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(71) Applicant: **ALSTOM Transport SA**
92300 Levallois-Perret (FR)

(72) Inventors:
- **Rizzo, Antonio**
40033 Casalecchio di Reno (BO) (IT)
- **Aisa, Pier Alessandro**
40057 Granarolo Emilia (BO) (IT)

(74) Representative: **Karaghiosoff, Giorgio Alessandro**
Studio Karaghiosoff e Frizzi S.r.l.
Via F. Baracca 1R 4° piano
17100 Savona (IT)

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(54) System for communication with trains on railway lines

(57) A system for detection of trains and digital communication with trains on a railway line with at least one track, which track is divided into a plurality of successive track segments, known as track blocks, and means for generating signals for detection of or communication with the train being provided for each of said track segments and receiving means allowing the track block to receive said detection and communication signals generated by a train by active signal generation or change of the detection and communication signals transmitted to the track block as well as means for processing the detection signals or the communication signals received from the track block to determine the operating or working conditions of the train and/or the track block based on the changes found in the received signals with respect to the transmitted signals and/or on the information contained in the communication signals transmitted by the train and means for generating signals indicative of the operating or working conditions of the train and/or the track block and for transmitting said status signals to a central railway network control unit, known as central Interlocking System, which is connected to said detection and communication unit and receives signals therefrom, indicative of the conditions of the train and/or the track block, and transmits control signals for detection of and communication with the train.

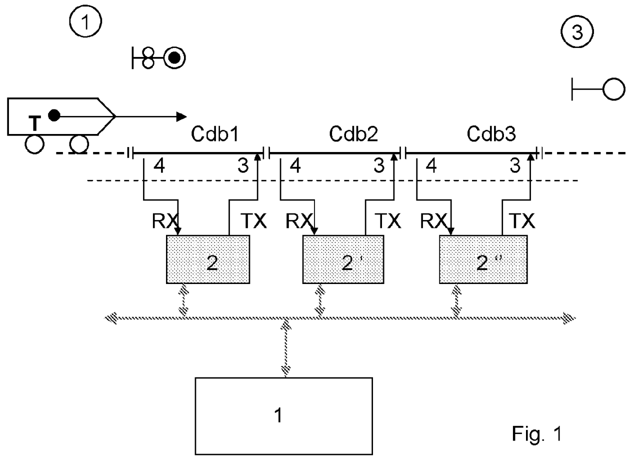

Fig. 1

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Description

[0001] The invention relates to a system for communicating with trains on railway lines, which system comprises the combination of features according to the preamble of claim 1.

[0002] Train detection systems are known in the art, as disclosed for example in a prior patent application by the applicant hereof, with publication number EP 1338492. This train detection system is known as track circuit. The track of a railway line is divided into a plurality of segments. Each segment, known as block, has a unit associated therewith, with a transmitter and a receiver designed for alternate connection to each other and to one of the two opposite ends of a corresponding track segment. One signal is injected by the transmitter to one end of the track segment and is received at the opposite end thereof. The transmitted signal has predetermined and appropriately defined frequency, amplitude and coding characteristics wherefore, when a train is present on the track segment, the short circuit between the rails of the track segment caused by the train axles causes a change, particularly a reduction of the signal and allows train detection.

[0003] Further prior art systems are the so-called axle counters, which include sensors for detecting the axles of a train passing a block.

[0004] In yet other systems the track and the segments are used for communication of messages between the train and the wayside unit and vice versa.

[0005] All the above prior art systems include electronic operating units, which are basically of hardware type and have a dedicated, special-purpose construction designed for the specific function thereof. For example, concerning the track circuits and as disclosed in the above document with publication number EP 1338492, whose information content is integrated herein by reference, the operating units of the track circuit located at the track, i.e. the trackside or wayside units, include all the sections required for their operation. Particularly, these operating units include track segment interface sections and diagnostic sections, as well as sections for generating the signals to be transmitted and for processing the receive signals and sections for communicating with the central railway traffic management unit, i.e. for transmitting train presence data to said central management unit and for receiving controls from said central management unit.

[0006] Document EP0771711 discloses a Audiofrequency track circuit with data transmission (digital TC) transceiver interface.

[0007] Also, still concerning the track circuits, various construction types are known, which are used in different systems, each involving specific advantages and drawbacks.

[0008] Thus, for example, in certain track circuits, the joint that connects the receiver and the transmitter to the track segment is controlled by a switch that, depending on the expected train direction, selects the transmitter end of the track segment, and consequently the receiver end, thereby actually defining a signal propagation direction within the track segment. These joints, known as directional joints, allow the use of acoustic or pulse signal coding techniques. The units, that are specially designed to operate in one of the above mentioned modes, cannot operate in other modes wherefore specific dedicated operating units have to be provided for each track circuit type, that have track interfacing heads with a construction specially dedicated to the particular signal coding and transmission mode and especially include the sections for generating the signal to be transmitted and for processing the received signal, which sections are constructed in accordance with the techniques used for coding and decoding or processing said signals for retrieval of train presence information. As a result, any technological modification to a railway line requires either the maintenance of the existing track circuit technology to avoid replacement of the operating units or the replacement of the operating units for adaptation to the new track circuit technologies, the latter option involving the replacement of parts of these operating units that might be used even in combination with the new track circuit technologies.

[0009] Furthermore, each of the various track circuit types have particular characteristics that make it more or less suitable to use in different operating, wear or degradation conditions of the track segments. In prior art, once a track circuit type has been selected and the operating units dedicated to the selected track circuit type have been installed, the operating mode of the track circuit cannot be changed unless the operating units are also replaced. Such replacement would involve cost drawbacks, and be unfeasible due to time constraints. Nevertheless, in certain cases, for instance in case of oxidative rail degradation, impulsive track circuits should be used, which ensure lower signal attenuation.

[0010] The operating conditions of the track can also depend on weather. Whole short weather variations might be neglected as transient events, there are climatic zones in which weather effects, such as rain, snow and ice are of seasonal nature and remain for a relatively long period of time, while being still of short duration when considering the time and costs required for shifting to train detection technologies other than those in use and particularly suitable for those weather conditions. It shall be further noted that, at the end of one season, a new season follows, with weather conditions changing again.

[0011] Yet another drawback of prior art track circuits is that each operating unit is connected independently of the others to the track and the central railway traffic management unit, i.e. the interlocking computers. This requires considerable costs in terms of both materials and installation.

[0012] The structural rigidity of the modes of the operating units associated with the track circuits is a constraint especially when adapting and maintaining existing lines, but also when making new lines having devices or systems from different manufacturers to be combined together, in which the selection of operation and construction technologies depends on tradition.

[0013] Track circuit types are also known in which the joints for connection of the transmitter and the receiver of the operating units are of non-directional type and the signal injected into the track circuits propagates in both directions.

[0014] Here again the operating units are constructed with a structure and an architecture dedicated to their intended tasks and namely to the track interfacing modes.

[0015] Concerning the track circuits, there exist a number of variants thereof, mostly including:

Jointless Audio Frequency ,
Mechanical Joint Low Frequency;
Mechanical Joint Impulsive.

[0016] A further drawback concerning all track circuits is that the controlled track sections cannot be longer than about 2 km. Even at such length, track sections require the provision of capacitors arranged along the track segment with the purpose of compensating for signal energy loss.

[0017] Furthermore, any failure or malfunctioning of an operating unit or a track circuit requires the track circuit and/or the corresponding operating unit to be restored, because the malfunctioning or damage condition triggers a restrictive signal for the corresponding track circuit, i.e. a train presence condition, which signal is transmitted to the traffic management unit. Here, if no replacement operating unit is available, then the corresponding track circuit will be idle, wherefore either it will be forced into a permissive condition or it will always indicate a malfunctioning condition.

[0018] Concerning the other units, such as the axle-counters and the track to train communication sections, these have substantially the same problems as the track circuits. Furthermore, if several different train detection systems are required to be simultaneously present on the same railway line, i.e. on the same track, e.g. particularly at least one track circuit, at least one axle counter and/or at least one system for exchanging messages from and to the train, a full operating unit is required in prior art for each of these systems, as many operating units being required as there are track segments or blocks.

[0019] Therefore, considering for example the above mentioned systems, hardware requirements will be three times as great, and this will generate problems both in terms of implementation times and costs and in terms of space requirements for the installation of operating units.

[0020] Thus, the object of the invention is to improve a system for communication with trains on railway lines in view of overcoming the above drawbacks without requiring any cost increase, while further simplifying and enhancing the efficiency of the general system architecture, towards a more flexible configuration of the communication methods being used.

[0021] The invention achieves the above purposes by providing a system for communication with trains on railway lines according to the preamble of claim 1, further comprising the combination of features of the characterizing part of claim 1.

[0022] As used in the present disclosure and claims, the term train detection system is not only intended to mean the track circuit that is used to detect the presence or absence of a train on a track block, but also any type of device or system adapted to receive feedback from a train on a track, which train passes the successive track segments that form the track. Particularly, the term train detection also includes axle counting devices and devices for communication with the train and transmission of messages to the train.

[0023] Therefore, according to the present invention, traditional operating units include, on the one hand, units designed for direct connection to the track and allowing interfacing with the track and transmission and reception of signals having a well determined structure and organization. On the other hand, central processing and control units are provided which also carry out the tasks of prior art operating units, i.e. define the structure of the signals to be transmitted, the detection result by processing the received signals, such as the presence/absence of the train on a given track block and/or the number of axles or even define the content of the messages to be transmitted to the train.

[0024] While the block interface units, interfacing with the individual track segments, substantially include controllable transmitter and receiver units and are hardware-based, the processing and control units are formed of a combination of hardware and software, including a computer with at least one program stored in its memory, to be executed by such computer, thereby forming a hardware/software operating unit adapted to accomplish the tasks of the processing and control units, required for determining the structure of the signals to be transmitted and the content of any messages to be transmitted, controlling the block interface units to transmit and receive and decode or extract information from the received signals.

[0025] Therefore, concerning the various train detection methods, the operating tasks involved in these methods are introduced in the processing and control units by the software which changes according to the method being used, whereas the hardware part for software processing and execution is substantially the same and the track interface units are substantially the same and are dedicated to the pitch of signal injection and extraction from and into the track.

[0026] Communication between the interface heads, i.e. the track interface units and the processing and control units advantageously relies on a communication network, with the interface heads and the processing and control units being connected thereto, each of them being identifiable by a unique ID code.

[0027] Therefore, thanks to the invention, one processing and control unit hardware configuration and a few specific interface hardware units will allow construction of several different train detection devices, such as a track circuit, an axle counter and/or a track to train communication unit, by simply providing different software programs to be executed by the processing and control unit, each of which software programs causing the processing and control unit to perform the typical tasks of one of the various train detection devices.

[0028] Particularly, considering the above train detection devices, one hardware configuration may be also provided for the track segment interface units, particularly in the form of signal transmitting and/or receiving units.

[0029] However, concerning the various track circuit variants, for example, here again the processing and control unit can perform the tasks of said different track circuit variants by executing a corresponding software program.

[0030] The flexibility of the present system, owing to the implementation of the tasks of train detection devices at software level, the device consisting of the combination of hardware and executable software, and also considering the combination with track interface units, whose tasks are limited to communication with the track and whose configuration is reduced to a minimized number of parts, provides further advantages.

[0031] A traditional train detection device construction may be provided, for example, in which each track segment comprises at least one interface unit and at least one processing and control unit for each interface unit with a track segment associated therewith.

[0032] Otherwise, one processing and control unit may be arranged to cooperate with multiple interface units, each associated with one or more blocks, i.e. track segments.

[0033] In both cases, the processing and control units may execute several different processing and control software programs, each being designed to cause the operation of the processing and control unit according to a different type of detection device and particularly a different type of track circuit.

[0034] In one practical example, for instance, a track segment has a track circuit associated therewith with pulse signal operation and, in the variant in which each interface unit has its own dedicated processing and control unit, a processing and control program for performing the tasks of an operating unit of a track circuit with pulse signal operation is stored in this processing and control unit. However, the track circuit for another track segment, e.g. an adjacent track segment, may be for example of the low frequency or jointless audio frequency operation type, wherefore a corresponding processing and control program is stored in the processing and control unit, whereby such processing and control unit performs the tasks of a track circuit of the low frequency or jointless audio frequency type.

[0035] Likewise, the above also applies to the case in which certain track circuits have an additional interface unit which is designed to form, in combination with the processing and control unit and a corresponding software program executed by such unit, an axle counting device or a track to train communication device. When this is possible, instead of providing two or more different track interface units for two or more different detection devices or track circuits, a common interface unit is provided. For injection of signals into a track segment and reception of signals existing on the track segment irrespective of the information to be transmitted or extracted from the signals, identical interface units can be used, the different tasks associated with the type of signal being transmitted, such as a particular coding or modulation of the signal transmitted to the track or a particular processing of the signal received for extracting the requested information being implemented in the processing and control software program executed by the processing and control unit.

[0036] The above described practical configuration example, in which each interface unit associated with a track segment has a dedicated processing and control unit associated therewith also applies to the variant in which a processing and control unit is associated with or serves multiple interface units, each associated with one of multiple track segments.

[0037] The above mentioned possibility of switching among several variant track circuit types by simply providing a different processing and control software program to be executed by the processing and control unit, which causes said unit to perform the typical tasks of the selected track circuit type, allows the track circuit to be adapted to the changing conditions of the track segments and possibly to the various conditions of operation of the track circuits, namely to weather conditions.

[0038] By simply using a different processing and control program, which implements the tasks of a different track circuit type or a different detection device type, a track circuit type and/or a detection device type may be set for each track segment and each weather condition to best suit the specific conditions of the track segments and/or the weather conditions.

[0039] Thus, for example, track circuits with pulse signal coding should be used in case of highly oxidized tracks, whereas other track circuit types that use different signal coding techniques and different signal frequencies can be more advantageous in case of heavy rains.

[0040] Advantages especially derive from an implementation of the different types of track circuit or train detection device that essentially consists in the storage and execution of a different processing and control software program, wherefore the system can be realistically and simply adapted to weather conditions, i.e. to short-duration changes of the operating conditions.

[0041] Particularly, if one processing and control unit is associated with multiple interface units of multiple track segments, then ascertained malfunctioning conditions of certain track circuits may be corrected. With common control of multiple track circuits, an operating fault of a damaged track circuit can be hidden and corrected at the processing and control unit. Hazards are obviously associated with the above arrangement, wherefore a parallel diagnostics system has to be provided to particularly make sure that a false train detection on a track segment is actually caused by malfunctioning of the corresponding track circuit.

[0042] In this case, a remedy action might consist in merging the damaged track circuit with the adjacent track circuit, and using the train presence or absence indication obtained from the correctly operating track circuit as an indication for the track segment associated with the damaged track circuit.

[0043] The wrong indication of the malfunctioning track circuit is thus hidden in a safe manner, without causing traffic interruptions either before or during repair of the damaged or malfunctioning track circuit.

[0044] The invention relates to further characteristics and improvements which form the subject of the dependent claims.

[0045] The characteristics of the invention and the advantages deriving therefrom will appear more clearly from the following description of a non-limiting embodiment which is illustrated in the accompanying drawings, in which:

Figure 1 shows a block diagram of the architecture of the system of the present invention.

Figure 2 shows a block diagram of the architecture of a train detection operating unit of the present invention.

Figure 3 shows a block diagram of the system in two possible variants of the present invention, in which the left half includes a processing and control unit for each interface unit or head, and the right half includes a processing and control unit that serves multiple interface units or heads.

Figure 4 shows a more detailed block diagram of the structure of the processing and control unit, according to the variant in which said processing and control unit serves multiple interface heads.

Figure 5 shows a block diagram of the processing logic section.

Figure 6 shows a block diagram of the transmitter module of the processing and control logic subsection.

Figure 7 shows a block diagram of the receiver module of the processing and control logic subsection.

Figure 8 shows a block diagram of the interface unit or head.

Figure 9 is a block diagram of the field interface.

Figures 10 and 11 show the block diagrams of the vital receiver and the AD converter of said field interface.

Figure 12 shows a block diagram of the structure of a track interface.

Figure 13 shows a block diagram of the track elements.

Figure 14 shows a block diagram of a coding example, using a track circuit type with non directional joints using DSSS signal coding.

[0046] Referring to Figure 1, a system for train detection, i.e. for occupancy detection in a railway line, or the like, and for digital communication with trains running along said railway line comprises at least one track that forms the railway line and is divided into a plurality of successive galvanically insulated segments having a predetermined length, known as blocks, which track segments form, in combination with the control and monitoring subunits 2, 2' , 2", an element named track circuit. In Figure 1, track circuits are indicated as Cdb1, Cdb2 and Cdb3. These track circuits use rails to send the signals that allow train detection on the corresponding track segment, and to communicate with a train. Moreover, the signals sent to each track segment may be used to detect any track failures or damages.

[0047] The system includes a central management and control unit, designated by numeral 1 and indicated as TDM. This management unit generates control signals to execute procedures for detection of a train T and/or procedures for communication with a train on said track and/or to execute diagnostic procedures and transmits them to the control and monitoring subunits 2, 2' , 2' ' associated with each track block or segment and forming therewith the track circuit Cdb1, Cdb2 and Cdb3. The subunits 2, 2', 2 " are operating units that are designed to execute the procedures for detection of the train T within the associated block, the communication procedures and/or the diagnostic procedures and transmit the control signals, i.e. the detected information about the presence or absence of the train T within the corresponding block and/or about proper communication being established with the train and/or the diagnostic signals relating to the track circuit to the central control and monitoring unit. Each control and monitoring subunit 2 is associated with each corresponding block to form a train detection device in the form of a so-called track circuit Cdb1 Cdb2 and Cdb3, and is connected to the terminal ends thereof by means of a transmitter 3 and a receiver 4. Each subunit 2 and its respective block, i.e. track segment associated therewith are uniquely identified by a predetermined identification code.

[0048] Namely, the subunits 2, 2', 2 " named TDH are of the type designed to operate in insulated double-rail track circuits. In this type of tracks, both rails are mechanically interrupted, and traction power is returned by inductive connections.

[0049] The control and monitoring subunits 2 are designed for use on two-direction track circuits and, to this end, a signal transmission reversal feature is provided to propagate train detection signals and coded communication signals in the direction opposite to the train running direction.

[0050] A train is detected by injecting a fixed current signal into each track circuit, i.e. a signal having a fixed current level once it is decoded. The signal transmitted by the transmitter to the track circuit towards the receiver in a direction opposite to the train running direction is received if no train is detected. When a train is present, the rails are shortcircuited by the train itself, and the receiver is not reached by any signal.

[0051] The control and monitoring subunit 2 can handle (transmit/receive/acknowledge) the following signals:

codes;
"fixed frequency" signal, which is used to obtain the occupied/unoccupied function when no code is provided (no path or routing).

[0052] The track circuit is coded by interrupting a carrier frequency a predetermined number of times per minute (amplitude modulation). This application uses four code types. These types are obtained by using a 50 HZ carrier interrupted 75, 120, 180 or 270 times a minute (the corresponding code is indicated by the number of interruptions per minute).

[0053] A nine code coding may be also used. In this case, the above mentioned PWM coded signal may be added or superposed to an additional signal derived by an identical PWM modulation of a carrier having a different frequency, i.e. a carrier of 100 to 200 Hz, particularly of 178 Hz.

[0054] The characteristics of the Fixed Current (CF) train detecting signal must ensure the maintenance of safety conditions even when insulation losses occur at the joints between adjacent track circuits. A track circuit architecture according to an embodiment that will be described in greater detail hereafter includes a transmitter for each track circuit, connected via the operating unit 2, 2’, 2" to the central railway traffic management unit 1. A modulation is introduced in the CF signal, which is different between adjacent track circuits and is adapted to ensure safety conditions even when power is transferred from one track circuit to the following one.

[0055] A possible solution that is also used in prior art, provides different CF signals (4 sets) to be appropriately allocated to track circuits so as to ensure that there is not the same signal on adjacent track circuits. In all sets, the signal is composed of a 50 Hz carrier alternately transmitted in phase and in phase opposition with respect to a hypothetical 50 Hz reference. The sets are differentiated by the time intervals between two successive phase steps. Opposed sections are connected via a 90 ms signal gap, corresponding to 4.5 50 Hz signal periods. By this arrangement, a constant amplitude signal is always provided at the output of a 50Hz tuned pass band filter, ensuring occupancy detection anytime.

[0056] The above constitutes one of the possible signal coding arrangements for the signals transmitted to the track for train detection using the train detection system of the present invention, which is further illustrated in Figure 2. It shall be noted that this architecture is also used with different types of train detection devices or with different track circuit variants. These variants are differentiated by the techniques they use for coding the transmitted signal and for demodulating the received signal to retrieve train detection information as well as by the techniques for interfacing the operating unit 2, 2’, 2 " with the track segment which can also use a non directional joint, that does not impart a unique direction of propagation of the signal transmitted over a track segment between a transmitter and a receiver of the operating unit.

[0057] Therefore, regardless of the specific signal coding technique and of the particular prior art track circuit type as described above, all train detection devices intended in the most general sense as used herein and defined above have the same architecture, particularly as regards the operating unit 2, 2’, 2 " and suffer from the same drawbacks as described in the general introduction hereto.

[0058] Figure 2 shows in greater detail the block diagram of the train detection system of the present invention, in which the operating units 2, 2’, 2 " have a different structure.

[0059] According to the present invention, the operating unit 2 is composed of several separate units, that is:

a processing and control unit designated by numeral 10 and named TDM (Train Detection Module);
a track segment interface unit or head designated by numeral 30 and named TDH (Train Detection Head);
and a unit for communication between the above two units 10 and 30, which is provided in the form of a digital communication network, such as an Intranet network or the like and is designated by numeral 20 and named TDN (Train Detection Network).

[0060] As mentioned above, this break-up of the operating units allows the train detection system to have a distributed topology, in which the processing and control units 10 are allocated in a technical room and interact with the track segments via the interface heads 30, i.e. trackside field units, using a typical digital network communication protocol through a communication network designated by numeral 20.

[0061] This architectural decomposition also causes the tasks carried out by the traditional operating units to be distributed among the various processing and control units 10 over the communication network 20 and the track interface units or heads.

[0062] The processing and control unit TDM 10 is a section that provides the processing platform of the train detection system. On the one hand, this unit receives information from the interlocking system, i.e. from the central railway traffic management unit 1 using the communication modules PSCOM 110. On the other hand, the processing and control unit generates the information to be transmitted to the track segments and/or to the train using the interface units or heads 30 and the communication network 20. Furthermore, through the network 20, the processing and control unit 10 receives the signals that the interface units or heads 30 detect from the track segments and transmit thereto, and processes them to identify the occupancy state of a specific track segment, i.e. the presence of a train within the specific track segment or to identify other parameters of the railway system or train, such as the number of axles or to identify the content of messages transmitted by the train through the track. The result of such processing is transmitted by the processing and control unit 10 to the railway traffic management unit 1 through a transmission interface 110. Transmission between the processing and control units 10 and the central railway traffic management unit 1 may be of the type known in the art as for example CAN-BUS or other protocols, which are widely used in transport systems.

[0063] As better explained below, the processing and control unit is composed of a hardware and software combination, the hardware part being of substantially general type and adapted to store and execute several different configuration and task implementation programs. Therefore, these programs include the instructions for the hardware part, for the processing and control unit to carry out the above specific tasks, which depend on the type of train detection device being used, i.e. specifically corresponding to a particular type of track circuit or axle counter or track to train communication system. By this arrangement, the processing and control unit exhibit a very high flexibility, and the detection system features may be changed in very short times and at very low costs.

[0064] As shown in Figure 3, the architecture may be provided in two general variants. One of these variants is shown on the left of Figure 3 and only implies that the traditional prior art operating units are divided into the operating units as mentioned above.

[0065] Here, at least two interface units or heads 30 are provided for each track segment designed to form a track circuit or a different circuit or device for detection of the train or other operating parameters or conditions of the train and the track segment, and one dedicated processing and control unit 10 is provided for each interface unit or head 30. All the processing and control units 10 communicate via the same communication network 20 with the corresponding track segment interface unit or head. This variant embodiment is defined as Single Track Topology and already provides considerable advantages as compared with prior art architectures.

[0066] Referring to the right side of Figure 3, the broken-down architecture of the system of the present invention provides a variant topology in which one processing and control unit serves and is thus connected with multiple track segments through the corresponding interface units or heads associated with each track segment.

[0067] As mentioned above with reference to prior art, each track segment, and hence each track circuit or other device for detection of or communication with the train including the track segment, is identified by a unique identification code, wherefore the processing and control units 10 and the track segment interface units functionally associated therewith can acknowledge and cooperate with each other without interfering with other pairs of processing and control units 10 and interface units 30 within the system.

[0068] Concerning the interface units, these are dedicated to track management and are located close to the corresponding track segment, or block. The interface units or heads receive control signals from the central or dedicated processing or control unit 10 depending on the selected one of the variants of Figure 3.

[0069] The controls contain information about the signal type that has to be generated and transmitted to the track segment.

[0070] Furthermore, the interface units transmit the signals received from the track segment to the processing and control unit 10 irrespective of whether the latter is a central unit or dedicated, as required by the use of a single-track or multi-track topology respectively, illustrated in Figure 3.

[0071] The connection allowing communication of the interface units 30 with the processing and control unit 10 relies on a digital communication network and shall be deemed an important part of the system architecture, because such communication section provides advantages in terms of system logic and power distribution.

[0072] Concerning the types of train detection devices that can be used with the train detection system of the present invention, these include:

jointless audio frequency track circuits;
low frequency track circuits with mechanical joints
pulse signal track circuits with mechanical joints axle counters.

[0073] The above list is provided for illustration purposes only and shall not be deemed to limit the configuration flexibility of the train detection system of the invention.

[0074] It shall be further noted, for example, that the joints 130 for connection of the track segment interface units may be of directional type, wherefore the track circuit operates like the one known in the prior art and described with reference to Figure 1 in which, depending on the train direction, the signal is injected to either end of the track segment and received at the opposite end of the same track. Otherwise, the track circuit type may include joints 130 with no directional feature, that cause two-way propagation of the signal injected at each block and hence from each interface unit 30 in the track. In this case, the signal transmitted to the track and the signal received therefrom will be coded and decoded in different manners, allowing to precisely and uniquely identify the relation between one component of the received signal and a given track segment.

[0075] The detailed construction of the processing and control units/s 10 is shown in the block diagram of Figure 4. Referring to Figure 4, the processing and control unit

10 has a processing and control section 210 with a two out of two configuration, also known as 2oo2. The processing and control section 110 has two processing logic subsections A and B, designated by numerals 310 and 310', which are connected via an internal bus to respective CPUs A and B, designated by numerals 410 and 410'. The two processing sections 310 and 310' also communicate with each other via a communication line, designated as xport. This port is used for synchronization of processes and exchange of vital data and is part of the 2oo2 platform. Likewise, the two CPUs A and B, designated by numerals 410 and 410', communicate with each other by a serial link line, designated by numeral 510.

[0076] The processing and control section further includes a power supply subsection 510 and a configuration subsection 610 which stores the configuration parameters of the detection devices that the processing and control unit has to use in combination with corresponding interface units 30.

[0077] The processing and control section 210 is connected to a communication interface PSCOM, designated by numeral 110, whereby said section 210 communicates with the central railway traffic management unit 1.

[0078] Furthermore, the processing and control section 210 has network communication interfaces A and B, designated by numerals 710, 710', connected to each of the processing logics 310 and 310'. The processing and control section 210 communicates via the network communication interfaces 710 and 710', through the network 20, with the individual interface units or interface heads 30, each of which is in turn designed to be connected with one of the track segments.

[0079] The CPUs 410 and 410' operate as an interface with a processing platform 2oo2 and manage the information generated by the corresponding processing section 310, 310'. These processing sections may be considered as interface drivers for interfacing with the external sections, i.e. the interface heads 30, and for access thereto for control and signal transmission and reception via the connector sections A and B 710 and 710' .

[0080] The CPUs 410 and 410' communicate with other sections of the processing and control unit 10 using internal bus modules.

[0081] Figure 5 shows in greater detail the structure of the processing sections 310 and 310' that have identical constructions.

[0082] Each processing section 310, 310'.

[0083] One of the relevant subsections is the digital signal processing section named DSP and designated by 311. This subsection is the receiving part of the processing engine and has the following tasks:

- Digital processing of signal flows coming from the interface heads 30;
- Generation of test signals to validate the receiving chains of the interface heads 30;
- Mathematical signal processing (RMS measures, FFT, i.e. Fast Fourier Transform analysis), etc.;
- Determination of the occupancy status of the various track circuits and/or information designed to be detected by a particular train detection device, such as an axle counter or a track to train message communication unit.

[0084] The DSP subsection 311 may execute various signal processing techniques, in the form of software programs to be executed by said DSP subsection and incorporating specific signal processing or treatment steps according to the processing or treatment methods as selected or required for the type of train detection device to be used. Therefore, a memory 311 is connected to the digital signal processing DSP subsection 311, for storage of the processing software or programs to be executed by said DSP subsection 311.

[0085] The other section, also programmable, is the configuration subsection 312 which allows configuration of the interface heads managed by the processing and control section 310.

[0086] Such configuration subsection 312, as well as the digital signal processing DSP subsection 311 communicate via an internal bus with a track to train communication logic subsection, for determining the direction and status of the interface heads, which is designated by numeral 313 and manages the information exchanged with the CPU A and CPU B sections 410, 410' through a communication bus 314. The TDM bus is a bus located in the processing and control unit 10 which manages the communication between modules and subsections, as well as the redundancy of the 2oo2 architecture and the vital protection of messages.

[0087] The management of information exchange by the subsection 313 includes management of message transmission from the interface heads 30 to the train, determination of the direction of propagation of the transmitted signal for each interface head 30 when a directional joint is provided as used in prior art and described with reference to the prior art of Figure 1, and such management further includes the status of the track segment relative to each interface head.

[0088] The interface heads 30 communicate with the processing and control sections 310 via the connector subsections 710, 710' which are in turn connected to the processing and control subsection 310 via a connector interface 315.

[0089] The latter is connected to the subsection 313 via a transmitter module 316 and to the digital signal processing DSP subsection designated by numeral 311 via a receiver module 317.

[0090] The purpose of the transmitter module 316, which is shown in greater detail in Figure 6 is to generate the train detection signal, e.g. including bit message modulation and phase control, to code the information and the messages of the transmit signal to be transmitted to the interface heads 30, to set the direction of propagation of the transmit signal for each interface head associated with a track segment.

[0091] Each transmitter module 316 comprises a main logic subsection 160 whereby it communicates with the track to train communication logic subsection 313 for determining the direction and the status of the interface heads. This main logic subsection 160 of the transmitter manages three subsections having different tasks, i.e. message coding, configuration of the transmit signal to be injected into the track signal, and check of the transmit signal to be injected into the track segment.

[0092] The configuration subsection includes a frequency generator 161 which, in this example, can provide two carriers of different frequencies F1 and F2, giving the symbols bit = 1 and bit = 0 depending on the configuration that has been read by the internal bus of the processing and control module.

[0093] The module 162 generates a FSK (Frequency Shift Keying) type modulation of the signal to be transmitted to the track segment using as an input the message provided by the bus subsystem TDM 314 and using the carrier signals with the frequencies F1 and F2 generated by the generator 161.

[0094] On the other hand, the signal checking module 164 determines the amplitude and phase of the signal transmitted to track circuits and the switching module 165 of the track determines the setting of the transmit signal propagation direction from the setting of the switch that sets the signal input end of the track circuit, when the joint of the track segment interface units is of the directional type.

[0095] The signal at the output of the FSK modulation module 163 is provided to a coding module 166 which adds signal phase and amplitude information to the signal to be transmitted to the track segment, and the signal so coded at the output of the coding module 166 is provided to a network interface 167 wherefrom it is provided to the connection interface subsection 315 for communication with a corresponding interface head 30 through the network 20.

[0096] Fig. 7 shows an exemplary receiver module 317. The receiver module communicates with the digital signal processing subsection 311 via an internal bus and comprises an interface for communication via said bus, designated by numeral 171. On the other hand, the receiver module 317 communicates with the interface heads 13 through the network 20 and via a network interface 172.

[0097] On the one hand, the receiver module transmits test signals to a data coder 174. The signals to be transmitted to the track segment are packed with information about the test signals that are used to certify the operation of the interface heads 30.

[0098] On the other hand, the receiver module receives from the interface head 30 the signals that the latter has received from a corresponding track segment and transmits them, via the network interface 172, to a data decoder 173. Such data decoder processes the signal received from the circuit with information about the recheck signals used to certify the operation of the interface heads 30 and the track occupancy status, whereas a demultiplexing subsection 175 demultiplexes the data from the decoder 173. In the particular example of Figure 6, the demultiplexing operation provides data to the bus interface 171.

[0099] An exemplary structure for the interface units or heads 30 is shown in Figure 8.

[0100] The interface unit 30 includes a field interface 301 for communication with the processing and control unit 10, which comprises the means for performing tasks of signal transmission and reception to and from the track segment; a track interface 302 whereby it communicates via track elements 303 with a track segment or block. The track interface 302 comprises the elements required for interconnection with the track segment, such as the tuning unit, wheel detectors, or the like. The track elements include track or rail parts, such as joints, capacitors and other devices, that are directly mounted to the track or the rails.

[0101] Figure 9 is a block diagram of the field interface 301.

[0102] A subsection 100 named COM has the purpose of managing transmission and reception and of coding and decoding the data flow of communication with the processing and control unit 10.

[0103] More in detail, in this example, the data flow is functionally broken down into the following signals:

- Transmit signals: these are data flows that represent the information used to build or generate the signals to be transmitted or injected to the track segment;
- Test signals: these signals are transmitted and received from the processing and control unit 10 to certify proper operation of the field interface section 301;
- Receive signals: these signals come from the track segment and are the track segment response to the transmit signals. These signals are processed by the processing and control unit 10 to retrieve information about the occupancy state of a track segment.

[0104] The transmit signals are provided to a power driver interface 101 which adapts the signal level and processes the messages from the processing and control unit 10 to control the power amplification subsection 103. This power amplification subsection 103 amplifies AC and pulse signals to ensure compliance thereof with the power requirements for the control of the various track interfaces. Particular advantages can be achieved by the use of a subsection that can dynamically adjust amplitude, frequency and phase of the signal to be transmitted. This section provides a transmit signal portion, named Transmission rechecker, which is designed to be checked by the vital receiver subsection 104. By this arrangement, the transmit signal transmitted to the track segment can be safely checked. The power amplifier 103 receives power from a power section 106 that generates the power amplification signal and converts the power source to be used for the power amplifier.

[0105] The identification key module 105 contains the unique identification key of the track circuit and has the purpose of checking the identity of the field interface.

[0106] The vital receiver provides test signals and receive signals to the processing and control unit 10 and communicates with a diagnostic data acquisition section 107.

[0107] The output of the power amplifier 103 provides the signal to be transmitted to the track segment and to a track switch 108. The latter is also connected to an input of the vital receiver 104, and the receive signal acquired from the track segment is provided to said receiver through it.

[0108] The input and output of the track switch 108 are connected to the track connection interface section on the left side 200 and the track connection interface section on the right side 200' of the track interface 302.

[0109] This block is only used when a Signal to Train feature is required, and the associated feature consists in connecting the transmit and receive signals with the right and left ends of the track segment to transmit information to the train in the direction of propagation towards the train, depending on the train direction over the track. The switch 108 is controlled by the processing and control unit 10 using the transmit signal itself.

[0110] The vital receiver 104 provides vital monitoring of all the parameters required to ensure safe operation of the system. Its main tasks are to acquire and manage the following signals:

- Receive voltage from the track segment (RX_Track signal);
- Adapted transmit signal (TX Recheck signal);
- Test signal used for safe operation of the receiver (TEST_SIGNALS signal);
- Identification key (ID KEY signal);
- Power supply (POWER SUPPLY RECHECK signal);
- Time base and reference voltage for A/D and D/A conversion;
- Diagnostic data (DIAG_DATA signal).

[0111] The vital receiver 104 has the purpose of managing analog to digital conversion of the signals transmitted and received to and from the track segment.

[0112] The safe architecture is based on a MooN platform, where M and N are natural numbers and particularly M = **N =** 2 in the minimum configuration of the present example. In the 2oo2 configuration, each section, each module and each signal are replicated once.

[0113] Figure 10 shows the structure of the vital receiver in greater detail.

[0114] The vital receiver comprises two adders 41, 42. These adders separate the input signals into two individual A/D conversion channels designated by numerals 40 and 40' and particularly separate the signals that come from the track segment TX-TRACK from the check signal TX-RECHECK signal that comes from the power amplifier 103. Also, the adders inject the amplitude test signal by providing an analog addition of the input signal and two test signals (TEST_V1 e TEST_V2) for each A/D conversion channel. An external clock 43 generates an independent time base that is used as a reference frequency for the A/D conversion channels. These channels perform analog/digital conversion of the following signals:

- RX-TRACK 1,2: signals received from the track segment with the test signal used to certify safe operation of the section (signals TEST_V1 and TEST-V2) superposed thereupon.
- TX-RECHECK 1,2: signals coming from the power amplifier 104 with the test signal used to certify safe operation of said amplifier (signals TEST_V1 and TEST-V2) superposed thereupon;
- DIAG DATA: Diagnostic data acquired by the diagnostic section and designed to be transmitted to the processing and control unit 10. These acquired parameters include, for example: temperature of the field interface devices 301, temperature of the track segment, current consumption, noise measures in- and out-of-band;
- IDENTIFICATION KEY: - information about the identity of the section (ID_KEY signal);
- POWER SUPPLY: - Information about the reference power supply values (POWER SUPPLY RECHECK signal);
- TEST_F1 , TEST_F2 : signals used to certify proper A/D conversion.

[0115] The structure of the A/D conversion channels 40 and 40' is shown in Figure 11.

[0116] The ADC analog to digital conversion section 410 and the multiplexer MUX 411 are controlled by a driver unit 412. The following signals are provided at the input of the multiplexer 411:

TEST_F: this signal is generated by the section 414 which receives at its input the signal of the external clock 43 and is used to certify the time base of each analog-to-digital conversion 40, 40';

TEST_PS: this test signal is generated by a power source monitoring section that receives at its input the power source signal;

TX_RECHECK: this signal is used to certify the signals to be transmitted to the track segment and is generated by the power amplifier 103 of the field interface 301 with the adder 41, 42 superposing thereupon the test signal TEST_V1 or TEST_V2 depending on which of the two digital conversion channels is used. The signal produced by the adder 41, 42 is provided at the input of the multiplexer 411 after being filtered by an antialiasing filter 415;

RX_TRACK: These signals are received from the track segment through the track elements 303 and the track interface 302, with the adder 41, 42 superposing thereupon the test signal (TEST_V1 or TEST_V2 depending on the A/D channel being used) and are provided at the input of the multiplexer 411 after being filtered by an antialiasing filter 416.

[0117] A voltage reference signal for the analog-to-digital converter 410 is further provided at the input of the multiplexer. This reference signal is generated by a section 417 that is part of the analog-to-digital converter 410.

[0118] Finally, diagnostic parameters acquired by the diagnostic subsection 107 are provided to the multiplexer 411.

[0119] The test signals TEST_V (i.e. TEST_V1 and TEST_V2 a depending on the A/D channel being used) are generated by two DAC sections 418 that are controlled by the processing and control section 10 using the TEST_V signal to certify safe operation of the analog-to-digital conversion process.

[0120] The analog-to-digital conversion section 410 turns the analog signals from the track segment into digital signals and transmits them through the network interface module 100 and through the network 20 to the processing and control unit 10 once the signals converted into digital form have been coded with the identification key in a section located at the output of the AD converter 410 and designated by numeral 419. Likewise, the test signals TEST V and TEST F are generated from TEST signals that come from the processing and control unit 10 in a section 420 specially designed therefor.

[0121] The track interface module 302 is shown in Figure 13 and consists of the part of the system that is designed to perform the tasks of interconnection with the track in terms of impedance matching and signal level adaptation to the track.

[0122] The present example has been only described with reference to track circuit features. However, when using axle counters and any other different train detection devices, such as devices for communication between the train and a wayside unit, the structure will be modified according to the peculiarities of these devices which are known in their general structure, wherefore adaptation to the system architecture of the present invention is well known to those of ordinary skill in the art, once adaptation has been described for the track circuit, which is one of prior art train detection devices.

[0123] The track interface 302 receives the transmit signals TX-SIGNALS, i.e. the signals to be transmitted to the track segment from the field interface 301 and provides them to the track elements 303 as TX_TRACK signals, after submitting these signals to the following steps:

cable adaptation 500: this step allows impedance matching between the signals provided by the field interface 302 and the cable impedance at which the signals are physically provided to the track to minimize power losses caused by impedance mismatching.

[0124] Galvanic insulation 510: electrical separation between the system and the track and particularly between the track and the field interface and the processing and control unit 10.

Preshunt 520: preshunt prevention features.
Joint impedance matching 530;
Overvoltage protection 540;
Track connection 550.

[0125] These steps are also carried out with the signals received from the RX_TRACK track through the track elements 303 and provided at the input of the field interface 302.

[0126] Concerning the track elements, these are schematically summarized in Figure 14. The track elements physically consist of the components or devices of the system that are located close to the track and are used to balance traction return currents, to compensate for track impedance, to ensure safe operation and to implement electric joints.

[0127] Electric connection with the track rails is provided by an electric receive and transmit joint 600. This joint is used to electrically separate adjacent track segments and balance the traction return current.

[0128] Obviously, the rails 610 that carry the track circuit signals and the traction return signal of the train are also to be considered as a track circuit element and hence as a track element.

[0129] The impedance joint 620 ensures continuity of the return current and ground connection of the rails.

[0130] The compensation capacity 630 allows equalization of the frequency response of the track and affords longer track segments of the track circuits.

[0131] Referring to the communication network 20 between the processing and control unit/s 10 and the track segment interfacing unit/s 30, this is a typical digital connection network that can be of various types and operate according to various protocols.

[0132] Without excluding other types, protocols or architectures of existing and future networks, a star topology is currently preferable for the logic network and possibly also for the power network. Alternatively, the power network may also have a ring topology.

[0133] In the former topology, power distribution and logic connections will be provided by the same cable. If fiber optic is used for logic connection, a mixed cable will be used, comprising the fiber optic cable and a conduction cable for power distribution. However, if different topologies are used for the logic and the power networks, like in the above variant, two separate cables will be provided and the power network will have a power cable laid along the track. A network structure example from the point of view of communication techniques is the ISO-OSI layer model. The network model is preferably, but without limitation, a client/server network model in which the processing and control units 10 act as servers and the track segment interfacing units act as clients. The communication technique is of the message passing type.

[0134] The above description only related to the example of track circuits. As explained above, the structure as described herein will not change in its general form with axle counters and other devices for detection of or communication with a train through the track. Changes or integrations may be required as would be obvious to those skilled in the art.

[0135] It shall be further noted that the above description relates to a specific track circuit example in which, like in Figure 1 showing the prior art, the joint for connection to the track is of the directional type, with signals being always transmitted along the track segments from one end of said segment to the opposite end in a direction opposite to that of the train, so that the transmitted signals propagate towards the train that enters or runs over the track segment.

[0136] The above disclosure and architecture, as well as the division of the operating units into interface units and processing and control units, both being programmable depending on the system configuration and the type of track circuit and signal coding being used, allow the system as described above to be changed to obtain a non directional track connection type. In this case, the signals transmitted to the track segments propagate in all directions and the received signals include various signal components deriving from the signals transmitted to the track segments.

[0137] In order to identify the receive signal associated with a transmit signal for a specific track segment, in this case the transmit signals are coded. First, two different frequencies are used for the transmit signals provided to the track. The transmit signals with the two different frequencies are distributed over the track circuits so that signals with different frequencies, corresponding to these two frequencies, are transmitted to two adjacent track segments.

[0138] Also, the transmit signals with different frequencies are coded, coding being also carried out using two different codes, each of said two codes being only used for coding signals having one of these two frequencies.

[0139] Signal coding is advantageously a Direct Sequence Spread Spectrum (DSSS) or a Frequency Hopping Spread Spectrum (FHSS) coding, allowing determination of the receive signal component associated with a particular track segment by decoding the receive signals through relation with the signal that is deemed to be associated with the relevant track segment.

[0140] The block diagram of Figure 15 shows the above principle, the same reference numerals being used therein to denote the same parts as in the previous figures.

[0141] It will be appreciated that this track circuit variant is obtained, according to the present invention, by only changing the track connection joint from a directional design to a non directional design and by storing a logic processing and control program in the processing and control unit and/or in other programmable units, the execution of which program causes the processing and control unit to operate according to the track circuit variant and a configuration program. This allows the system to be changed as desired by the customer, and as required by the track and weather conditions, by only storing a different processing and control program and without requiring heavy hardware changes.

Claims

1. A system for communication with a train, comprising:

a) a railway line having at least one track, which track is divided into a plurality of successive track segments, known as track blocks;

b) means for generating and transmitting signals for communication with the train being provided for each of said track segments;

c) and means for receiving from the track block said communication signals produced by a train by active signal generation or change of the communication transmitted signals to the track block;

d) means for processing the communication signals received from the track block to determine the operating or working conditions of the train based on the information contained in the communication signals transmitted by the train;

e) means for generating status signals indicative of the operating or working conditions of the train and for transmitting said status signals to a central railway network control unit;, known as central Interlocking System, which is connected to said communication unit and receives signals therefrom, indicative of the conditions of the train;

f) the means for receiving control signals for communication with the train from said central railway network control unit;

g) one or more local interface heads are associated with each track block for interfacing with a corresponding track block, which include: the means for generating and transmitting signals for communication with the train to the corresponding track block and the means for receiving from the track block said communication signals produced by a train by active signal generation or change of the communication signals transmitted to the track block;

h) said local interface heads further include an interface for digital message communication, according to a predetermined communication protocol, with a separate central processing and control unit;

i) said central processing and control unit includes a digital message communication interface which operates with the same communication protocol as the local track block interface heads;

j) and said processing and control unit includes hardware in whose memories a processing and control program is stored, to be executed by said hardware and whereby said processing and control unit generates and transmits the control signals to the local track block interface heads for triggering said local interface heads to generate and transmit predetermined communication signals and for receiving communication signals;

k) and whereby the processing and control unit processes the communication signals received from the local interface heads to determine the operating or working conditions of the train based on the information contained in the communication signals transmitted by the train, and generates the status signals indicative of the operating or working conditions of the train;

l) whereas said central processing and control unit communicates with the central railway network control unit railway traffic management unit for transmitting thereto messages transmitted by the train and for receiving therefrom messages to be transmitted to the train;

m) the interface heads and/or the track block and the processing and control unit have means for diagnostic check of their operating conditions, **characterized in that**

n) the diagnostic means and the means for integrating two or more track circuits are a diagnostic program and a track circuit integrating program which is stored and executed by the processing and control unit or a subsection of said unit.

2. A system as claimed in claim 1, **characterized in that** the interface heads for interfacing with each track block constitute the units for transmitting and receiving communication messages to and from a train unit, which also has a transmitter and receiver unit, said communication messages being transmitted through the track blocks over which the train passes, whereas the processing and control unit constitutes the unit for controlling transmission and reception of the communication signals and the unit for generating the messages to be transmitted to the train and interpreting the messages received from the train, a software program being stored in said processing and control unit, for generating and interpreting messages and controlling the transmission and reception of messages to and from a train, which software program is executed by said processing and control unit.

3. A system as claimed in claim 1 or 2, **characterized in that** the interfaces for communication between the track block interface heads and the central processing and control unit operate with a network communication protocol, a communication network being provided.

4. A system as claimed in or more of the preceding claims, **characterized in that** multiple parallel processing and control units are provided, which are arranged along a railway line, each controlling and processing the signals of a subset of local interface heads that are connected to corresponding track blocks of a subset of track blocks, whereas each processing and control unit communicates independently with the central railway traffic management unit, each local interface head and/or each track block and each processing and control unit being uniquely identified by an identification code that is associated to the signals for communication between the interface heads and the corresponding processing and control unit and between said processing and control units and the central railway traffic management unit.

5. A system as claimed in one or more of the preceding claims, **characterized in that** the interface heads, interfacing with each track block constitute the transmitter unit and the receiver unit of a so-called track circuit, for generating a train detection signal and transmitting said signal to the track block and for receiving said train detection signal from said track block, whereas the processing and control unit is the unit that controls the transmitter and receiver units and the means for processing the detection signals received from the track block for determining the presence or absence of a train on said track block.

6. A system as claimed in claim 5, **characterized in that** the interface heads and/or the track block and the processing and control unit have means for diagnostic check of their operating conditions.

7. A system as claimed in claim 6 **characterized in that** the processing and control unit has means for generating signals for simulated indication of the presence or absence of the train within one or more track blocks.

8. A system as claimed in claim 6 or 7, **characterized in that** the processing and control unit has means for integrating two or more track circuits corresponding to two or more adjacent track blocks in a single composite track circuit and, in case of failure of one of said two or more track circuits, the transmitter and receiver units of the faulty track circuits are replaced by at least one transmitter unit and one receiver unit among those of the working circuit/s, said at least one transmitter unit and at least one receiver unit serving the assembly of two or more integrated track circuits.

9. A system as claimed in one or more of the preceding claims 6 to 8, **characterized in that** the diagnostic means and the means for integrating two or more track circuits are a diagnostic program and a track circuit integrating program which is stored and executed by the processing and control unit or a subsection of said unit.

10. A system as claimed in one or more of the preceding claims, **characterized in that** the interface heads for interfacing with each track block constitute the sensor of a so-called axle counter, whereas the processing and control unit constitutes the control unit of the axle counter sensor and the unit for determining the number of axles by processing of signals received by said sensor, a software program being stored in said processing and control unit for processing signals of axle counting sensors and for controlling said axle counting sensors, which software program is executed by said processing and control unit.

11. A system as claimed in one or more of the preceding claims, **characterized in that** the track circuit is of the type with mechanical joints, in which the track segments are mechanically and electrically separated, i.e. galvanically insulated from each other.

12. A system as claimed in one or more of claims 1 to 11, **characterized in that** the track circuits are of the jointless type.

13. A system as claimed in one or more of the preceding claims 1 to 12, **characterized in that** the interface heads in the track circuit are connected to the corresponding track block via directional joints, which define the signal direction over the track segment from one end to the other of said track segment, by associating at one end the interface head for transmission and at the other end the interface head for reception.

14. A system as claimed in one or more of the preceding claims 1 to 9, **characterized in that** the interface heads in the track circuit are connected to the corresponding track block via non directional joints, which do not define the signal direction over the track segment from one end to the other of said track segment, signal transmission and reception occurring according to Direct Sequence Spread Spectrum (DSSS) or Frequency Hopping Spread Spectrum (FHSS) communication techniques.

15. A system as claimed in claim 14, **characterized in that** each track block of a succession of track circuits arranged along a track has a joint for connection of the transmitting and receiving track block interface heads, which is of the broad frequency band type, and the transmitting interface heads transmit a signal coded according to one of two different codes and having one of two different frequencies to the track block through the associated joint, the signals transmitted by adjacent detection heads being respectively coded with two different codes and said signals having two different frequencies, whereas each receiving interface head receives all the signals transmitted over the track from the different transmitting interface heads, the correct receive signal, having the frequency and code expected for the receiving interface head of a predetermined track circuit, i.e. a predetermined joint, being determined by relating the received signal with the signal having the expected code and frequency for the receiving interface head of a predetermined track circuit, i.e. a predetermined joint.

16. A system as claimed in claim 15, **characterized in that** the coding sequences are sequences with pseudo-orthogonal properties used for modulation/demodulation of the signal transmitted over the track circuit by DSSS (Direct Sequence Spread Spectrum) or FHSS (Frequency Hopping Spread Spectrum) techniques, with such configurations as to maximize protection from typical noise emitted by DC and AC powered trains, while also maximizing mutual interferences between the track circuits.

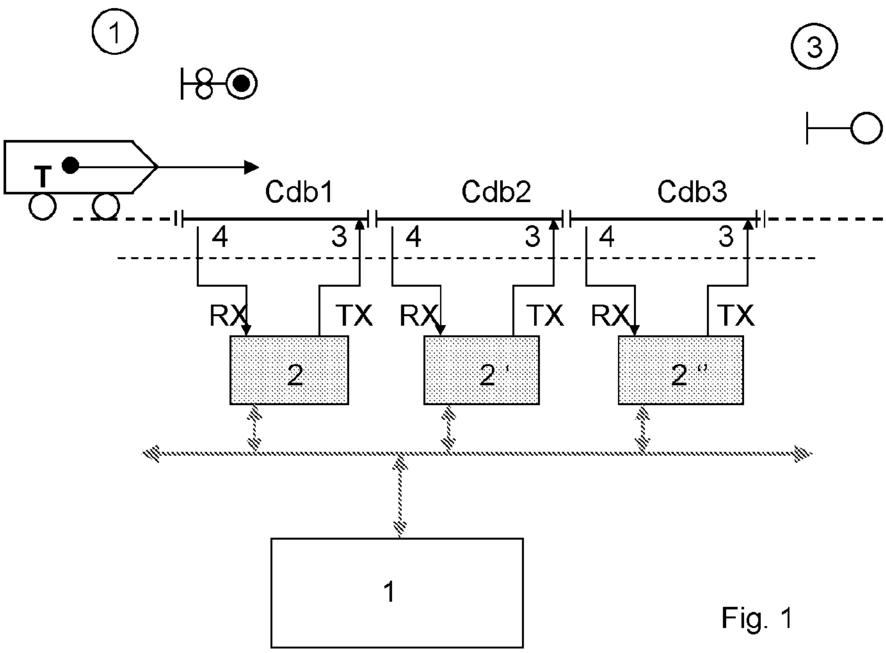
1
3
T
Cdb1
Cdb2
Cdb3
4
3
4
3
4
3
RX
TX
RX
TX
RX
TX
2
2 '
2 ''
1

Fig. 1

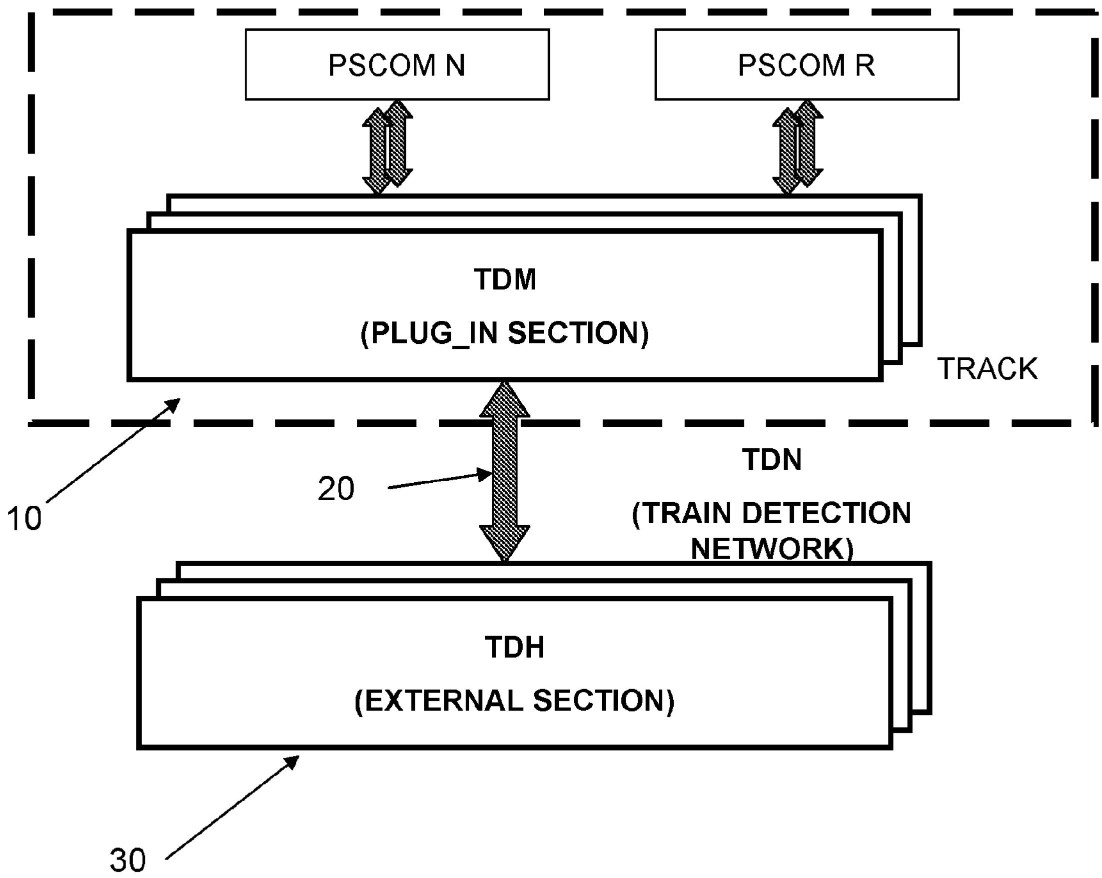
PSCOM N
PSCOM R
TDM
(PLUG_IN SECTION)
TRACK
TDN
(TRAIN DETECTION
NETWORK)
20
10
TDH
(EXTERNAL SECTION)
30

Fig. 2

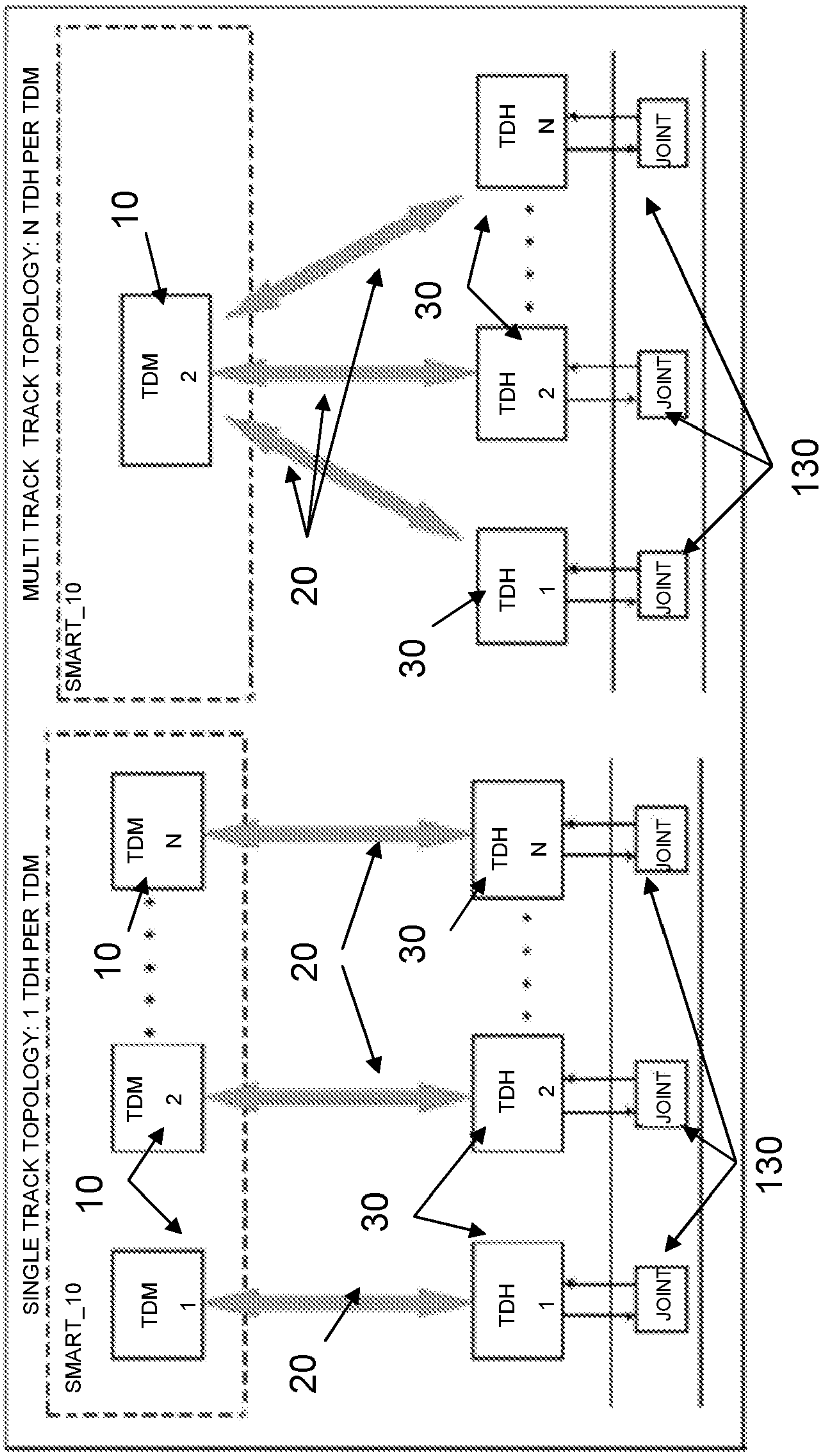
SINGLE TRACK TOPOLOGY: 1 TDH PER TDM
SMART_10
TDM 1
TDM 2
TDM N
TDH 1
TDH 2
TDH N
JOINT
JOINT
JOINT
10
10
20
20
30
30
130
MULTI TRACK TRACK TOPOLOGY: N TDH PER TDM
SMART_10
TDM 2
TDH 1
TDH 2
TDH N
JOINT
JOINT
JOINT
10
20
30
30
130

Fig. 3

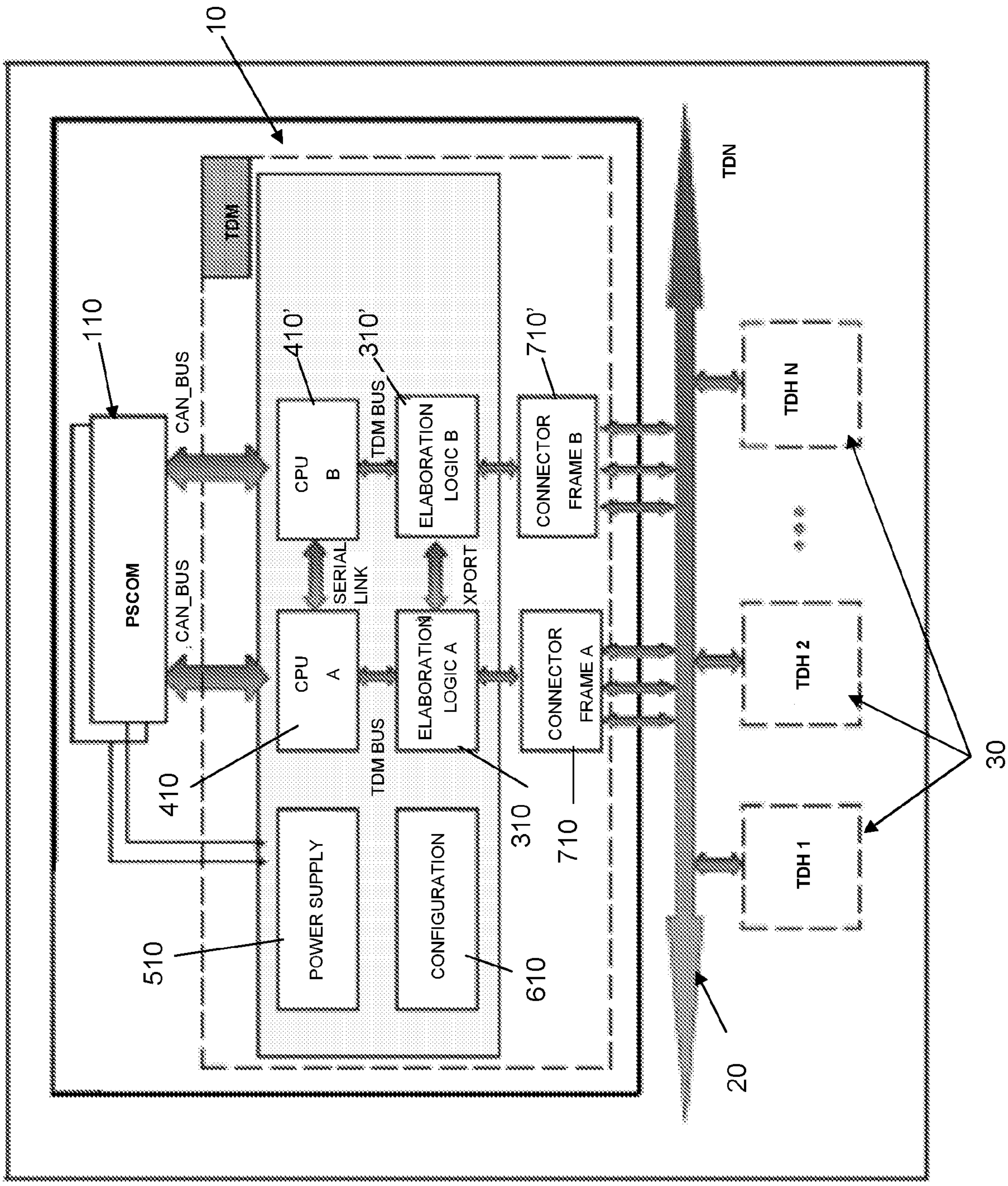
10
110
PSCOM
CAN_BUS
CAN_BUS
TDM
CPU B
CPU A
SERIAL LINK
TDM BUS
TDM BUS
ELABORATION LOGIC B
ELABORATION LOGIC A
XPORT
CONNECTOR FRAME B
CONNECTOR FRAME A
POWER SUPPLY
CONFIGURATION
410
410'
310
310'
510
610
710
710'
TDN
TDH 1
TDH 2
TDH N
20
30

Fig. 4

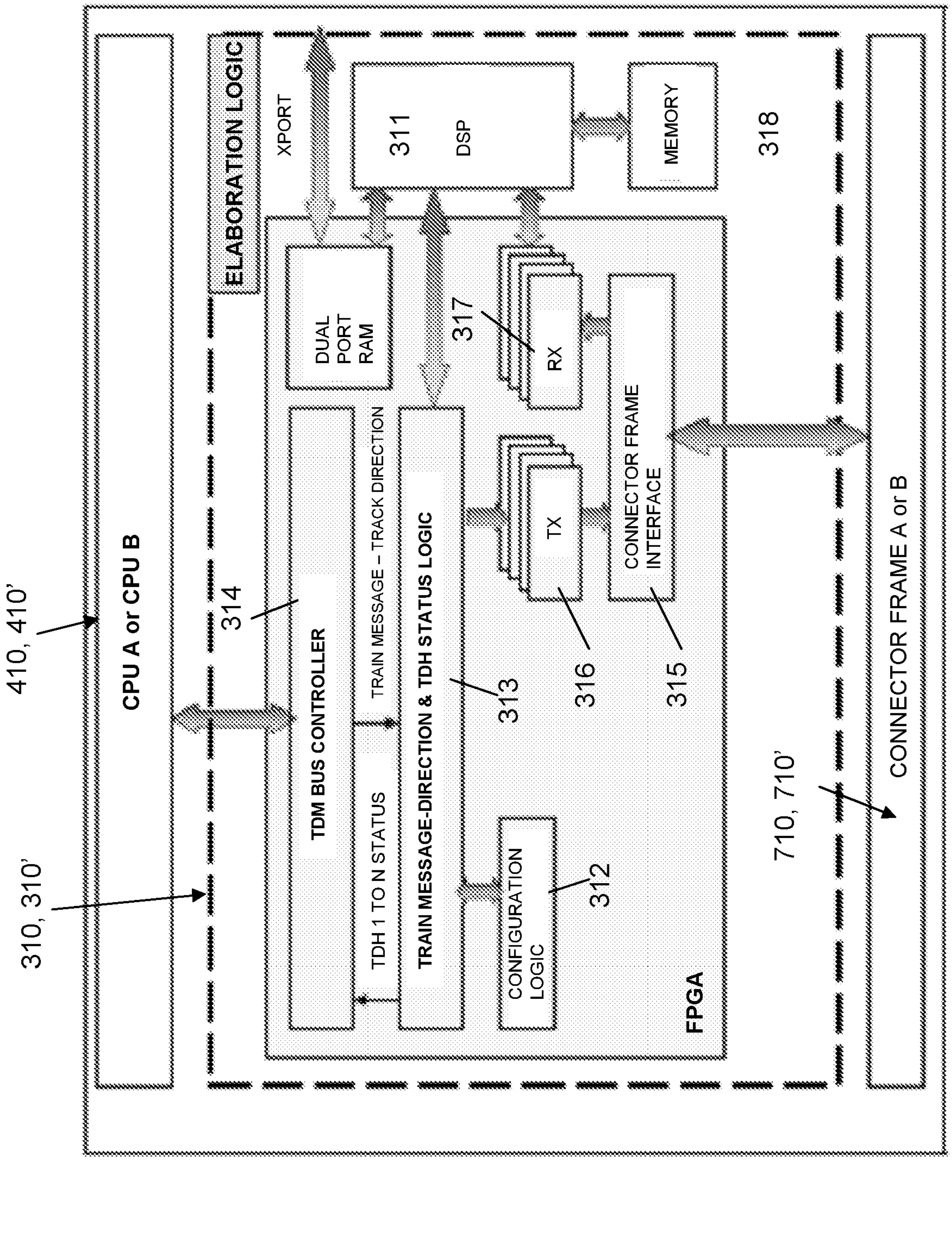

Figure 5: ELABORATION LOGIC A and B module

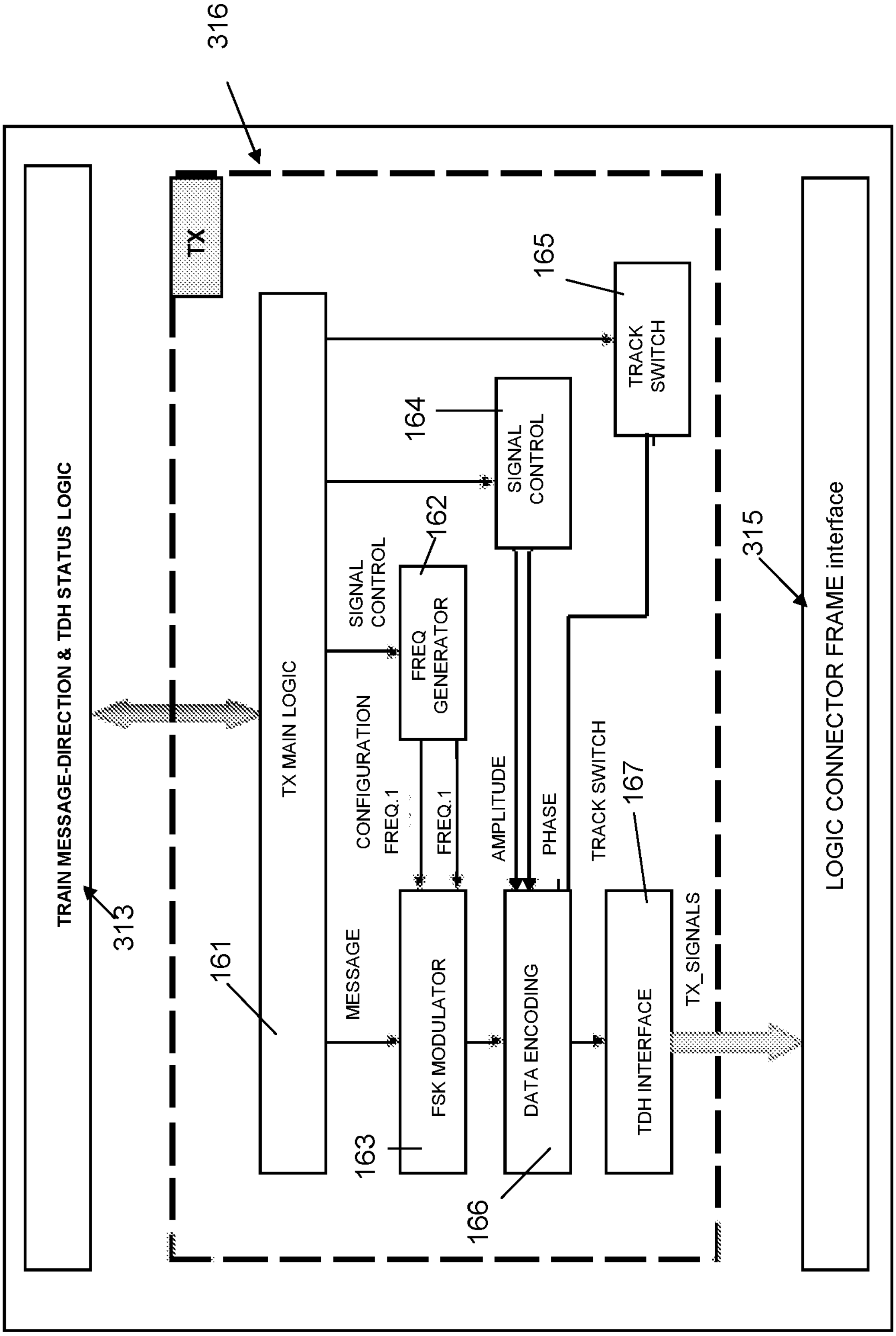

Figure 6: TX module

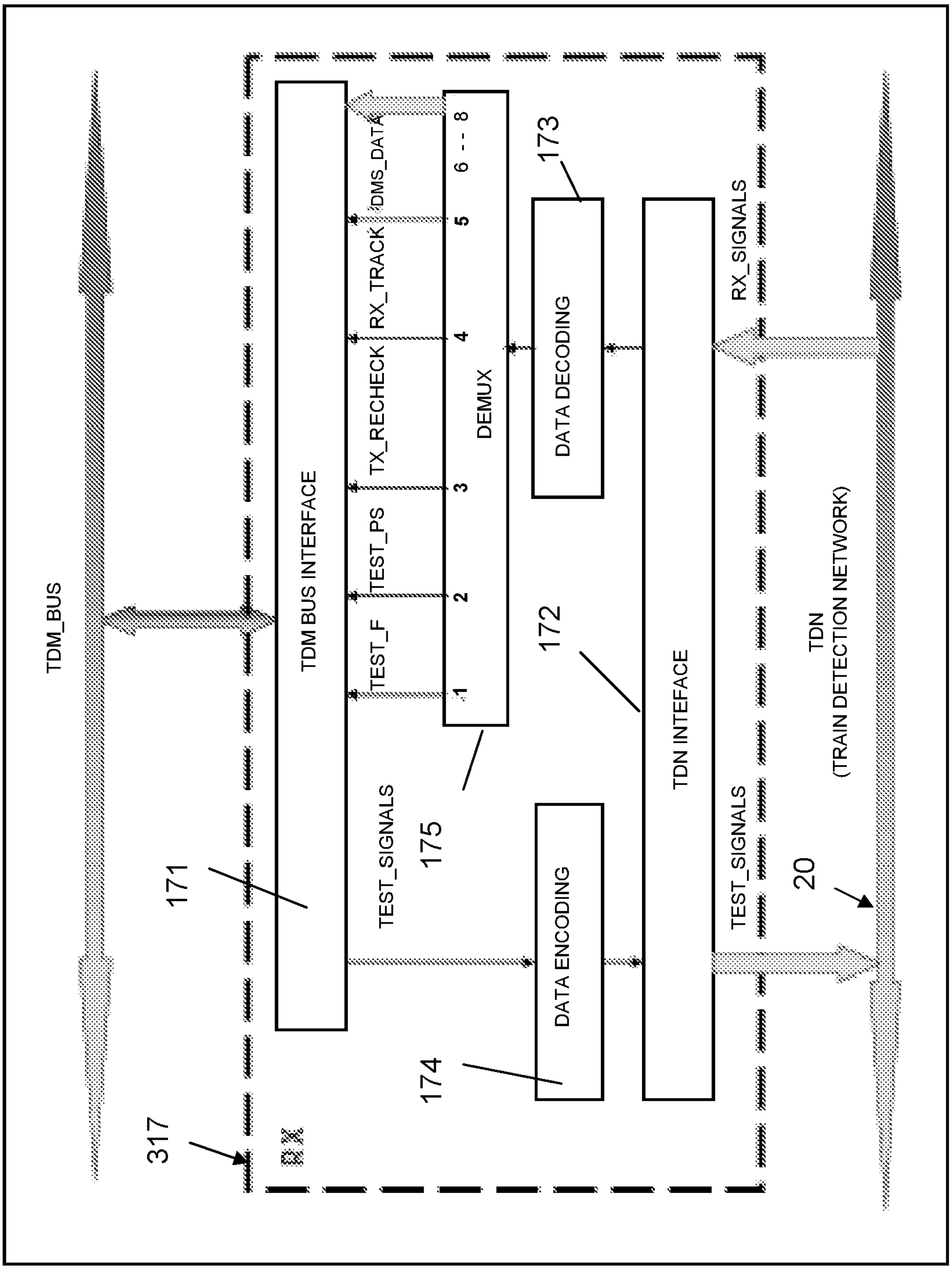

Figure 7: RX module

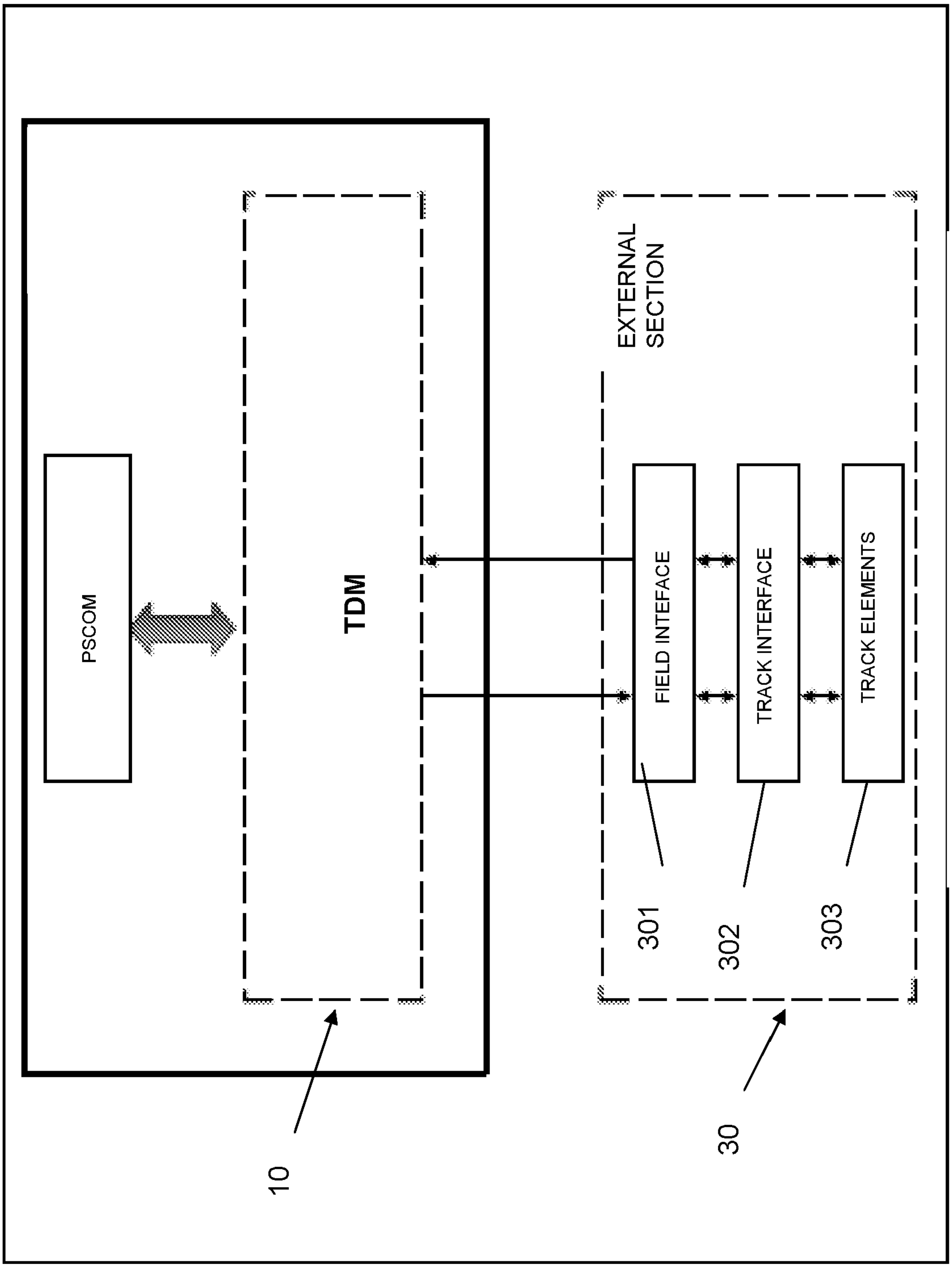
PSCOM
TDM
EXTERNAL SECTION
FIELD INTEFACE
TRACK INTERFACE
TRACK ELEMENTS
301
302
303
10
30

Figure 8

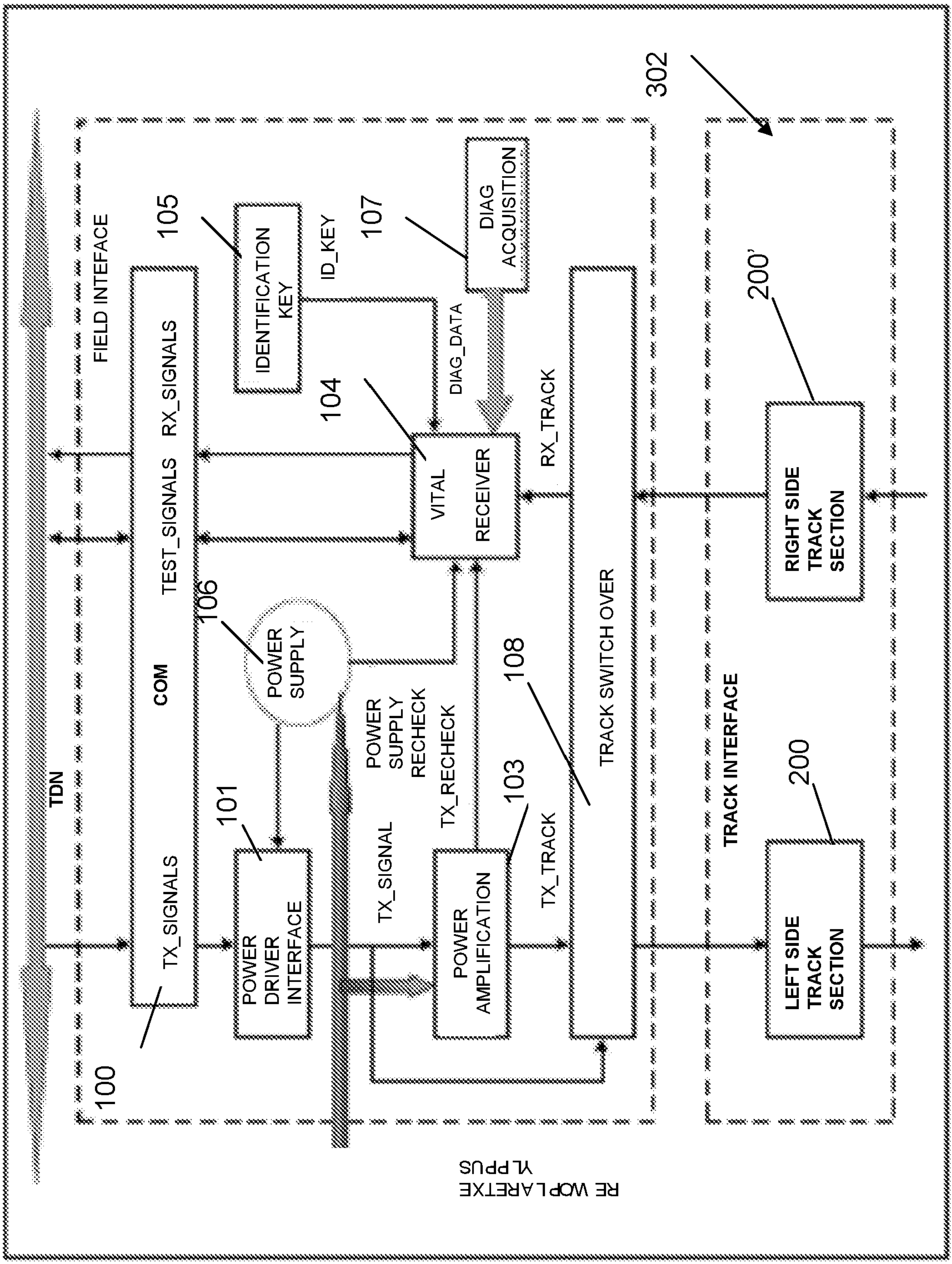

Figure 9: Field interface block diagram

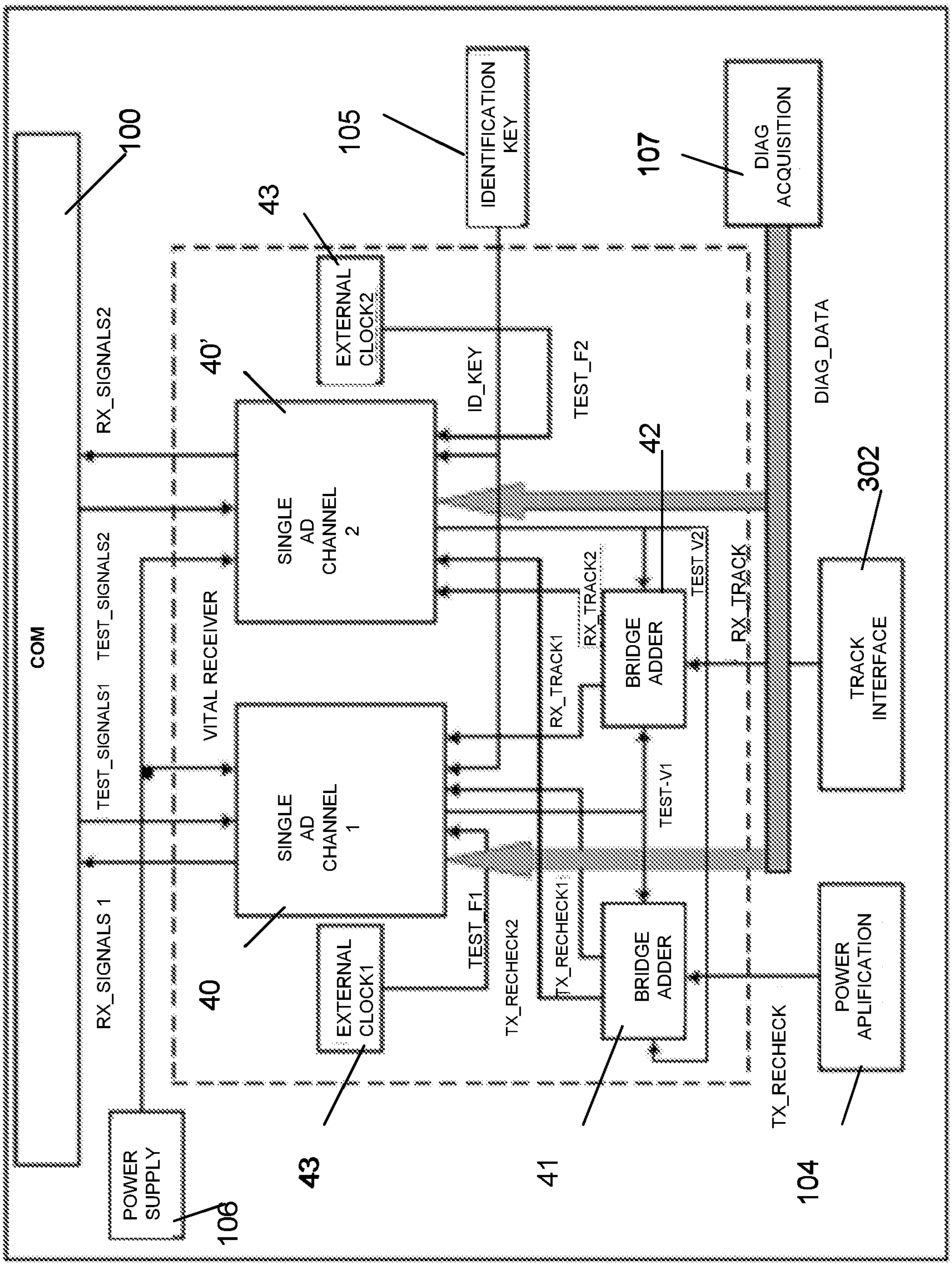

Figure 10: Vital receiver block diagram

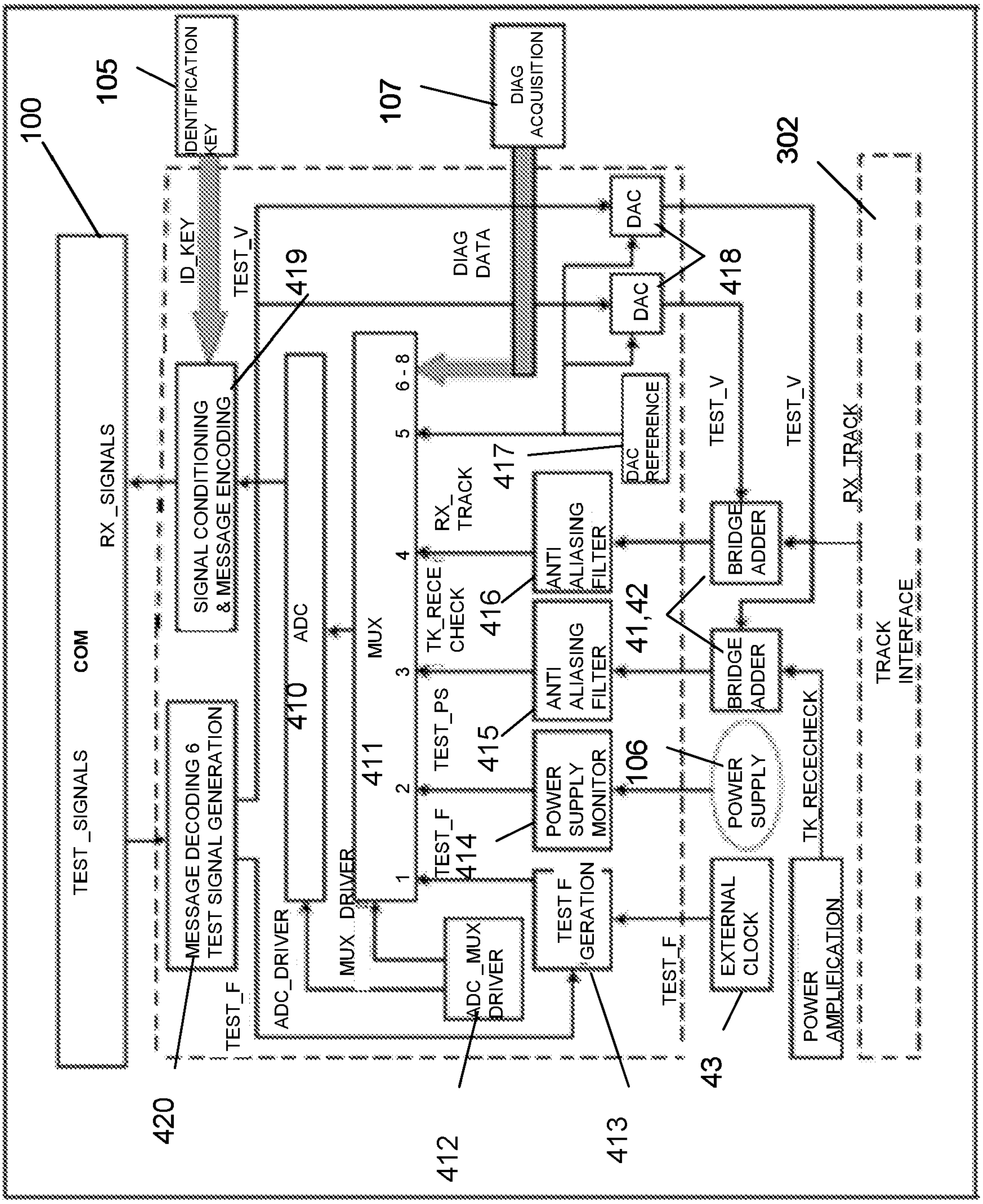

Figure 11. single AD Channel

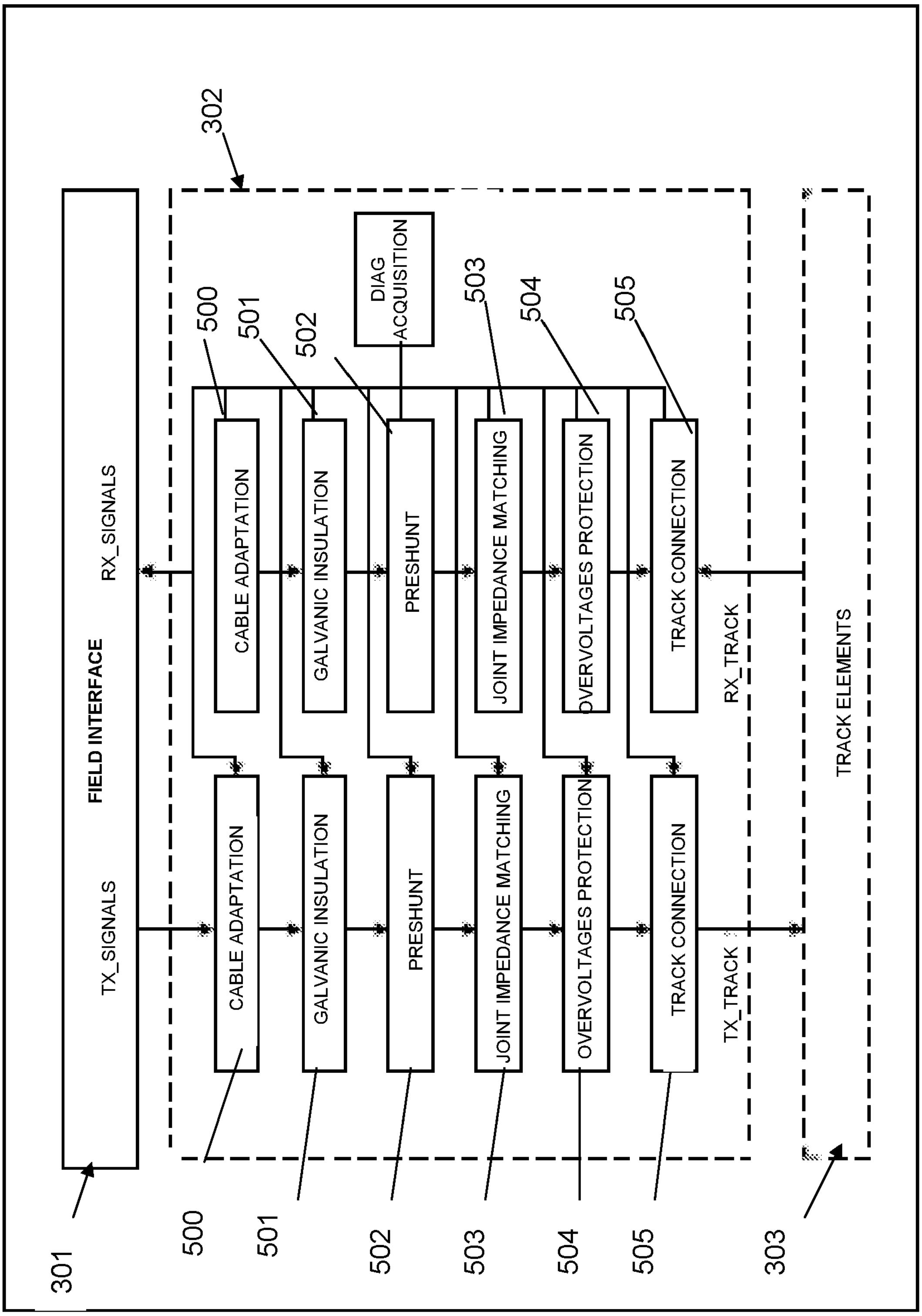

Figure 12: Track Interface

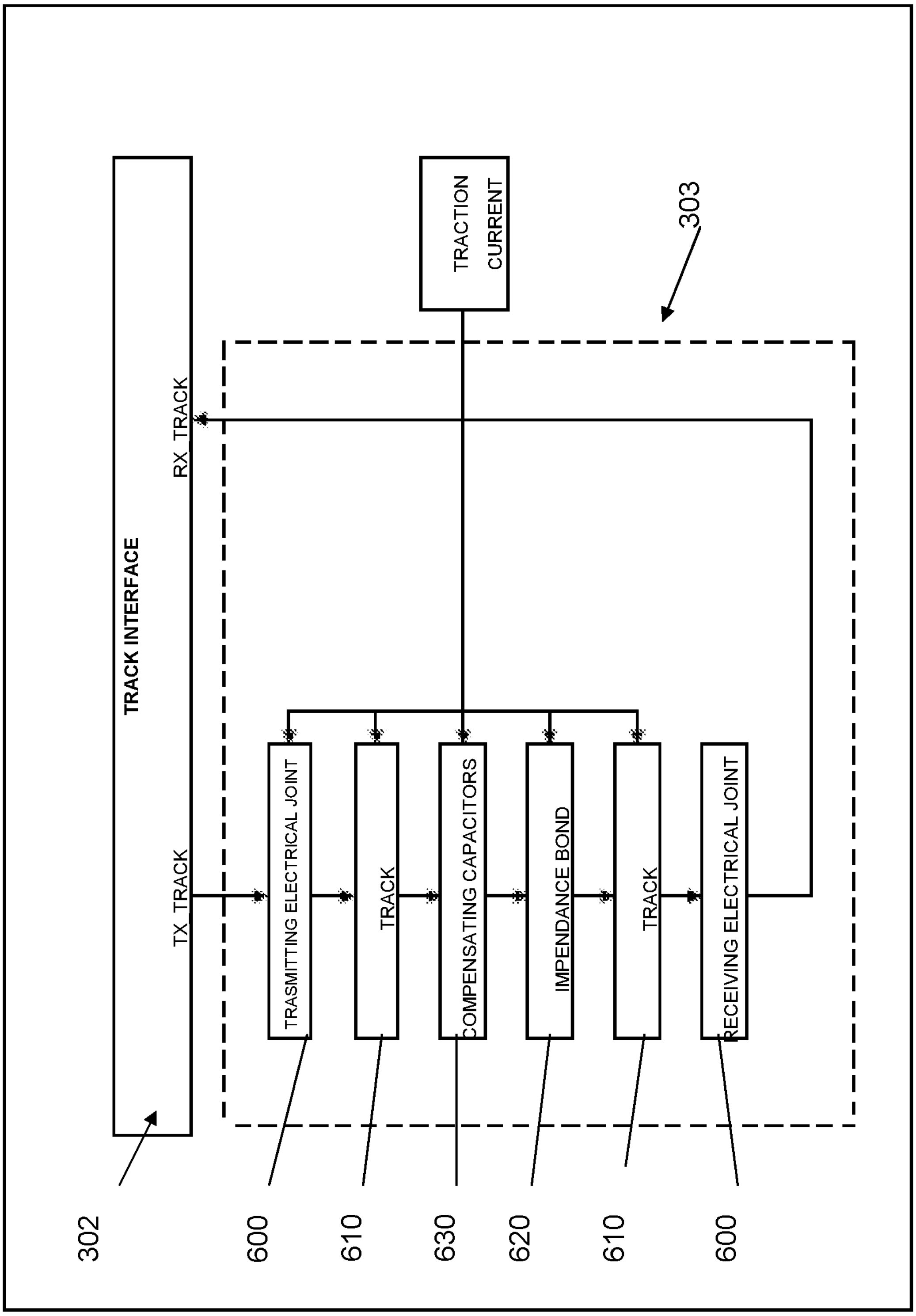

Figure 13: Track Elements

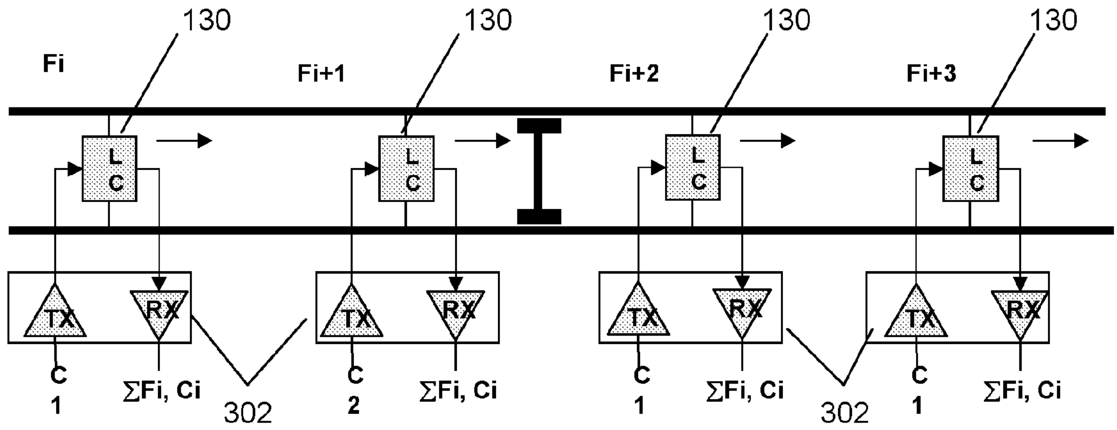
130
130
130
130
Fi
Fi+1
Fi+2
Fi+3
L
C
L
C
L
C
L
C
TX
RX
TX
RX
TX
RX
TX
RX
C
1
ΣFi, Ci
302
C
2
ΣFi, Ci
C
1
ΣFi, Ci
302
C
1
ΣFi, Ci

Fig. 14

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1338492 A **[0002] [0005]**
- EP 0771711 A **[0006]**