Design and Development of an Automatic Three-phase Sequence Reversal Detection and Correction

Dr.S. Sentamilselvan and S. Janakiraman

Abstract--- The occurrence of faulty grid systems in three-phase power systems has dominated many companies, especially in the industrial sector, with three-phase power supply equipment. This is also referred to as the phenomenon of phase change, in which the sequence of three phases is inadvertently shifted during the maintenance of a utility power source or a motor driven engine, which is most likely after power restoration: severe damage and unanimous appreciation of such equipment and personnel. Too much damage prevents the effect of phase-cycle sensing devices such as the reverse three-phase system. The design and construction of equipment to detect and reverse-phase reversal involves the incorporation of timer relay circuits into the heart's electromagnetic contacts of the controller.

Keywords--- Phase-sequence, Phase-reversal, Under-voltage, Protection, Phase-loss, Automatic-reversal Detection-correction.

I. INTRODUCTION

The three-phase system combines three-phase motors and other rotating instruments to run in the opposite direction by changing the phase. In many cases, this can cause much damage to equipment and machinery and personnel, especially if the motor is attached to the cutting tools or the conveyor belt. Also, the accidental reversal of direction causes the gear teeth to break, the chain to break, and the trigger at the end of the submersible pump motor shaft; Causing damage to operators and major economic losses.

Dr.S. Sentamilselvan, Associate Professor, Department of EEE, SCSVMV, Kanchipuram, Tamilnadu, India.
E-mail: sentamilselvans@gmail.com
S. Janakiraman, PG Scholar, Department of EEE, SCSVMV, Kanchipuram, Tamilnadu, India. E-mail: janakiraman776@gmail.com

A 3-phase monitoring system with phase protection is inevitable. Therefore, three-phase motors and other rotating sensitive three-phase equipment can combine the reverse phase at any time, especially for people who carry equipment like escalators or lifts. Three-phase motors and rotation sensing tools such as mining, pumping, lifts, cranes, generators, irrigation are used.

The three-phase AC supply consists of three stages with the same amplitude and a phase shift of 120 degrees from each other. And is usually expressed as L1, L2, and L3. Also, after the voltage or current waveforms of these phases have reached their respective peak values, other time intervals are in a specific order. The phase rotation or phase sequence is defined as where each step of the three-phase power reaches its maximum value.

Phase Reversal (Incorrect Phase Sequence)

A phase shift occurs when any two phases of a three-phase power supply are exchanged with the normal line. In most cases, this may be due to a deliberate mistake in installing the equipment, such as maintaining electric engines, changing the power supply, or in the event of a power outage, than before the power outage. These conditions can cause damage to many rotation-sensitive devices (such as lifts, screw and scroll compressors, centrifugal pumps, and conveyors) because they operate in opposite directions. In many cases, this can severely damage equipment and machinery. As well as fatalities; Motors are attached to cutting equipment or belt conveyors. However, the voltage and current amplitudes are unaffected and remain the same regardless of the order. You can change the phase order of a three-phase power supply by changing the two-phase power supply of the three-phase power supply. 1-2-3 phase array device, first L1, then L2, and finally, L3 reaches its maximum value. However, in some cases, letters such as R, Y, and P or A, B and C refer to three phases;

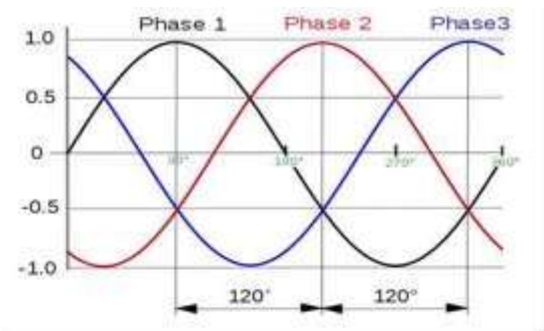

Figure 1: Three-Phase Alternating Current Waveform

For a 1-2-3 phase array device, first L1, then L2, and finally, L3 reaches its maximum value. However, in some cases, the letters R, Y and P or A, B and C refer to three phases.

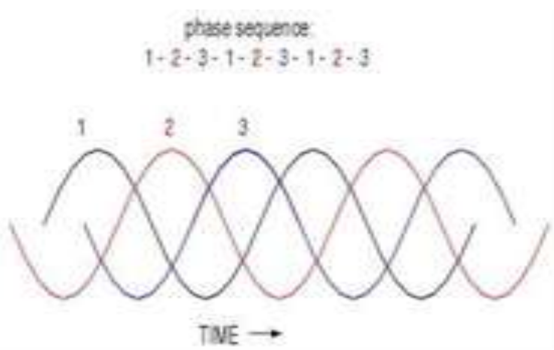

Figure 2: Clockwise Rotation Phase Sequence: 1-2-3

The two-stage array is RYB or ABC and YRB or ACB, respectively. Phase sequence identification is a pure convention. There really is no standard; in this way, the grid rotates (clockwise or clockwise). The wiring rules require only the power grid cycle to maintain the entire installed.

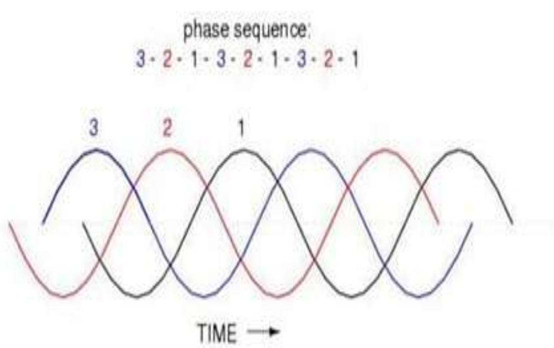

Figure 3: Anti-clock wise ROTATION phase Sequence: 3-2-1

Unbalanced Voltage

The exact sinusoidal amplitude is basically the voltage, and any deviation in the current waveform is called an imbalance or phase shift. At the same time, under the condition of voltage imbalance, the performance of the affected three-phase motor is negative, resulting in an unsteady current. According to the voltage fluctuations, some of the typical results of early motor failure are due to motor performance and the fall of excessive heat. Voltage imbalance is due to next-generation network failures, opposite impedance converter banks, and large single-phase or three-phase load networks. From single-phase loads to re-installed customers, the resulting voltage fluctuations are usually not evenly distributed in the 3-phase system distribution. The steady-state loads are connected in the same way, with the other two-phase conductors and carrying a significantly higher current than the result of line-to-line voltage.

Under Voltage

Low voltage is described by IEEE 1159 because the average voltage drop of a three-minute power system is typically 90% of the power frequency for more than 1 minute. This is defined below the optimal value, function, or rating of the voltage below the system or the plug-in power supply voltage. This is usually caused by under-loaded or overloaded equipment and equipment transformers. Its destructive effects include equipment malfunction, premature failure, excessive heat, and shutdown due to extreme heat flow, especially the motors.

Overvoltage

When the power supply voltage rises, the high energy of connected equipment or loads exceeds the rated voltage. Technically, a voltage level with a nominal voltage lasting more than several minute is when the voltage exceeds. This can cause the current to flow higher and create a higher current voltage. In both cases, the device's electrical insulation system may deteriorate, reducing the life of the invention, or cause damage to the equipment as a result of cost overruns.

Phase Loss (Phase Failure)

Three-Phase Power when a grid is open, a phase failure occurs. It is also referred to as a two-phase single-phase three-phase motor due to the loss of the previous phase voltage. High current flows through the heat generated in the other two wires and stator windings. A phase loss after rapid detection and repair can cause equipment malfunction or motor burnout.

II. Design Characteristics

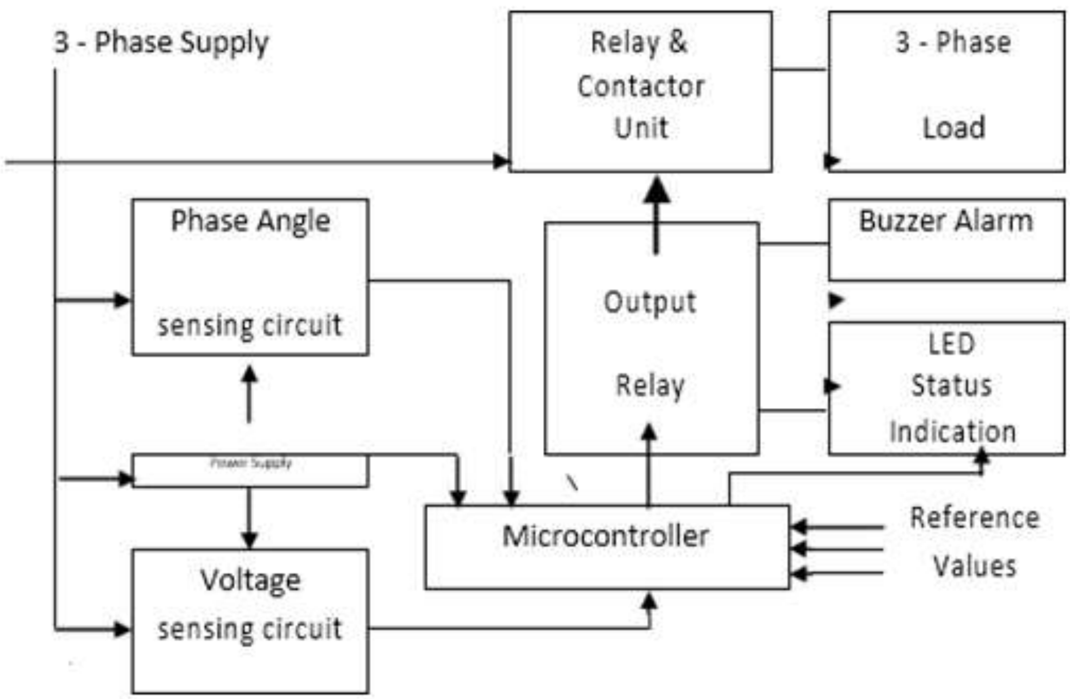

Figure 4: Block Diagram of an Automatic

Phase Reversal Correction System

The design involves monitoring the three-phase power supply network by detecting phase line bumps in the 3-phase power supply network. It uses a switching system to connect the consumer when installed, ensuring that the power supply is suitable for use and that any of these abnormal conditions will be disconnected. A detailed description of the system design module diagram, circuit connections, and operating system of the entire system is made.

III. Design Specifications

It is essential to determine the specification of the components to avoid system failure when needed. It is to obtain appropriate design calculations and analyses to determine the value of parts or equipment. The 5.5 kW three-stage squirrel-cage motor with 400 volts, 50-Hz power with a 0.8 lac power factor. To determine the amount of contact used, the full load current of the engine is obtained as follows: To determine the amount of communication used, the total load current of the engine, **I'm** is obtained thus.

$$\mathbf{P} = \frac{\sqrt{3}\times V\times Im\times\eta\times cos\theta}{1000}$$

Where nominal power (in kW)

V: is the voltage between Phases

I'm: rated current (in Amps)

η: per-unit efficiency

cosϕ: power factor.

From above,

$$I'm = \frac{P\times 1000}{\sqrt{3}\text{x } V\times\eta\times cos\theta}$$

The system is powered by a 5.5 kW three-stage squirrel-cage motor with a 400-volt power factor of 0.8 lag and 50 Hz power.

Assuming that the premium performance class is IE3, the motor performance is delivered at 89.6%. Converts all known parameters

Motor current I’m = 5.5 x 1000

3 x 400 x 0.896 x 0.8

=11.09A

Based on the motor current above, it would be economical to expect that a 12-A (AC-3) contact would be sufficient to select a higher efficiency, and poor engineering practices would not operate on the motor's full rated nominal power. To determine the size of the security device, the estimated current must be calculated, and the value obtained is used for the measurement of the safety device. The power consumption of the individual control components is calculated directly from the respective data sheets and the total load of the entire control circuit at an operating voltage of 220VAC.

For a single-phase circuit:

S = IV.

Where S = Apparent Power

I = Current.

V = Voltage.

IV. System Description And Characteristic

The heart of the system is a three-phase power tracking relay that continuously monitors the input power for phase line, phase loss, high voltage, and low voltage. It combines a voltage and phase-angle sensing circuit based on the microcontroller's multi-function monitoring relay, which operates independently using its power control distribution. The control voltage of the system is derived from one of three stages.

The tracking relay, when detecting phase change, is a reversible communication of the automatic signal to adjust the phase order, thus ensuring continuity of supply. When the fault is corrected, the monitor is automatically reset, and the transmission of the signal must be reset to the original sequence. In addition, in the detected phase angular displacement, the following phases are invalid; this reduces the supply to the contact coil, thereby enabling the combined loads (or multiples) to be de-energized, to avoid single-phase conditions.

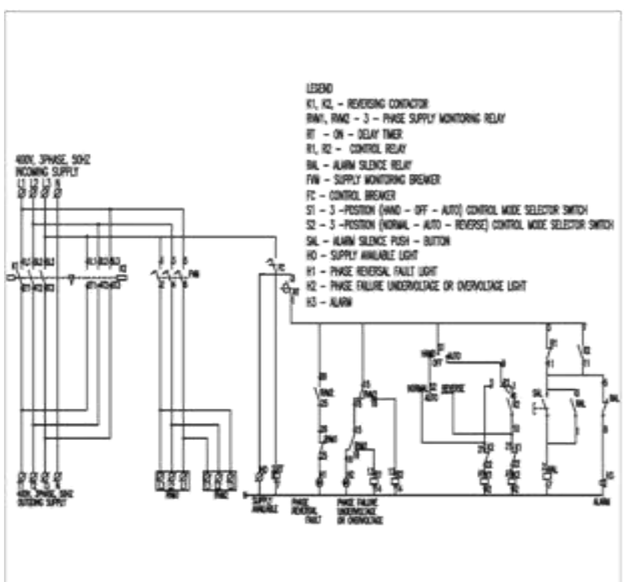

Figure 5: Circuit Diagrams of an Automatic 3-phase Sequence Reversal and Correction

V. PHASE SEQUENCE DETECTOR

There are three voltage or electromagnetic fields that have the same three-phase structure, but an electric angle of 120 degrees displaces the frequency.

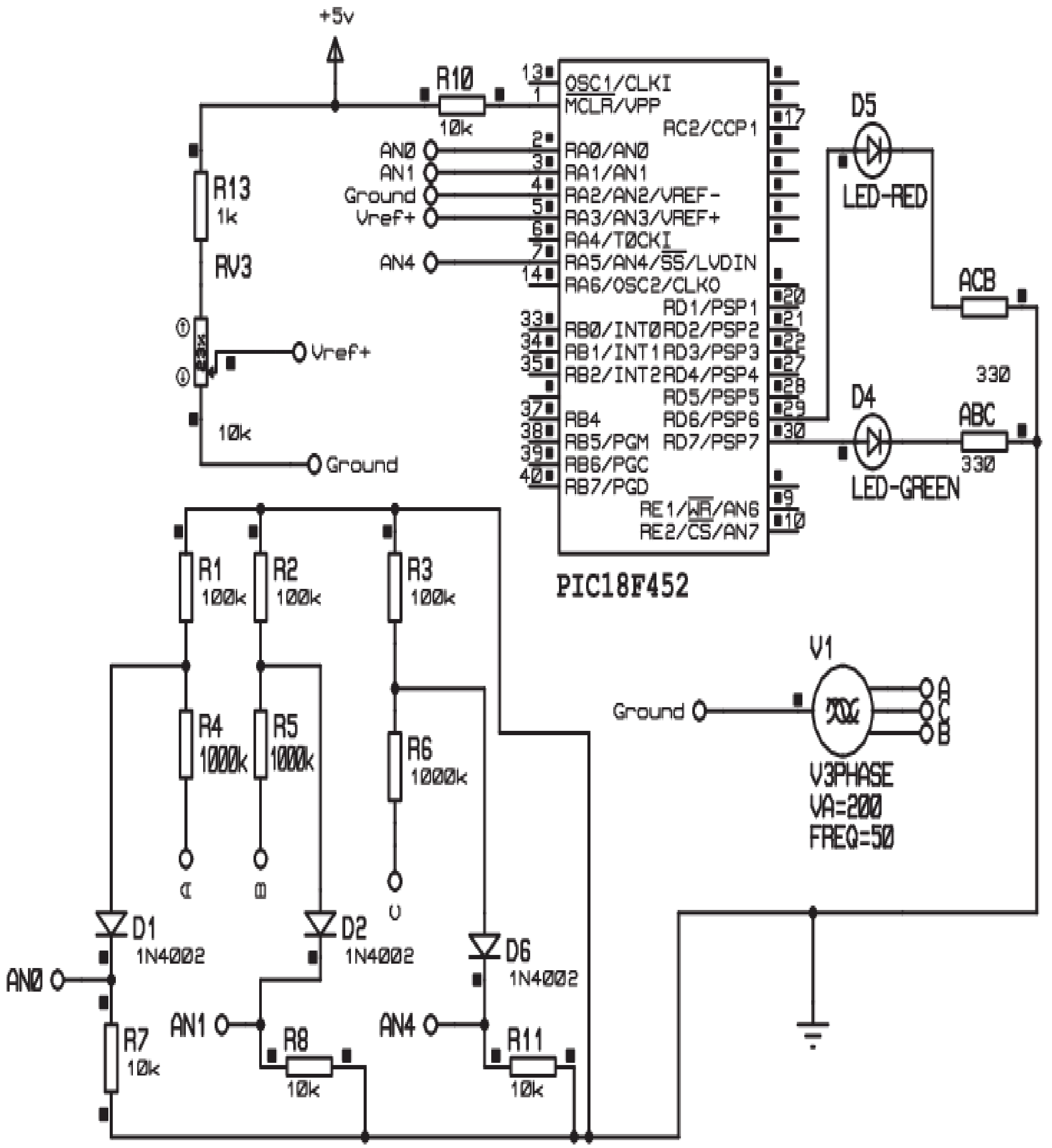

Figure 6: Schematic Diagram of 3-phase Sequence Detector

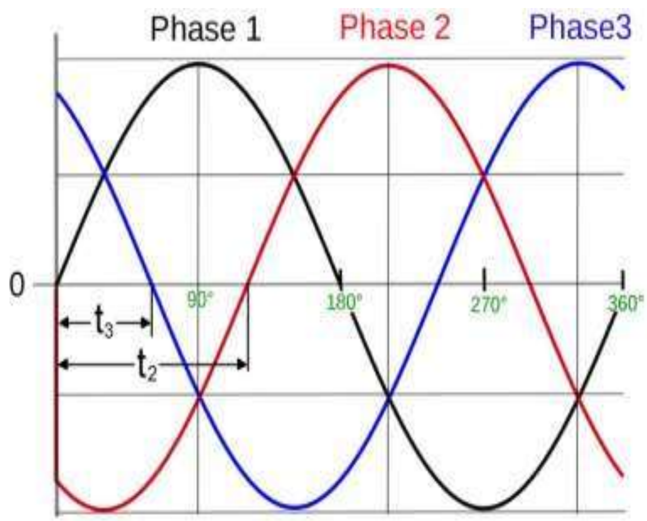

Figure 7: The Waveforms for the 3-phase AC System

From the above observations, the waveform measured from the reference point at p (to be determined) at the point where the crossing is zero, and T is the period of the waveform. One can now identify the phase sequence by quantifying the negative time series of the p-the waveform of the point that crosses the first zero of the TP from the reference point. Consider a uniform in-phase sinusoidal distribution, as proposed by the proposed method. A phase diagram marked 0 in the passage is selected for reference, the other being 1, 2, B, N-1. The angle between any two consecutive phases is 360 / n degrees and the large lag angle of the p-the stage.

Looking closer at taking Phase-1 as the reference phase, it becomes clear that after time intervals t2 and t3, phase 2 and phase 3 have their zero intersections compared to the "0" point, respectively. The reference point is selected so that the reference point waveform is hybridized to zero in the positive direction (i.e., low to high) at that time. The phase 2 waveform is the hybrid time in a positive direction, and the hybridization time of the waveform in phase 3 is zero time t2 is in a negative direction. The time interval of waveform t2 in step 2 is negative (low), and the time interval of a waveform in phase 3 is t3 positive (high). The above method repeats each cycle.

Solid State Relay

The monitoring relay also monitors the power supply to ensure that the voltage range does not exceed or exceed the predetermined threshold value; If it is detected at or above the voltage level, the contact is deactivated, resulting in a three-phase power supply. Reconnection is automatic if the delivery is confirmed to be suitable for use. Adjustable travel delay of the gate between 380 volts and 415 volts on the upper crucible can prevent malfunction.

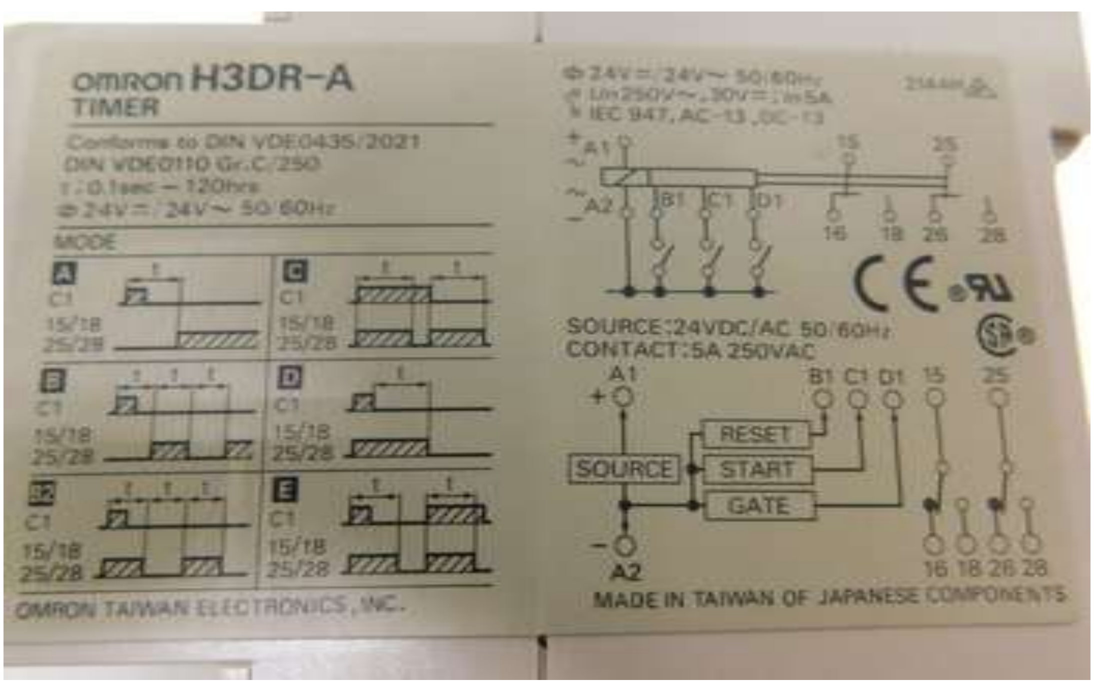

Figure 8: Omron H3DR-A Multifunction Solid State Timers 100-240 VAC 50/60 Hz

If any abnormal condition is detected, it burns until the wrong state is removed. If any of these conditions occur, an audible alarm is activated. If depressed, the Alarm Disable button will disable the alarm. 1.5 square millimeter single core control flexible cable wiring is used. For a load current of 142.32 mA, a 1-A rated safety device with suitable tripping characteristics is sufficient. However, this is not always a regular requirement because it is not still easy to get into the market. Additionally, as mentioned earlier, the control device is used to secure the control wiring, not the control device. Therefore, a single polar 6 amp miniature circuit breaker was chosen the current-carrying capacity of an individual core control flexible cable with 1.5 sq. Millimeter in a rated circuit breaker of 6 amps is more significant than 142.32 milliamps load current but small.

VI. Mode Of Operation

Input power terminals L1, L2, L3, and N; Swap in RVM2). The indicator lamp H0 is radiated in the presence of the supplied signal, and at the same time, the time relay receives the RT energy. When the set delay time is over, the time contact RT / 1-3 operates, which activates the main control circuits. If the rotational direction of each phase is correct, then there will be three phases when it is driven; in an instant, RVM1 receives energy, but RVM2 does not receive energy. Open Contact RVM1 / 25-26 While Open Contact RVM2 / 25-28 Is Open. In this way, the electricity is disconnected from the "reverse cycle fault" lamp H1. At the same time, the conversion contact RVM1 / 15-18 is activated, which allows the coil of the control relay R1 to be energized by the serial-connected shift contact RVM2 / 15-16, in a closed rest state. At the same time, the change contact R1 / 9-5 is closed, and the open contact R1 / 11-3 is opened. Since the RVM2 is not energized, the transforming contact is placed in the RVM2 / 15-18 residue. The control relay R2 does not receive power because the power supply is interrupted via RVM2 / 15-18. Keep the R2 / 10-6, and R2 / 11-7 contacts open separately. When disconnecting contact is opened, R1 / 11-3 and R2 / 11-7 remain in the disconnected position; the lighting buzzer alarm H3 is turned off.

Automatic Operation

The two control mode selector S1 and S2 are switched on to "Auto," and the switching contact R1 / 9-5 operates so that contact K1 gains power through the serially connected sub-span contact K2 / 21-22. The primary contacts of the connections are K1 / 1L1 -2T1, K1 / 3L2-4T2, and K1 / 5L3-6T3, while the three-phase power supply to the outgoing supply terminals T1, T2, and T3. Auxiliary gap contact K1 / 21-22 also opens, cutting to supply contactor K2 to ensure that contactor K1 cannot be inadvertently excited K2 when closed.

In case of invalid phase order, in an instant, RVM2 receives energy, and RVM1 does not. The closed contact operates the RVM2 / 25-28, and the "phase reverse fault" light is switched on via the H1 series-connected open contact RVM1 / 25-26, which is in its closed rest position. Besides, the transforming contact acts as RVM2 / 15-18, stimulates the control relay R2, and breaks the control line to control the relay R1. At the same time, open contacts R2 / 10-6 and R2 / 11-7 operate. Since RVM1 is not energized, the exchange and auxiliary contacts R1 / 9-5 and R1 / 11-3 are in their respective closed and open rest positions.

After closing the final contact R2 / 11-7, the breaking contact R1 / 11-3 is opened; By opening the contact RAL / 8-5, the flashing buzzer alarm H3 is activated, with audible alarm and visible continuity and flashing lights. When the Mute button SAL is pressed, the Alarm Disable relay receives SAL power. The opening contact opens RAL / 8-5, which blocks the power supply to the lighting buzzer H3. When the button is released, the alarm mute relay RAL maintains its position by closing the closed contact RAL / 1-3. If the power is off, the alarm will sound, and if the phase reverse is not corrected, the signal will not look again. When RVM1 is now running, and RVM2 is not running, the above will be repeated. Since the power switch contact for the control relay R1 is disconnected by the RVM2 / 15-16, all communications in the control relay R1 are kept at their respective resting positions; Contact R2 / 10-6 is turned on, RVM2 is energized, it is shut off, and contact K2's coil-series change-over contact R1 / 9-1 and sub-breaker contact K1 / 21-1. And it is powered by 22.

The power supply sequence is incorrect. The sub-breaker communication K2 / 21-22 is opened, which ensures that contact K1 is not energized when the contactor K2 is closed—a security measure to prevent conflicts between two different phases.

If one or more phases fail to connect, neither RVM1 nor RVM2 will run. If one of the errors is enabled during this error, both will be executed immediately. In both cases, the relay's output contacts are at their respective regular resting positions. On the one hand, serial-coupled switching contacts RVM1 / 15-16 and RVM2 / 15-16 allow current to the indicator light H2, indicating a "phase failure" failure, on the other hand, the control relays R1 and R2 prevent power gain. Therefore, the open contact R1 / 11-3, which is kept free, activates the flashing buzzer siren H3 by opening the contact RAL 8-5, which is an audible alarm and visible continuous and flashing light. When the SAL button is pressed, the signal is disabled. The function is similar to the one above. The "phase fault" indicator will continue until the fault is removed. Similarly, when the shift contact R1 / 9-5 is in its original open position, it prevents contact K1 from activating and closing the connection R2 / 10-6 disconnects the power supply to the contact K2 coil. In this way, regardless of the phase cycle of the power supply, when a phase failure is detected, the power output is disabled.

After a period of delay between 0.1 seconds and 10 seconds between low voltage and overvoltage detection (i.e., energy falling above or below a predetermined threshold setting), and RVM1 and RVM2. The fault signal and other functions for phase failure are described.

VII. CONCLUSION

The design and construction of the prototype power system provide tertiary protection, preventing phase reversal, phase loss, low voltage, and high voltage failure-phase power system. It always monitors the installation of the 3-phase power supply. If the phase reversal is detected, it will automatically refer to the reverse mode and connect to the fault line of the effect-adjusted contacts. In the case of low voltage or high voltage conditions, it reduces the set of delay times supplied to the connected load over time. Also, at the detected phase loss, it immediately destroys the capacity (or charges) delivered to the connection. If something goes wrong, an audible alarm is activated. If depressed, the Alarm Disable button will disable the alarm. The false indicator signals for these unhealthy conditions, and the rest will flash until the wrong state is removed.

REFERENCES

[1] B.C. Mecrow, J.W Finch, E.A. EI-Kharashi and A.G. Jack, “Switched reluctance motors with segmental rotors”, IEE Proc. of Electr. Power Appl., Vol. 149, Pp. 245-254, (2002).

[2] B.C. Mecrow, J.W Finch, E.A. EI-Kharashi and A.G. Jack, “The design of switched reluctance motors with segmental rotors”, Conference Record of ICEM, No. 336, 2002.

[3] B.C. Mecrow, E.A. El-Kharashi, J.W. Finch and A.G. Jack, “Preliminary performance evaluation of switched reluctance motors with segmental rotors”, IEEE Transactions on Energy Conversion, Vol. 19, Pp. 679-86, 2004.

[4] J. Oyama, T. Higuchi, T. Abe and K. Tanaka, “The fundamental characteristics of novel switched reluctance motor with segment core embedded in aluminum rotor block”, In International Conference on Electrical Machines and Systems, Vol. 1, Pp. 515-519, 2005.

[5] J. Oyama, T. Higuchi, T. Abe and N. Kifuji, “Novel switched reluctance motor with segment core embedded in aluminum rotor block”, IEEJ Transactions on Industry Applications, Vol. 126, No. 4, Pp. 385-390, 2006.

[6] N. Vattikuti, V. Rallabandi and B.G. Fernandes, “A novel high torque and low weight segmented switched reluctance motor”, IEEE Power Electronics Specialists Conference, Pp.1223-1228, 2008.

[7] H. Chen, Z. Shao and Y. Zhu, “Rotor Speed Testing and Closed-loop Control for Switched Reluctance Motor Drive Based on Fuzzy Logic”, Proceedings of the 5th Word Congress on Intelligent Control and Automation, Pp. 4458-4462, 2004.

[8] Z. Xuezhong, L. Chuang and L. Diji, “Angle Position Control of Switched Reluctance Generator”, Journal of Nanjing University of Aeronautics & Astronautics, Vol. 33, Pp.64-67, 2001.

[9] J. Kim and R. Krishnan, “High Efficiency Single-Pulse Controlled Switched Reluctance motor drive for high speed application analysis design and experimental verification", Industry Applications Society Annual Meeting, Pp.1-8, 2008.