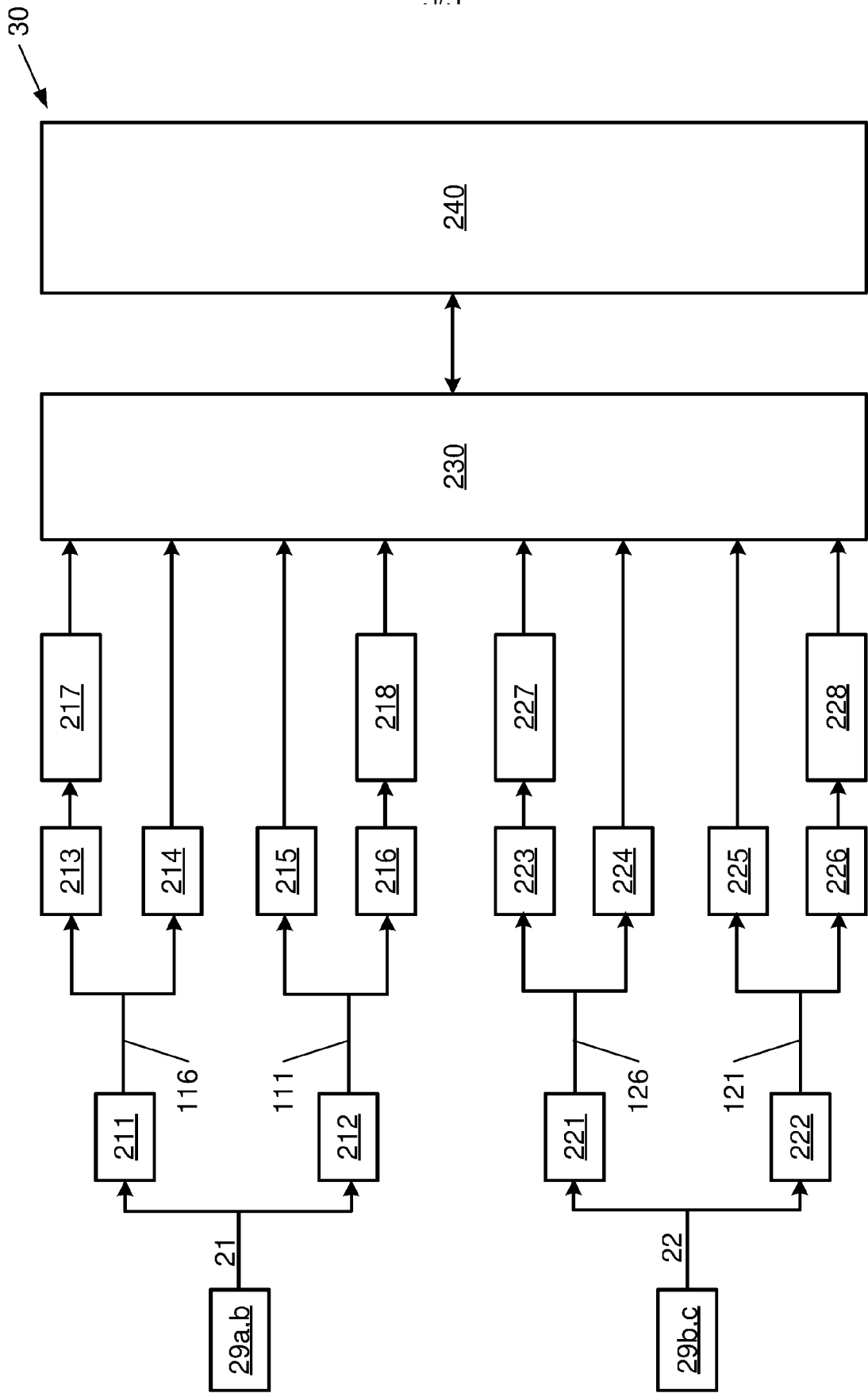


Fig. 5



EUROPEAN SEARCH REPORT

Application Number

EP 21 17 9687

5

10

15

20

25

30

35

40

45

50

55

2

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	CN 108 132 433 B (BEIJING NAT RAILWAY RES & DESIGN INST SIGNAL & COMMUNICATION LTD) 14 February 2020 (2020-02-14) * figures 2 - 5; and corresponding parts of the description *	1-15	INV. B61L3/12 B61L27/00
A	DE 197 08 518 A1 (SIGNAL CONCEPT GMBH [DE]) 1 October 1998 (1998-10-01) * figures 1 and 2; column 3, line 39 - column 6, line 41 *	1-15	
A	EP 2 186 706 B1 (ALSTOM TRANSPORT SA [FR]) 18 April 2012 (2012-04-18) * figures 1 - 3; paragraphs [0017] - [0034] *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B61L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 November 2021	Examiner Plützer, Stefan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 21 17 9687

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-11-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 108132433 B	14-02-2020	NONE	
DE 19708518 A1	01-10-1998	NONE	
EP 2186706 B1	18-04-2012	AT 553977 T	15-05-2012
		CN 101738569 A	16-06-2010
		EP 2186706 A1	19-05-2010
		FR 2938229 A1	14-05-2010
		PL 2186706 T3	28-09-2012
		RU 2009141756 A	20-05-2011

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 3067246 A [0005]