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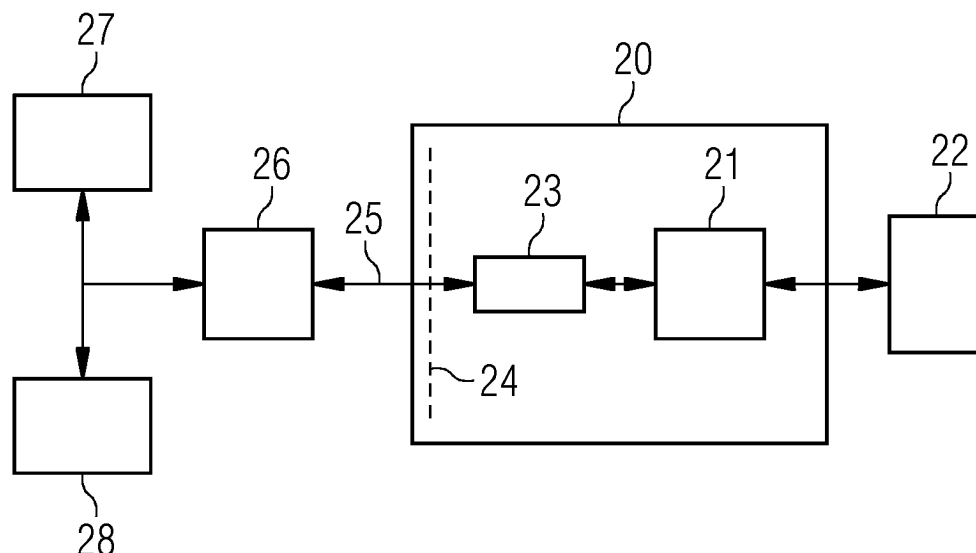
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(54) **RAILWAY WAYSIDE OBJECT CONTROLLER**

(57) A railway wayside object controller (20), railway signalling infrastructure and methods of operating the railway signalling infrastructure are described. The analysis of data obtained by the wayside object controller

(20) is done remotely, with only raw, unprocessed digital data being transmitted from the wayside object controller. This removes the requirement for data processing to be done locally on site within the signalling infrastructure.

FIG 2



Description

[0001] The present invention relates to a railway wayside object controller, in particular, a railway wayside object controller for use in communicating digital signals for, and analogue signals from, trackside equipment.

[0002] Railway signalling equipment controllers, often known as "object controllers", are used for controlling and monitoring trackside equipment along the railway. This equipment includes devices such as points, point machines, axle counters, track circuits and signals. These object controllers need to be robust to survive in the railway environment, and have a long in-service supported lifetime.

[0003] Whilst in general object controllers in use in the present day are adequate, there are a number of issues with them that may be experienced. For example, in order to meet the daily needs of the object controller, the equipment used within them is expensive. This is due to the reliability and safety requirements based upon the required levels of redundancy needed to meet various rail standards. In addition, large design safety margins and the use of high-grade components to meet the environmental conditions the object controller will experience all add to the overall cost. The physical object controller requirements may also be an issue, since they require equipment housings to be built, the footprint of which may not be compatible with the available site size, or the site may be inaccessible for pouring concrete for foundations. The IP rating under IEC 60529 is also a consideration, as the electronic equipment inside the object controller may require ventilation. This is typically done using ventilation grids, which then require additional weatherproofing to avoid water ingress.

[0004] Obsolescence may also be another concern. Complex components within the object controller, such as microprocessors and memory modules, will become obsolete far more quickly than the object controller itself. Technical support for object controllers is generally of the order of twenty-five years or more, which necessitates periodic redesigns to take into account component upgrades and replacements. Diagnostic capabilities are based upon being able to send a snapshot of the current state of a traditional wayside object controller to a diagnostic terminal.

[0005] A traditional wayside object controller configuration in Figure 1. Figure 1 is a schematic representation of a traditional wayside object controller within a signalling system. The wayside object controller 1 comprises an analogue signal processing unit 2, a local digital processing unit 3 and a waveform digitisation and generation module 4 linking the two. The analogue processing unit 2 communicates with the trackside equipment 5, and the local digital processing unit 3 communicates with an interlocking 6 and a diagnostics terminal 7. The analogue communications take place via a copper cable, since the wayside object controller 1 is located close to the trackside equipment it controls and is therefore in

direct communication. This is done by means of a series of I/O connections provided on the wayside object controller 1, and capable of producing or detecting specified voltages and/or power levels. These connections enable the movement of points, detection of switch positions and lamp illumination in signals. The digital communications take place via a network ethernet connection or serial link, since both the interlocking 6 and the diagnostics terminal 7 are located remotely from the trackside equipment 5 and the wayside object controller 1, typically in a relay room or signalling control centre. The local digital processing unit 3 carries out significant signal processing before sending information upstream to the interlocking 6 and diagnostic terminal 7. This may include debouncing signals, monitoring power levels, ensuring waveforms meet required specifications and generating diagnostic data streams.

[0006] The limitations of this tradition design are twofold, firstly in the complexity of the local digital processing unit 3, which may require frequent upgrades in the field, and the bandwidth limitations of the network ethernet connection or serial link to the interlocking 6 and diagnostic terminal 7. The latter in particular limits the amount of data that may be transmitted between the wayside object controller 1 and the interlocking 6 and diagnostic terminal 7. Mitigation of these issues is usually attempted by using incremental design changes between each generation of object controller, for example, upgrading communication links and hardware whilst ensuring IP ratings are maintained. While this may be a commercially successful solution, there still exists a need to be able to improve upon the overall design to avoid the occurrence of these problems in the first place. Since the analysis of all data is carried out on site, only a summary of such data is provided for diagnostic purposes. This data processing must be done in a safety critical system where it is not simple to include additional diagnostic functionality and capability.

[0007] The present invention aims to address these issues by providing a railway wayside object controller, comprising: an analogue signal processor adapted to send and receive analogue data relating to the operation of trackside equipment; a signal converter coupled to the analogue signal processor and adapted to convert reversibly between digitised waveforms and analogue signals; and a digital communications interface connected to the signal converter and adapted to transmit digitised waveforms to a remote digital processor.

[0008] Offloading the data analysis by providing only analogue-digital and digital-analogue conversion with a communications interface able to transmit raw, unprocessed digital waveforms to a remote digital processor removes the need to process data locally on site in the wayside object controller and therefore reduces components, complexity and costs.

[0009] Preferably, the analogue signal processor comprises at least one I/O port adapted to connect to an item of trackside equipment.

[0010] Preferably, the digital communications interface is adapted to connect to at least one of a cellular communications network, a radio communications network, an ethernet link, a serial communications link or a parallel communications link.

[0011] The present invention also provides a railway signalling infrastructure, comprising: trackside equipment located at a railway track; a railway wayside object controller as outlined above connected to the trackside equipment; a digital processor remote from the trackside equipment and adapted to analyse the digital waveforms received from the railway wayside object controller and output digital data; and an interlocking adapted to receive the digital data from and transmit digital data to the digital processor.

[0012] Preferably, the analogue signals relating to the trackside equipment comprise voltage signals and power signals. More preferably, the analogue data sent by the analogue signal processor actuates trackside equipment.

[0013] The railway signalling infrastructure preferably further comprises a diagnostics terminal adapted to receive the digital data from the digital processor. The digital signal from the digital processor may comprise a diagnostics data stream reflecting the condition of the trackside equipment.

[0014] The remote digital processor may be located with the interlocking. The remote digital processor and/or the interlocking may be part of a distributed computing system. Preferably, the digitised waveforms are raw, unprocessed digital data.

[0015] The present invention also provides a method of operating a railway signalling infrastructure, comprising: sending instructions for the operation of trackside equipment, comprising digital data, from an interlocking to a remote digital processor; transmitting, using the digital processor, the digital data to a digital communications interface at a railway wayside object controller; converting, at a signal converter, the digital data received by the digital communications interface to analogue data; and sending, using an analogue signal processor, the analogue data to the trackside equipment.

[0016] The present invention also provides a method of operating the railway signalling infrastructure, comprising: receiving analogue data from trackside equipment at an analogue signal processor; converting, at a signal converter, the analogue waveforms into digitised waveforms; transmitting the digitised waveforms from a digital communications interface of the railway wayside object controller to a remote digital processor; analysing the digitised waveforms at the digital processor; and sending the analysed digital data to an interlocking and/or a diagnostics terminal.

[0017] Preferably, the digitised waveforms are raw, unprocessed digital data. The digitised waveforms may be stored at the remote digital processor for subsequent analysis.

[0018] The present invention will now be described by way of example only, and with reference to the accompanying drawings, in which:

5 Figure 1 is a schematic representation of a traditional wayside object controller within a signalling system; Figure 2 is a schematic representation of railway infrastructure comprising a wayside object controller in accordance with embodiments of the present invention within a signalling system;

10 Figure 3 is a flowchart illustrating the steps of a method of operating a railway signalling infrastructure in accordance with an embodiment of the present invention; and

15 Figure 4 is a flowchart illustrating the steps of a method of operating a railway signalling infrastructure in accordance with a further embodiment of the present invention.

20 **[0019]** The embodiments of the present invention take the approach that rather than using a wayside object controller to collect, analyse and send data, the data analysis may be done remotely. There is no need to include a digital processing unit within the wayside object controller since a digital communication link may be
25 utilised to send and receive raw digitised waveforms directly to an interlocking or diagnostics terminal rather than the pre-processed data transmitted by and to a traditional wayside object controller. The railway wayside object controller may therefore comprise only an analogue
30 signal processor adapted to send and receive analogue data relating to the operation of the trackside equipment and a signal converter coupled to the analogue signal processor and adapted to convert reversibly
35 between digitised waveforms and analogue signals. In addition, an upgraded digital communications interface connected to the signal processor and adapted to transmit digitised waveforms to a remote digital processor is provided, enabling the digitised waveforms to be sent
40 directly to a remote digital processing unit.

[0020] Figure 2 is a schematic representation of railway infrastructure comprising a wayside object controller in accordance with embodiments of the present invention within a signalling system. A railway wayside object
45 controller 20 comprises an analogue signal processor 21, which is adapted to send and receive analogue data relating to the operation of trackside equipment 22. The wayside controller 20 also comprises a signal converter 23 coupled to the analogue signal processor 21 and
50 adapted to convert between digitised waveforms and analogue signals. A digital communications interface 24 is connected to the signal processor and adapted to transmit digitised waveforms to a remote digital processor 26. The analogue signal processor 21 comprises at
55 least one I/O port (not shown) adapted to connect to an item of trackside equipment 22, such as a set of signals. The digital communications interface 24 is adapted to connect to a communications network 25, which may be a

cellular communications network, a radio communications network, an ethernet link, a serial communications link or a parallel communications link. In general, since an existing wayside object controller will have an ethernet connection, this will be utilised by a wayside object controller 20 of the embodiments of the present invention. In any case, the communications network 25 chosen will have sufficient bandwidth to transmit the raw, unprocessed digitised waveforms. The trackside equipment 22 is located at a railway track and connected to the wayside object controller 20. A digital processor 26 is located remote from the trackside equipment 22 and railway wayside object controller 20. This digital processor 26 is adapted to analyse the digitised waveforms received from the railway wayside object controller 20 and output digital data that has been processed and analysed, for example, by debouncing signals, monitoring power levels, ensuring waveforms meet required specifications and generating diagnostic data streams. An interlocking 27 is provided that is adapted to receive the digital data from, and to transmit digital data to, the digital processor 26. The digital processor 26 may be located with the interlocking 27, in a relay room or signal centre. Alternatively, where the interlocking 27 is implemented in a cloud computing environment, the remote digital processor 26 and/or the interlocking 27 are part of a distributed computing system. This would be the case with the DS3 implementation of Siemens' WESTRACE Mk II available at www.siemens.com, whereby railway traffic management systems, such as signalling, are operated within a cloud computing environment.

[0021] A diagnostics terminal 28 may also be included within the railway infrastructure. This enables an engineer to review digital data provided by the digital processor 26, either in a pre-analysed format or in the digitised waveform format provided by the signal converter 23. The digital processor 26 creates a diagnostic data stream that reflects the condition of the trackside equipment 22, since fluctuations in the digitised waveforms indicate power and voltage variations in the input and output of the wayside object controller 20. The diagnostics terminal 28 is also located remotely from the trackside equipment 22 and the wayside object controller 20, and may itself also be a cloud implementation along with the interlocking 27.

[0022] As described above, the analogue waveforms comprise voltage signals and power signals relating to the trackside equipment 22. For some trackside equipment, the voltage signals comprise DC signals, and for other trackside equipment, the voltage signals comprise AC signals. The signal converter 23 samples the analogue waveforms input to it by the analogue signal processor 21 to determine whether incoming signal is AC or DC before digitalisation. Conversely, when digital signals are received from the digital processor 26, the signal converter 23 converts these to an analogue signal which is output by the analogue signal processor 21 to the trackside equipment 22. The digitisation process follows a

standard methodology to produce digital signals depending upon the required sampling rate (and so, for example, may be done using a Successive-Approximation Approach SAR, a Delta Sigma $\Delta\Sigma$ approach or a Pipeline approach). For the reverse process of converting the digital data received from the remote digital processor 26, a standard methodology such as Direct Digital Synthesis (DDS) may be used. The signal converter 23 is therefore provided with both ADC (analogue-to-digital) and DAC (digital-to-analogue) conversion capacity, and is able to convert signals reversibly depending on the signal type.

[0023] The digital communications interface 24 is used to both transmit digitised waveforms in a raw, unprocessed state representing either trackside equipment 22 operations data and receive digital data representing trackside equipment 22 instructions. Incoming digital data contains information sent by the interlocking 27 for an event that is required for the operation of the trackside equipment 22, such as movement of points. This is converted to analogue signals by the signal converter 23 and output by the analogue signal processor 21 to the trackside equipment 22. For example, incoming digital data may contain instructions to move a set of points, or to illuminate a lamp in a set of signals. The analogue information received from the trackside equipment 22 by the analogue signal processor 21 may be the confirmation that this event has occurred, which when digitised is transmitted back to the interlocking 27. These processes will now be described in more detail.

[0024] Figure 3 is a flowchart illustrating the steps of a method of operating a railway signalling infrastructure in accordance with an embodiment of the present invention. The method 300 begins, at step 302, by sending the instructions for the operation of trackside equipment 22, comprising digital data, from an interlocking 27 to a remote digital processor 26. Next, at step 304, using the digital processor, the digital data is transmitted to a digital communications interface 24 at the railway wayside object controller 20. At step 306, the digital data received by the digital communications interface 24 is converted to analogue data by the signal converter 23. Finally, at step 308, using the analogue signal processor 21, the analogue data is transmitted to the trackside equipment 22. This analogue data sent by the analogue signal processor 21 actuates trackside equipment.

[0025] Figure 4 is a flowchart illustrating the steps of a method of operating a railway signalling infrastructure in accordance with a further embodiment of the present invention. The method 400 begins, at step 402, by receiving analogue data from trackside equipment 22 at an analogue signal processor. Then, at step 404, the analogue waveforms are converted into digitised waveforms at the signal converter 23. Once in a digitised format, at step 406 the digitised waveforms are transmitted from the digital communications interface 24 of the railway wayside object controller 20 to a remote digital processor 26. Here, the digitised waveforms are received in their raw,

unprocessed state, and at step 408, are analysed by the digital processor 26, for example, to debounce the signal and determining if the received digitised waveforms meet certain criteria. Finally, at step 410, the analysed digital data is sent to an interlocking and/or a diagnostics terminal.

[0026] The use of the embodiments described and shown in Figures 3 and 4 in relation to moving a set of points will now be described as an example of how the embodiments of the present invention function. A route called by a signaller at an interlocking 27 located remote from the railway will require the use of trackside equipment to ensure that a train is able to travel the route safely. As part of an example route, it is necessary to move a set of points *P* from a first position to a second position to enable a train to cross a junction on the railway. When the signaller calls the route, the interlocking 27 generates the digital data required to move the set of points *P*. However, since the set of points *P* require voltage signals locally to be able to move, the embodiment of the present invention illustrated in Figure 3 is used first. The instructions, in the form of digital data and sent from the interlocking 27 via the remote digital processor 26 over a communications network 25 to a digital communications interface 24 located at the wayside object controller 20. The communications network used is an ethernet network connection, but other network connections, including cellular connections, may be utilised instead. Once received at the digital communications interface 24, the instructions are converted to an analogue signal using a standard DAC methodology such as DDS at the signal converter 23, creating an analogue waveform version of the original digital instructions to move the set of points *P*. The analogue signal processor 21 outputs these analogue signals via a direction connection between one of its I/O ports and the set of points *P*. The voltage signals cause the set of points *P* to move from the first position to the second position as required.

[0027] However, the interlocking 27 requires confirmation that the set of points *P* have moved. This is where the embodiment of the present invention as shown and described in Figure 4 is used. The analogue signal processor 21 will receive an analogue waveform of voltage information indicating that the set of points *P* has moved as part of the standard operation of the set of points *P*. This waveform is then converted to a digitised waveform using a standard ADC method at the signal converter 23. Once digitised, the waveform is transmitted by the digital communications interface 24 over the communications network 25 to the remote digital processor 26. The bandwidth of the communications network is sufficient to transmit the raw, unprocessed digitised waveform to the remote digital processor 26. Once received, the remote digital processor 26 processes the digitised waveforms to produce analysed data such as debouncing signals, monitoring power levels, ensuring waveforms meet required specifications and generating diagnostic data streams from the raw data generated by the set of

points *P*. The analysed data also comprises details of the confirmation from the set of points *P* that they moved from the first position into the second position. This confirmation is fed back to the interlocking 27, enabling the route setting to continue.

[0028] However, if the set of points *P* do not move from the first position to the second position or become stuck, then the voltage levels and power data fed back to the analogue processor 21 will indicate this. Whilst this information may be passed back to the diagnostic terminal 28 and analysed by the remote digital processor 26 in the same way as confirmation data, it is also possible that the raw, unprocessed digitised waveforms can be passed to the diagnostic terminal 28 via the remote digital processor 26. By passing data through without processing, the diagnostic terminal 28 can be used to examine the analogue waveforms showing the actual status of the set of points *P* without any risk of data being distorted or delayed. Furthermore, the digitised waveforms may be stored in their raw, unprocessed state by the remote digital processor 26 or an associated memory, and accessed as and when required using the diagnostic terminal 28.

[0029] The embodiments of the present invention described above offer several advantages when compared to traditional object controllers. The digital processing is off-loaded to a remote and preferably centrally located processor, bringing the ability to reduce unit costs, installation costs and power requirements. Each wayside object controller in accordance with the embodiments of the present invention requires less equipment having stringent requirements for use in harsh environments (such as temperature ranges, electromagnetic compatibility, environmental requirements) as well as fewer bespoke hardware items. Typically, there are tens of wayside object controllers per interlocking, therefore using a single remote digital processor centralised to the interlocking in a more benign environment means that far less expensive hardware may be used, particularly if a cloud implementation is considered. This provides an opportunity to use COTS (Commercial Off The Shelf) hardware at a much lower cost than previously possible. The other advantage of requiring less hardware trackside is that the size of the wayside object controller may be reduced, meaning smaller enclosures and less heavy engineering required for foundation building and installation. The IP rating of the wayside object controller can also be increased due to the reduction in hardware, as heat and power dissipation are also reduced. This may also reduce the size or number of housings or protective enclosures required, as well as the need for ventilation and additional weatherproofing. The power requirements for the wayside object controller are reduced as there is no local data processing being carried out. Aside from reducing the environmental impact of signalling in general, this opens up the possibility of using alternative energy sources such as solar or wind power rather than a grid connection to power the wayside object controller. Hard-

ware reliability is improved due to reduced component complexity, and as traditional wayside object controllers already have a functioning communication link the change of data type transmitted over this link does not impact negatively on reliability. The diagnostic potential of the embodiments of the present invention are greatly improved as, as outlined above, the raw data obtained from trackside equipment in the form of the digitised waveforms can be stored for retrospective and/or offline analysis.

Claims

1. A railway wayside object controller, comprising:

an analogue signal processor adapted to send and receive analogue data relating to the operation of trackside equipment;
a signal converter coupled to the analogue signal processor and adapted to convert reversibly between digitised waveforms and analogue signals; and
a digital communications interface connected to the signal converter and adapted to transmit digitised waveforms to a remote digital processor.

2. A railway wayside object controller as claimed in claim 1, wherein the analogue signal processor comprises at least one I/O port adapted to connect to an item of trackside equipment.

3. A railway wayside object controller as claimed in claim 1 or 2, wherein the digital communications interface is adapted to connect to at least one of a cellular communications network, a radio communications network, an ethernet link, a serial communications link or a parallel communications link.

4. A railway signalling infrastructure, comprising:

trackside equipment located at a railway track;
a railway wayside object controller as claimed in any of claims 1 to 3 connected to the trackside equipment;
a digital processor remote from the trackside equipment and railway wayside object controller and adapted to analyse the digital waveforms received from the railway wayside object controller and output digital data; and
an interlocking adapted to receive the digital data from and transmit digital data to the digital processor.

5. A railway signalling infrastructure as claimed in claim 4, wherein the analogue signals relating to the trackside equipment comprise voltage signals and power

signals.

6. A railway signalling infrastructure as claimed in claim 5, wherein the analogue data sent to the analogue signal processor actuates trackside equipment.

7. A railway signalling infrastructure as claimed in claim 4, further comprising a diagnostics terminal adapted to receive the digital data from the digital processor.

8. A railway signalling infrastructure as claimed in claim 7, wherein the digital signal from the digital processor comprises a diagnostics data stream reflecting the condition of the trackside equipment.

9. A railway signalling infrastructure as claimed in any of claims 4 to 8, wherein the remote digital processor is located with the interlocking.

10. A railway signalling infrastructure as claimed in any of claims 4 to 8, wherein the remote digital processor and/or the interlocking are part of a distributed computing system.

11. A railway signalling infrastructure as claimed in any of claims 4 to 10, wherein the digitised waveforms are raw, unprocessed digital data.

12. A method of operating a railway signalling infrastructure, comprising:

sending instructions for the operation of trackside equipment, comprising digital data, from an interlocking to a remote digital processor;
transmitting, using the digital processor, the digital data to a digital communications interface at a railway wayside object controller;
converting, at a signal converter, the digital data received by the digital communications interface to analogue data; and
sending, using an analogue signal processor, the analogue data to the trackside equipment.

13. A method of operating a railway signalling infrastructure, comprising:

receiving analogue data from trackside equipment at an analogue signal processor;
converting, at a signal converter, the analogue waveforms into digitised waveforms;
transmitting the digitised waveforms from a digital communications interface of the railway wayside object controller to a remote digital processor;
analysing the digitised waveforms at the digital processor; and
sending the analysed digital data to an interlocking and/or a diagnostics terminal.

14. Method as claimed in claim 13, wherein the digitised waveforms are raw, unprocessed digital data.
15. Method as claimed in claim 14, wherein the digitised waveforms are stored at the remote digital processor 5 for subsequent analysis.

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FIG 1

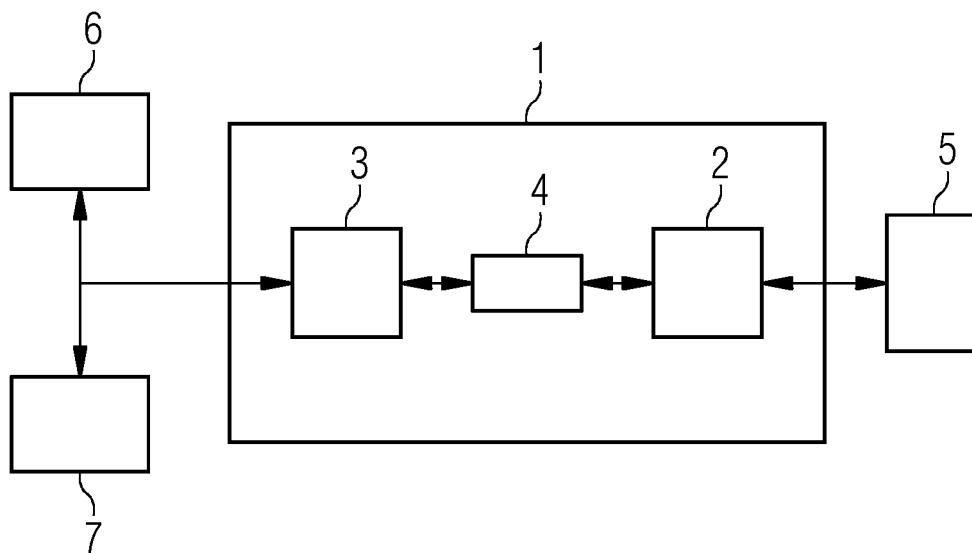


FIG 2

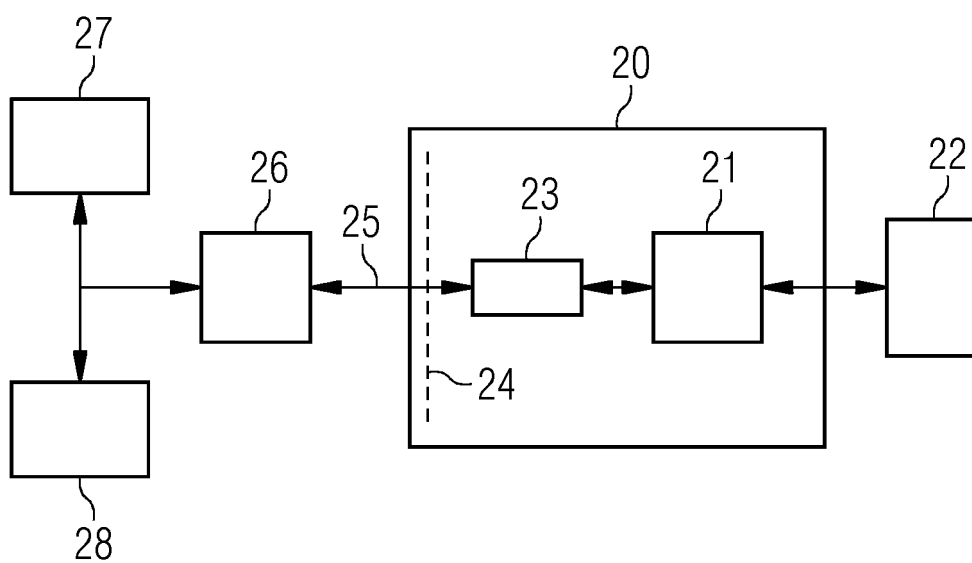


FIG 3

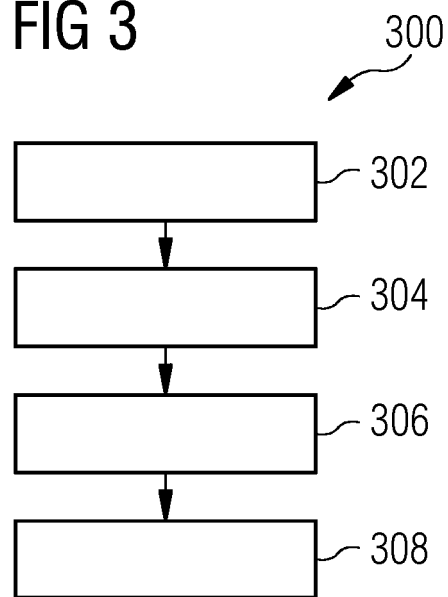
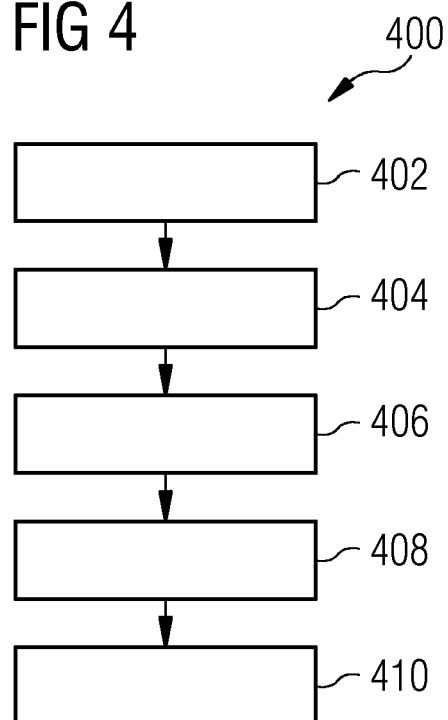


FIG 4





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