Creating Laboratory Models for Auto Backup Power

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Abstract **–This article is presented the design and implementation of a laboratory model of the panel automatic start of reserve (AVR). The model manages switching switches from primary to backup power.**

Keywords – **Panel AVR, Backup power, Relay time, Frequency inverter.**

I. INTRODUCTION

The electrical supply system for industrial enterprises (ESSIE) is a set of devices used for generating, transferring and distributing electricity. The purpose of ESSIE is to supply electrical consumers.

The main schemes for ESSIE are: external and internal schemes, industrial units distribution networks for low voltage.

The type of the scheme depends on: the size and type of enterprise; the category of the electrical consumers; the amount of power consumption; the location of the enterprise and the type of electrical consumers.

The requirements for the schemes are to be: dependable; flexible and adaptable (to different modes of work); economical; with high quality power (voltage); convenient and safe to operate with; with the possibility of expansion and development.

By provision of electricity the electricity consumers are divided into four categories - null, first, second and third.

The null category is reserved for those electricity consumers, where an electrical blackout could threaten the life and health of people, cause a threat to national security, cause property damage, cause disruption of complex technological processes, disturbance of vital economic facilities, communication systems and TV.

First category consumers are those, in which power failure leads to considerable material losses, poor mass production and the disruption of a complex technological process. The second category of consumers are those in which the power outage creates a halt in mass production, a downtime for workers, facilities and industrial transport and also disrupts the normal living conditions for a large number of people. The third category of consumers are all the consumers who do not fall in the previous categories [1, 3, 6].

The electrical power supply can be performed:

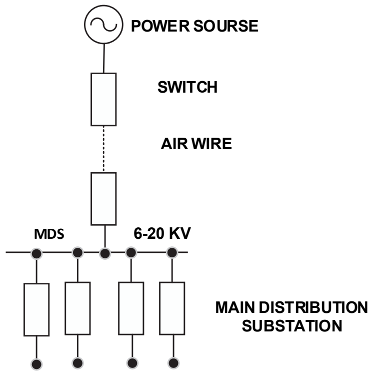

Fig. 1. Electrical power supply

- By getting power from one power source, for consumers "2" and "3" category – (Fig. 1);
- By getting power from two power sources - circuit ARA (Automatic Reserve Activation) to consumers of "0" and "1" category (Fig. 2).

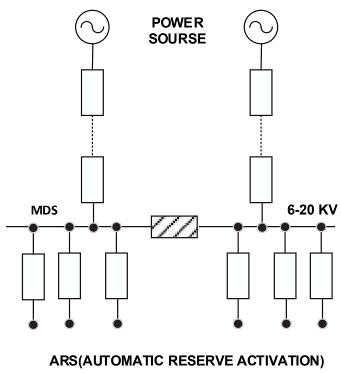

Fig. 2. Electricalcircuit with two power sources

Automation in power supply systems of industrial enterprises is being realized with different technical solutions. Among them are the so called automatic reconnection devices (AR); automatic current and frequency discharge devices (ACD, AFD) and devices for automatic switching to backup power and equipment (ABP).The automatic start of the backup power reserve (ABP) is implemented through different technical approaches. The circuit solutions for the realization of ABP are very diverse, and so is their physical performance. The choice of a particular solution depends on the idea of the designers, the requirements from the investors and the existing element base.An ABP panel is a panel that provides an automatic start of the Reserve or automatically switches to backup power. It comes down to electrical installations, which must provide unobstructed continuous operation of electrical equipment in hospitals, airports, mines, factories with continuous uninterrupted work cycles, gas stations, anywhere, where an electrical power supply outage would endanger the lives of people, would cause mass production accidents or loss of materials and data [1, 2].

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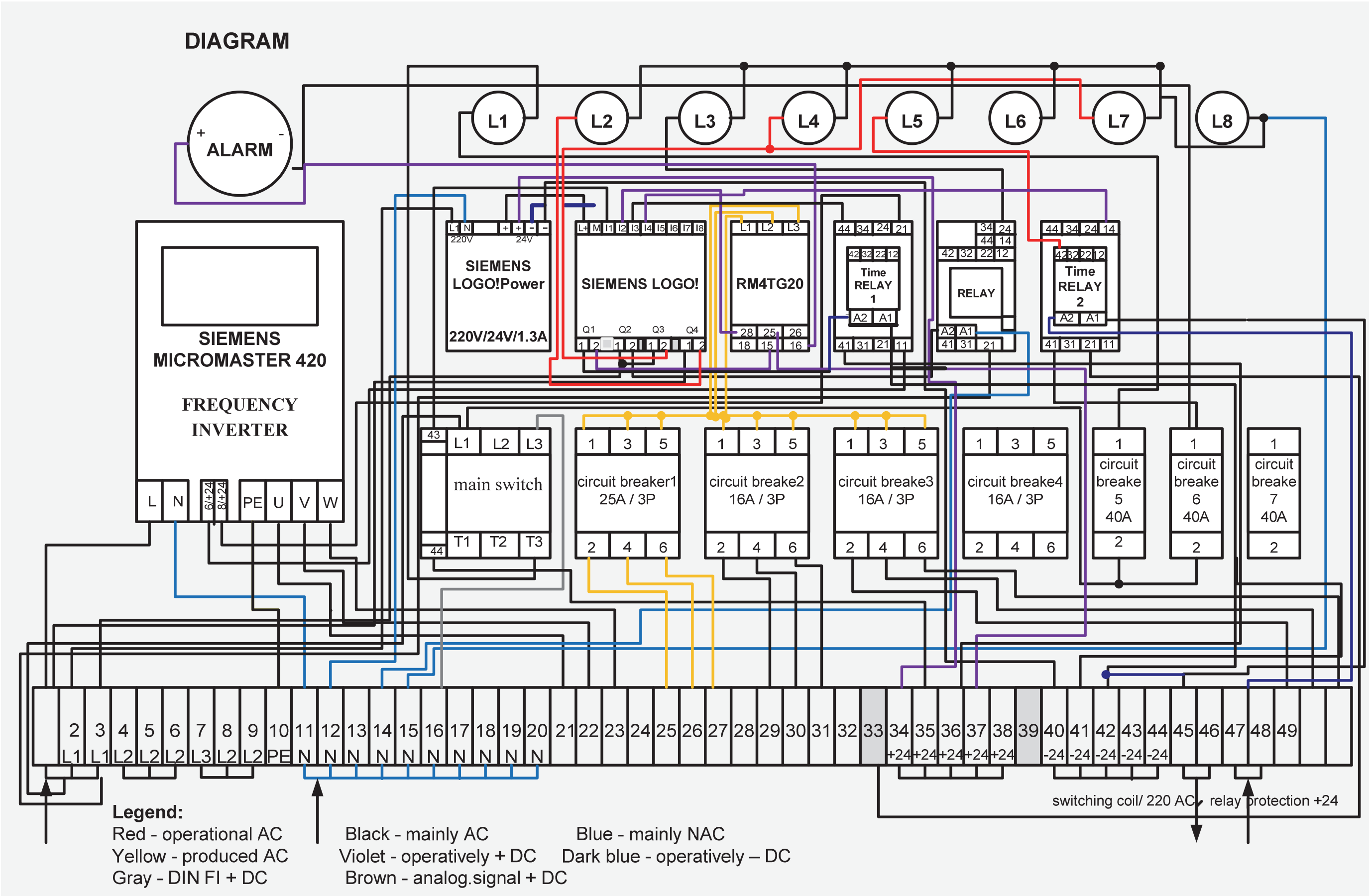

Fig. 3. (*a*) Block and one-line diagram of the panel

This is done by building a bridge, connecting the currently used electrical network to another one, independent of the first network or by connecting to a backup generator of electricity. Namely the connection between the two networks or between the network and the generator is achieved via a panel ABP.

The ABP is a system of circuit breakers and an electronic component, which monitors the status of the network using predefined data and if necessary restores power by switching to the reserve power supply in case of an emergency power outage or a shutdown caused by a mistake.

If a network doesn't have a built ABP board, then one is designed and built individually for each network. There may be full backup or part backup. The full backup can power the whole site.

The part backup supplies only the important components and excludes some of the non-vital consumers.

This can be done manually or automatically by changing the program settings of the ABP board.

For example, in the case of a gas station voltage outage, the fuel dispensers, the cash register area and the alarm installation would continue to work, everything else which is unnecessary - coffee machines, storage lighting would not be powered by the ABP panel.

As another example, in a hospital, the operating room would obviously have to work with full equipment.

Upon restoration of the operating voltage, the ABP panel should work in reverse order and shut off the backup power reserve as to prevent a circuit overload or machinery and equipment shutdown.

The ABP panel must have monitoring systems including an ammeter, a voltmeter, LED status indication and a microprocessor to control the workflow of all systems in the device.

The ABP panel must have a mechanical and electrical interlock, which prevents shifting and simultaneous electrical supply from both sources and must provide an automatic start and stop in case of power outage or restoration.

The ABP panel designs and physical implementations are as diverse as the objects to which they apply.

II. Design and Implementation of a Lab Model of the ABP Panel

A. Scheme Implementation

Modern training of students in the engineering and science fields requires the use of models and installations intended for gaining practical skills.

As a result of that, a lab model of the ABP panel has been created for students studying in specialties Engineering and Electric Supply.The model aims to control circuit breakers - switching from primary to backup power [4, 5, 7].

For the creation of the lab model, a “TEPO” type panel has been used - size 60/66 cm.

The following electronic components and materials have been mounted in the panel:

- Frequency inverter - SIEMENS MICROMASTER 420;
- Power supply 220V/24V - LOGO! SIEMENS POWER;
- PLC LOGO! SIEMENS;
- Phase monitoring relay – RM4TG20 Schneiderelectric;
- Time relay „BP 1”, ”BP2” – 2 pieces;
- Relay „P” – 1 piece;
- Automatic circuit breaker with a fault registration module /shutdown/;
- Automatic circuit breakers NOARK25A, 16A 3P и 40A 1P;
- Terminal blocks;
- Conductors for conductivity.

Fig. 3. (*b*) Scheme realization

Fig. 3*a* shows an arrangementof the panel. Fig. 3*b* shows the scheme realization.

B. Principle of Operation of the ABP Panel

Established laboratory setting simulates primary power outage from 20 kV circuit breaker, shuts off circuit breaker HH in the main scheme and turns on circuit breaker HH on reserve power supply from a diesel generator.

The designed panel is linked to a diesel generator. In the control panel of the generator two variables are fixated: voltage and time.

The minimal voltage and the starting time are adjusted, i.e. in case of a decline in the voltage the diesel generator activates and starts working after a certain time period has passed.

There are several power sources in the terminal block panel:

- External voltage 220V for supplying a Frequency Inverter and LOGO!POWER;
- Voltage 24V DC from LOGO!POWER for supplying the elements in the panel
- Voltage 220V, received from the generator.

The frequency inverter uses 220V, as for DC 24V uses its own.

The working algorithm is as follows:

- Relay protection ROCON RFI 421 in case of power outage activates circuit breaker CH SF1 and it changes its state to OFF;
- Circuit breaker SF1 through block Alarm terminal 26 gives signal to terminal 48, while it relay for the time 2 to terminal A1 (+24V voltage from the panel model is given to circuit breaker SF1 on terminal 25);
- Time Relay 2 after activation sends signal to input I4 of LOGO!;
- After the controller receives a signal through input I4, it sends a signal to outputs Q1 и Q4;
- Q1 triggers the coil of the relay for the time period relay for the time 1 with a delay of 0” sec and sends a signal +24V to terminal 15 to the phase monitoring relay ;
- Q4 sends 220V to lamp 5;
- Q4 sends 220V to terminal 46 (terminal 46 sends a 220V signal to motor movement of main circuit breaker HH, it turns off);
- Time relay BP 1 sends signal simultaneously to input I3 of LOGO! and to DIN of frequency regulator;
- The frequency inverter starts diesel acceleration;
- If everything is okay with the diesel generator, then PM4 receives at L1,L2,L3 normal voltage and sends a signal to input I2, while it opens Q2. The output is with operating voltage 220V;
- Q2 receives a signal from I2 , after which it sends a signal to relay P;
- Relay P turns on lamp 3, which shows that the diesel generator is turned on normally and supplies the electrical circuit;
- Input I3 is awaiting signal, which it will receive if RM4 doesn't receive normal voltage from the generator in a time period of 10 secs. In that case a signal is sent to Q3, lamp 4 lights up ”NOT RUNING” and also lamp 7.

C. Experimental Results

In the setting presented above the following experiment was carried out:

- Sending a 220 V power supply from the main power source. Green indicator 1 on the panel lights up. It shows the presence of a main power supply (Fig. 4).

Fig. 4. Green indicator 1 “MAIN POWER PRESENTED”

- Disconnection from the main power supply with the activation of an alarm. Red indicator 2 lights up. The frequency regulator reads „0”. In this moment the time delay period starts, which aims to prevent unnecessary activation of the diesel engine, in case the main power supply is restored in the meantime (Fig. 5).

Fig. 5. Red indicator 2-alarm “NO MAIN POWER”

- The frequency inverter is turned on and the diesel engine starts up. The light indicator is still red. The diesel engine is imitated from the combination “frequency inverter - induction motor”(Fig. 6).

Fig. 6. DIESEL ACCELERATION

Fig. 7. ”DIESEL ACCELERATION”

- After reaching a certain rotation frequency, the induction motor has reached its maximum because of the connected capacitors, it has reached its nominal voltage 230 V and has activated its circuit breaker. The green light indicator 3 lights up, the measured voltage is 230 V and the red light indicator shows the still missing main power supply (Fig. 8).

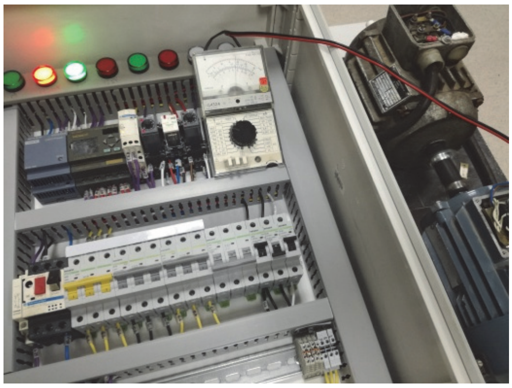

Fig. 8. System is powered by back-up supply

- With restoration of the main power supply the diesel generator stops after a certain time period, by which a gradual cooling of the diesel generator is being imitated.

III. Conclusion

The proposed lab setting is a very useful electrical installation that grants students the opportunity to gain knowledge and skills in the electric supply field - monitoring and management of electrical networks and partly their automatization.They create the working algorithm depending on the stages of the process. They get familiar with the functioning of the electrical network when there is a main power supply in case of an emergency blackout - turning off relay protection on 20 kV side, verification of AR (Automatic Reconnection) device, turning off main circuit breaker on 0,4 kV side, activation of an emergency diesel engine, switching to a backup power supply, work during backup power supply usage and restoration of the main power supply.

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