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Doctoral School of Electrical Engineering

OPTIMIZATION OF THE PRODUCTION PROCESS OF ELECTRICAL PANELS

SUMMARY

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CHAPTER 1

PRODUCTION AND DISTRIBUTION OF ELECTRICAL ENERGY

Electricity is the engine of current economies; its production involves the use of other energy sources that, exploited through specific methods, allow obtaining electricity with better and better returns. Each method of obtaining electricity has a whole series of advantages and disadvantages, the most and the biggest disadvantages refer to the pollution of the environment, pollution that has become a very controversial topic in the last period due to the climate changes generated by the greenhouse gases obtained by burning fuels.

Electricity is used in a variety of ways to power various devices, machines and facilities. The use of various electrical technologies is dictated by the multitude of advantages they present compared to other processing technologies. [1]

The advantages of using electricity in industry are obvious, high temperatures of over 2000K can easily be achieved by intermittent control and waveform modulation using process computers and PLCs.

Efficient use of electricity is important to reduce costs and environmental impact. Energy-saving technologies and renewable energy sources are increasingly important to meet the challenges of climate change and the depletion of natural resources. [2] The use of electricity for industrial or domestic purposes requires the existence of three important components that make up the chain of production and consumption of electricity. The three components involved are the production, transport and use of electricity.

1.1 ELECTRICAL NETWORKS

The transport and distribution of electricity is carried out through electrical networks, therefore, it is important to understand the topologies of the networks used and the main types of equipment that are part of these distribution networks.

An electrical network is defined as a grouping of electrical and mechanical components used directly in the transport and distribution of electrical energy from its production to final consumers or a well-defined section of this distribution chain. [3]

The totality of electrical receivers, consumers, connecting and measuring devices together with the supply networks form the electrical installation of a consumer. Due to their different importance, electricity consumers can be divided into 3 categories, category 3 being the least important consumers where the interruption of electricity can cause only relatively little inconvenience or loss. [4-6]

1.2. PROTECTION AND CONTROL EQUIPMENT USED IN ELECTRICAL PANELS

Electrical switchboards are essential to protect electrical circuits and manage the distribution of electricity in a building or industrial facility. They are equipped with various protective devices such as fuses, circuit breakers, protective relays and other accessories to ensure the safety of consumers and equipment powered from them.

These protection, command and control devices are designed to detect and intervene in emergency situations such as overloads, short circuits or other anomalies that could endanger the operation of the electrical system or the health and safety of its users.[7 -8]

1.2.1. Fuse protection of electric circuits

The electrical fuse consists of an insulating body, usually of a ceramic or plastic material, inside, which are placed properly calibrated fuse wires or strips. The fusible element is made of a good electrically conductive material, material that has a known specific melting point and a well-determined thermal behavior in relation to the ambient temperature.

When the electrical current passing through the contacts of a fusible element exceeds the rated value, the fuse wires or strips heat up and melt.

The melting occurs in a well-defined time interval and thus interrupt the electrical circuit preventing the overload or short circuit from damaging other elements in the circuit, these components act as sacrificial elements because they are very cheap and easy to replace in case of damage.

Normal or conventional fuses have a standard reaction speed, they are designed to interrupt the electric current in a relatively short time after the specified response curve (aM,gG,gM Conventional fuses are used in applications where an extreme reaction is not required fast, the electrical installation being more permissive or the operating regime requiring high currents of short duration.

Ultrafast fuses are designed to interrupt electrical current in a very short time, making them ideal for protecting sensitive circuits or semiconductor electronic devices because even a small delay in interrupting the current can cause significant damage.

1.2.2. Circuit breaker protection of electrical circuits

Circuit breakers and **automatic switches** are essential components of electrical installations, they perform several important functions such as protection of consumers against overloads, short-circuit protection of electrical circuits and consumers, as well as manual connection or disconnection of circuits and consumers from the electrical network**.**

In the technical language, two names are used to differentiate between circuit breakers and higher power protection switches; these established terms are MCB (Miniature Circuit Breakers- Mini interupătoare) and the term MCCB (Molded Case Circuit Breaker) which refers to larger circuit breakers that are capable of operating at rated currents in the hundreds of Amps. [8]

Existing insulation faults in electrical installations cause the appearance of discharge currents but also residual differential currents (CDR). These differential currents can occur if there is an accidental leakage of current to earth from an electrical circuit in which case part of the current entering the equipment drains directly to ground via other paths

The potential consequences of these insulation defects are serious and include the risk of electric shock, the risk of fire or explosion, and even the risk of power failure.

1.2.3. Control equipment used in electrical switchboards

Electromagnetic contactors are electromagnetic devices used for switching and controlling electrical circuits, they are essential in the realization of modern power systems but also in all industrial systems and applications.

The main contacts of the contactor are sized to allow the rated current to pass for a long time without damage and to allow a very large number of actuations, even in the order of

millions without suffering considerable damage due to the extinction of the electric arc produced in the normal operation of electromagnetic contactors.

According to the type of load for which a contactor is sized, we distinguish 4 main classes more often used for alternating current and 5 classes for direct current as shown in table 1.1.

AC1	For controlling receivers with non-inductive or weakly inductive loads having a power factor between 0.95 and 1
AC2	To control the start of motors with contact rings and those used for countercurrent braking
AC3	For starting motors with the rotor short-circuited and when stopping them on the go, used in heavy duty regimes but with pauses between actuations
AC4	For frequent starting and stopping of short-rotor motors
DC1	For controlling non-inductive or weakly inductive receivers
DC3	For starting, stopping, blocking and dynamic braking of electric motors
DC5	For series motors, start, stop dynamic braking
DC6	For incandescent lighting
DC12	For controlling resistive loads and those of the static switch type

Tab. 1.1 Classification of contactors according to the type of electrical load

1.3. LOW VOLTAGE ELECTRICAL PANELS

Electrical switchboards are assemblies of electrical devices, components and conductors physically grouped on a support, with a role in monitoring, controlling and distributing electricity to other electrical devices or to areas with a well-defined purpose.

Distribution boards have a simpler structure and only incorporate functions to protect inputs and outputs from the board, but they can also include functions to monitor electrical parameters.

Automation switchboards are more complex due to the large number of circuits and command and control functions performed.. All these methods of monitoring and controlling the controlled circuits are done by means of circuits having pre-wired logic in the switchboard or with the help of intelligent equipment such as PLC.

1.3.1. Technical parameters of electrical panels

To be able to describe an electrical panel as accurately as possible, it is sufficient to know its physical dimensions, the rated current or rated power, the rated voltage and the type or manufacturer of the equipment it contains, together with the electrical diagram in its single-wire form or multifilar.

In order to be able to create an electrical panel some parameters related to the way in which the actual panel is to be made must be defined. These parameters are reffering to the type of case, the material from which the case is made, the minimum degree of protection of the case, the directions of inputs and outputs from the switchboard, possibly the dimensions of the cables that will be connected to it.

The nominal current is defined as the sum of the currents that feed the electrical panel on all the inputs intended for this purpose simultaneously. For small currents, up to 80-100A, comb-type or isolated distribution block-type distribution systems can be used, but above these values, main busbar systems made of good conductive materials (Aluminum or Copper) are used, to which they are connected directly all the arrival or departure circuits by means of conductors sized according to the nominal current of the respective equipment. [9].

1.3.2. Classification of low-voltage switchboards according to their purpose in the local distribution scheme

If we make a classification of low-voltage electrical panels according to their destination within the local electricity distribution scheme, electrical panels can be divided into general electrical panels (TEG), main panels (TP) and secondary panels (TS).
The general switchboard is the one that supplies electricity to the entire building, it being supplied directly from the electricity network or from its own alternative sources.

The main switchboards may be missing if the number of supplied consumers is reduced or if one opts for the direct supply of the secondary switchboards directly from the general switchboard in order to obtain a higher degree of safety by not interrupting the supply due to faults in other secondary switchboards fed radially from same main electrical panel.

1.3.3. Classification from the point of view of protection of the components against the environment

If we consider the way in which the internal components of the electrical panel are protected from actions of the environment, then we distinguish the following three types of panels: open electrical panels, closed electrical panels, encapsulated electrical panels.

In the case of **open electrical panels**, the apparatus are mounted on grills, racks or insulating materials without protective casings. The electrical apparatus and the connecting conductors are visible and unprotected; the user is not protected in any way against direct touching of the parts by hand or with any tool dangerous, that's why this type of panel is considered to have a degree of protection IP 00.

Protected electrical switchboards are an evolution of non-protected or open ones, they have an enclosure in which the apparatus is protected against mechanical damage, dust and moisture from the environment. This type of electrical panels can be executed in various shapes and sizes according to needs.

Sealed or encapsulated electrical switchboards are electrical switchboards in which the electrical apparatus is mounted in metal casings or casings made of prefabricated and sealed plastic materials in order to ensure complete protection of the equipment against dust and water present in the environment where they are mounted, the casings ensuring a high degree of protection (IP 65 or higher).

CHAPTER 2

MAIN TYPES OF ELECTRICAL PANELS

In order to be able to use the electricity at the final consumers, it is reduced in standardized voltage steps from the transmission levels to the distribution levels and then to the consumption levels, voltage values that can be used directly by consumers and equipment electricity that they own

The transport and distribution of electricity at low voltage is done by means of equipment and types of electrical panels whose names and structures are known and established within the electricity distribution companies and manufacturers of low voltage electrical panels. The creation of these standard distribution boards is based on national and regional regulations that impose the structure, dimensions and type of equipment used for each type of electrical board.

2.1. INDOOR (TDRI) AND OUTDOOR (CD) NETWORK DISTRIBUTION BOARD

The TDRI panel (Indoor network distribution panel) this is the first existing electrical panel on the low voltage side of the step-down transformer, it is mounted in the same building as the power transformer. Due to fact that this electrical panel is operated strictly by authorized persons, it does not require the presence of a casing with a high degree of protection, there are cases when it is completely missing or is replaced by a metal structure on which a metal mesh is fixed with the role of delimiting the area.

This electrical panel is dimensioned so that it can ensure the nominal current of the transformer and possible accidental overloads. The protection on the entrance of the electrical panel allows the limitation of the total absorbed power and the protections of the outgoing circuits are so dimensioned as to ensure the protection of all the power cables that leave this panel to the rest of the distribution network.

In order to monitor the network parameters and the actual load of the transformer, a measurement circuit made with a network analyzer with a communication port is provided on the general input that allows integration into the monitoring system of the electricity supplier.

For the case where the voltage-lowering transformer used is intended for outside and is fixed on one or two overhead poles, then the distribution board is called CD (Post Aerial Distribution Box).

This type of electrical panel has a structure made up of a metal base that it ensures its attachment to the base of the pole on which the serviced transformer is located. It also includes a set of cases fixed back to back, on one side being the main switch that protects the output of the transformer, and on the other side are the starting circuits.

2.2. (FD) TYPE DISTRIBUTION PANEL

The electrical switchboard type FD (Distribution Box) is an electrical switchboard made up of a casing made of metal or composite material that allows obtaining the degree of

protection suitable for outdoor installation, a distribution system sized to withstand the current of the largest of the columns food. Circuit protection is achieved using MPR type fuses (with High Breaking Power) mounted on vertical three-phase separators with simultaneous actuation for all fuses, or in exceptional cases, SIST type sockets are used.

The universality of distribution wires and the large number of circuits that can be interconnected with their help is given, on the one hand, by their simplicity, but also by their role in making nodes in low-voltage distribution networks.

The large dimensions of the distribution cables are a cause of the long distances they must travel from one node to another without producing too large voltage drops at their nominal load, a case often encountered in electricity distribution projects.

2.3. SINGLE-PHASE (BMPM) OR THREE-PHASE (BMPT) TYPE METERING PANEL

The final part of the electricity distribution chain is represented by the consumer, in order to ensure the distribution and measurement of the energy supplied to him, the Metering Block type (BMPM or BMPT) or FDCP type (Distribution and Metering Grid) are used landing) for customers located in shared homes or at short distances from each other.

The single-phase or three-phase measuring blocks are electrical panels of similar sizes and shapes, which aim to separate the consumers' circuit from that of the electricity supplier and at the same time ensure the metering of the electricity consumed and generated by the users who have this right, it is about consumers who are also prosumers at the same time.

Due to the multitude of standards and technical norms specific to the country's areas, a meter block will have different configurations depending on the supplier in whose network this electrical panel is installed. So there are totally different electrical configurations, some that only incorporate short-circuit and overload protection, others that additionally have differential protection, or overvoltage protection.

2.4. (FDCP) TYPE DISTRIBUTION AND METERING PANEL

FDCP type electrical switchboards (Distribution and metering panel) are switchboards that incorporate a distribution panel and several metering points for various users. This type of electrical switchboard lends itself to urban agglomerations where space is limited, thus obtaining a single electrical switchboard that is more compact, cheaper, more aesthetic and easier to install than a series of BPM type switchboards for each individual user.

The number and type of consumers fed from an FDCP-type distribution and metering panel can vary widely. The limitations of such an array are determined by the actual space available in the field and the maximum length of routes permitted by the site.

The type of casings used in the construction of this type of electrical panels are chosen in such a way as to comply with the requirements of the electricity suppliers.

These requirements clearly specify the material, the minimum degree of protection accepted, the required fastening system as well as the diameters of the conductors used for each separate starting circuits.

2.5. USER DISTRIBUTION BOARD (TDU)

The last board in the supply chain is the user board. It can have any shape and can be placed indoors or outdoors depending on the consumer's electrical project. If we are talking about an ordinary single-phase household consumer, then this switchboard is most often a single-phase one with a nominal current between 16 and 63A, with a small number of circuits.

For the protection of the circuits and the columns that are fed from it, thermo-magnetic circuit breakers are used that have nominal currents of 6-16 A, and breaking currents of 4.5-6 kA and rarely 10kA.

It is recommended to feed the TDU switchboard through a Combined Differential Circuit Breaker that offers increased protection by providing overload or short circuit protection as well as protection against grounding. For human protection, a maximum value of 30mA is recommended for differential protection for ordinary lighting circuits and sockets and a maximum of 10mA for circuits that supply circuits intended for bathrooms, showers or bathtubs.

2.6. CONTROL BOARDS FOR PUBLIC LIGHTING CIRCUITS

Control boards for public lighting circuits are boards designed to control public lighting by means of a twilight sensor, a time scheduler or more recently by means of a programmable automaton, which can be controlled remotely and monitored in real time.

These electrical switchboards do not belong to the group of those intended strictly for the distribution of electricity, nor to the group of electrical automation switchboards, because they contain power circuits to supply the street lighting but also some simple automation elements in addition to the distribution ones.

In the power part, the switchboard contains a power contactor capable of controlling the lighting network and a circuit that allows the distribution and protection of several lighting circuits simultaneously. Also in this case, but in a separate compartment, there is also the smart meter or terminal for measuring the electricity consumed.

2.7. POWER FACTOR COMPENSATION ELECTRICAL BOARDS

Power factor compensation boards are special electrical boards designed for automatic power factor compensation, with the help of special calibrated electrical capacitors, which are connected in turn in the circuit under the command of an automaton dedicated to this purpose.

In order not to overcompensate the power factor, the automatic takes into account the measured instantaneous values but also a history and an average value obtained from the previous measurements made. Any exceeding of the values imposed for the time intervals measured by the measuring devices of the energy suppliers attracts the sanction of the consumer for non-compliance with the minimum allowed power factor.

For the design and construction of an electrical panel intended for power factor compensation, the manufacturers of capacitors and contactors used specify the minimum and maximum values for the protection fuses used and the type of contactors for each type of capacitor separately.

In order to dimension the panel in the first phase, it is necessary to establish the maximum value of the battery, the number of steps required and the nominal voltage of the electrical panel. This nominal voltage can be increased if the values of the predominant harmonics are very high.

The final value of the compensation table and implicitly of the compensation battery is obtained by direct measurements of the average power factor and the power consumed over a period of time. Or it can be obtained directly by calculations based on the values measured by the energy supplier over different time intervals, the necessary calculation takes into account the number of shifts worked, the value of the average power factor for each 15 minutes or for each individual hour. The monitored time intervals can be one or more consecutive calendar months from the measurements from which the minimum and maximum measured values are taken.

2.8. AAR TYPE ELECTRICAL PANELS.

Power paths and backup power sources are used as a basic method to ensure continuity of supply to critical or special consumers, doubling all power paths for these consumers expensive but is imposed by specific regulations for consumers whose interruption would lead to material losses significant or loss of life.

The ultimate goal of AAR installations is to ensure the continuous supply of consumers from multiple available sources and the automatic switching of consumers from one source to another when its parameters no longer correspond or there is a risk of exceeding the maximum available power. [10-11]

The power part of such equipment comprises on the one hand the measuring and switching elements, and one or more intelligent equipment that monitors the parameters of the connected networks and the state of the protections of the supply and outgoing lines.

AAR-type low-voltage electrical switchboards are intended for the automatic connection of the backup source in case the electrical parameters of the main source are not appropriate, or in the case of a total lack of supply voltage on the main source. [12-13]

2.9. RTU TYPE ELECTRICAL PANELS

Electrical automation panels intended for remote control are called RTU (Remote Terminal Unit) type panels, they are equipped with a means of communication and an intelligent terminal or just a simple data logger depending on the complexity of the task to be performed. RTU-type switchboards are an integral part of distributed SCADA-type systems, they locally centralize the information from the electrical switchboards to which it is directly connected, store the data and wait for their request by the higher level, namely the monitoring and control application called SCADA for short.

For efficient and fast communication, the designer can choose a simpler communication protocol such as the Modbus type communication, or a more efficient one in terms of flexibility and the amount of data transmitted such as the DNP3 protocol.

DNP3 communication modules have their own memory in which they save the data together with a time signature and thus when the communication is restored the data can be automatically transferred to the SCADA server. This method of backfilling the information gaps ensures that all the data is intact if the disconnection it is not long lasting because the storage space is limited and then for this reason one by one the older information is overwritten by the new ones.[14-16]

A fully functional practical application that monitors a potable water supply point and remotely controls a pressure control valve via Modbus communication was presented at CONFERENG 2022.[17]

2.10. TABLOURILE ELECTRICE PENTRU PROTECȚIE ÎMPOTRIVA INSULARIZĂRII

The term islanding in the framework of electrical networks refers to the phenomenon that arises in a cogeneration system when there is a deliberate or accidental disconnection of the connection between the local cogeneration network and the national energy system.

The islanding phenomenon can be detected by means of local network parameters after disconnection from the national system.

Electromechanical or electronic generators use the national grid for reference, the voltage produced closely following the achievement of perfect synchronization at all times so as not to produce imbalances or overloads for the connected equipment.

The national Romanian energy regulatory authority has imposed strict requirements on all those who inject power into the grid to limit the injected power when the grid parameters differ from the nominal ones.

Thus it is required to limit the power injected into the grid to a maximum of 40% of the nominal power for a deviation in addition to only 2 Hz from the nominal frequency of the electrical network and it is required to keep the injected power constant when the frequency decreases to compensate for a possible overload of the system.[18]

For reasons of system safety, ANRE has imposed the use of inverters that have the specific functions of RoCOF and Uf/Ut isolation detection, and if the inverters used cannot provide these protections, then it is necessary to make an electrical interface board mounted between the prosumer and network. This interface board must be able to detect anomalies in the network and cause the prosumer to disconnect until these parameters return to normal.[19-21]

This electrical isolation problem as well as the complete schematic of such a prosumer interface electrical panel were presented in a paper published at the CONFERENG 2023 conference. [22]

2.11. ELECTRICAL PANEL FOR PUMPING STATIONS

Electrical switchboards for pumping stations basically consist of two or more power circuits and a system for controlling them. Depending on the power of the pumps and the desired output parameters, we can have combinations of starting contactors with soft starters and frequency converters.

Pumping stations with several pumps use a switching system of the starting equipment and those that allow to change the flow. Therefore, we can have a single soft starter for five pumps and a single converter, but several sets of contactors for direct connection of of these pumps after they have been started and brought up to rated speed under load.

The use of the PLC allows a more efficient control of the output speed of the pumps and thus achieves an important energy saving due to the long operation of the electric motors in the composition of the pumping group.[23-25]

A complete practical application with electrical diagram, description of the mode of operation and a functional configuration was described in the paper entitled *Designing a modern drinking water pump station* published in the Annales of the Eftimie Murgu Reșita University. [26]

2.12. LOCAL LEGISLATION RELATING TO ELECTRICAL PANELS

The Low Voltage Directive (LVD) is the document that imposes minimum security conditions for electrical products sold within the EU member states. This document does not clearly provide what are the specific requirements that must be respected, it only prepares the legal framework and requires the use of specific standards already existing for low-voltage electrical equipment in order to be able to respect the minimum security and safety requirements.

The low voltage directive refers to all electrical devices that are powered by alternating voltages in the range of 50..1000V and to electrical devices that are powered by direct voltages between 75 and 1500 V DC. An important aspect is that the directive only refers to the voltages present at the external terminals of the equipment and not to the generated internal voltages, with which the user has no way to come into contact directly.

Compared to the old EN 60439 standard, the new standard removed the terms TTA (type-tested assemblies) and PTTA (partially type-tested assemblies) which represented their total or partial compliance with the laboratory tests imposed by the standard. The new standard

removes this dualism and imposes the term electrical assembly according to the standard for any device or electrical panel that is built and verified according to the new test methods.

The international standard was adopted as a harmonized Romanian standard under the name of SR-EN 6143 and falls under HG 457/2003 on ensuring the safety of users and a minimum execution standard for electrical switchboards built by specialized companies.

he SR-EN 61439[27] standard is made up of several parts, each of them having a distinct role, acting in different fields or having well-defined goals:- SR-EN 61439-1 Reguli generale de aplicare

- SR-EN 61439-2 Apparatus assemblies (electrical automation panels)
- SR-EN 61439-3 Distribution boards
- SR-EN 61439-4 Electrical panels used on construction sites
- SR-EN 61439-5 Switchboards for distribution networks
- SR-EN 61439-6 Prefabricated bar channel systems

2.12.1. General rules for the placement of electrical panels in the field

The low-voltage switchboards can be mounted, on the plinth, apparently on the wall or semi-buried in the wall. The physical mounting location is dictated by the project, the way the cables are laid and the degree of protection of the electrical panel.

Regardless of the placement of the panels, the possibility of their expansion and the manner and ease of revisions and repairs carried out on these panels by the maintenance teams must be taken into account. The possibility of expansion must be foreseen from the design phase, by keeping a 30-40% reserve area for modular equipment and a minimum of 10% for larger equipment, in order to be able to reach and exceed the estimated operating period of 10-15 years.

2.13. CONCLUSIONS AND PERSONAL CONTRIBUTIONS

The suggestively named Electrical Panel Names application made in Visual Basic .NET aims to unify names and standardize them between all departments and areas in the company. The description of the application and the method how to use it are presented in chapter 4 where all the proprietary applications intended to optimize the manufacturing process of electrical panels are presented.

For the dimensioning of low-voltage AAR switchboards, I created a PC application intended to help the switchboard designer in the design stage by automatically choosing the components of the AAR switchboard based only on the selection of the powers of the two power sources. After choosing the configuration of the panel and the power of the two sources, the program generates a list of materials that also contains a housing that corresponds functionally to the configuration made. The application and the method how to use it is described in detail in chapter 4.

In addition, to help the designer, we have come up with another PC application that assists the switchboard designer in quickly and correctly choosing a configuration for the power supply circuit of low voltage electric motors. The dimensioning takes into account the most common starting configurations, namely direct starting and star-delta starting, methods still used for simpler drives due to their robustness and simplicity.

CHAPTER 3

THE MANUFACTURING PROCESS OF ELECTRICAL PANELS

The design and construction of electrical panels is an important task and requires knowledge of the norms, standards and technical norms in force.

The design of electrical switchboards can be done based on an already existing detailed scheme, in which case the designer must choose the final configuration, the equipment used and their location within the switchboard. The chosen configuration must comply with all the requirements and specifications required by the designer of the respective wiring diagram. The switchboard designer is obliged to request clarifications where things are not clear enough or where he believes there are certain dimensioning or design mistakes.

To help in the proper dimensioning of the power circuits of the electrical panels and the necessary cable section, we have created two applications intended for the PC, they were presented in two conferences (Computer Aided Design Of Low Voltage Electrical Installations" and "Design Of Low Voltage Electrical Circuits For Industrial Receivers") both are presented in detail in Chapter 4.

The mechanical joints within the busbar systems are made with flexible elements such as special elastic washers, which maintain a firm contact without damaging the joined bars during their expansion and contraction due to thermal phenomena or vibrations produced by the equipment around the electrical panel.

3.1. THE MANUAL DESIGN OF ELECTRICAL BOARDS

The manual design process of the electrical panels requires the realization of all electrical dimensioning calculations with the help of empirical or less accurate methods, then the amount of heat produced inside the enclosure is determined due to the thermal losses produced in the conductors, devices and the busbar system used.

Based on the results, the ventilation or air conditioning requirement for the dimensioned electrical panel is determined, taking into account the average and maximum temperature to which it will be subjected during use.

The simplest sizing calculation method for the main current paths and for the switchboard distribution system is the demand coefficient method. This coefficient, together with the active and reactive power, representing the bases of the dimensioning of electrical panels, therefore knowing the average and maximum power factor of the consumers dictates the cable selections and the size of the command and control equipment within the dimensioned electrical panel.

The average values resulting from the calculations are considered to be more accurate for the main and general switchboards than for the secondary ones, where the multitude of consumer types and wiring typologies of the consumer's final network dictates the actual demand coefficient which can vary within wide limits being too covering in some cases and not covering in others

Due to the dynamic behavior of the powered equipment and due to the simultaneity of their use, the electrical panel, although it fully ensures the protection of each consumer individually, it is inadequately dimensioned from the point of view of protection against long-term heating caused by current harmonics produced by consumers. That's why only circuits that supply household consumers or whose long-term behavior is known and easy to predict are dimensioned according to the demand coefficient method.

3.2. COMPUTER-AIDED DESIGN OF ELECTRICAL PANELS

The use of the manual method of designing electrical panels requires designers who have solid knowledge of design and practical knowledge of the work carried out.

The very good knowledge of used casings and equipment is an important asset because it allows the identification of possible problems or omissions from the early stages of the project.

The rather high costs of staff specialization do not allow smaller companies to send to their specialization only a maximum of 2 people who will then train the hired staff according to their pedagogic knowledge and skills. Because of this training may not be sufficient and may lead to defective specialization and various problems that can generate huge losses for the company through improper use of design applications and managed information.

To counteract the disadvantages related to training in current practice, mixed design methods are used, in which whole sections are processed with the help of the computer, but the final documentation is prepared manually, and the connections and formatting of the final documents are done by a single person who checks the validity of the whole design.

Within this mixed design method, various dedicated programs find their application, they have an important role in making configuration decisions and project data processing, but also CAD (Computer-Aided Design) graphic design programs, programs that allow the creation of electrical diagrams and complete final documentation in a fast and accurate way.

3.3. CLASSIFICATION OF PC APPLICATIONS USED IN THE DESIGN OF ELECTRICAL BOARDS

A first classification could be made according to the degree of automation that the application offers and implicitly how many aspects of the design are covered by using it. The most widespread applications are those that allow either the drawing up of electrical diagrams according to the standards in force or allow direct dimensioning by means of graphic methods of electrical panels.

Complex and complete applications that allow the organization of projects as well as the dimensioning of circuits while also providing a graphic support for the creation of written documentation are very expensive and difficult to adapt to certain ways of working.

Most of the time, it is preferred to use certain dedicated applications that solve only a certain part of the entire design process, the user being the one who then merges the data obtained from these dedicated applications, so in practice applications are used:

- calculation and dimensioning of power supply circuits
- designing electrical circuits in buildings
- drawing up electrical diagrams for panels
- designing and dimensioning electrical panels
- records of documents and projects sorted by versions and revisions

3.4. THE STAGES OF REALIZING THE PROJECT OF AN ELECTRICAL PANEL

To start the design process of an electrical panel, the design engineer must choose the best and shortest method of making the respective electrical panel in order to be able to meet the required deadlines and comply with the specific requirements of each type of panel.

Based on the nominal data received from the customer, which also includes the mounting location, the minimum degree of protection and other strictly necessary information, it is determined whether the switchboard proposed for construction is a low voltage, standardized type or dedicated to voltages higher than 1000V.

Following the steps, it is determined that the panel it is a low-voltage switchboard or not. The designer must decide, based on the configuration and the power of the consumers, the maximum current for which the respective switchboard must be dimensioned and its placement in one of the three categories, switchboard electrical distribution panel, electrical automation panel or typical electrical panel for energy suppliers.

Each of the three types of boards has a series of general and some special characteristics that make it unique in its own way, and this makes it necessary to use sizing methods specific to each type of board.

3.4.1 Design of a low voltage switchboard

In order to be able to design a low-voltage switchboard, the maximum current that the distribution bus system supports must first be known.

Due to the major differences in the approach required for each type of electrical panel and due to the different number of parameters required for the design, I have logically divided the scheme into independent modules. Each such module deals strictly with the steps required for a certain type of product, the module being embodied by a separate application or by a new logical scheme applicable to the respective dimensioning and design case.

After the decision on the fact that we have to design an electrical distribution panel, based on the nominal current, he decides on the approach of using a dedicated software for dimensioning the main busbar system and the main circuit breaker in the case of currents greater than 1600A .

For rated currents below 800A, the electrical panels can be made accurately enough with the help of CAD-type applications and the maximum dimensions of the component dimensions. The bar system can be configured precisely enough with the help of the Autocad application, where the designer draws the paths to follow between the main components and the bar system.

Routes are chosen in such a way as to minimize the number of turns and joints in order to reduce the number of connections to be made and tested, but also to not produce local heating in the nominal working regime of the electrical panel.

In order to ensure a high thermal stability of the electrical panels, the current paths are chosen for an ambient temperature of 40 degrees or for an internal temperature of 55 degrees.

The correction factors used for the current paths, for each individual material, are defined in the electrical panel standard SR-EN 61439 together with the calculation formula for the different ambient temperatures.

3.5. DESIGNING A SCADA-TYPE APPLICATION

SCADA, short for Supervisory Control And Data Acquisition, refers to a complex measurement and control system. SCADA automations are used to monitor and control chemical, physical or transportation processes. Data acquisition begins at the RTU (Remote Terminal Unit) or PLC (Programmable Logic Controller) level, involving the reading of gauges and equipment status, which are then transmitted to the SCADA system for analysis and action.Cele trei componente ale sistemului SCADA sunt:

1. One or more RTUs or PLCs.
2. Master Station and HMI Computer(s).
3. Communication infrastructure.

The RTU (Remote Terminal Unit) connects to the monitored equipment, monitoring their status (eg the open/closed position of a relay or valve) and measuring parameters such as pressure, flow, voltage or current. The RTU can also control equipment by sending signals, such as closing a relay or valve or adjusting the speed of a pump.

A PLC (Programmable Logic Controller) is a small computer equipped with a microprocessor, used to automate processes, such as controlling a machine in an assembly line. A PLC's program, usually created by an engineer based on process requirements, can handle complex sequences. Today, the difference between a programmable computer and a PLC is becoming smaller and smaller. However, PLCs are recognized for their robustness, while computers still have some shortcomings.

Master station and HMI station are components of a SCADA system, this term refers to the servers and software responsible for communicating with remotely located equipment (RTU, PLC, etc.) as well as HMI software (Human-Machine Interface) running on workstations in the control room. In small SCADA systems, the master station can be a single PC. In large systems, the master station may comprise multiple servers, distributed software applications, and disaster backup units.

3.5.1 Example of the design of a SCADA type application intended for the control of a water supply installation.

Any graphical interface for a SCADA application or a regular PC application uses simple, general graphical structures over which the details of each individual page are superimposed, so that all pages are based on a common color theme managed by a Template common. All screens have in their composition a common navigation area and a list of alarms visible from all application interfaces.

In the upper left a set of buttons redirecting us to the screen with active alarms, pre-sorted according to the selected button as can be seen in figure 3.1. The numbers present on the right side of the alarm buttons indicate the number of alarms of the type to which that button refers. If we do not have active alarms of a certain type, the number next to them is missing and the icon stops flashing.

Figure 3.1. *Alarm centralizer*

Each category of alarms has its own color, so that you can be identified more easily and to draw attention to more important alarms such as burglary alarms or those that generate danger or endanger equipment.

To change the values in the system, they are editable through data fields, which have a white background color, this clearly differentiates them from the values that are only displayed, which have a light yellow background color to be able to value fields be easily identified.

After entering the desired value in the input field, the value will be compared with the accepted limits for that field and will be validated or not. After validating the data, it will be sent to the set equipment, we will receive the confirmation of the value entered in the equipment visually when the value in the respective field has changed to the value entered by us initially.

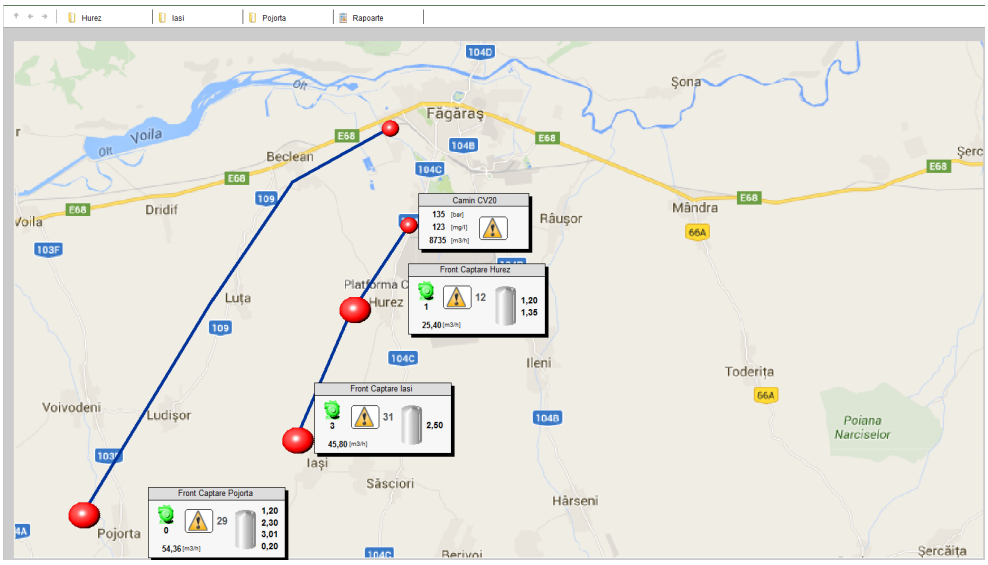


Figure 3.2. *SCADA application main window*

The main page of the SCADA application implemented within the project has as its main page a map showing the locations of the three capture fronts and briefly some main data regarding their status, in figure 3.2 you can see the home screen of the SCADA application. Also on the same home screen you can see a graphic representation of the CV20 home as well as some snapshot values of the measures present in the home at the entrance to the city.

It can be seen that at each catchment front the momentary levels of the tanks are displayed as well as the number of pumps in operation at the time but also the total flow rate of the catchment front. The number of active alarms for each of the capture fronts is also visible, and by activating any alarm icon it will redirect us to the alarm management page directly, the alarms page being accessible from any page via the specific icons displayed at the top of all pages.

Due to the fact that the number and type of equipment used at each capture front differs, the treatment of each capture front is done individually, and the pages of the capture fronts present only the equipment contained within them and the particular connection diagram for each individual case.

The capture place no. 1 is composed of the following two pages:

- Capture place Main Page
- Water pumps page
- Individual windows for each individual pump
- The windows of the 2 chlorine injection points
- Fire valve window
- Parameter settings windows

The main page of the capture front shows us on the left side the 5 submersible pumps and their operating status when accessing the page, as can be seen in figure 3.3.

The status of the pumps is represented in the system by an icon that symbolically presents the pump through a full equilateral triangle located in a black circle.

The fill color of the triangle can be gray if that pump has no fault and is currently off. If the color of the triangle is green, then the respective pump is in working order and does not show any damage. Instead, the red color of the triangle shows us that the respective pump has a fault and cannot be put into operation due to the breakdown.

The pump symbol can be completed by a warning sign on a yellow background, in which case it indicates that a warning has occurred in the operation of the respective pump, a fault condition that does not prevent the operation of the pump but represents a warning condition due to exceeding certain parameters or lack of measurement and control elements.

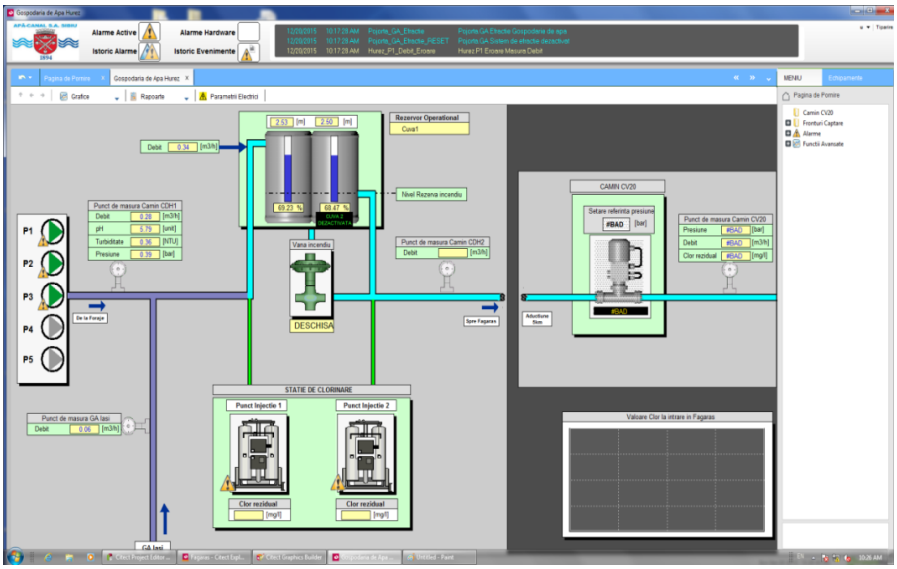


Figure 3.3. *Capture place Main Page*

In order to be able to view all the parameters of each individual borehole, the boreholes page must be accessed by clicking with the mouse on the white portion where the boreholes are represented.

The page of the boreholes related to the Catchment Front can be seen in figure 3.4, an image that shows us a detail of the way of interconnecting the pipes from a functional point of view and also allows us to simultaneously view the flow rates of the boreholes.

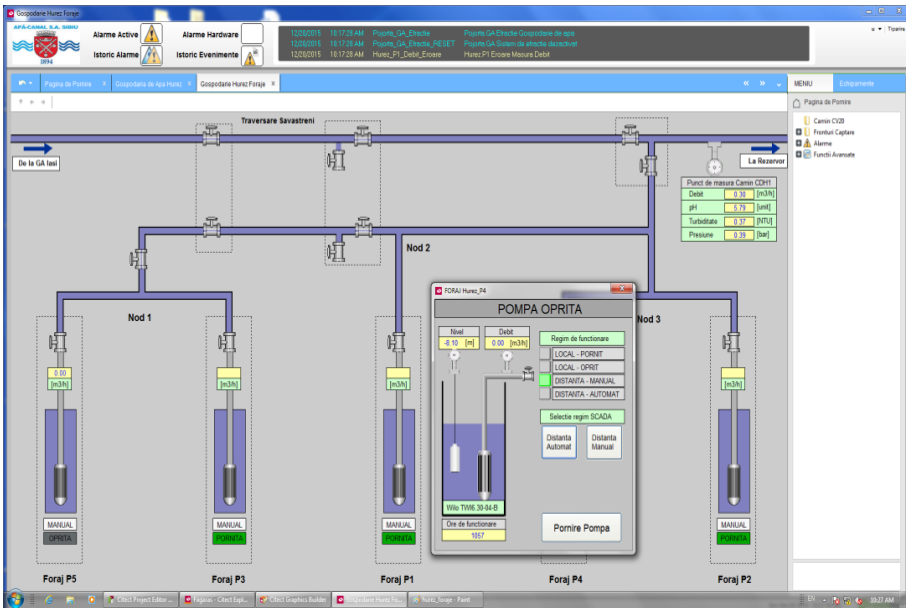


Figura 3.4. *Individual windows for each individual pump*

By selecting any borehole with the mouse, a new window opens positioned to the right of the selected borehole. All 5 drill windows can be opened at once, interacting with any of them in no particular order.

The individual window of the drill indicates the control mode of the respective drill, which can be LOCAL or REMOTE, but also the MANUAL or AUTOMATIC work mode.

In the LOCAL control mode, the drilling can only be controlled locally from the panel door in the well, the remote control buttons being disabled. This working mode is a failure or test mode, in this case its operation can only be interrupted locally and the automatic process does not take into account its state.

The selection of the control mode (LOCAL or REMOTE) can only be made from the door of the control panel in the respective well by operating a selection key.

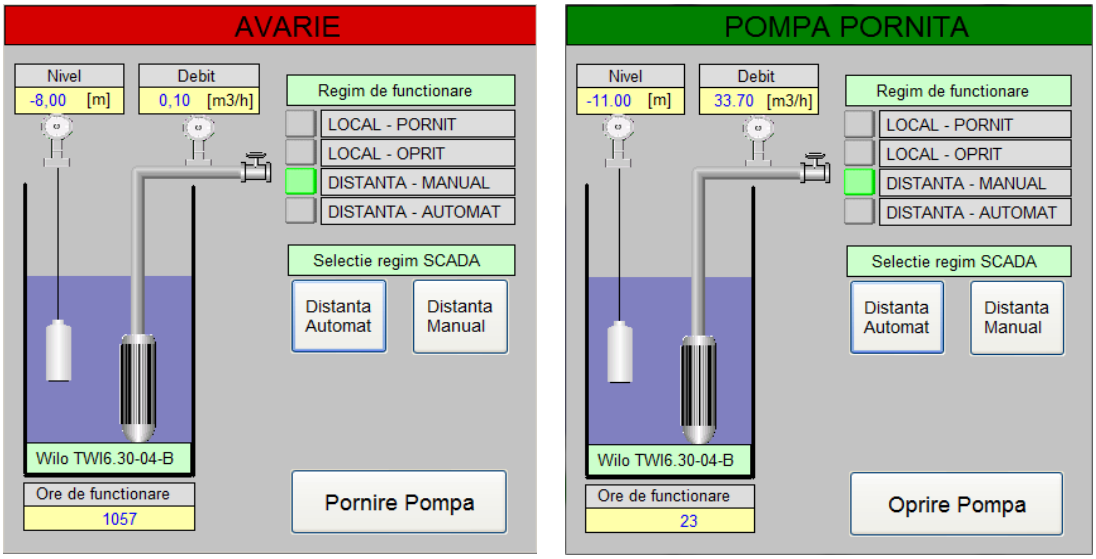


Figura 3.5. *Interfața fereastra foraj, a) în starea de avarie b) în starea de pornit*

The selection of the AUTOMATIC or MANUAL working mode can be done by pressing the buttons in the respective drilling window. The two buttons are not visible when the command mode is set to LOCAL, as they would have no practical function.

Depending on the current state of the pump, the control button present at the bottom is the one corresponding to a valid command, i.e. if the pump is on it allows stopping it and if it is off it allows it to start.

In the upper part of the well window, the operating status of the pump is indicated or the word FAILURE as can be seen in figure 3.5.a and 3.5.b, this message only appears if we have serious damage to the respective pump that prevents the pump from starting and operating in normal conditions when the text Pump On appears in the title of the window and the color of the upper part changes from red or gray to green to signify normal operation.

In addition to the operating status of the submersible pump, the hydrostatic/hydrodynamic level measured by the level sensor in the wellbore also appears in that window. The value is negative because it represents the difference in level from elevation 0 (well cap flange level). As well as the value of the pumped water flow rate, measured by the electromagnetic flow meter in the well cabin

The pumping stations can be viewed by accessing the icon on the screens of capture fronts 2 or 3 containing pumping stations. The corresponding icon looks the same as in the image below, two pumps are symbolized inside it, and the meaning of their colors is similar to the pumps in the capture front, where the gray color means the pump is off, and the green color shows us that the respective pump is working at that moment**.**

After accessing the icon, a pop-up window shown in figure 3.6 will open, it contains a simplified scheme of the pumping station and which allows us to view its state and also allows us to modify the desired working mode.

If the selected command mode is LOCAL then, as in the case of drilling, the command can only be made locally from the door of the pump station panel, this mode being one of breakdown or tests. In normal operation, the pump station is set to REMOTE mode so that it can be controlled remotely.

The selection of MANUAL or AUTOMATIC work mode can be done by accessing the corresponding buttons.

The operation of the pumping station in MANUAL mode allows the individual control of the pumps, but it is not possible to start both pumps at the same time. If one of the pumps is

running and the second pump is commanded to start, it will not start until the other pump has stopped operating.

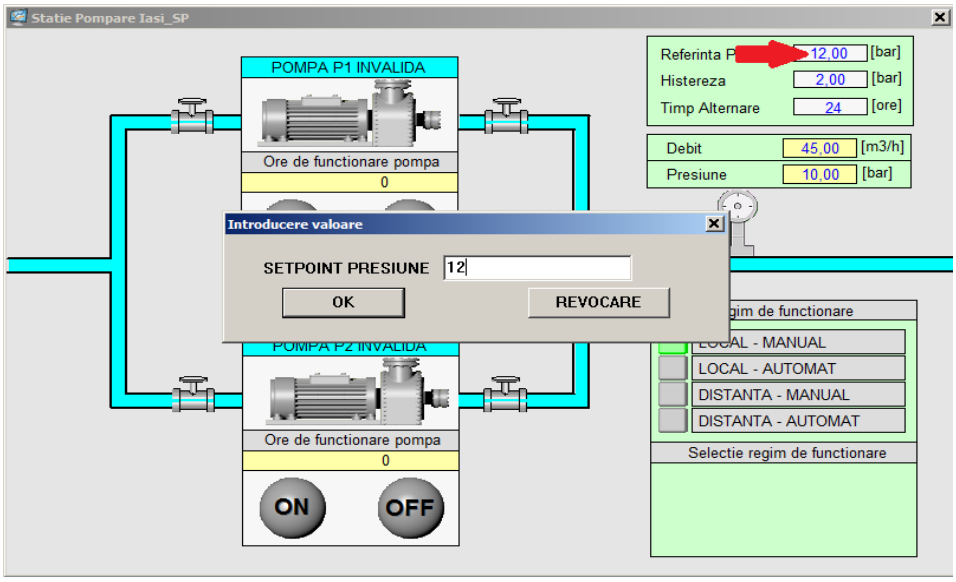


Figura 3.6. *Pagina de control a stației de pompare*

In the AUTOMATIC working mode, the operation is controlled by the programmable automaton in the pumping station panel that has implemented a program that aims to achieve a target pressure chosen by the user and alternate the pumps to achieve a uniform wear of them. In this case the operation is independent of the operator, the control buttons related to the two pumps will be inactive and will have a gray color.

3.6. CONCLUSIONS AND PERSONAL CONTRIBUTIONS

Due to the multiple problems faced by a new designer, he needs support available at any time regardless of the available time of colleagues. That's why, in order to help designers, we created a simple application that guides the designer step by step and helps him choose the type of project, the equipment, the scheme and the optimal method to go through the dimensioning stages based on his own experience and that of other designers. old in the department, briefly synthesized in the logical schemes presented in this chapter.

For the dimensioning of the circuits, you can use your own applications made to assist the designer in the process of collecting data and creating the final project, these applications are presented in detail in chapter 4 of the work.

CHAPTER 4

CONTRIBUTIONS REGARDING THE OPTIMIZATION OF THE DESIGN AND CONSTRUCTION PROCESS OF ELECTRICAL PANELS

As a result of an experience of over 7 years as a designer in a small company, whose main object of activity was the production of electrical panels, being employed in a position that allowed me to follow the various aspects and real problems with which faced the design and production departments, I managed to solve a large part of them with the help of self-developed PC applications.
In the following chapter I will try to briefly treat these applications, insisting more on the interface and the way of using the applications made to understand their role in the production chain.

4.1. SIZING APPLICATION FOR ELECTRICAL DISTRIBUTION PANELS

The dimensioning application was made using the LiveCode Community Edition programming language, a free platform that allows the creation of rich and easy-to-manage graphical applications for the main PC and mobile platforms, providing a number of net advantages compared to other similar development platforms . for self-made applications by integrating in a single file all the objects needed by an application in a similar way to a database that also includes the work interface.[28-29]

The interface of the application has been made in a simplistic manner that allows easy navigation among the various stages required for the dimensioning of an electrical panel and thus allows a quick entry of the necessary data. Due to the way of making the application, the user enters only the strictly necessary data for the current design stage, the requested information being minimal in order not to confuse the user, so that in each stage only the strictly necessary information is requested and based on them the following requests are formulated.

The first step refers to the introduction of the general identification data of the project in progress, the second step allows choosing the distribution structure from the table. After the placement of consumers is finished, the application based on the stored tables of values and simultaneity coefficients sizes each of the input elements on these busbar systems taking into account the loads generated by the consumers fed by them.

The third work stage is the selection of powered equipment from the list provided by the application, the addition and modification interface is shown in figure 4.1.

After selecting the type of equipment, we are asked for information regarding the nominal power of the added equipment, their number and the need to size the related cables.

If cable sizing is chosen, then we will also need to enter a desired maximum length to be able to calculate the voltage drop for the chosen cable. At any moment we can add other equipment, we can modify the powers or the lengths of the inserted cables, these data will be taken in the final stage of the results without requiring any validation step.

The fourth stage for dimensioning the electrical panel is the verification of the generated results, in this stage we can generate the obtained results or return to the previous step to make the various necessary adjustments.

As an additional option, the power cable sections can also be dimensioned for the equipment entered as consumers, the equipment selected for this will be put in a separate list from where additional options related to the material and the way of laying these cables can be chosen according to of project.

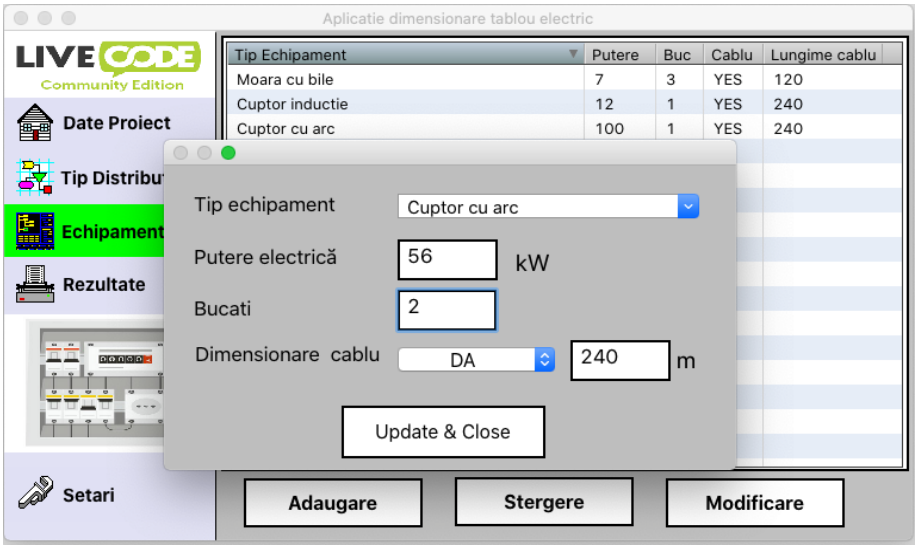


Figure 4.1. *Equipment selection*

Management of equipment and cables used for sizing is each done on a separate card within the main application stack. In each column we have entered the maximum current allowed for the respective cable for one of the combinations of single-phase or three-phase circuit and surface or buried mounting for cables made of copper or aluminum.

For the easiest possible management of these data, they can be changed directly in the table on the related card, the data being saved automatically when leaving the current card or closing the application completely. We have also made it possible to import and export data in the universal CSV format, a format that allows easier data management in tabular form with the help of Excel-type applications.

The application made was presented in a scientific paper called **Computer Aided Design Of Low Voltage Electrical Installations** accepted and presented in the ICASS 2022 international conference. [30]

4.2. ASSISTED SIZING APPLICATION FOR THE AAR-TYPE ELECTRICAL PANELS

In order to ease the dimensioning and the choice of the equipment needed to create a device, AAR designed and created an application using the Visual Basic .NET programming language [31-32], an application that is intended to help the designer in the process of dimensioning the components of a device AAR type.

To be able to use the application it is not necessary to know the internal structure of an AAR or the exact way of its operation, It is sufficient to know the power of the generator and the main power transformer, power resulting from dimensioning calculations or from the material lists.

The program provides two distinct standard configurations, transformer-transformer and one transformer-generator, the distinction between them is given by the need for additional control and monitoring of a generator in relation to a transformer regarded as an auxiliary source for a given consumer. Another clear distinction could be that the standardized powers for generating sets have different values than transformers and therefore the correct configuration must be chosen to obtain the most accurate results.

After the choice of the configuration follows the choice of the power of the sources, the interface provides a series of standardized powers for transformers and generators, thus facilitating the choice of nominal powers and does not require the use of the keyboard as can be seen in figure 4.2. Populating these drop-down lists is done by the routine called **Populare_data(),** which retrieves information related to power ratings from the **Source.csv** and **Generator.csv** files in the application database.

After choosing from the drop-down box the value of one of the sources, the program calculates the nominal current of the source and displays it immediately below the drop-down box of that source. Based on these rated currents, the physical size of the circuit breakers used is determined, thus establishing the total size including that of the distribution bus system suitable for the currents carried.

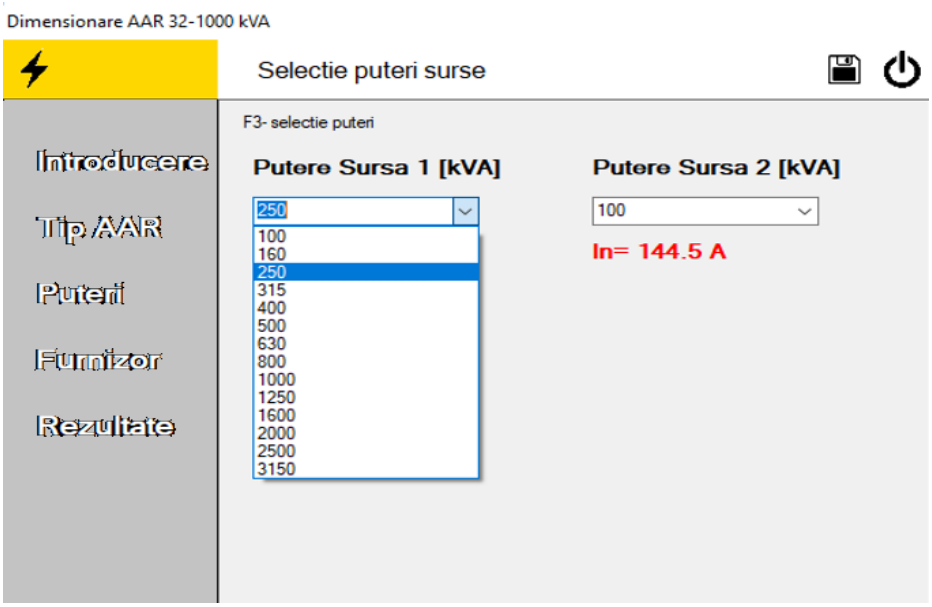


Figure 4.2. *Dimensioning application power selection*

To determine the type of switches and auxiliary components needed to make a functional AAR device, the application uses several csv files for all required components. The logical connection between the component elements being made based on the physical dimensions of the two switches, dimensions resulting from their electrical dimensioning.

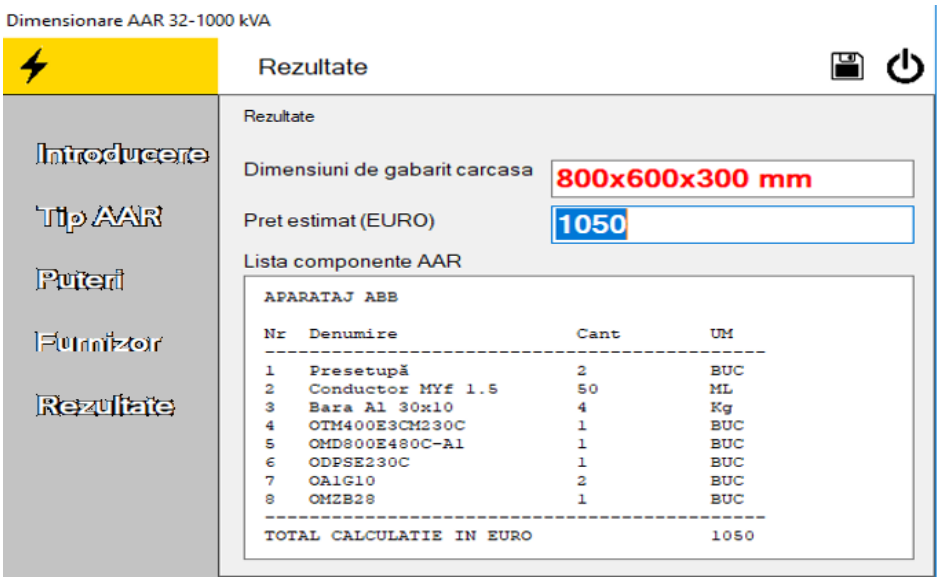


Figure 4.3. *Sizing application results obtained*

If for switches and housings it was mandatory to enter unique equipment in the selectable value files, here within this file you can enter several benchmarks that correspond to certain gauges of the selected switches, benchmarks that will be taken over in the final configuration and will make up the final price of execution for the electrical panel thus dimensioned.

In figure 4.3 we have the list of necessary equipment and an estimated price for making an AAR-type electrical panel based on the selection of sources with a maximum current of 400A with equipment from the supplier ABB. In this case, a compact type equipment made with two mechanically interlocked separators and a dedicated controller without a communication port was used.

The application determines the minimum dimensions necessary to create a functional electrical panel, a price quote required for bidding as well as a list of equipment from the selected supplier.

The created program is useful both in the bidding stage and in the execution phase when not enough concrete data are made available, so as not to lead to an overestimation or oversizing of this type of equipment.

The initial application was presented in Craiova in 2018 at the ICATE conference, under the title of "**Computer assisted equipment selection for components of electric panels.**" [33], since then the application is currently used in a company producing electrical panels, being a useful and easy to update tool.

4.3 POWER CABLES SIZING APPLICATION BASED ON TYPE OF EQUIPMENT

To assist the designer of electrical panels, we have created a software application capable of dimensioning and verifying a single electrical circuit based on its behavior together with the power cables. Due to the fact that most of the length of the supply line for a consumer is outside the electrical distribution panel, the overall behavior of this circuit is largely determined by the length and characteristics of its supply cable.

So it is necessary to treat the respective circuit in a uniform way and thus choose an appropriate type of protection for the protection of the equipment but also of the power cable keeping the voltage drops within limits accepted by the respective consumer.

The voltage drops on the cables feeding three-phase consumers are generated on the one hand by the ohmic resistance of these cables and on the other hand by the behavior of the respective line in alternating current generated by the inductances and electrical capacities between the conductors and the ground.

To help the designer of electrical circuits, we have created a PC application that helps to check and properly dimension the circuits taking into account the usual average reactances for each type of cable. [34]

The cable sizing application is made using the Live Code version 9 programming language, the application allows the easy creation of friendly and interactive GUIs. Applications made with this programming language are actually a collection of graphics objects, code and a database all integrated in the form of a single file. This way of integrating everything in the form of an integrated file is also used by the Microsoft application Access developed by Microsoft.

A great advantage of the implementation of the application is that the User is asked to answer only the relevant questions about the configurations he has chosen and is thus guided from start to finish with small and precise steps towards obtaining the desired values without enter non-essential data and without going through configurations or settings that are not found in the final form of the proposed project, nor have an influence on the results thus obtained.

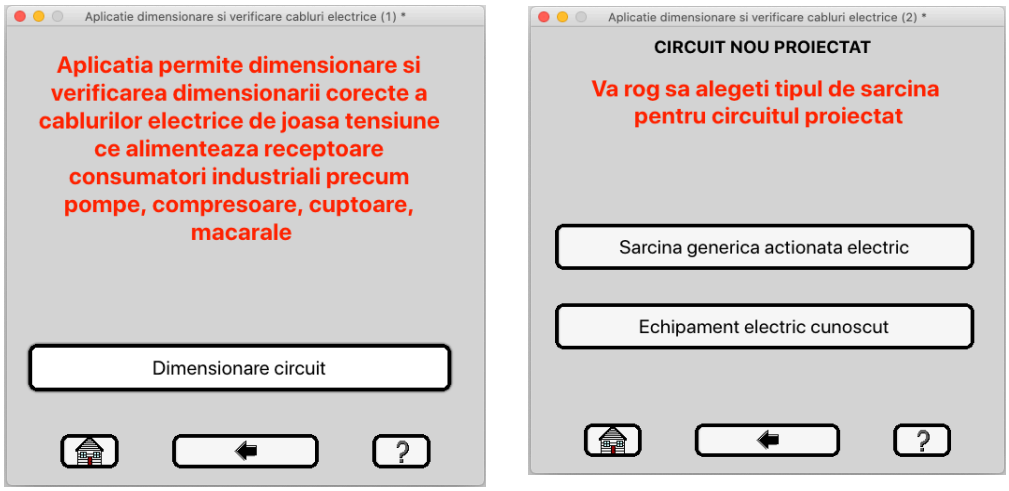


Figure 4.4. *Graphical interface a) home page b) choosing the type of equipment*

In order to properly size the equipment, the application may ask the user to select certain additional information, necessary for proper sizing, for example in the case of a motor start, the application asks for the type of starting mode used to allow the proper sizing of cables and protections for their starting mode.

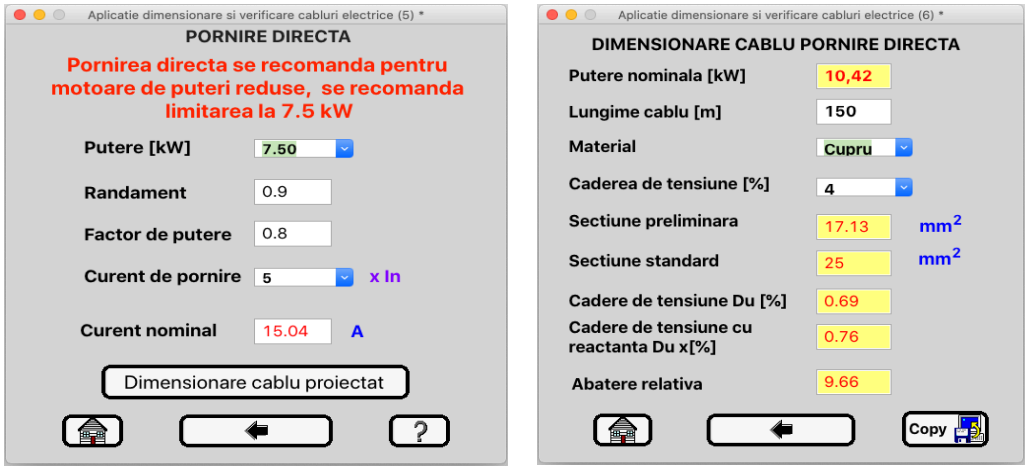


Figure 4.5. *Graphical interface a) cable sizing page b) startup mode*

Due to the fact that the application was designed to be able to run on mobile terminals as well, it has a small, simple and easy-to-understand interface, offering at the bottom of the main window a set of navigation buttons characteristic of mobile applications. On the left side we have a button that returns us directly to the home page, and in the central part we have a button that allows going back one step at a time to resume or modify some data already entered, the application interface and the mentioned elements can be seen in figure 4.4 .a.

After choosing the desired starting type, the application requests the motor data and allows choosing the starting current from a range imposed by values, in the lower part of figure 4.5.a you can see the nominal current calculated for sizing based on the data already entered up to that moment.

Since the dimensioning of the supply line must take into account the maximum load to which it will be subjected without damage, the most unfavorable regime must be chosen, in our starting case, this being chosen as the starting point for the dimensioning checks imposed on the line respectively.

In figure 4.5.b you can see the negative influence generated by the reactive component of the supply line, in the lower part of the window there is a calculated field where you can also

see the value of the relative deviation of the two values of the voltage drop with and without the reactive component.

The resulting data can be directly copied to the computer clipboard using the copy function, visible as a button on the application results page, as can be seen in figure 4.5.b, all visible data on the results page will be exported as a table with two columns, in text form in the first column being the names of the fields from which the results are taken, and in the second column the values are saved together with the related measurement units.

The automatic data saving mechanism is based on a relatively simple method by which the application is divided into two component parts, the first being an executable type file for the targeted platform (having the extension .exe, jar or .app) and a second file which is kept in the native format of the application (having the extension .livecode), this second file is automatically loaded when the executable part is launched, and when the application is closed, the file is updated with the entered data, which is possible due to the existence of the separate part with the code in memory what is executed the second file having the role of data file.

The presented application is part of a paper that was presented at the ICEES 2022 conference.[35]

4.4. ELECTRIC MOTOR START DIMENSION APPLICATION

Dimensioning and control of motor electric drive circuits is based on well-known classical schemes.[36-37]

In order to make it easier to choose the components needed to create a classic drive scheme, we created a computer application that allows, with the help of a minimal graphic interface, the correct sizing and the choice of the necessary components based on configurable lists of equipment for each individual supplier.

The lists of materials used to create the application were taken directly from the catalogs of the manufacturers of electrical equipment for all the powers of the engines most often used in the case of manufacturers approved by the designers of a company in the field of manufacturing electrical panels in the country. Material lists can be easily edited and adjusted to achieve other desired configurations or to update equipment already introduced.

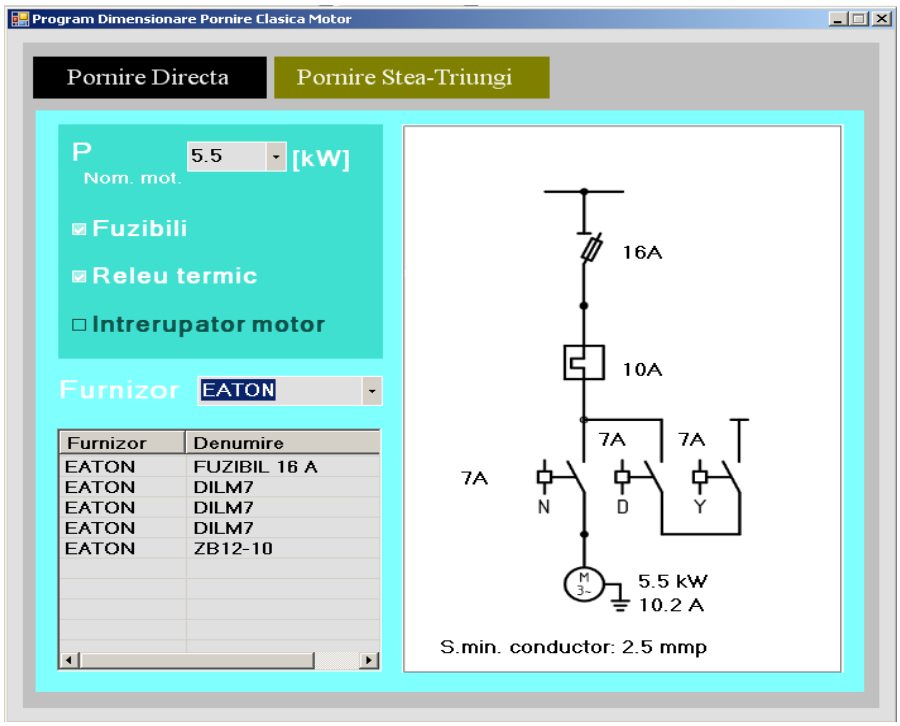


Figure 4.6. *Engine start sizing application interface*

Figure 4.6 shows the interface of the motor start sizing application, the interface allows the selection of direct or star-delta starting depending on the desired motor power and the need.

The final structure of the actuation scheme will be displayed on the right side of the window where the necessary nominal values for the components are entered, so that in the absence of some components from the database or a supplier, these equipment can still be properly dimensioned only on the basis of a catalog from that supplier.

After choosing at least one protection element for the selected actuation from among the existing ones, the program displays a single-wire diagram corresponding to the already selected components and the selected actuation type.

The fuse protection is sized to protect against short circuits and is therefore doubled by thermomagnetic protection to ensure adequate protection for possible long-term overloads.

Using the application is simple due to the way it was built, so no specific order of component selection is required, any selection made refreshes the selected drive scheme and refreshes the list of required components.

The components already stored in the CSV files, which make up the database of the application, are taken directly from the catalogs of the suppliers of the used equipment and thus make up verified action solutions. The equipment entered in these tables are linked to the application through their rated current, current calculated based on the power of the motor selected from the drop-down list.

The application calculates according to the nominal and peak currents the minimum section required for the wiring of these components within the electrical panel, being a real help for quickly checking the various circuits and drives before proceeding to their machining.

The application has a simple structure consisting of a main window, three libraries where the functions necessary for the operation of the application are found and the actual database made up of csv files. The csv files found in are imported when starting the application into DataTable objects for easier data retrieval.

To ensure the correctness of the imported data, the existence of all the necessary files and the correct order of the columns inside them are first tested. If these conditions are met, then all 5 files are loaded from the hard disk one by one, otherwise a character string is generated in which all the errors encountered are collected to be displayed at the end of the data import

If in the process of searching for a component the entire table is traversed and still no component is found that corresponds to the imposed technical requirements, then the application warns us about the component not found and puts in the generated table the requested nominal current and the name of the selected supplier without specifying a particular code, thus ensuring certainty that that component will not be omitted from the order even if it is matched with a similar component from another supplier.

The generated list can be easily exported by double-clicking on the respective list, the components being saved in the PC clipboard from where they can be added directly to the quantity lists or other tables.

4.5. APPLICATION NAMES OF ELECTRICAL PANELS

Knowing the multitude of problems related to product names and their implications, I looked for concrete solutions to these problems together with the heads of departments. After several discussions, a scoring scheme was arrived at which, once implemented, simplifies the production process and allows for a precise cataloging of product types. This process of standardizing names and classifying electrical panels being a mandatory requirement for the product standardization process.

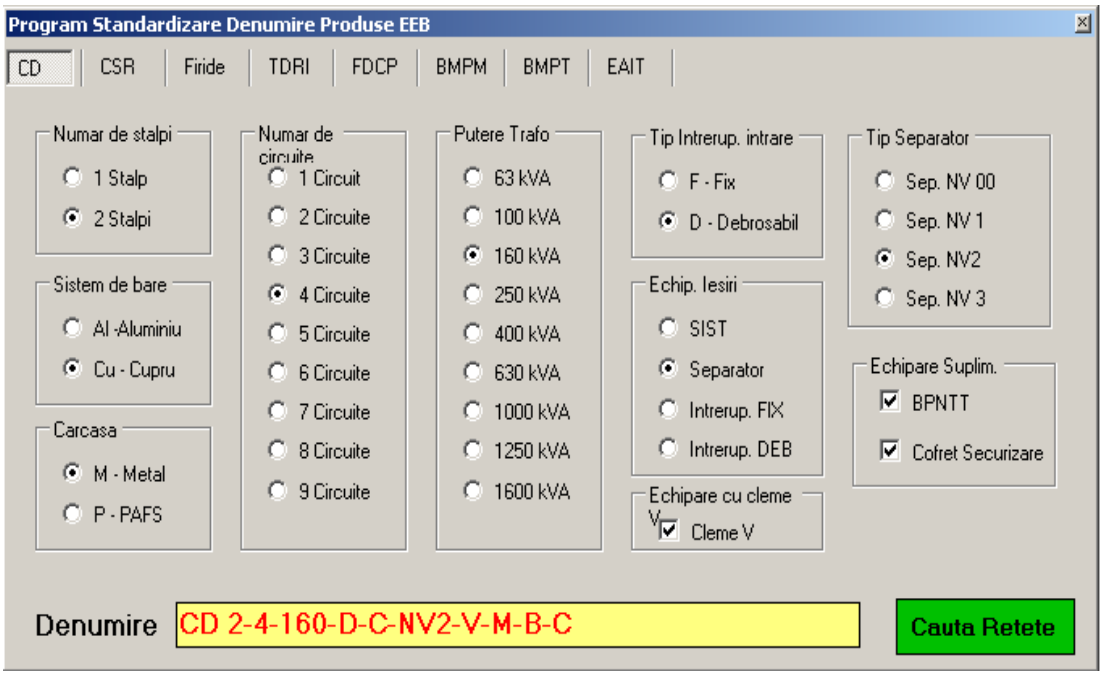


Figure 4.7 *Interface of the product name generation application*

The application for the realization of the uniformization of names was realized with the Visual Basic .NET 2005 development environment. This application is composed of a single form on which we have placed a TabControl type object that contains on each tab a type of electrical panel along with the settings and options that make sense in the context. Each time the page of the Tab object type is modified, the name generated based on the selections made on the current page is redisplayed. Figure 4.7 shows the application interface and the fact that we have selected a CD type switchgear with a rated power of 160kVA, with two pole mounting, Copper distribution system in a PAFS type plastic enclosure, has 4 distinct outputs realized with NV2 type fuse disconnectors equipped with V-type clamps and also has a null break protection device. At the bottom of the window you can see the name automatically generated based on the selections made.

The generated product name is automatically copied to the clipboard of the PC when the user, using the mouse, activates the text box containing the generated name by left-clicking on it. The usefulness of this device is that no typing or copying problems can occur when entering new products in the management program and then they are mistakenly sent to the design department and then to the production department.

Using the proposed program it is possible to identify already calculated products, by simply searching for the already generated landmark, and thus no more precious time is wasted in managing and recalculating these existing landmarks; increasing at the same time the working speed and relieving the design department of tasks that are often pointless.

The program also has the option to decode a name once it has been selected and copied from the management or sales program. The application decodes the sent message and opens the related layout where it sets the options present in the received name if it is a correct one and generates an error message otherwise.

The application is very useful because it has considerably reduced the number of product recipes generated to design and has led to a standardization of orders given by all sales department employees, who can now more easily fill in for a missing colleague, as each area of the country has specific products with different names that are easy to confuse.

4.6. APPLICATION FOR ORGANIZING PHOTOS OF COMPLETED PROJECTS

This project arose out of a need to quickly sort and sort images of completed electrical switchboard projects. Until the realization of the application all the pictures were taken by the CTC or production department, and kept on a memory card in a digital type camera dedicated for this purpose.

The realized mobile application has multiple purposes, the first and most important being to allow multiple people to take pictures of different finished products at the same time simultaneously without the possibility of overwriting them when downloading them to the finished projects directory

The second purpose is to gather structured information for the maintenance teams working within the company to troubleshoot problems with existing complex equipment. This second requirement also arose from a need observed by me in identifying and retrieving information related to the various existing equipment and machinery in use.

Often recurring or unique problems were noted on various sheets or registers in a succinct and inaccurate method, or not even noted if they were small malfunctions, leading to the impossibility to find and use this information in a timely manner, so we modified the original application in the sense that we added a new feature so that those who need these applications are not forced to use two separate applications on the phone, especially since both use the same routines for renaming files and access to the camera of the mobile device.

The extension of the mobile application allows taking pictures of the various problems discovered, saving the name of the equipment with problems or faults and attaching observations with great ease, the application interface and the names of the generated files can be seen in Figure 4.8.

The list of equipment can be easily modified directly from the application, this is done directly from the application settings and they remain permanently saved for later use, so the application does not need to be updated periodically for this reason.

The filenames of the generated files include, as with the panel locations, the current date and time for accurate retrieval and to avoid overwriting them to multiple faults for the same equipment.

All the equipment information, switchboard names and the date the images are taken are saved in the automatically generated name for each image taken based on the data entered and the equipment selected.

Figure 4.8. *Application interface for the maintenance department*

Naming and saving the data at the time of creation greatly simplifies the subsequent management of these files without the need for further sorting. The application interface for finalized electrical switchboards can be seen in Figure 4.9, where from the drop-down list on the right-hand side select the type of electrical switchboard, and on the left-hand side enter the unique identification number of the project of which it is part. This number is unique for each of the completed switchboards, regardless of the identification number of the technical project according to which they are realized, thus allowing the exact retrieval of the completed project.

After selecting the identifying information of the switchboard, multiple images of the site can be made successively without having to re-enter them.

All of these site images are then copied by each user directly to a local server in a dedicated location, organized by directory for each calendar year.

Figure 4.9. *Application interface for the production department*

The management program used by the company allows the sales department to open the desired projects and access the final site images to make sure they are the configurations requested by the customer before sending the final offer or finished product to them.

To allow access to these images directly from the management application, each computer has a shortcut in the form of a network directory used as a physical storage unit, to the directory path where these pictures are saved, and the shortcuts in the management application are actually link fields between the project stored in the application and the images saved in the directory allocated for the finalized products, including those of the project in question.

4.7 ELECTRICAL SWITCHBOARD PRODUCTION MANAGEMENT APPLICATION

The production of electrical panels within a company imposes many problems and interconnections between the various departments of supply, warehouse and design due to the complexity and dynamic nature of the process. In order to increase the speed of data acquisition and to ensure the accuracy of the data, we developed an acquisition system consisting of two separate applications that also manage and track the time spent by a project in the production chain.

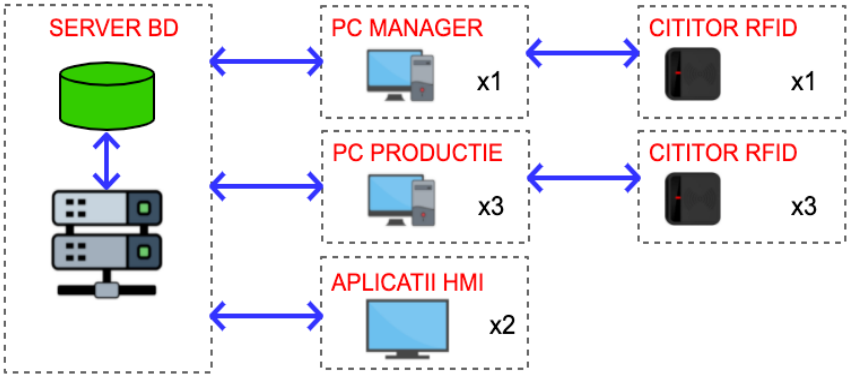


Figure 4.10. *Structure of the production management system*

The final structure of the project has an extended structure, as can be seen in figure 4.10 where we have represented by arrows the logical links between the project components.

The application used by the production manager to carry out and track production is called Project Management Program or PGP for short, and the application for the production halls is called HMI Application or AHMI as we will call them in the following.

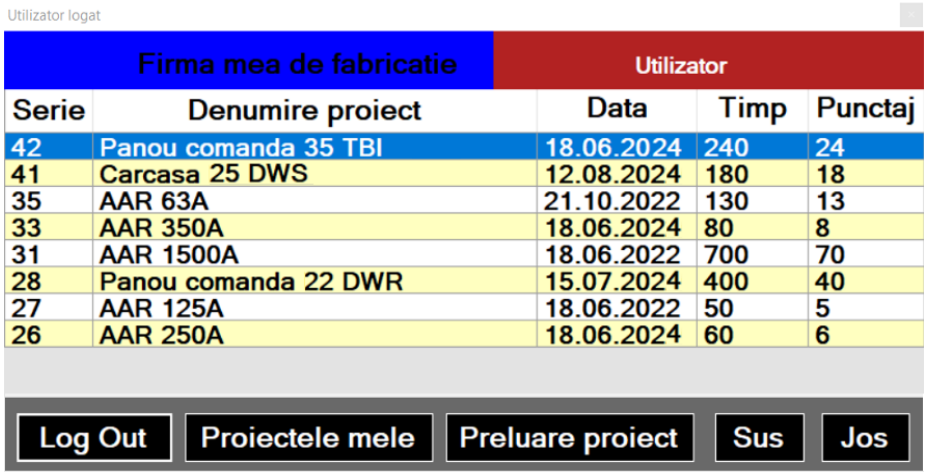


Figure 4.11. *The AHMI application window after user login*

User authentication is performed using existing RFID cards used for clocking in and out of employee shifts. We have chosen this method due to the existence of this system on the one hand, and due to the security and simplicity of their use compared to a classic user-password system requiring frequent data changes.

The AHMI interface shown in Figure 4.11. shows after login two more buttons that allow the user to consult the list of his own projects taken but not finalized and a second button that allows the user to take a new project from those available to all employees.

The projects available to be retrieved from the general list are filtered so that the authenticated user has access only to projects that have a difficulty level up to the employee's own level, the user's level of training is modifiable in the user management application.

The AHMI application is designed in such a way as to allow only one project to be worked on at a time, in order to allow a correct counting of the execution time for the product in question and also so that the manager can have a clear picture of the projects actually being worked on and can create a situation with the workload of each employee.

Execution times are very important because they are set as maximum time limits to be respected for each type of product and also provide the transparency necessary for a good working environment based on trust.

Information on projects in progress, ordered according to the time left to complete the projects and displayed on visible screens in the production halls, increases employee productivity thanks to the phenomenon of competition between employees, from which everyone involved stands to gain.

The interface of the "Project Manager" application is shown in figure 4.12, it includes several graphical interfaces for each important operation related to the project or employees and a code module file where all the routines related to the database and results processing are grouped.

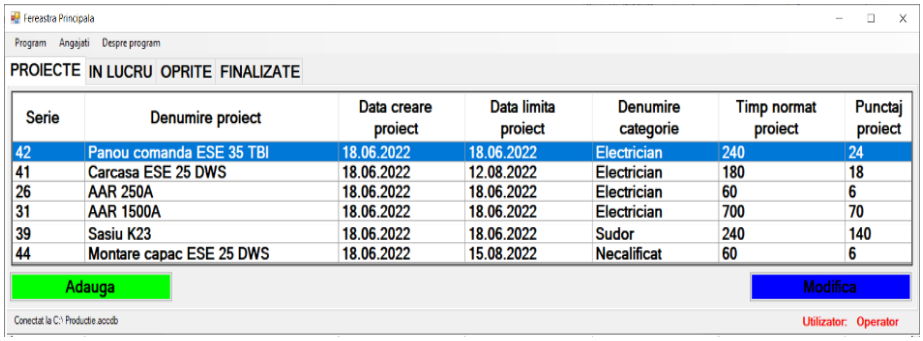


Figure 4.12. *Project Manager main application window*

The interface comprises a number of four distinct lists, each presenting the projects in the database in a slick and easy to follow manner. So the TabControl object in the main window of the application has four distinct pages of which the first three are the most useful, the last one is just a history where you check the execution times or the person who realized one of the projects.

The first page, the one suggestively named Projects shows all the memorized projects that have not yet been taken over by any worker, the second one, the In Work list, shows all the projects that are taken over by workers and are actually being worked on at the time of visualization. The third window is intended to help the application operator easily identify suspended projects and the reason for their suspension.

Any Operator in production may suspend the execution of one or more projects taken directly from the AHMI application in the production hall, provided that he justifies in writing the reason for doing so. Stopping or suspending a project shall require the project timer to be stopped and entered in the list of Stopped Projects.

The importance of the application is dictated by the precise tracking of the execution of the realized projects, to an accuracy of 5 minutes for each product. Product tracking is performed through an automatic mechanism that increments the execution times for all ongoing projects.

The two applications represent an integrated project and production time management system, which is far superior to the approximate record keeping with Excel tables kept until project implementation. The role of this system is to collect production data as clearly and accurately as possible and to eliminate as much as possible errors related to unequal or poor assignment of work tasks by realizing the proper workload of all employees.

4.8. MACHINERY SPARE PARTS MANAGEMENT APPLICATION

Due to the multitude of machines and the increased complexity, it is impossible to keep track of all the components and finding them in the warehouse poses serious problems for the warehouse managers, that's why to come to their aid we have created a Visual Basic application that allows the maintenance department to quickly identify the components and their

equivalents in the warehouse to reduce as much as possible the intervention time on defective machines and machines.

The problem of record-keeping stems from the accounting limitations of the application used, which does not allow the reuse of product codes in the case of purchases made from third companies, thus leading to multiple codes for exactly the same products, making it difficult to find and manage them.

The realized application has a simple interface that can be seen in Figure 4.13, the interface consists of a single window that allows both searching and updating the list of components based on the export directly from the accounting application. Users who are not logged into the application can only use the application to search for components needed for repair. The main window has in its center a Datagrid object which is populated with the data stored on the company server in the MySQL database dedicated to production and maintenance management.

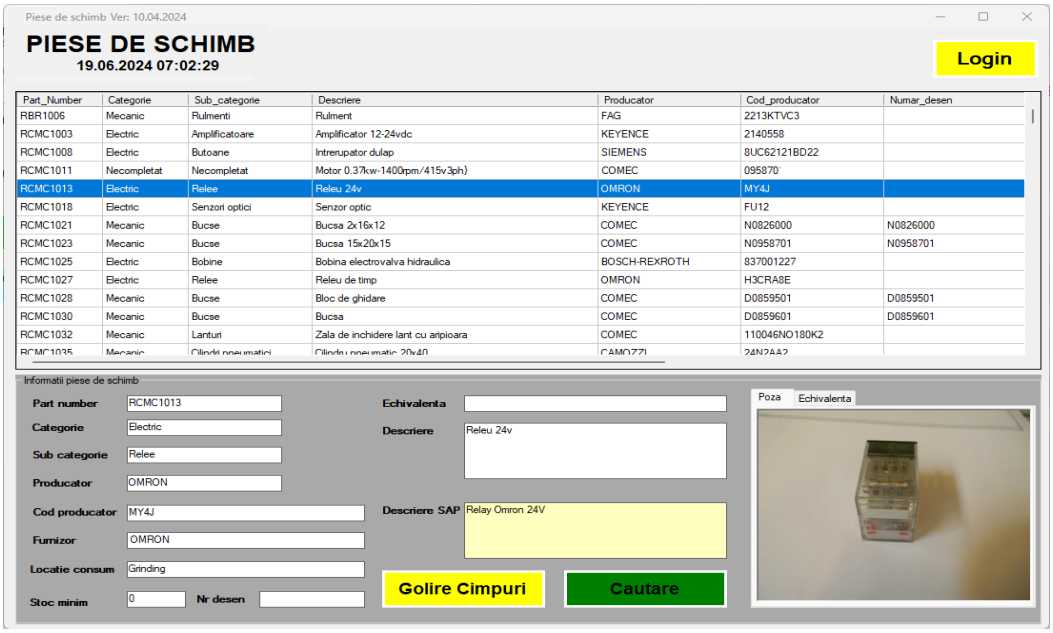


Figure 4.13. *Graphical interface of the electrical component management application*

The two departments don't have direct access rights to the company's management application for privacy and licensing reasons, so the only way to access the parts list and find the locations of parts wanted is through this simple but very useful application.

For the components that have images saved on the company's server in the path dedicated to component images, the application automatically uploads the image that has the name of the component in the file name, thus avoiding the direct registration of the name in the database and then saving the corresponding file, so that when adding a file that has the name of the component it will be automatically brought to its selection from the list of available components, being a simple and efficient mechanism for managing images for component identification purposes.

An export file from the accounting application is used to update the data already stored in the database, this export contains information populated only in certain fields and that is why when importing them an additional processing of the file must be performed in order to truncate the blanks in all imported fields and then identify the fields that are really empty, otherwise we risk overwriting useful information such as description or auxiliary code with empty values consisting only of blank spaces.

Importing new data requires two steps, the first step is opening and retrieving the records from the file and the second step is actually updating the database tables.

The application has proven to be very effective and useful and is routinely used by managers and the maintenance department to identify components needed for current repairs or to compile new critical parts lists. Parts considered critical have values other than 0 in the minimum stock column, and when they are consumed from stock, a need mail is automatically generated to the supply department for stock renewal.

4.9. RAW MATERIALS AND FINISHED PRODUCTS TRANSPORTATION MANAGEMENT APPLICATION

In order to support the departments in charge of transports, we have developed a distributed monitoring system capable of informing in real time any changes in the status of transports, thus minimizing the time needed to communicate any changes in the transport schedule for the current day.

The system consists of 4 large monitoring screens for the warehouse and one for the management office. For access to the two different gates we have an Android tablet, and for application management several workstations in the two departments in charge of Finished Goods Dispatch and Raw Material Supply.

Figure 4.14 shows the complete structure of the realized system and how the various components interact. It can be seen that only tablets and mobile phones connect to the WEB service and the rest of the applications connect via the native MSQL connector to the Microsoft SQL database for all applications realized using Visual Basic .NET, web applications or applications designed to run on the users' PC workstations.

The Desktop application is realized in Visual Basic .NET and is composed of 3 distinct windows, the main window contains 3 Panel objects, each of them being dedicated to visualize data from one of the 3 departments, Gate, Store or Dispatch depending on the rights of the user logged in on the PC.

When the application starts, it checks the name of the current user authenticated in the system and, depending on the rights defined in the user table, opens the window with the page to which he/she has rights. If the user has full rights then on launching the application he is greeted by a window where he can choose any of the four available options.

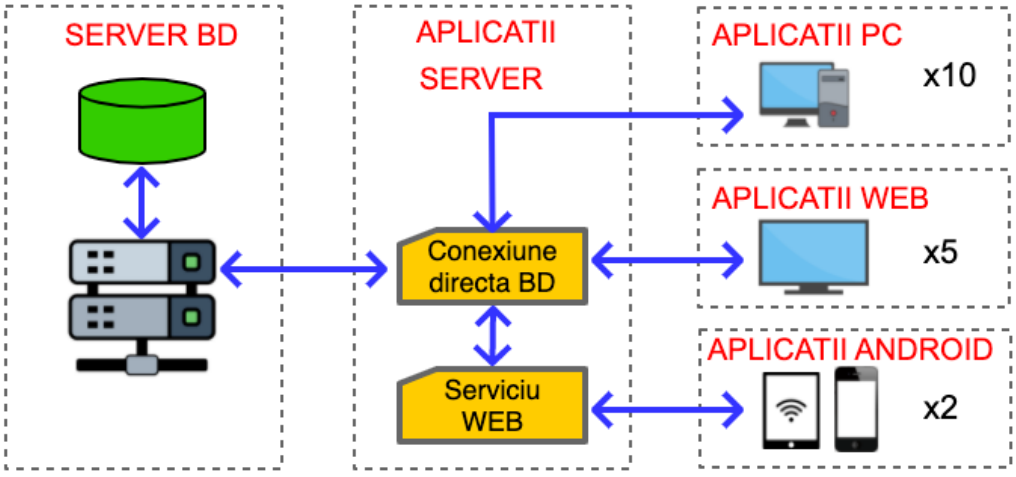
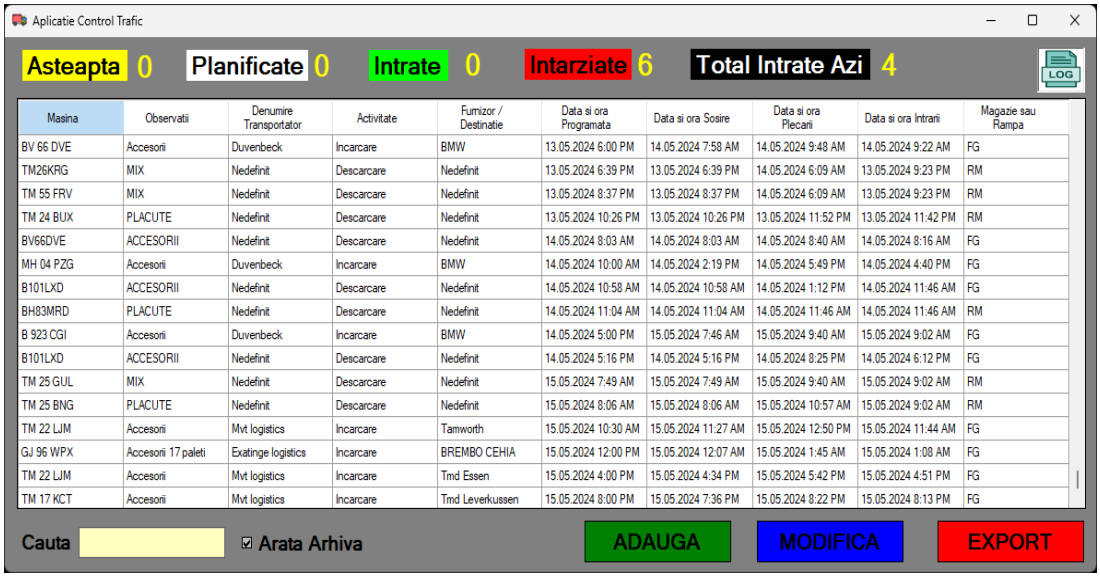


Figure 4.14. *Structure of the entire system*

The first option, suggestively named Gate, is used for all mobile devices running Windows 7 or later operating systems, which can successfully replace a faulty tablet or can substitute for it in case of a problem with the web service on which it depends.

The planning and transportation department is the most intensive user of the application, adding new shipments to arrive, modifying existing records and reporting on carriers. Figure 4.15 shows the main window of the application when used by the planning department.

The application uses a single main window on which it hides or displays one of the 3 Panel objects depending on the rights of the authenticated user. We chose this structure to have a single application running on all workstations because it is simpler to manage and has the advantage that many of the database access routines are common and thus do not require duplication and thus no need to modify all applications when implementing new requirements or modifying the database.



Masina	Observatii	Denumire Transportator	Activitate	Furnizor / Destinatie	Data si ora Programata	Data si ora Sosire	Data si ora Plecarii	Data si ora Intrarii	Magazie sau Rampa
BV 66 DVE	Accesorii	Duvenbeck	Incarcare	BMW	13.05.2024 6:00 PM	14.05.2024 7:58 AM	14.05.2024 9:48 AM	14.05.2024 9:22 AM	FG
TM26KRG	MIX	Nedefinit	Descarcare	Nedefinit	13.05.2024 6:39 PM	13.05.2024 6:39 PM	14.05.2024 6:09 AM	13.05.2024 9:23 PM	RM
TM 55 FRV	MIX	Nedefinit	Descarcare	Nedefinit	13.05.2024 8:37 PM	13.05.2024 8:37 PM	14.05.2024 6:09 AM	13.05.2024 9:23 PM	RM
TM 24 BUX	PLACUTE	Nedefinit	Descarcare	Nedefinit	13.05.2024 10:26 PM	13.05.2024 10:26 PM	13.05.2024 11:52 PM	13.05.2024 11:42 PM	RM
BV66DVE	ACCESORII	Nedefinit	Descarcare	Nedefinit	14.05.2024 8:03 AM	14.05.2024 8:03 AM	14.05.2024 8:40 AM	14.05.2024 8:16 AM	FG
MH 04 PZG	Accesorii	Duvenbeck	Incarcare	BMW	14.05.2024 10:00 AM	14.05.2024 2:19 PM	14.05.2024 5:49 PM	14.05.2024 4:40 PM	FG
B101LXD	ACCESORII	Nedefinit	Descarcare	Nedefinit	14.05.2024 10:58 AM	14.05.2024 10:58 AM	14.05.2024 1:12 PM	14.05.2024 11:46 AM	FG
BH83MRD	PLACUTE	Nedefinit	Descarcare	Nedefinit	14.05.2024 11:04 AM	14.05.2024 11:04 AM	14.05.2024 11:46 AM	14.05.2024 11:46 AM	RM
B 923 CGI	Accesorii	Duvenbeck	Incarcare	BMW	14.05.2024 5:00 PM	15.05.2024 7:46 AM	15.05.2024 9:40 AM	15.05.2024 9:02 AM	FG
B101LXD	ACCESORII	Nedefinit	Descarcare	Nedefinit	14.05.2024 5:16 PM	14.05.2024 5:16 PM	14.05.2024 8:25 PM	14.05.2024 6:12 PM	FG
TM 25 GUL	MIX	Nedefinit	Descarcare	Nedefinit	15.05.2024 7:49 AM	15.05.2024 7:49 AM	15.05.2024 9:40 AM	15.05.2024 9:02 AM	RM
TM 25 BNG	PLACUTE	Nedefinit	Descarcare	Nedefinit	15.05.2024 8:06 AM	15.05.2024 8:06 AM	15.05.2024 10:57 AM	15.05.2024 9:02 AM	RM
TM 22 LJM	Accesorii	Mvt logistics	Incarcare	Tamworth	15.05.2024 10:30 AM	15.05.2024 11:27 AM	15.05.2024 12:50 PM	15.05.2024 11:44 AM	FG
GJ 96 WPX	Accesorii 17 paleti	Exatinge logistics	Incarcare	BREMBO CEHIA	15.05.2024 12:00 PM	15.05.2024 12:07 AM	15.05.2024 1:45 AM	15.05.2024 1:08 AM	FG
TM 22 LJM	Accesorii	Mvt logistics	Incarcare	Tmd Essen	15.05.2024 4:00 PM	15.05.2024 4:34 PM	15.05.2024 5:42 PM	15.05.2024 4:51 PM	FG
TM 17 KCT	Accesorii	Mvt logistics	Incarcare	Tmd Leverkussen	15.05.2024 8:00 PM	15.05.2024 7:36 PM	15.05.2024 8:22 PM	15.05.2024 8:13 PM	FG

Figura 4.15. *Fereastra principala pentru departamentul de planificare*

The operator in the warehouse department decides which of the already arrived cars he wants to enter and then selects the car from the list shown and presses the Enter button, at this moment the red color appears on the tablet and blinks the row containing the car that should enter at that moment.

Each add, validate pick up or departure operation is recorded in the system and thus all these operations are expedited due to the awareness of permanent monitoring of dead times throughout the entire goods receiving process.

The web application is realized as a dynamic web page viewable in a compatible Chrome or Firefox browser, the data is sized to allow a proper full-screen view at full HD native resolution without borders of any kind with the font sized at 200% of normal size.

Another key component of the system is an application called Web API, which is a web service application that is built using the Visual Basic .Net programming language and can be run on a web server that has .NET Core 6.0 support installed. Calling the web service's own functions is done through GET functions, these services return strings that form JSON (JavaScript Object Notation) data structures, these data strings are easily processed by any mobile application.

The mobile application for access control is realized using the Livecode Community Edition development environment and consists of two different windows, one of which is smaller in size for introducing new machines into the system, and another one which is the maximum size of the tablet or mobile terminal on which this application runs.

For our case we used two ProDivx 10 inch tablets using Android version 9 operating system, which have integrated on the front side of the tablet a set of LED lights that act as warning systems. These perimeter lights are RGB and can be controlled via commands sent to the virtual serial port to which they are logically connected. The interaction between these

tablets and the transportation tracking system is done via wireless communication and a web service hosted on the company's own server.

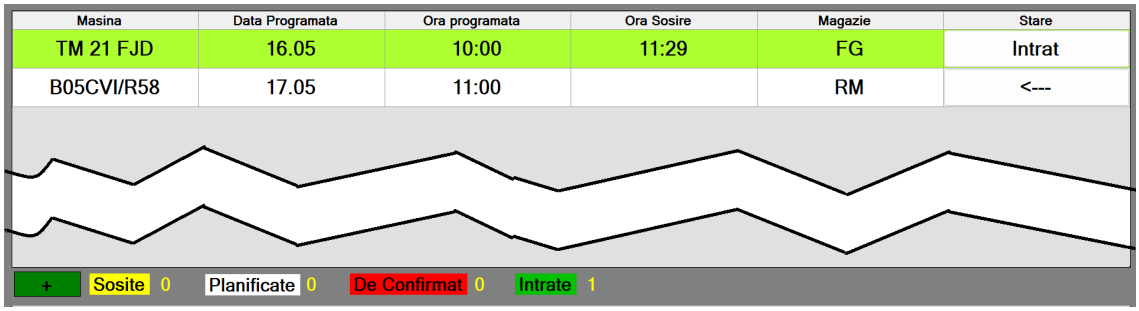


Figura 4.16. *Interfața aplicației mobile*

Figure 4.16. shows the interface of the mobile application, most of the window is occupied by a DataGrid object that is populated every minute with the cars that have already entered or are scheduled to enter the unload. At the bottom is the main information the gate attendant needs, namely: The number of cars that have already entered today, the number of cars yet to arrive that need to be confirmed as having arrived, the number of cars that have already arrived that are still waiting, and the number of cars scheduled to arrive for the current day.

When there are no more cars waiting in the waiting list at the gate, the previously green LED turns completely off to signal the end of the day's activities.

4.10. INTERACTIVE DEVICE FOR TESTING ELECTRICAL SWITCHBOARDS.

The interactive electrical measuring device represents an evolution of a traditional measuring device as it interactively assists the CTC department employee in measuring and testing the electrical switchboards produced by the company.

The usefulness of this device derives from the fact that it guides the operator by indicating the measurement points and comparing these values with those declared in the test algorithm for the switchgear under test.

The device allows to measure the actual voltage values but also to identify the phase from which the measuring point to be checked is supplied in order to confirm the correct connection of the consumers and the equal distribution on phases according to the technical project.

Each electrical panel is subjected to several tests, some mechanical and some electrical, to confirm the proper location of the main and auxiliary elements. Each electrical panel is tested on the basis of a typical scenario stored in the database to which the PC application has access and which forms a unitary whole together with the electrical measuring device as shown in Figure 4.17.

The PC application records the tested boards and their results, as well as the generation of certificates of conformity and test reports for already tested boards. In the event of the existence of defects or non-conformities found, the program allows a detailed report to be made with the measurements made and the values found to be inappropriate.

The application transmits through the serial port to the measuring device commands regarding the measurements, and the measuring device sends responses to the PC application regarding the measured values and the correctness of the measurement performed. Each measurement request sent also has a verification key to ensure the correctness of the data and the synchronization of the two equipment running in an asynchronous mode with respect to each other.

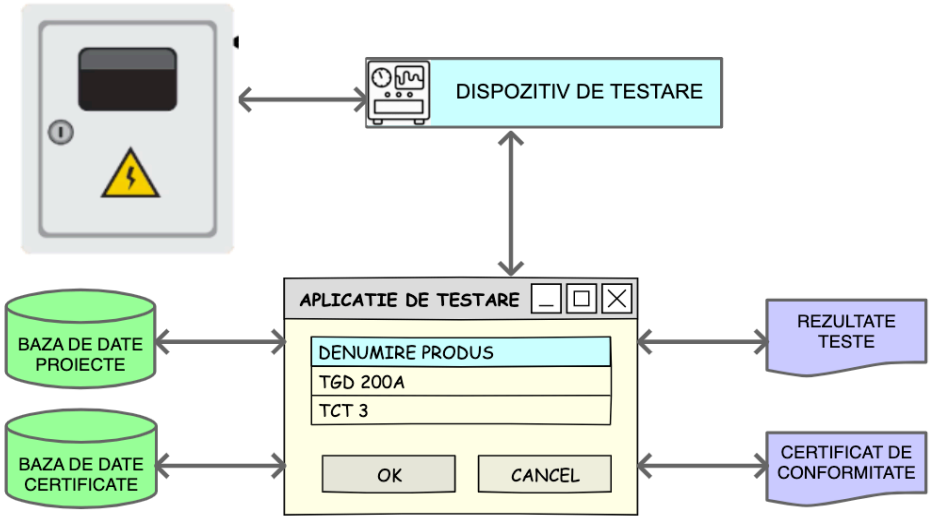


Figure 4.17. *Structure of the test equipment*

The main application stack contains four objects of type Card, each of which is a self-contained interface that can be accessed using card traversal commands from the programming environment, depending on the state of the application at that time.

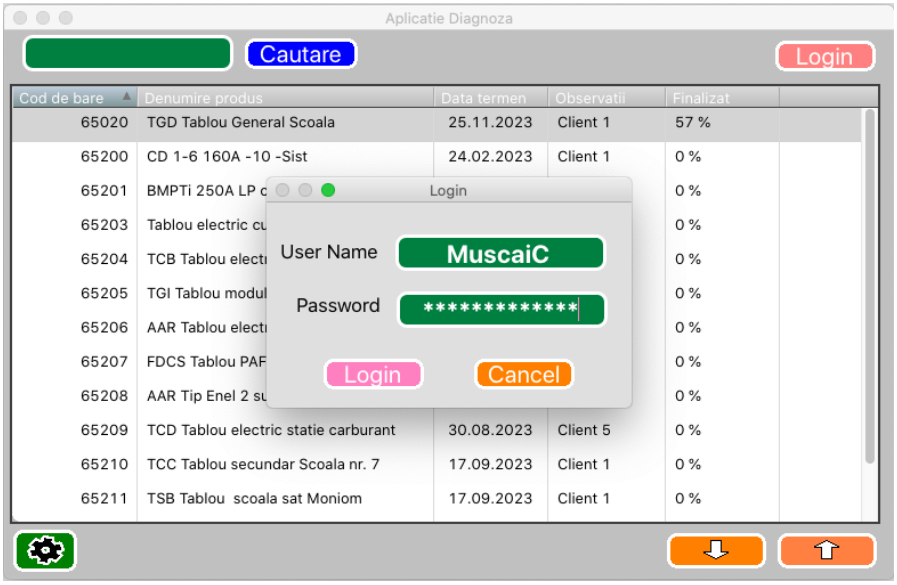


Figure 4.18. *Main application window, Project List card*

The Project List card contains a list of the projects stored in the database regardless of their status, this list being the starting point for any testing carried out using the PC application and the electronic tester, the interface is simple and easy to understand, in figure 4.18 you can see the application interface and the user authentication window, this window opens automatically when selecting a project or settings window if the current user's rights do not allow interaction with that graphic object.

Each of the projects in the list has a column in which the degree of completion is entered next to each one, automatically calculated by the application based on the number of successfully completed tests from their total, so a project not started will have 0% and a complete one will have 100% When trying to open a completed project, we will be redirected to the results page where we can list at any time the certificates of conformity and the tests carried out on the respective electrical panel.

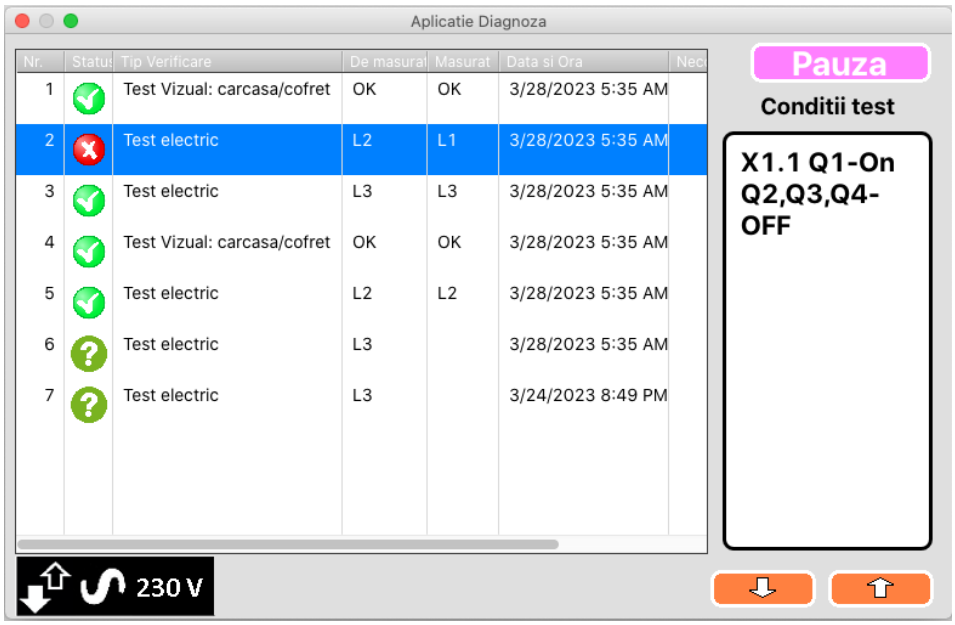


Figure 4.19. *Test window*

The test card contains in the central part a list of the checks to be carried out, in the lower part we have the status of the communication with the electronic measuring device and the current value measured by the device. On the right side we have a field where the conditions of the current test are entered, which is the measurement point and the conditions under which the test is performed, if this is required, the interface is shown in figure 4.19.

The electronic measuring device (MDE) presented in figure 4.20 is an intelligent device that performs the galvanic separation between the measured voltage and the connecting cable to the personal computer. The presented device allows the acquisition of measured signals and their comparison with typical levels sent by the PC application through the communication channel between the two devices.

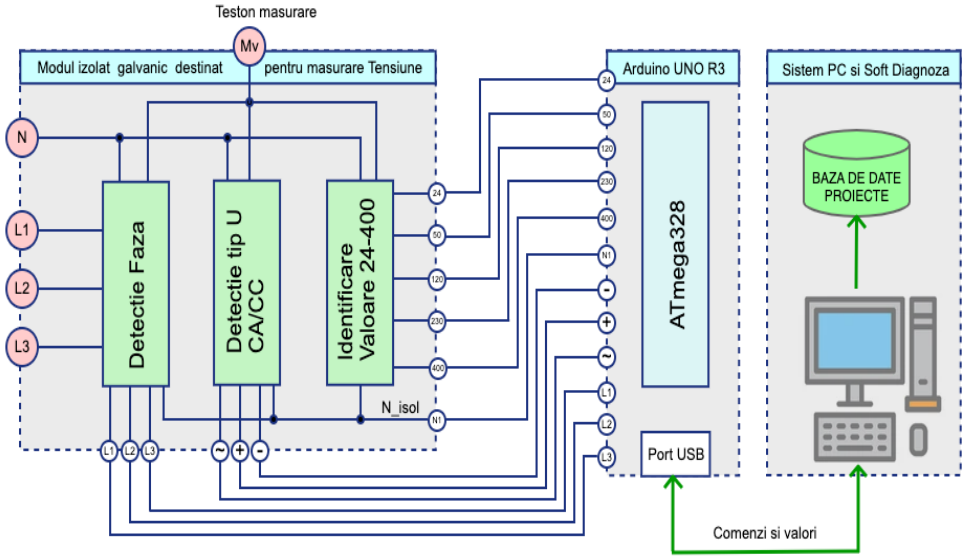


Figure 4.20. *Schematic diagram of the electronic measuring device*

The structure of this device is made up of 4 distinct modules, 1 being the current phase detection mode, it compares by means of dividers and optocouplers the voltage level with standardized levels, successfully identifying which of the network phases is presented at the measurement point at a given moment. The second module is responsible for identifying the

type of applied voltage, direct or alternating, and the third module deals with identifying the voltage thresholds applied to the measurement point.

The instantaneous values are taken by the digital inputs of the microcontroller, analyzed and compared with the value requested by the PC application at that point. If after 5 consecutive measurements the requested value is not reached even though there is voltage detected on the common input, then the actual value reached and the fact that the requested value differs from the measured one is returned to the PC application.

As a conclusion, the operation of the MDE equipment is based on the simultaneous performance of four electrical measurements between the tip of the device placed at the measurement point in the electrical panel and the three phases with which it is supplied, and by the additional measurement of the potential difference compared to the common zero point of the equipment and the electrical panel under test. [38].Folosirea componentelor electronice uzuale și a microcontrolerelor pentru realizarea de echipamente specifice nu este o noutate, fiind o metodă des folosită în cercetare și în industrie pentru reducerea prețului de cost și creșterea fiabilității echipamentelor de măsură și control.[39-40]

The PC application and the description of the structure of the test device were published in the journal UPB in 2023.[41]

4.11. APPLICATION FOR STRUCTURING THE DOCUMENTATION FOR ELECTRICAL PANELS

One of my first applications made in the design department was the technical documentation management application. When I came to the department, I noticed that for objective and subjective reasons, the documentation required for staff training was first scattered in several locations, moreover, there were duplicate documents in different locations and others were completely missing, these could be partially recovered from the existing computers in within the department.

Ca nou venit am fost pus de multe ori în fața faptului împlinit că nu reușeam să găsesc suficient de repede informațiile necesare proiectării.

As a newcomer I was often faced with the fact that I could not find the information needed for the design quickly enough.

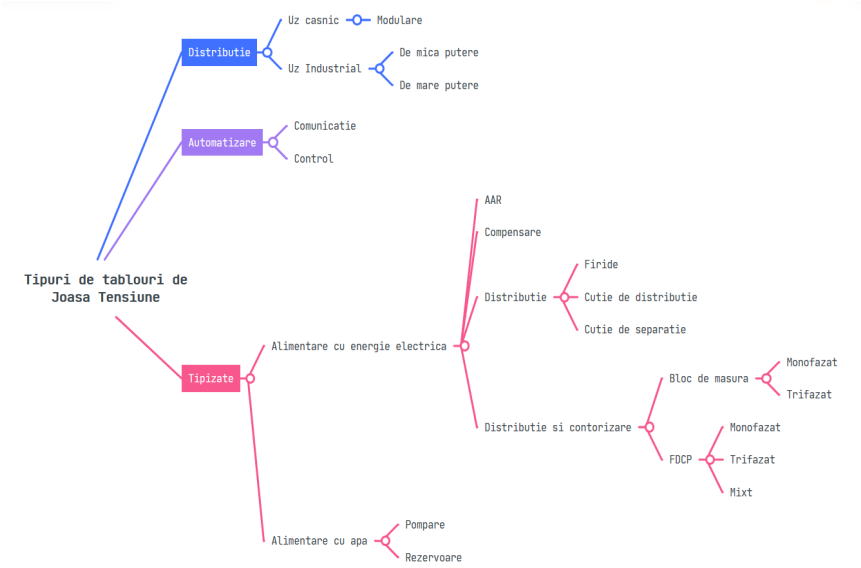


Figure 4.21. *The main types of low-voltage switchboards*

After an intense work of sorting and finding the documentation, I managed to structure it according to the need, now there was the problem of how to access it, at first it was just a simple shortcut placed on the desktop, then I used the location mapping on the server as a virtual disk and finally I decided to create a link between the information so that it could be browsed in a way other than folder by folder, especially since the structure was quite a large tree and involved a lot of effort to navigate.

Figure 4.21 shows the structure of the directories from which I started when I sorted the technical documentation, here I included all types of electrical panels produced within the company.

At first he wanted me to create a static web page that those who needed information could call directly, but the approach was not very successful due to the limitations imposed by the security settings that every time a link was accessed, it asked to confirm the navigation and the opening of each file of HTML type in part for security reasons that could not be removed.

And for these reasons I decided to create an application that can be run directly from the PC and that does not have the problems mentioned above, moreover, modifying the application to add or modify some pages is very simple and intuitive.

Most of the application consists of text controls for messages and navigation buttons, the logic of operation of these buttons is similar, differing only in the destination they lead to by activating them.

In figure 4.22.a we have the capture of the home page, the card contains the navigation buttons and a single button to start the process of selecting a type of electrical panel. In figure 4.22.b we have the screenshot from the first step which represents the root of the tree shown in figure 4.21, from here I chose the "Typed tables" branch, then from the list I chose "Distribution and metering" and finally "Measurement blocks" and "BMPM". After the last selection made, we are in the situation in figure 4.22.c where we can choose the area of which the client is a part, for which we want to create the BMPM table.

Figure 4.22. *a) home screen, b) root of the structure , c) vendor selection*

The larger buttons directly open the common root of the selected energy supplier, and the smaller ones strictly open the way to the documentation and respectively to the location images for the products of that type made over time within the company.

If the designer is not sure of the area the client belongs to, then he can use the button on the bottom right, the one for help. In the case of provider selection cards, a new window is displayed in which the image with the providers and the counties that compose it is loaded from the server from a fixed location in the root of the documentation.

The application, although simple in construction, is a really useful tool for the design department because it allows the documentation to be easily found even by those without experience.

CONCLUSIONS AND OWN CONTRIBUTIONS

In the paper I presented only a part of the entire production chain, I omitted the cash flow and supply part because that part is not that well known to me and due to the financial-accounting implications where I did not have the right to intervene in the decision company management.

Instead, the practical experience I have related to the drafting method and the design stages allowed me to create these applications aimed at optimizing the design process.

The realization of the production tracking application appeared as a necessity due to the imprecise record of production times and the actual workload of the employees in the production area. The request came from management as it became increasingly important to estimate production times and costs to enable the lowest possible selling prices to be achieved without affecting revenue.

The contribution of the own applications currently used within the company is significant and eases the work of the design and production department. But each of the applications solves a specific problem that arose at a given time without being part of a larger control structure that also targets the rest of the departments. The company uses the WinMentor Enterprise application on the financial and accounting side, which solves a large part of the problems of this department, but it is very rigid for the production side because it does not allow the creation of alternative paths or variations in the already implemented production flow.

I. Own Contributions

1. 1. The conception an building of an application that facilitates the dimensioning and choice of the necessary components for the realization of low-voltage AAR-type electrical panels.[1]
2. **Electric panel documentation management application***,* reduces search times for electrical panel design and execution documentation.
3. **Interactive electrical panel testing device**, it is a rapid electrical panel testing system with the help of computer and electronic measuring device communicating with PC application. [11]
4. **Raw material and finished product transport management application**, it allows to make a precise record of the transports and how the reaction times for each one are respected. The application also allows real-time tracking of the loading or unloading process in terms of waiting times and those actually spent by a transport from entering to leaving the company.
5. **Machinery spare parts management application,** allows the urgent finding of the necessary electrical or mechanical components for the reappearance of machines within the company.
6. **Electrical panel production management application**, is an application made with the aim of eliminating subjectivity in the calculation of execution times for electrical panels, each project being counted individually within the application, and at the end of the month, production reports and working times are generated for all projects undertaken and completed.

7. **Application for organizing pictures of completed projects** is an application for Android mobile phones. The application allows automatic saving and renaming of images taken with finished products. The purpose of the application is to allow the easy retrieval of projects and images of finished products that, until the application was created, were taken in bulk on a digital camera.
8. **Application for creating names of electrical panels**, is an application that helps the bidding department to define product names according to clear rules to allow their uniformity between the various departments. The application allows the selection of a type of electrical panel from a list and then with the help of the graphic controls the desired configuration is decided, the application generating the name that renders the respective configuration, a name that is then copied in the documentation or in the management application.
9. Application for sizing power cables based on the type of equipment, is an application that allows designers to size the input circuit of an electrical panel and implicitly the size of the power cables based on the electrical loads produced by the equipment that wants to be powered from this panel . The application calculates simultaneity factors and average power factor based on the type of powered equipment and their power. [8]
10. **Electric motor starting circuit dimensioning application**, allows the quick dimensioning of classic starting circuits for electric motors, by selecting the desired power and starting method. The application returning a list of required electrical materials from the supplier selected from those entered in the database.

II. List of original works

1. B. L. Protea, **C. Muscai**, V. Navrapescu, E. Spunei, I. Piroi and F. Piroi, "Computer Assisted Equipment Selection for Components of Electric Panels," *2018 International Conference on Applied and Theoretical Electricity (ICATE)*, Craiova, Romania, 2018, pp. 1-5, doi: 10.1109/ICATE.2018.8551483.
2. **Cristian Muscai**, Bogdan Protea, Valentin Navrapescu, Monica Roșu „Designing a modern drinking water pumping station", Analele Universităţii "Eftimie Murgu" Reşiţa Anul 2019 , Vol 26, Issue 1, p169, 2019, ISSN 1453 – 7397
3. I. -C. Mituletu, **C. -M. Muscai**, G. -R. Gillich and L. -B. Protea, "Angular Positioning Device with Wireless Accessibility," *2020 International Symposium on Fundamentals of Electrical Engineering (ISFEE)*, Bucharest, Romania, 2020, pp. 1-4, doi: 10.1109/ISFEE51261.2020.9756174
4. I. -C. Mituletu, **C. -M. Muscai**, G. -R. Gillich and L. -B. Protea, "Microcontroller Based STFT-Vibration Analyzer," *2020 International Symposium on Fundamentals of Electrical Engineering (ISFEE)*, Bucharest, Romania, 2020, pp. 1-4, doi: 10.1109/ISFEE51261.2020.9756178.
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6. Liviu-Bogdan Protea**, Cristian-Mircea Muscai** ,"Design Of Low Voltage Electrical Circuits For Industrial Receivers", Engineering 67(1) 2022, DOI: 10.24193/subbeng.2022.1.21, Vol 67, No1,2022
7. M.F. Predus, M.D. Stroia, C. Haţiegan, C.Popescu, **C.M. Muscai**, „Design And Construction Of A Remote Measurement And Control Facility For A Water Supply Project", Scientific Conference with International Participation "CONFERENG 2022", Targu-Jiu, November 25-26, Annals of Constantin Brâncuşi University of Târgu-Jiu - Engineering Series, No. 2, Pp. 152-157, 2022.
8. M F Predus, **C.M. Muscai**, C Popescu, C Hatiegan, „Computer Aided Design Of Low Voltage Electrical Installations", International Conference on Applied Sciences (ICAS 2022) 24/05/2022 -

28/05/2022 Banja Luka, Bosnia and Herzegovina, Journal of Physics: Conference Series, Volume 2540, doi:10.1088/1742-6596/2540/1/012010, 2023.
9. M F Predus, **C M Muscai**, C Popescu, C Hatiegan, „The Importance Of The Metal Reinforcement Of Low Voltage Cables In The Process Of Identifying Defects", International Conference on Applied Sciences (ICAS 2022) 24/05/2022 - 28/05/2022 Banja Luka, Bosnia and Herzegovina, Journal of Physics: Conference Series, Volume 2540, DOI 10.1088/1742-6596/2540/1/012011, 2023.
10. **C.M. Muscai**, MD Stroia, C Popescu, C Hațiegan, „Integration Of The Equipment For Renewable Energies In The Electricity Distribution Networks", Scientific Conference with International Participation "CONFERENG 2023", Targu-Jiu, November 24-25, Annals of Constantin Brâncuşi University of Târgu-Jiu - Engineering Series, No. 3, Pp. 13 - 18, 2023.
11. Valentin NAVRAPESCU **, Cristian Mircea MUSCAI,** „Parameters Measurement And Identification Equipment For On-Line Testing Of The Electric Panels", UPB Scientific Bulletin, Series C (Electrical Engineering and Computer Science), Vol. 85, Issue 4, 2023, ISSN 2286-3540
12. MD Stroia, C Hațiegan, MF Preduș, **C.M. Muscai**, „An Automated Approach For Traffic Light Control At Pedestrian Crossings", Journal of Physics: Conference Series, Volume 2714, 11th International Conference on Applied Sciences (ICAS 2023) 24/05/2023 - 27/05/2023 Hunedoara, Romania, 2024.

III. Prospects for Further Development

For the next years we plan to make a customized application that interacts directly with the Oracle database of the WinMentor application and allows the query and insertion of new data for the HSE, CTC and supply departments, departments that have not developed work modules within the application .

For the implementation of the proposed, namely the integration of this new software, there is the support of the company but also of the manufacturer and the integrator. At the moment we have managed to create dedicated functions that allow searching and viewing projects in real time and tracking their status in our own application made in Visual Basic 2008.

Production tracking allows the generation of customized events for the departments involved in production, thus drastically reducing the waiting times between project validations and the supply or takeover of finished projects by the CTC department.

Another improvement would be for the circuit sizing applications to be all merged into one application with a common interface that would allow for easier design of switchboards through sample boards for the designer to choose from a library. graphics.

The dimensioning of each individual circuit can be done by several means, by the direct choice of some known components or by indirect methods that require the selection of the supplied consumers, the length of the connection cables with them and the expected behavior in operation.

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