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(54) **Actuating and monitoring module for operating units of wayside equipment of railway systems or the like**

(57) An actuating and monitoring module, particularly for operating units, i.e. wayside equipment, of railway systems or the like, particularly for switch machines, comprising:

a source of a DC power signal;
a line for supplying said power signal, also known as control signal, to said operating unit, which line connects the outputs of the power signal source to the inputs of the operating unit;

switching means in the power signal supply line for switching the operating unit on and off by remote enabling/disabling controls,

characterized in that
according to the invention, the actuating module has automatic switching means for switching the inputs of the unit and/or the outputs of the power signal source to the short circuit state, in the disabled unit state, i.e. with no power signal on the supply line.

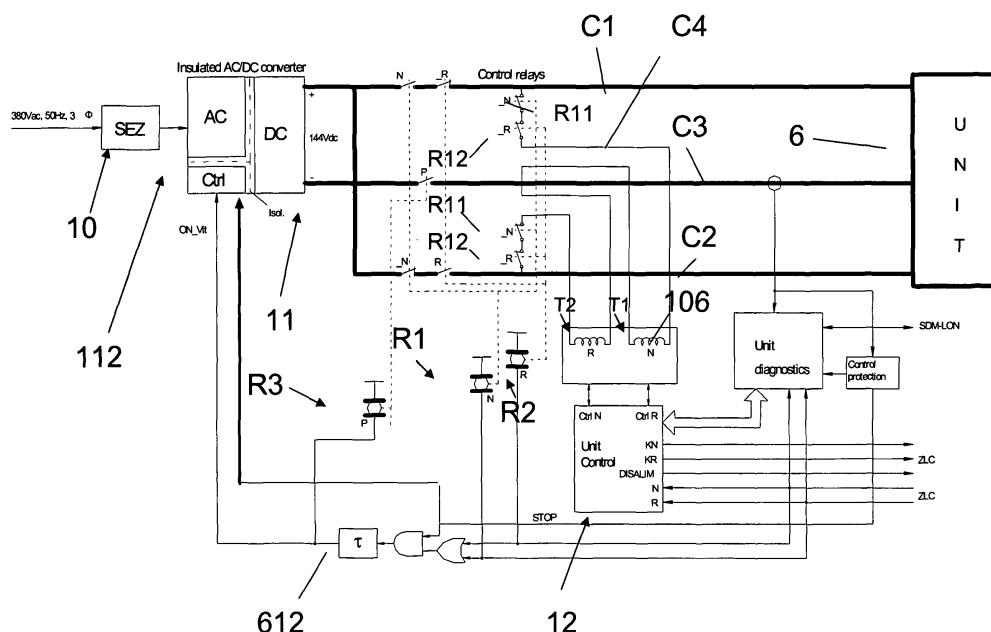


Fig. 2

Description

[0001] The invention relates to an actuating and monitoring module, particularly for operating units, i.e. wayside equipment, of railway systems or the like, comprising:

a source of a DC power signal;
a line for supplying said power signal, also known as control signal, to said operating unit, which line connects the outputs of the power signal source to the inputs of the operating unit;
switching means in the power signal supply line for switching the operating unit on and off by remote enabling/disabling controls.

[0002] Particularly, the invention addresses actuating and monitoring modules for railway systems or the like, in which the control or actuating signal to the operating unit is a Direct Current signal. Furthermore, this actuating and monitoring module shall be operable in railway systems in which the train is supplied with Alternating Current power.

[0003] Typical operating units are switch machines for railway switches or the like and/or other wayside equipment having solenoids controlled by a central station.

[0004] Railway equipment or operating units are arranged in remote positions, at a long distance from the actuating and monitoring module, which is generally situated in the premises that also contain other control and monitoring units, known as cabins.

[0005] Therefore, there exists on the one hand the need of reducing the number of conductors used to connect the actuators and the wayside devices, the system being only partly distributed, as the central location is in series communication with the various zone controllers (containing the equipment actuating subsystem), which may be even placed at a considerable distance (2 - 3 km) from the wayside equipment. On the other hand, the conductors of the communication lines shall still comply with length limits, imposed by electric and electronic needs.

[0006] In the particular field of railway systems, actuating and monitoring modules and operating units must operate at high degrees of safety and in a vital manner. Thus, should any malfunctioning occur, the units affected thereby are brought back to safety conditions, which are generally restrictive conditions.

[0007] Particularly, when AC power is supplied to trains, the safety conditions for operation on AC electrified lines essentially require protection against any undue control caused by induced and conducted voltage at 50 Hz, as well as a protection key on the feedback signal, which in prior art system is a fixed 400 or 120 Hz carrier.

[0008] An undue control may be caused by the fact that, if one of the conductors of the communication line is in contact with the ground at two locations, i.e. one at the wayside device, i.e. the operating unit, and the other near the cabin, which contains the actuating and moni-

toring module, an induced and/or conducted AC noise voltage may occur on that conductor, due to the traction current at 50 Hz. In this case, if an AC-to-DC converter is provided at the output of the module, the noise voltage generates a current having a non-zero average value, circulating across the converter, the non faulty conductor and the load. Thus, this noise signal may simulate an undue accidental control signal.

[0009] An undue feedback may be caused by the presence of a signal having a certain frequency in the cable, still in case of a double ground fault. Once more, the noise signal may simulate an undue feedback signal, which might be interpreted as an indication that the remote operating unit has switched to a given operating state, and false information might be generated thereby.

[0010] As is better explained below in the disclosure, the solution to these problems of prior art actuating and monitoring modules is not obvious at all. Particularly, the need to improve safe control and/or monitoring using vital functions, in the context of AC train electrification at 50 Hz, and the need to reduce or maintain the number of conductors in communication lines are at least partly in contrast with each other.

[0011] Therefore, the invention has the object of providing an actuating and monitoring module which, using simple and inexpensive arrangements, overcomes the safety problems of prior art modules having the same basic operation principles, while improving other safety features not directly associated to the AC traction problem.

[0012] First, the invention solves the above problem by an actuating and monitoring module, particularly for operating units, i.e. wayside equipment of railway systems or the like, as described hereinbefore, which has automatic switching means for switching the inputs of the unit and/or the outputs of the power signal source to the short circuit state, in the disabled unit state, i.e. with no power signal on the supply line.

[0013] Advantageously, the switching means include at least two relays, one of which is connected in series with at least one conductor of the supply line, whereas the second relay is connected in series with a short-circuit line for shorting the power signal outputs of the power signal source and/or the power signal inputs of the operating unit, a third protection relay being connected in series with at least one second conductor of the power signal supply line, the latter relay disconnecting said conductor and being open when the operating unit is in its idle condition, i.e. with no power signal, and closed when the operating unit is in its operating condition, i.e. in the presence of a power signal.

[0014] Particularly, the equipment or operating units referred to herein include the so-called switch machines, which are driven by a DC motor. For the switch points to be driven in either direction from either operating position, known as "normal" or "reverse" position, the polarity of the power signal supplied to the motor has to be reversed. This occurs thanks to a supply line having three conduc-

tors, two of which are for the power signal and are alternately connected to the power output of a source of said power signal and one is a return conductor for said power signal, which is common to the two alternating operating states of the supply line.

[0015] More generally and without being bound to the case of switch machines, the invention contemplates an operating unit having three inputs, i.e. one input for a common power signal return conductor and two further inputs for alternating supply of the power signal to one of said inputs using two separate power signal supply conductors, each connected to one of said two further inputs and each alternately connectable to one output of the power signal source, there being provided at least three relays:

a first and second actuation or control relays which have disconnecting contacts connected in series to both supply conductors and the disconnecting contacts of said two actuation or control relays being connected in series with each other in the same conductor and operating in inverted arrangement, wherefore by energizing either actuation or control relay one of the two inputs of the operating unit are alternately connected to the output of the power signal source.

a third short-circuit relay in a line for short-circuiting connection of the inputs of the operating unit to each other and/or to the outputs of the power signal source, and which short-circuit relay has disconnecting contacts which are connected in series in said short-circuit line and which disconnecting contacts are normally closed, with said inputs and/or said outputs in a short-circuit state, when said two actuation or control relays are in a state of disconnection of the corresponding conductor, said short-circuit relays being excited to the short-circuit line contact opening state by the signal that energizes at least one or both of said actuation or control relays.

[0016] According to an advantageous embodiment, the third relay may operate through a pair of normally closed contacts of each of the two actuation or control relays.

[0017] According to an advantageous embodiment, a fourth protection relay is provided which has contacts connected in series to the return signal conductor in the power signal supply line, which protection relay is in the open contact state when there is no control signal coinciding with the signal that energizes at least one of said two actuation or control relays and the short-circuit relay.

[0018] In the particular embodiment specifically designed for motor-driven switch machines, which switch machines are used to throw the switch points of a turnout or a switch between two opposite limit stop positions, i.e. normal and reverse, said switch machines having three inputs, including one common input for a power signal return conductor and two inputs for alternate supply of

the power signal, each causing, when supplied with said power signal, the motor to rotate in either direction, the module of the invention thus comprises

two conductors for supplying the power signal to each of the two power signal inputs, which conductors are designed to be alternately connected to the power signal output of the power signal source by means of two actuation or control relays, each of which actuation or control relays has contacts for disconnecting either conductor, operating in inverted mode, the disconnecting contacts of the two actuation or control relays being connected in series with each other in each of the two power signal supplying conductors;

a short-circuit line that connects the outputs of the power signal source and/or the inputs of the switch machine when there is no power signal or the actuation or control relays are not energized, while the disconnecting contacts of the two power signal supplying conductors are closed, and which short-circuit line includes a short-circuit relay having disconnecting contacts that are normally closed when said relay is in the disenergized condition, said relay being controlled by the signal that controls the supply or control relays.

[0019] Here again, a protection relay is advantageously provided, whose disconnecting contacts are located in the power signal return conductor and which is energized to the open state by a signal coincident in time with the disenergization state of the two actuation or control relays, which signal is generated by a source other than that of the signal for controlling the two supply or control relays.

[0020] In a further improvement of the invention, the equipment, operating units or more specifically the switch machines also have means for generating a signal to check that the equipment, operating units and/or particularly the switch machines have switched to the proper operating states. These means include an oscillatory circuit that generates a signal at a predetermined frequency when the unit switches to one of said predetermined operating conditions, the oscillatory circuit being driven to generate the feedback signal at the predetermined frequency when a capacitor of predetermined capacitance is introduced in a loop of said circuit, by means of switches that are switched closed by means for detecting one of said operating states, whereas feedback signal receiving/transmitting means are provided, preferably connected in series with the short-circuit line.

[0021] In a preferred embodiment a line may be provided for communication with the operating unit to be controlled, such as a supply line for transmitting power signals of the operating unit, i.e. control signals as described above, which line has at least two, three or more conductors,

which feedback signals are generated by an oscillatory circuit which generates a signal at a predetermined frequency when the operating unit switches to either of the predetermined operating states;

the oscillatory circuit being formed by an inductor con-

tained in the actuator, the conductors of the communication lines between the control actuator and the operating unit and a separate capacitor for each predetermined operating state of the operating unit, the operating unit having feedback switch means operated thereby upon transition from a first to a second of said predetermined operating states;

the whole in such a manner that, as an operating state is attained, a feedback signal having the predetermined unique frequency is automatically generated, which feedback signal is detected by detection means of the actuating and monitoring module, which detection means include means for analyzing the feedback signal to check the correctness of the feedback signal frequency and generate a signal to indicate that the operating unit has correctly switched to the corresponding operating state, and which module of the invention further includes means for modulating the feedback signal according to a predetermined modulation protocol.

[0022] Various embodiments may be envisaged, including one that includes a local feedback signal generator having a local feedback signal carrier generating section and a local pulse amplitude modulation signal section, which local feedback signal generator is triggered to generate said feedback signal by a variable capacitance resonant circuit loop, which is composed of a local inductor, a resistor provided by the conductors of the communication line between the module and a remote operating unit and the contacts of the feedback switch of said remote operating unit, and a separate capacitor for each operating state of the remote operating unit, which capacitors are located in the remote operating unit and are alternately connected together in the resonant grid by the feedback switch depending on the operating state of the operating unit, whereas the module includes a local receiver having means for analyzing the feedback signal with respect to the frequency of the feedback signal carrier and the frequency of the pulse amplitude modulation of said feedback signal carrier, and which feedback signal analyzing means are of the vital type and generate a vital signal indicating that the operating unit has correctly switched to the corresponding operating state.

[0023] Thanks to the above arrangements, the actuating module of this invention obviates the above mentioned prior art drawbacks.

[0024] Further improvements will form the subject of the dependent claims.

[0025] The features of the invention and the advantages deriving therefrom will appear more clearly from the following description of a few non-limiting embodiments which are illustrated in the accompanying drawings, in which:

Figure 1 is a simplified diagram of a Vital Computer Station Apparatus for large stations including the actuating module of the present invention which is used

as a turnout control module.

Figure 2 is a block diagram of a module of this invention used as a turnout control module according to the example of Fig. 1.

Figure 3 shows a simplified diagram of the communication interfaces of the module of Fig. 2.

Figure 4 is a block diagram of the Actuating Board of the module of the previous figure.

Figure 5 shows a detailed diagram of the module configuration regarding control, short-circuit and protection relays and generation of the control signals, in an embodiment in which three conductors are only provided for supplying both the power signal and the feedback signal.

Fig. 6 shows a variant embodiment in which the turnout is connected by six conductors, including three conductors for the power signal and three conductors for the turnout position feedback signals.

Fig. 7 shows the connections of a Monitoring and Diagnostics Board.

Figure 8 is a block diagram of the switch point Position Monitoring Section.

Figure 9 is a block diagram of the diagnostics module.

[0026] Figure 1 is a diagram of a system known as Vital Computer Station Apparatus for large stations which uses a turnout control module, referred to herein as MGD, designated by numeral 1, representing an embodiment of the most general actuating module of this invention.

[0027] As shown in Figure 1, the system defined as Vital Computer Station Apparatus comprises a Central Logic Computer 2 with one or more vital operator interfaces, designated by numeral 3, connected thereto. The Central Logic Computer 2 executes a logic program for monitoring the railway system and transmits controls to Zone Logic Computers (ZLC), designated by numeral 5, through a communication network 4. These Zone Logic Computers are designed to generate actuating or state-changing controls for wayside equipment, such as light signals, turnouts, etc. In Figure 1, numeral 6 generally designates the wayside equipment, numeral 5 designates the Zone Logic Computer which is designed to control the switch machines of the turnouts, and numeral 5' designates other Zone Logic Computers.

[0028] The Zone Logic Computers transmit controls to actuating or driver modules, which generate the power signals for controlling or actuating the wayside equipment and receive feedback signals therefrom, and which include the module of this invention.

[0029] Figure 2 is a block diagram of the actuator architecture and Figure 3 shows the interfaces to the other system units.

[0030] The turnout control actuating module of this invention interfaces (arrow 101) with the Vital Computer Station Apparatus to receive the turnout throwing controls and further has interfaces with the mains, arrow 201, with the operator, arrow 301, and obviously with the turn-

out, arrow 401 and with a diagnostics system, arrow 501.

[0031] The interface 201 with the power supply system provides a three-phase supply current, 380 VAC, 50 Hz.

[0032] The interface 101 connects the actuator 1 to the Zone Logic Computer 5 and allows reception of controls and transmission of wayside unit feedbacks through the vital I/O; particularly three feedback signals, KN, KR and DISALM are transmitted to the Zone Logic Control 5, and the Zone Logic Computer transmits the two N and R control signals to the actuator 1 for throwing the turnout switch points to either operating positions, known in the art as Normal position "N" and Reverse position "R".

[0033] The actuator interfaces with the diagnostics system, by the interface 501, through a communication network (designated by numeral 8 in Fig. 1) and known as Field Diagnostic Bus or FDB. All the diagnostics data of the external unit 6 are transmitted through such interface.

[0034] The interface 401 with the unit 6, i.e. the switch machine of the turnout uses special terminal boxes, which are mounted to the unit and contain devices that form the electric termination of the position monitoring circuit.

[0035] Two connection arrangements may be provided between the actuator 1 and the unit 6, which will be further described hereunder in greater detail.

[0036] In a first arrangement, the actuator 1 is connected to the unit 6 through a cable having 3 conductors C1, C2, C3 (classical connection: control + feedback). In this case, both the power signals for actuation of the switch machine motor and the switch point position feedbacks (Figs. 2 and 5) are transmitted through said three conductors C1, C2, C3.

[0037] In an alternative embodiment, two separate cables are provided, each having 3 conductors C1, C2, C3 and C1', C2', C3', i.e. a first cable having three conductors C1, C2, C3 for control signals and a second cable, also having three conductors C1', C2' and C3' for feedback signals. The latter connection arrangement allows to increase the maximum distance between the cabin and the unit. This is also required if the DC motor inside the switch machine has no mechanical limit contact (which means that the control current is not automatically switched off at the end of the control).

[0038] The user interface 301 includes:

- Signal lights to show the operating state of the subsystem;
- Test Points to be used for measuring certain electric magnitudes of the actuating module;
- Devices for configuring the functions of the actuating module.

[0039] In operation, the module of this invention is designed to accomplish the functions of: controlling the turnout; monitoring switch point positions.

[0040] Furthermore, the actuating module 1 of the present invention acts as an interlocking subsystem and

is required to meet certain safety conditions, i.e. any unsafe state must be detected and the system must be later forced into a safe state in as little time as to ensure compliance with any application-specific requirements.

[0041] Safety states for the actuator of the invention include: no power supply to the unit; no unit position monitoring.

[0042] Particularly, the module 1 is based on an inherent fail-safe architecture: the actuator 1 transfers power to the unit 6 in a vital manner, i.e. only when there is a control intention in the logic 5, which is expressed through the actuation of a Vital Output port 101 and with a sufficient delay to cover the response time of the Zone Logic Computer 5 in case of undue control.

[0043] Concerning the position monitoring functions, the MGD subsystem uses operation principles that were already used in prior art actuators operating in AC electrified lines.

[0044] The actuating module 1 is an assembly composed of a disconnecting part and a module, which is in turn composed of hardware boards having well-defined functions, as reflected in principle by Fig. 2.

[0045] The boards are function-specific, namely:

- a power supply panel, containing the electric disconnecting device 10 of the module,
- an Actuating Board 11, which generates the voltage required for controlling the unit and incorporates the required control circuits,
- a Monitoring and Diagnostics Board 12, which essentially handles the turnout position monitoring functions, the steps of controlling and protecting it, as well as all unit diagnostics and communication with the diagnostic system.
- the Actuating Board 12 comprises electronic circuits and relays, which accomplish the following functions:
 - an AC/DC conversion unit 112 for adequate power supply to the unit;
 - relays R1 and R2 for controlling the N or R throwing function, having inverted R and N_ contacts, designated by R11 and R12, which are located in a conductor C4 designed to short the inputs of the unit 6 and/or the AC/DC conversion unit 112;
 - auxiliary functions required for proper operation of the electronic circuits;
 - low power circuit supply;
 - protection relay R3 in the conductor C3.

[0046] It shall be noted that, in Figure 1 and in the others, the relays are indicated by the electromagnetic energizing unit as a part of the whole and the contacts are actually shown in their position in the conductors C1, C2, C3 and C4.

[0047] Thus, as shown in Figure 2 and in Figures 5 and 6, the motor of the switch machine is of the DC type and, for rotational drive in either direction to cause switch point displacement from normal position to reverse po-

sition and vice versa, the two conductors C1 and C2 that supply the power signal to one input for rotation in one direction and to another input for rotation in the opposite direction, respectively incorporate normally open contacts of the relay R1 which are closed in the energized state of the relay R1 and normally closed contacts of the relay R2 which are open when the relay R2 is in the energized state and have a reverse operation as compared with the normally open contacts of the relay R2 incorporated in the conductor C2, and connected in series with the normally closed contacts of the relay R1, which are open when the relay R1 is energized. This configuration allows the power signal to be transmitted either on the conductor C1 or on the conductor C2 depending on whether the relay R1 is energized for throwing the switch points to the normal position or the relay R2 is energized for throwing the switch points to the reverse position.

[0048] Referring to Figure 4, the Actuating Board is composed of the following functional units:

- an EMI filter 212 for reducing noise introduced in the 380 V network;
- an inrush current limiter 312, for attenuating initial start-up current peaks;
- an uncontrolled AC/DC converter 112';
- an unstabilized and isolated DC/DC converter 112" which forms the conversion unit 112 with the AC/DC converter;
- an auxiliary power supplies 512, also used by the Monitoring Board;
- a PWM signal generator 412;
- control relays R1, R2 which set the direction of rotation of the motor of the switch machine in the energized state, as described above and as better explained hereafter and disconnect the output of the power source 112 and short circuit C4 the wires C1, C2, C3 in the disenergized state.

[0049] All the above functional units cooperate to perform the turnout control actuation function.

[0050] The control disconnection function (SEZ) is accomplished by a galvanic power disconnection device 10; this disconnection device 10 ensures protection for the wayside assistant of the DM in case of power failure and/or in case of turnout maintenance.

[0051] The throw control (to the normal "N" or reverse "R" positions) is implemented by three printed circuit relays R1, R2, R3 whose normally open contacts NR1, RR2 or normally closed contacts N_ and R designated by R11 and R12 are introduced in the power circuit as shown in Figures 5 and 6. Particularly, two normally closed contacts N_ and R_, designated by R11 and R12, of the relays R1 and R2 hold the power source 112 shorted C4, when there is no control signal KN or KR and, as better explained hereafter, allow circulation of the alternating current of the monitoring circuit overlying the control circuit.

[0052] The third relay R3 is an auxiliary protection relay

which is energized in the control step by circuits other than those that control the relays R1 and R2. The protection relay R3, which is normally disenergized, is used to disconnect the wayside cable (by operating on the common return conductor C3) from the AC-DC converter 112 on the power output and thereby afford considerably improved safety conditions in the idle state, particularly on AC electrified lines, in case of cable insulation failure to the ground.

[0053] More in detail, the Actuating Board 12 is composed of an AC/DC power converter, whose output is vitally enabled by vital outputs of the zone logic computer 5; this "enabling" signal is indicated in Fig. 4 and Fig. 7 as ON_Vit.

[0054] Furthermore, Fig. 2 and Fig. 4 shows that, from the moment in which the Zone Logic Computer (ZLC) exerts its control intention by transmitting the control signal Kn or Kr, energization of the unit 6 may only occur after a minimum time τ . This "delay" is vitally ensured by a suitable delay circuit 612.

[0055] Finally, an input is provided for a stop signal which has a protective function, for example, in case of abnormal power absorption by the unit and any other hazardous event, thereby preserving the integrity of the electronics of the Actuating Board 112 and/or the motor in the switch machine 6.

[0056] Figure 7 shows the connections of the Monitoring and Diagnostics Board. As shown in Figure 7, the board interfaces with:

[0057] The local Logic Computer 5 (ZLC) through the three signals: KN, KR and DISALIM, transmitted to three vital inputs respectively and through the N and R signals received from two vital outputs;

the unit 6, i.e. the switch machine, to detect its operating state, i.e. the position of its switch points (Field_Ctrl_N and Field_Ctrl_R signals); the Actuating Board 12, from which it receives the I MAN signal (containing the information about the level of current circulating through the power output) and the service power supply, and to which it transmits the N and R control signals for the relays R1 and R2, the stop signal, which turns the power converter 112 off at the end of the control operation or in abnormal situations, and the vital enabling signal ON_vit, which enables the DC/DC converter 112".

[0058] The board is composed of three functional sections:

- a turnout Position Monitoring Section (having vital operation)
- a Protection and Supervision Section
- a Diagnostics Section.
- a turnout Position Monitoring Section

[0059] This section implements the TC and RC functions, i.e. transmission and reception of feedback signals

for determining the position of the switch points. It accomplishes the turnout state monitoring functions, and communicates information through two position feedback signals KN and KR, connected to two vital inputs of the Zone Logic Computer (ZLC) 5.

[0060] The feedback signal is transmitted and received at about 400 Hz from and to the unit through transformers T1 and T2, the former T1 for the Normal switch point position signal KN and the latter T2 for the Reverse switch point position signal KR.

[0061] As mentioned above, the interface with the unit 6 may include 6 or 3 conductors, depending on whether or not a dedicated wire is used for feedback signals.

[0062] Figures 5 and 6 show two simplified diagrams of connection options.

[0063] It will be appreciated that, in the classical 3-wire connection as shown in Figure 5, the transformers T1 and T2 for transmitting and receiving signals at 400 Hz are in the short-circuit branch C4 of the power output whereas, in the option with a separate cable for feedback signals C1', C2', C3', as shown in Figure 6, the transformers T1 and T2 only have one point in common with the power circuit. Complete separation is not possible, due to the need for the Cable Insulation Check Section of the Monitoring Board, which is directly connected with the output of the Power Section, to check the efficiency of such insulation on both wires.

[0064] In the first option, i.e. the classical option of Figure 5, the presence of the auxiliary control relays R1 and R2 allows the position monitoring transformers T1 and T2 to be connected in parallel with the power circuit, thereby avoiding the need for oversize series-connected transformers designed to have the DC current requested by the motor flowing therethrough.

[0065] Figure 8 shows the block diagram of the switch point Position Monitoring Section.

[0066] The operating principle of safe detection of switch point position, when switch points have been thrown into the proper position, relies on the circulation of current at a frequency of about 400 Hz generated by an oscillator (carrier generator); this oscillator is only triggered if the cpn or cpr contact of the position cam inside the switch machine inserts a capacitor Cn or Cr in the circuit loop, which capacitor is in the terminal box 106 of the wayside device 6.

[0067] As mentioned above, the two carrier generators 20 and 21 are amplitude modulated to provide an additional safety key, particularly needed in 50 Hz drive system applications. An ON/OFF amplitude modulation is selected, having a 100% modulation depth, a 100 ms period and a duty cycle D = 90%.

[0068] Referring to Fig. 8, it can be appreciated that the feedback signal is transmitted and received through transformers, whose high isolation secondary windings are connected to the unit.

[0069] If the amplitude of the feedback signal exceeds a certain level and the carrier frequency and the modulating frequency are recognized, then the corresponding

vital input to the Zone Logic Computer (ZLC) 5 with the KN or KR signals is enabled. In the idle state, in case of a sufficiently long monitoring failure, the RIT timer block 613 maintains the corresponding vital input of the local Logic Computer (ZLC) 5 "low" for as long as required for the latter to detect it; thus, it allows the local computer 5 to detect any so-called "short monitoring failures".

[0070] The module of the invention also has a Protection and Supervision Section. This section has operational supervision functions. These functions are accomplished by a microcontroller, and the section receives information by interfacing with the other functional blocks of the actuating module 1. The Protection Section energizes the control relay R1 or R2 according to the control intention (N and R signals) of the local Logic Computer (ZLC) 5; after the control step, the protection section also energizes the monitoring relays CTN or CTR, which further allow the feedback signal generated by one of the two transmitters T1 and T2 as described above to flow into a single receiver, which is always on.

[0071] The Supervision and Protection Section is also designed to disable power delivery by the Actuating Board 12 during the control step, through the control protection function, by generating stop and DISALIM signals or a DISALIM signal only, in response to predetermined events.

[0072] The events that trigger the control protection function are:

- Surge at the power output;
- A voltage at the power output lower than a predetermined threshold (undervoltage);
- A number of successive control operations per minute greater than admitted;
- Overtemperature of power transistors;
- Control operation timeout;
- Unacknowledged control.

[0073] The stop signal has the purpose of inhibiting the DC/DC converter 112" of the Actuating Board 12. In the above cases in which a stop signal is triggered, the DISALIM signal is also generated to drive the third vital input of the local logic computer 5.

[0074] The control protection function may be also performed outside the control step, in case of wayside cable failure, in the loop (not monitored) of the next control operation; in this case, the DISALIM signal is only generated.

[0075] For improved reliability of the surge protection function, a periodic test is performed to check proper operation of the circuits designed to receive the control current.

[0076] As shown in Figure 9, the Diagnostics Section receives the following parameters from the two Position Monitoring and Protection and Supervision Sections:

- Control current (DMD, DP);
- N and R control voltage (DMD);

frequency of feedback signals (DT, DR);
 wayside cable insulation (CIC);
 turnout position feedback signals KN and KR (DT, DR);
 and makes them available for the diagnostics system through an interface with the ECHELON NODE 22 (FDB network), as well as other information about the status of the actuating module (i.e. correct operation or failure)

[0077] The Diagnostics Section is mainly implemented in the microcontroller 24 that performs the Protection and Supervision functions, as shown in Figure 9.

[0078] Such microcontroller 24 directly acquires all the magnitudes to be subjected to diagnostics, interfaces with the Cable Insulation Check circuit 25 (CIC) and with the Echelon "node" 22, which is used as a communication unit on the Field Diagnostic Bus 8 (FDB) network.

[0079] Furthermore, the microcontroller 24 performs tests on the cable insulation check circuit, either upon user's request (user interface panel) or in a periodic and automatic manner.

[0080] The Cable Insulation Check (CIC) section 25 essentially comprises a 0.5 Kz square wave generator, connected to the input of the wayside cable C1, C2, C3 through a resistor of a suitable resistance, and a circuit for vector measurement of the absorbed current, which can detect cable insulation failure to ground, i.e. any reduction of cable insulation resistance, which can be configured in a step-wise manner.

[0081] The operation of the actuating module as described above and with particular reference to its turnout control embodiment is as follows:

[0082] The switch machines 6 are controlled by the actuator 1 which provides power supply to the unit 6 and performs monitoring functions thereon.

[0083] During the control operation, due to the special architecture of the system, the feedbacks of the unit 6 are necessarily lost.

[0084] The interface is composed of two identical sections, one of which transmits at a certain time the indication of the (normal or reverse) position of the turnout unit 6 to the local Logic Computer (ZLC) 5. During the control operation, none of the two sections provides a valid output for the ZLC, as the mechanical members of the switch machine disconnect the contacts of both positions and the short circuit branch C4 of the power output is always open and prevents generation of feedback signals Kn and Kr.

[0085] The operation of the actuator implies the following steps:

Step I

[0086] Assuming a turnout in "normal" position, the output transformer T1 of the normal position monitoring transmitter is closed on the remote capacitor CN. This triggers 400 Hz oscillation and enables relative position

feedback (KN). The output transformer T2 of the reverse position monitoring transmitter is closed on a low impedance, in the classical case. Thus, its oscillator is off and the output KR is disabled. In the 6-wire connection configuration, the above transmitter operates idly, thereby causing an oscillation at a frequency from 700 Hz to 2.5 kHz, which cannot enable the output KR.

Step II

[0087] Upon switching from normal to reverse, the Zone Logic Computer (ZLC) 5 enables its vital output (R); after a short time, the CTN relay will be disenergized and the normal KN feedback will be immediately lost, whereupon the control relay R1 is energized. Then, a control protection Stop signal is transmitted to enable operation of the DC/DC converter 112". After another short vital delay, the ON_Vit power supply is enabled, to energize first the protection relay R3 and then the section for controlling the power DC/DC converter 112". Now, the actuator provides a rated voltage of 150 VDC to the winding of the motor, which causes displacement in the "reverse" direction.

Step III

[0088] When the motor of the switch machine terminates rotation (the control time depends on the type of switch machine used), causes the control circuit in the switch machine to open, whereby DC power failure occurs. This event initiates the end sequence of the control step; the control protection Stop signal is generated again whereupon the 150 VDC is cut off. Then, the control relay R2 is released and restores the short-circuit of the power output. Immediately after, the monitoring relay CTR is energized; this allows disenergization of the protection relay R3 which cuts off the vital power supply ON_Vit. If the switch points have moved to the required position, monitoring contacts are established and insert the remote capacitor CR which triggers the reverse position oscillator. Now, the resonance capacitor CR is connected instead of the motor winding, allowing circulation of the 400 Hz feedback signal and, after an intrinsic delay time (τ_c) a "1" output is obtained on the reverse position vital input (KR).

Step IV

[0089] Then, the system logic cuts off the control operation thereby disabling the corresponding vital output (R).

[0090] According to one improvement, it is possible to also control and monitor switch machines that do not automatically cut off current upon termination of the control operation. In this case, a 6-wire connection is used, and the system may be configured to enable the monitoring relay CTR after a configurable delay from the time of closure of the control relay R2, regardless of whether the

control current is cut off or not. In this case, the end of the control operation is determined as the monitoring frequency is reached and the corresponding feedback is obtained.

[0091] Thanks to the above construction, the actuating module of the invention can handle abnormal operation statuses and ensure the highest safety.

[0092] Besides start up, there are substantially two distinct operating states: the former is the state in which the module operates for most of the time and is characterized by the lack of controls, with the monitored unit in the Normal or Reverse position; the latter operating state is the one in which the unit is controlled, and feedbacks are necessarily lost.

[0093] In addition to these two states, which represent normal operation of the module, there are "abnormal" states, characterized by malfunctioning in the module, the unit and connection therebetween.

[0094] The causes that lead to abnormal states and the behavior of the MGD will be described below:

Current protection

[0095] This occurs during a control operation, with the unit being disenergized by a Stop signal. At the same time, the DISALIM signal is also generated. The turnout may be monitored or not.

Unacknowledged control

[0096] This event may occur in response to a control operation. An unacknowledged control triggers a DISALIM signal. The turnout may be monitored or not.

Control operation Timeout

[0097] This event may occur during a control operation. Once the control operation timeout is reached, the unit is disenergized, the control operation is interrupted and a DISALIM signal is generated. The turnout may be monitored or not.

Undervoltage protection

[0098] This event may occur during a control operation. This protection does not disenergize the unit, whereby the module will try and terminate the control operation. When the latter is terminated, a DISALIM signal will be generated. The turnout may be monitored or not.

Wayside cable failure protection

[0099] This event may occur when there is no control operation and the turnout is monitored, in a normal or reverse position. In case of failure of the live pole of the monitoring circuit for the position that is not monitored ("third wire") the module triggers a DISALIM signal, to prevent voltage from being transmitted, during the next

control operation, to a circuit that has no load.

[0100] In case of a three-wire connection, this protection may be excluded during configuration.

[0101] In case of a six-wire connection, the above described detection is not significant. Thus, protection has to be necessarily excluded during configuration.

[0102] Maximum allowed successive control operations in one minute

[0103] This event occurs at the end of the last admitted control operation. Once this control operation is terminated, a DISALIM signal will be generated. The turnout may be monitored or not. This protection may be configured during setup.

15 Overtemperature protection

[0104] This event occurs during a control operation. This protection does not disenergize the unit, whereby the module will try and terminate the control operation. When the latter is terminated, a DISALIM signal will be generated. The turnout may be monitored or not.

Inefficient current sensing circuit protection

25 [0105] Periodic tests are performed for checking proper operation of control current measuring circuits. Whenever a test fails, a DISALIM signal is generated.

30 Claims

1. An actuating and monitoring module, particularly for operating units, i.e. wayside equipment, of railway systems or the like, particularly for switch machines, comprising:

a source of a DC power signal;
a line for supplying said power signal, also known as control signal, to said operating unit, which line connects the outputs of the power signal source to the inputs of the operating unit;
switching means in the power signal supply line for switching the operating unit on and off by remote enabling/disabling controls.

characterized in that

it has automatic switching means for switching the inputs of the unit and/or the outputs of the power signal source to the short circuit state, in the disabled unit state, i.e. with no power signal on the supply line.

2. An actuating module as claimed in claim 1, **characterized in that** said means are electromechanical means.

3. A module as claimed in claim 1 or 2, **characterized in that** said switching means include:

- at least two relays, one of which is connected in series with at least one conductor of the supply line, whereas the second relay is connected in series with a short-circuit line for shorting the power signal outputs of the power signal source and/or the power signal inputs of the operating unit,
- whereas a third protection relay is connected in series with at least one second conductor of the power signal supply line, the latter relay disconnecting said conductor and being open when the operating unit is in its idle condition, i.e. with no power signal, and closed when the operating unit is in its operating condition, i.e. in the presence of a power signal.
4. A module as claimed in one or more of the preceding claims, **characterized in that** the operating unit has three inputs, i.e. one input for a common power signal return conductor and two further inputs for alternating supply of the power signal to one of said inputs using two separate power signal supply conductors, each connected to one of said two further inputs and each alternately connectable to one output of the power signal source, there being provided at least three relays:
- a first and second actuation or control relays which have disconnecting contacts connected in series to both supply conductors and the disconnecting contacts of said two actuation or control relays being connected in series with each other in the same conductor and operating in inverted arrangement, wherefore by energizing either actuation or control relay one of the two inputs of the operating unit are alternately connected to the output of the power signal source. a third short-circuit relay in a line for short-circuiting connection of the inputs of the operating unit to each other and/or to the outputs of the power signal source, and which short-circuit relay has disconnecting contacts which are connected in series in said short-circuit line and which disconnecting contacts are normally closed, with said inputs and/or said outputs in a short-circuit state, when said two actuation or control relays are in a state of disconnection of the corresponding conductor, said short-circuit relays being excited to the short-circuit line contact opening state by the signal that energizes at least one or both of said actuation or control relays.
5. A module as claimed in one or more of the preceding claims, **characterized in that**, as an alternative to the third short-circuit relay, the first and second actuation or control relays have a pair of short-circuit contacts, which are controlled by said actuation or control relays and are closed in the idle state of said actuation or control relays.
6. According to an advantageous embodiment, a fourth protection relay is provided which has contacts connected in series to the return signal conductor in the power signal supply line, which protection relay is in the open contact state when there is no control signal coinciding with the signal that energizes at least one of said two actuation or control relays and the short-circuit relay.
7. A module as claimed in one or more of the preceding claims, **characterized in that** the relays are controlled by a microprocessor which receives feedback signals from a Monitoring and Diagnostics board, which in turn generates said signals in response to controls of a control logic unit.
8. A module as claimed in one or more of the preceding claims, **characterized in that** it comprises a delay circuit for introducing a time delay between the control signal for actuating or enabling the operating unit and the transmission of the power signal to the operating unit or the connection of the operating unit to the power signal generator with said power signal at its output.
9. A module as claimed in one or more of the preceding claims, **characterized in that** the operating unit is equipped with means for generating feedback signals confirming actuation and/or switching thereof to an operating state, which signals are generated as the control operation or the operating function is performed by the operating unit during power signal supply, said feedback signal generators being formed at least partly of the short-circuit line or components connected to said short-circuit line.
10. An actuating module as claimed in one or more of the preceding claims, **characterized in that** it is designed for actuation of a motor-driven switch machine, and which switch machine throws the switch points of a turnout between two opposite limit stop positions, i.e. normal and reverse, said switch machine having three inputs, including one common input for a power signal return conductor and two inputs for alternate supply of the power signal, each causing, when supplied with said power signal, the motor to rotate in either direction, there being provided:
- two conductors for supplying the power signal to each of the two power signal inputs, which conductors are designed to be alternately connected to the power signal output of the power signal source by means of two actuation or control relays, each of which actuation or control

relays has contacts for disconnecting either conductor, operating in inverted mode, the disconnecting contacts of the two actuation or control relays being connected in series with each other in each of the two power signal supplying conductors;

a short-circuit line that connects the outputs of the power signal source and/or the inputs of the switch machine when there is no power signal or the actuation or control relays are not energized, while the disconnecting contacts of the two power signal supplying conductors are closed, and which short-circuit line includes a short-circuit relay having disconnecting contacts that are normally closed when said relay is in the disenergized condition, said relay being controlled by the signal that controls the supply or control relays.

11. An actuating module as claimed in claim 10, **characterized in that** it has a protection relay, whose disconnecting contacts are located in the power signal return conductor and which is energized to the open state by a signal coincident in time with the disenergization state of the two actuation or control relays, which signal is generated by a source other than that of the signal for controlling the two supply or control relays
12. An actuating module as claimed in claim 10 or 11, **characterized in that** the switch machine has means for generating a feedback signal, including an oscillatory circuit that generates a signal at a predetermined frequency when the switch machine switches to one of said two predetermined operating conditions, the oscillatory circuit being driven to generate the feedback signal at the predetermined frequency when a capacitor of predetermined capacitance is introduced in a loop of said circuit, by means of switches that are switched closed by means for detecting one of said operating states, whereas oscillating feedback signal receiving/transmitting means are provided, preferably connected in series with the short-circuit line.
13. An actuating module as claimed in one or more of the preceding claims, **characterized in that** it has a pulse width modulation, which requires a modulating signal that can be generated either by the microcontroller that controls the auxiliary relays and diagnostics, or by an active wayside circuit, connected in parallel to the remote capacitors, or to said capacitors as mentioned in the preceding claim, and supplied by said feedback signal on which the modulator operates.
14. An actuating module as claimed in one or more of the preceding claims, **characterized in that** it com-

prises means for detecting the oscillating feedback signal, which means comprise feedback signal analyzing means for checking the correctness of the carrier frequency and the modulating frequency of the feedback signal and generate a signal to indicate that the operating unit has correctly switched to the corresponding operating state.

15. A module as claimed in one or more of the preceding claims, **characterized in that** it comprises means for detecting the lack of any feedback signal, which means compare the time during which no feedback signal has been detected with an adjustable maximum allowed threshold, and which means control, with the actuator in the idle state, means for locking, suppressing and/or delaying the signal indicating that the operating unit has correctly switched to the corresponding operating state during a predetermined time longer than the maximum cycle time of the logic of the zone computer, or generate a signal indicating that the operating unit has not correctly switched to the operating state when the time during which no feedback signal has been detected exceeds said maximum allowed threshold.
16. A module as claimed in one or more of the preceding claims, **characterized in that** it includes contacts that are normally closed in the disenergized state of the actuation or control relays.
17. A module in which the unit control or monitoring functions are obtained with the help of force guided relays, which can be exposed to sticking and undue energizing in case of failure, wherefore such relays must be all monitored by each other and/or by the electronics, to avoid undue unit controls (not required by the apparatus) and to initiate a position monitoring failure if said relays are not switched to the position desired by the apparatus logic.

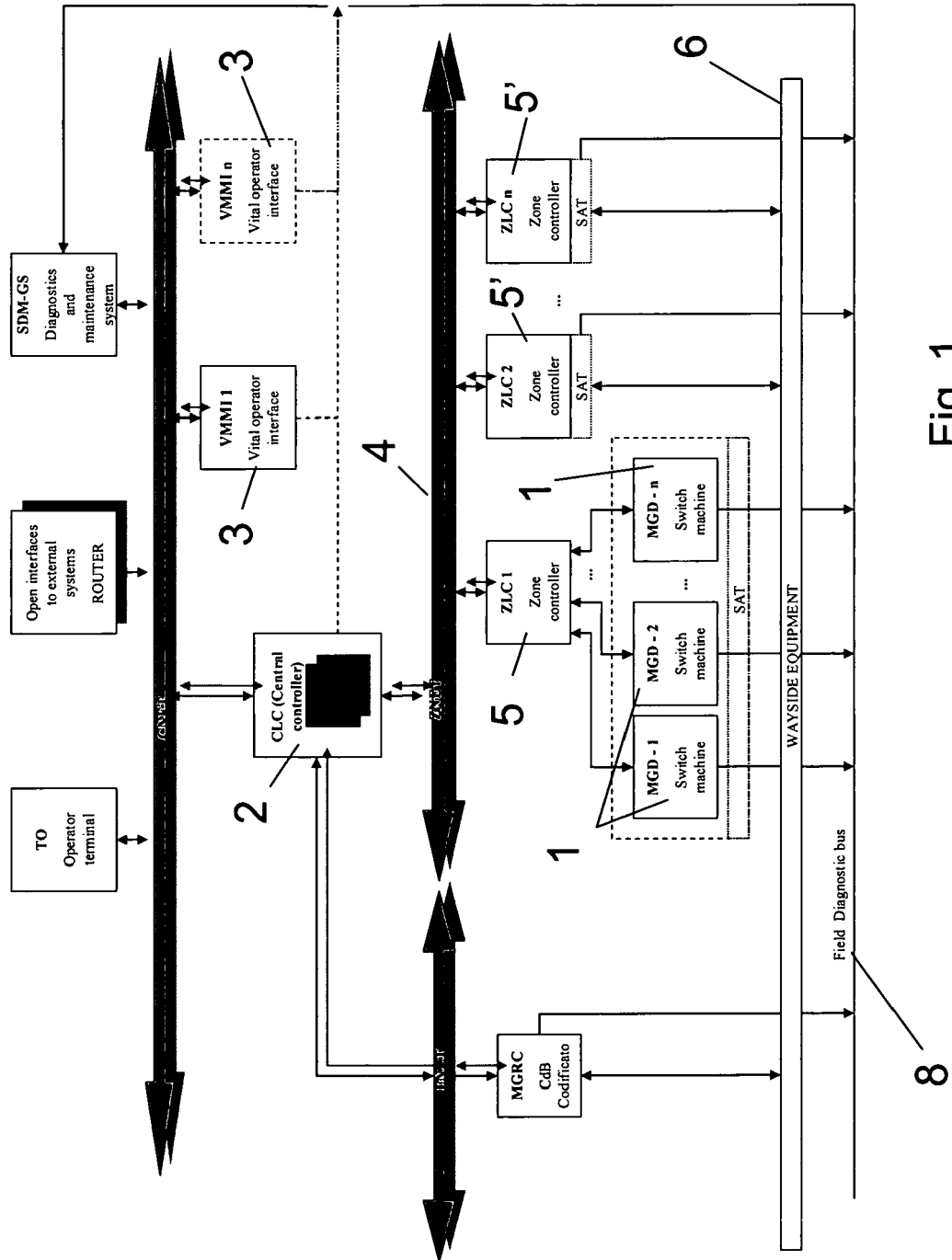


Fig. 1

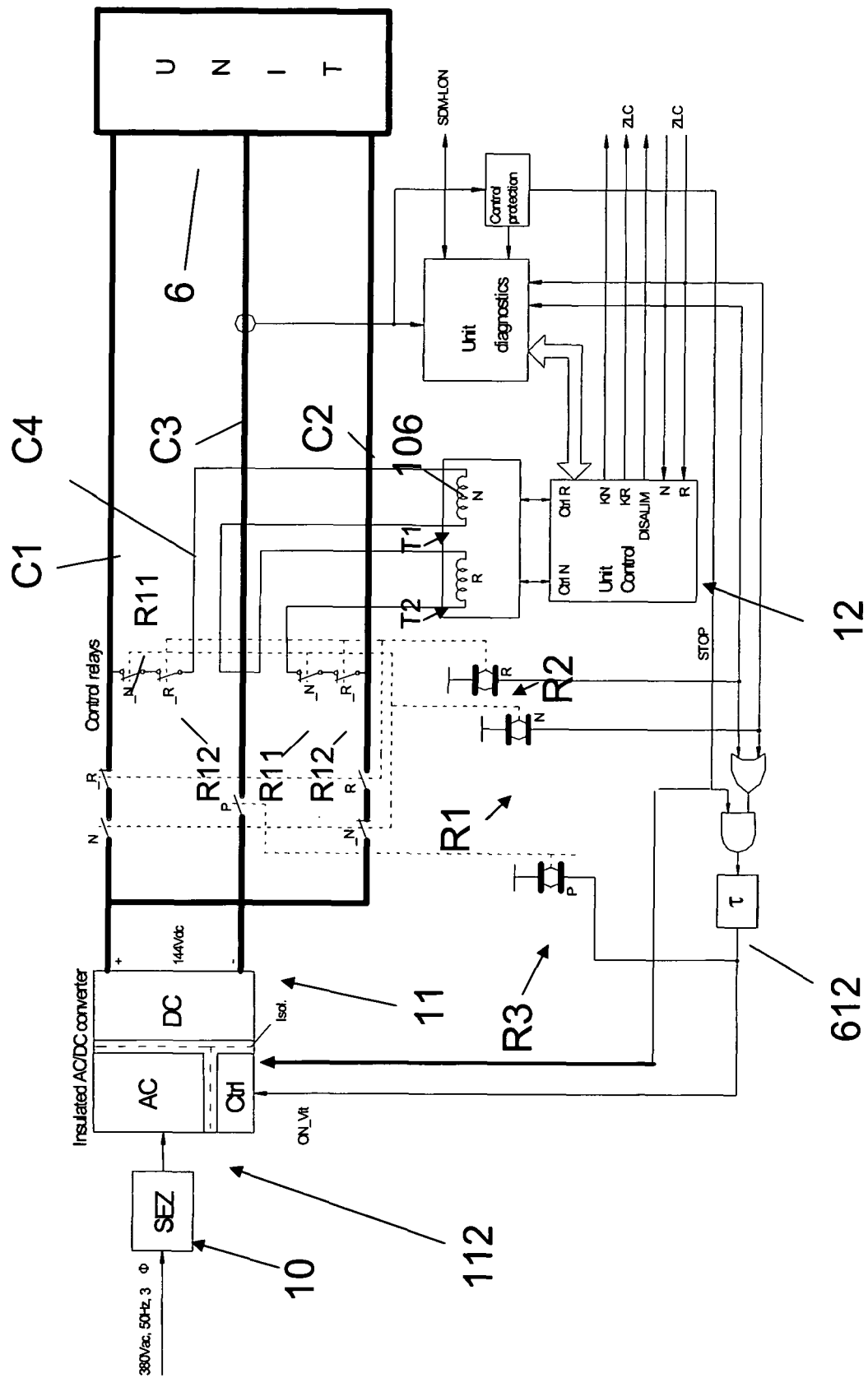


Fig. 2

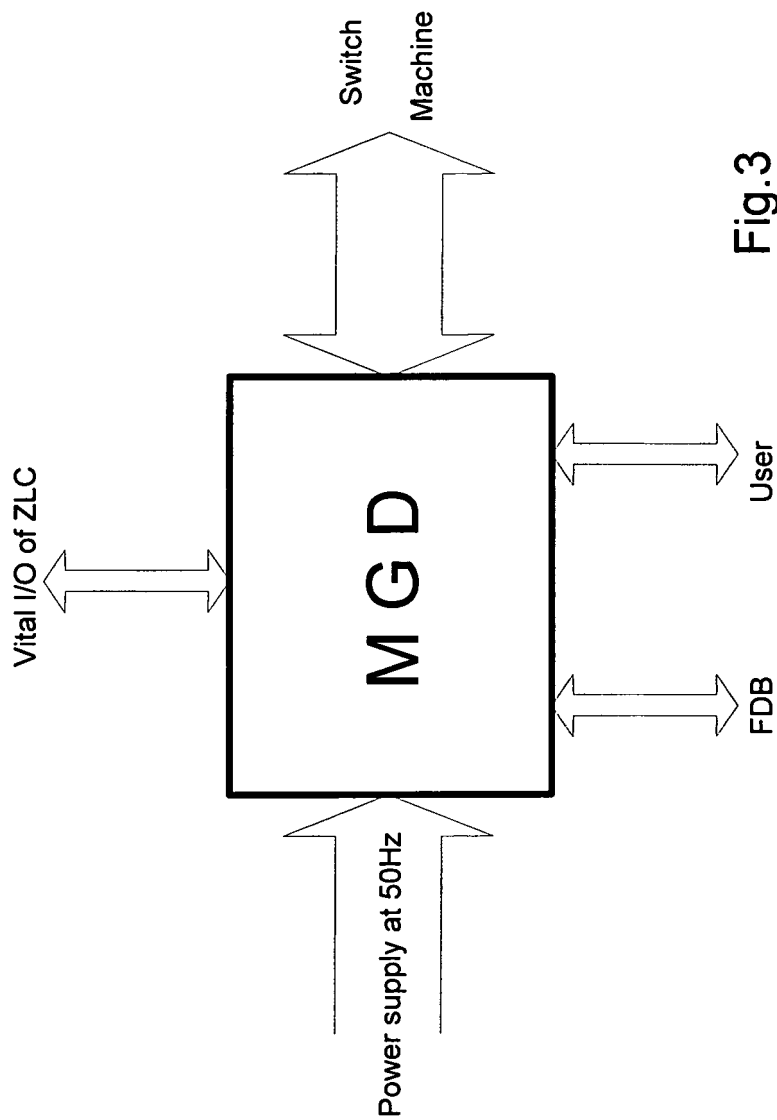


Fig.3

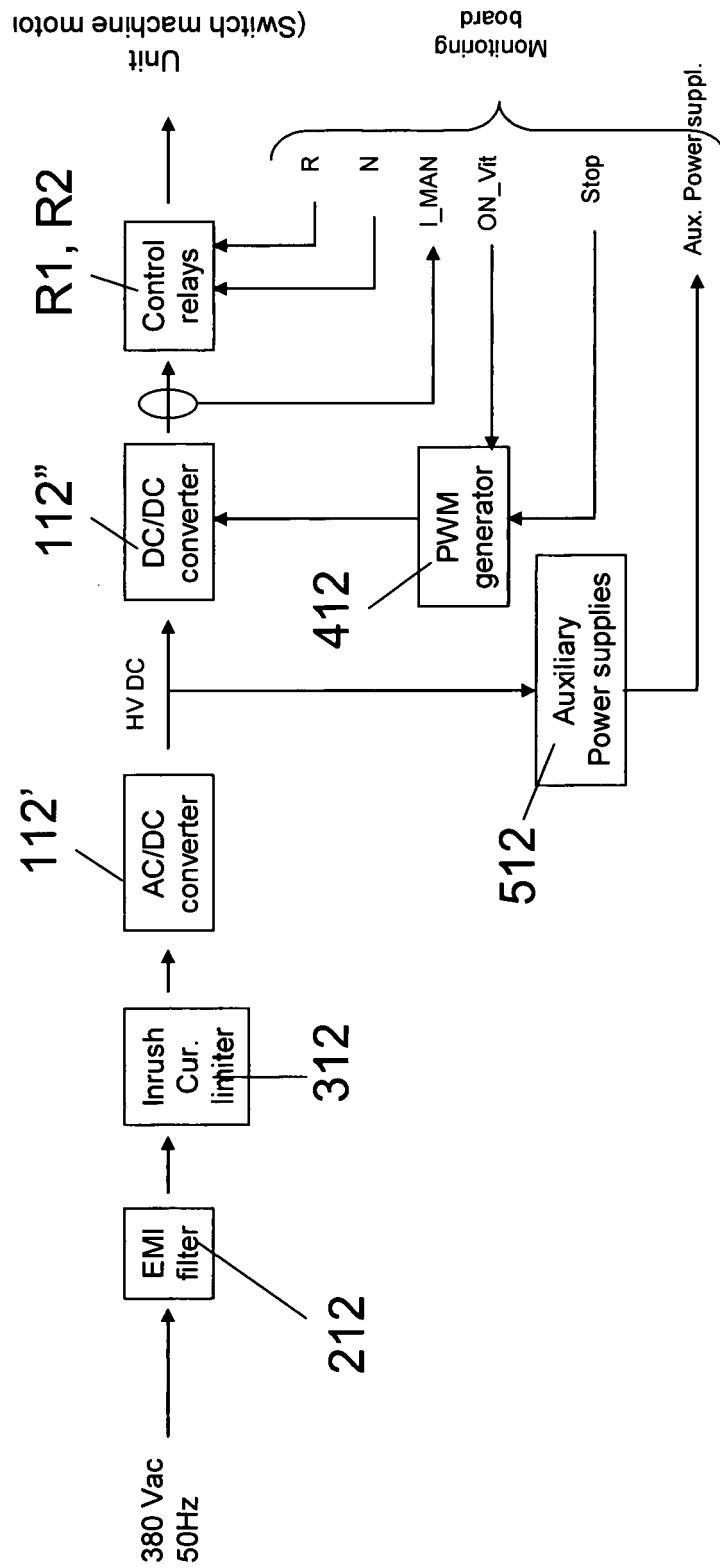


Fig. 4

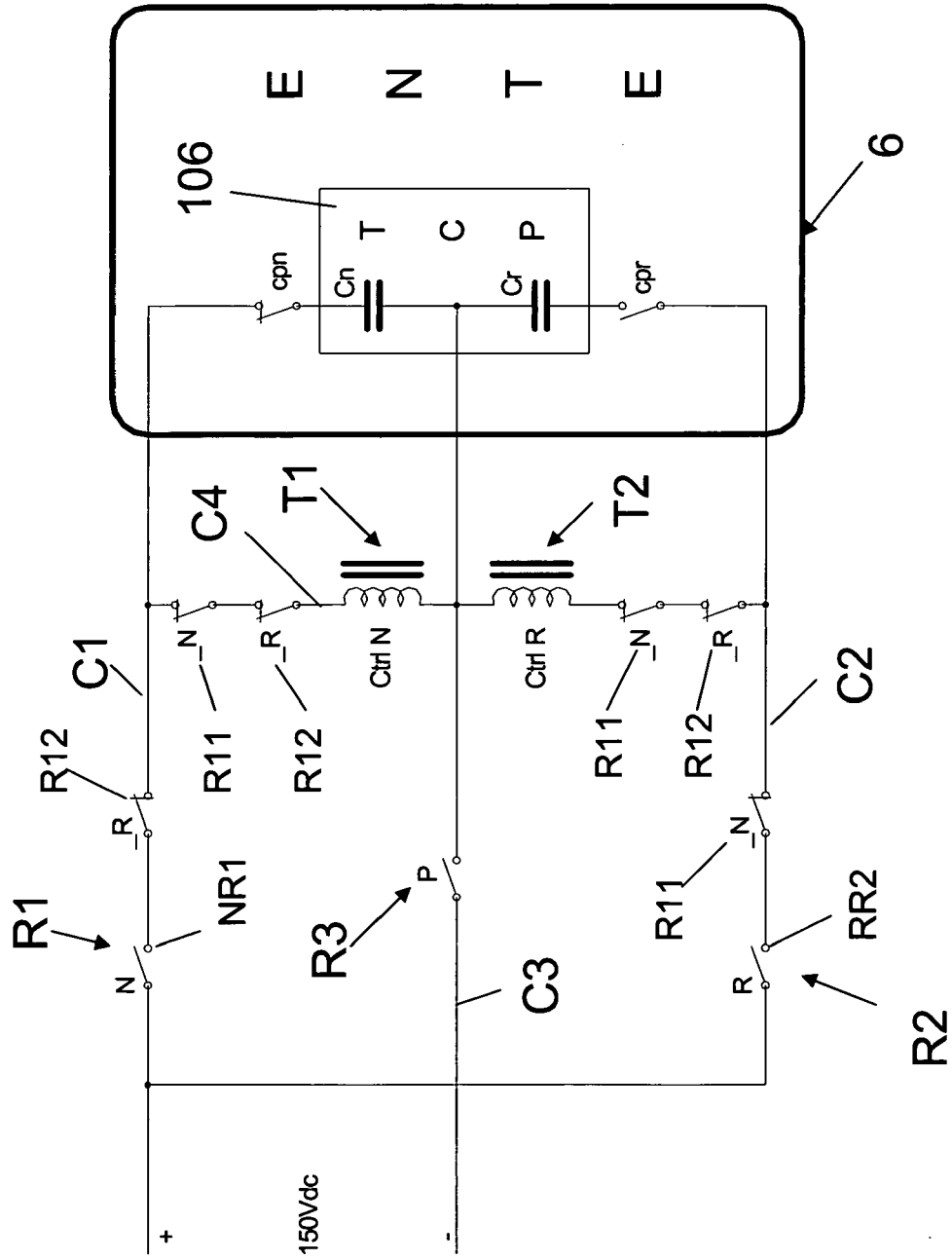


Fig. 5

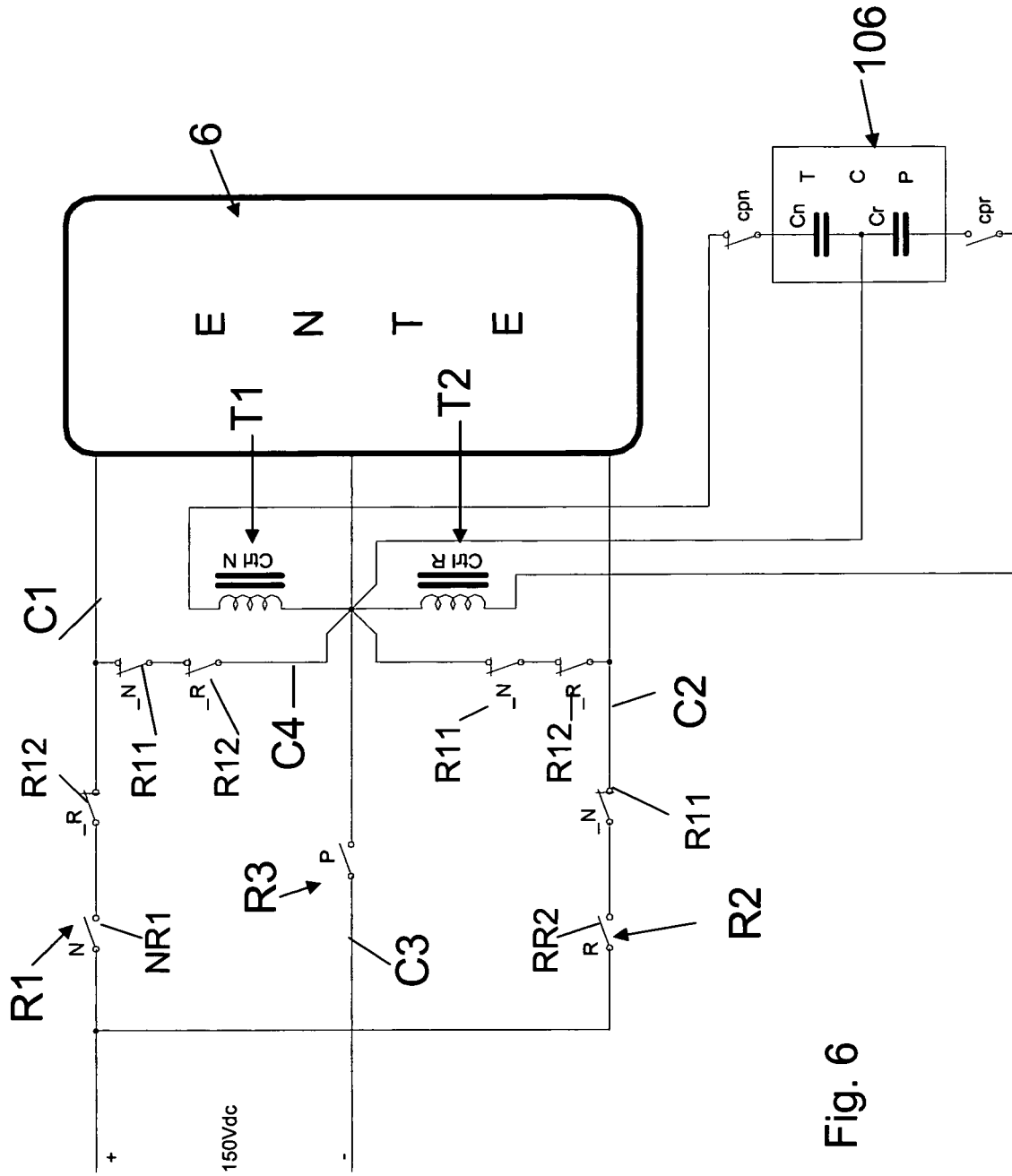


Fig. 6

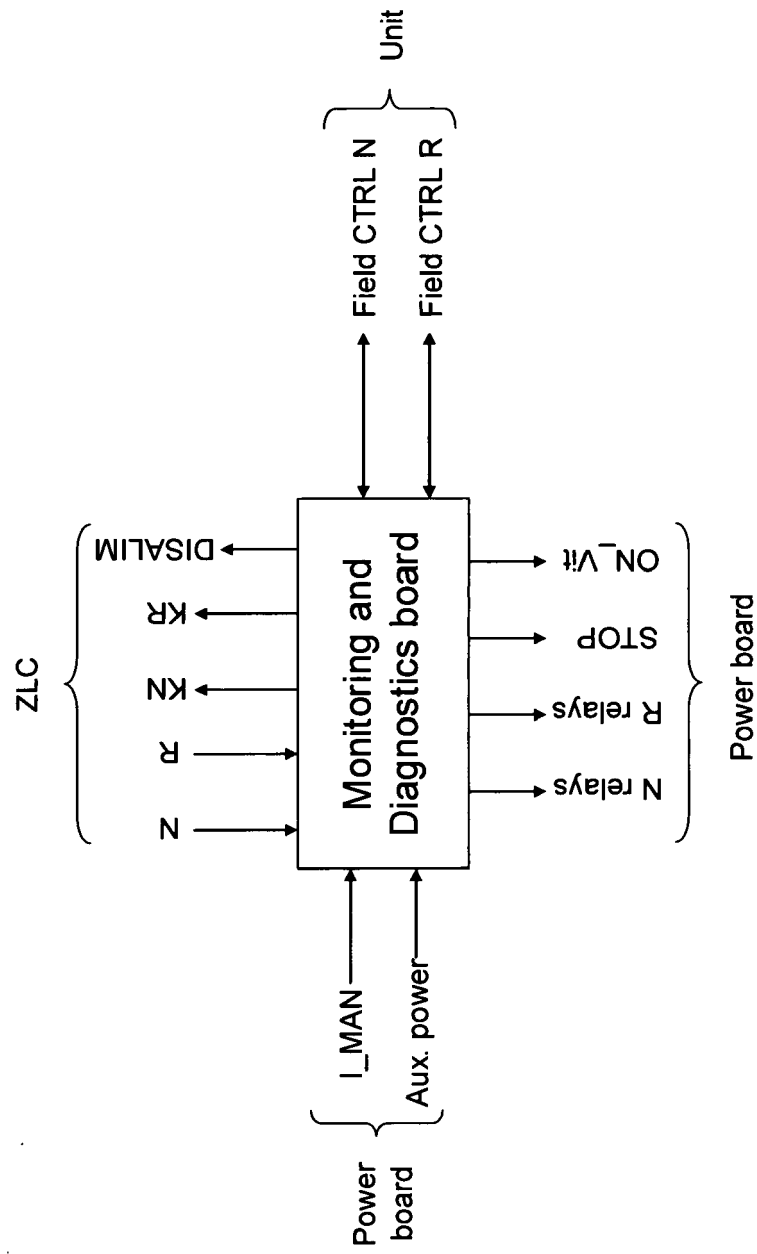


Fig. 7

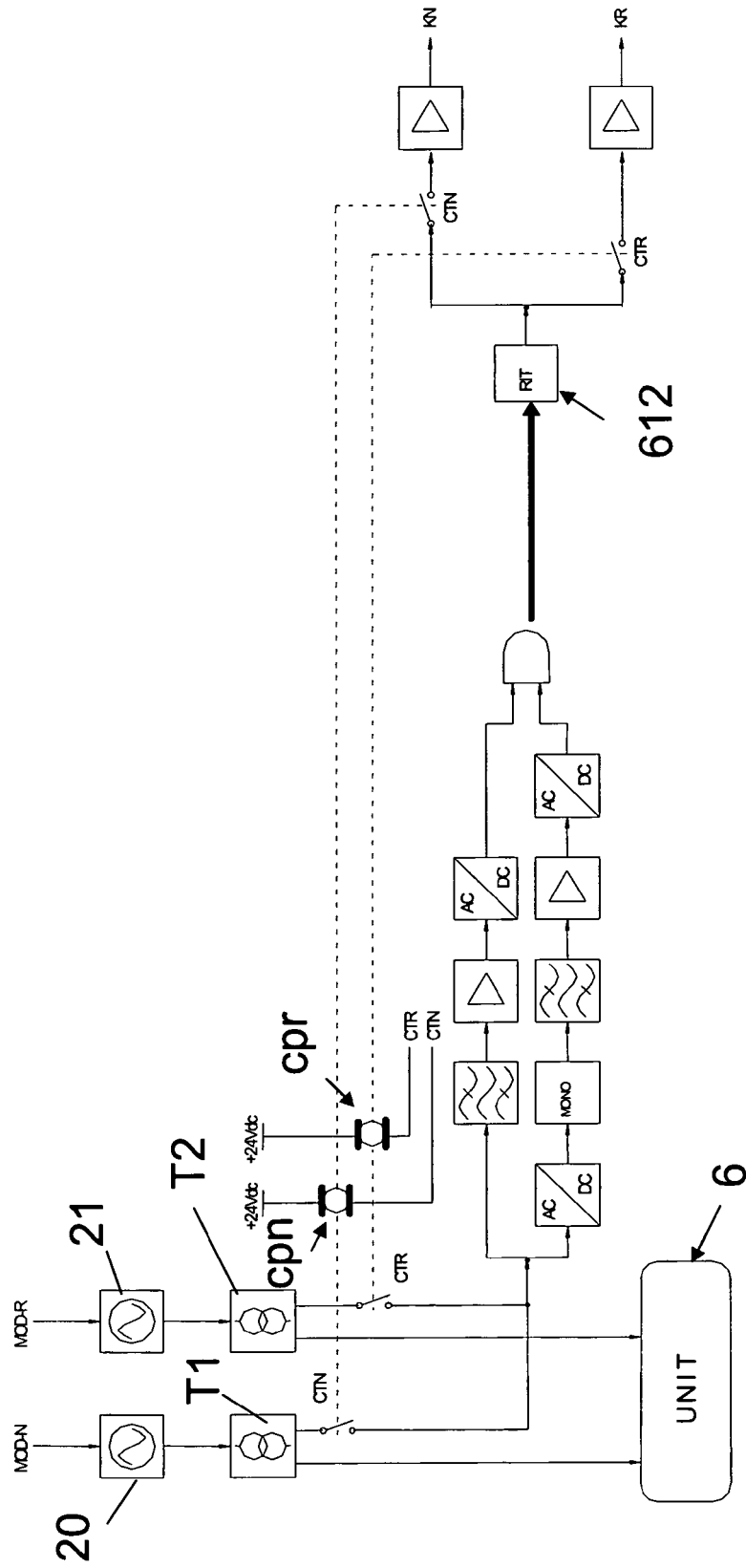


Fig. 8

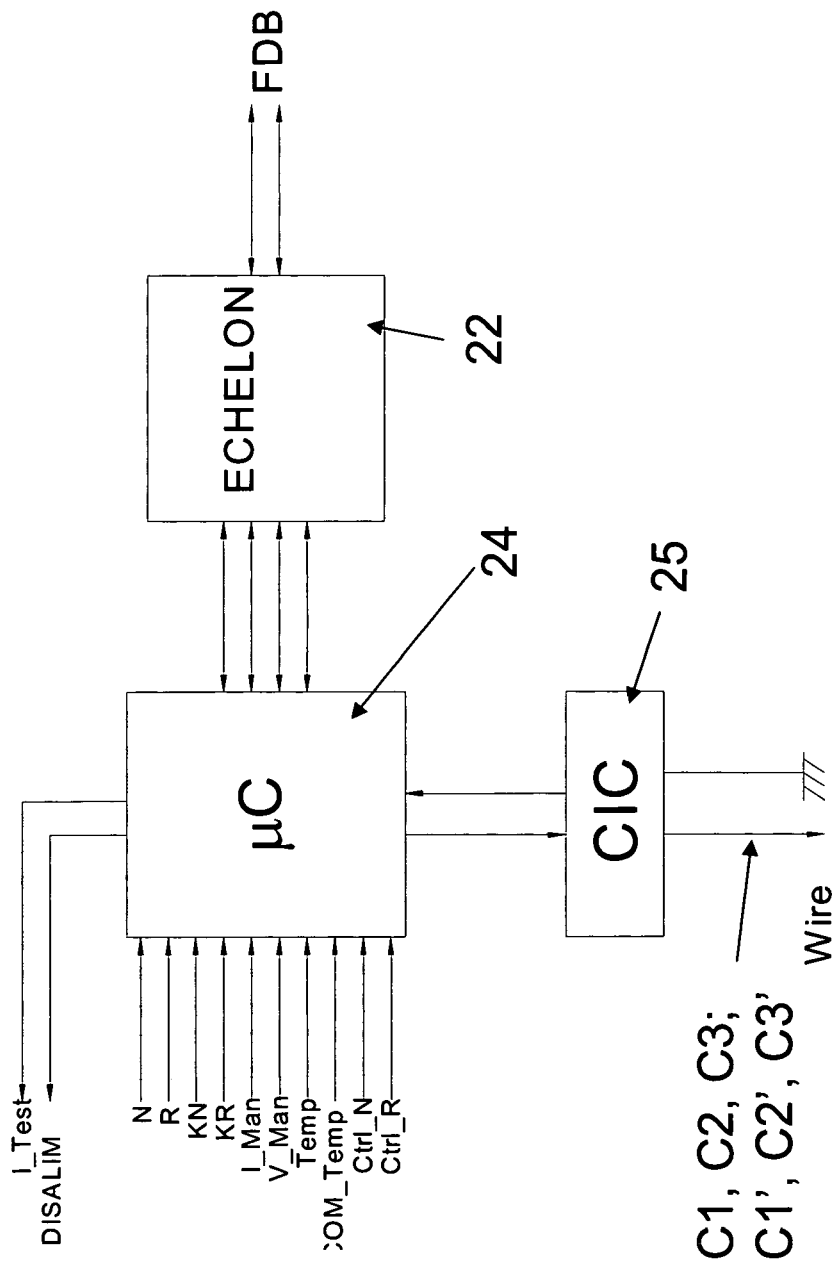


Fig. 9



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EUROPEAN SEARCH REPORT

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