Volume 6, Issue 2, April 2019 ISSN: 2348-8565 (Online)

International Journal of Modern Engineering and Research Technology

Website: http://www.ijmert.org Email: editor.ijmert@gmail.com

3-Ø Induction Motor Protection Test Setup Using REM615 Relay

Virendra Pandya
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:virendra.pandya@gmail.com

Mohammed Abbas Saiyed
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:abbassaiyed1997@gmail.com

Maulik Savaliya
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:savaliamaulik@gmail.com

Faizan Chopda
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:faizan.chopda@gmail.com

Brijesh Shah
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:brijeshshah01234@gmail.com

Sayonee Parikh
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:sayoni.parikh@yahoo.in

Farhan Khan
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:farhan401097@gmail.com

Sanjay Patel
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:dunkersanjay7@gmail.com

Jaimin Rathod
Department of Electrical Engineering,
Indus University
Ahmedabad, (Gujarat), [INDIA]
Email:jaiminrathod50@gmail.com

ABSTRACT

This paper aims at the protection of 3-Ø Induction motor using REM615 relay of ABB Group. This relay is dedicated for supervision, control and protection of asynchronous motors i.e induction motors. These motorsare widely used in industries because of its robustness, resistance to dust, dirt and corrosive atmosphere of the industries. Hence, it becomes important for us to protect this motor from all kinds of possible faults. This paper focuses on the protection of the induction motor from faults like Thermal overload and Motor Start-up Supervision. By setting the appropriate threshold values, the fault conditions are simulated. The programing in relay is done using PCM600 software. For the simulation of faults, the power circuit and the control circuit has also been designed and explained.

Keywords:—*Faults, Induction motor, Protection, Relay*

I. INTRODUCTION

Protection of motors has now became a salient part in industries. With advancement in motors, it becomes crucial to make sure that the protection techniques do not fall behind. The induction motors are the chiefly used motors in industries because of their durability, self-starting ability unlike many other motors. They also have good speed regulation, good starting torque and feasible overload capacity. They also have great full load efficiency varying from 85% to 97%. They require less maintenance, are economical and reliable. Hence, it becomes inevitable to protect such almost ideal motors. Aside from these great pros these motors have, they do possess some cons like high starting current-which is around 7-8 times of full load current. Below full load the power factor is poor.

REM615 relay used for the protection is an IED (Intelligent Electronic Device) (Numerical Relay) that provides trip commands whenever the electrical values like current, voltage etc. crosses the threshold values set in the relay. It is a relay of Relion series dedicated for motor protection of 615 series of ABB Group. Numerical relays have many advantages like Self-checking facility, reliability and dependability, very low burden, fiber optical communication and many like such.

II. Faults in Induction Motor

Thermal overload:

The load on an induction motor is mechanical. Hence, when the load increases beyond the loading capacity of the motor the rotor speed decreases and hence slip increases, as shown by the equation below:

$$\frac{Ns - Nr}{Ns} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where
s=fractional slip

Ns= Synchronous speed = $\frac{120 * f}{p}$ (rpm)
f=frequency (Hz)
p=number of poles
Nr=Rotor Speed (rpm)

Now as the rotor speed decreases, the slip increases as per equation (i). Hence, the rotor current increases as per the equation, I_2

$$\frac{s * E_2}{\sqrt{R_2^2 + (s * X_2)^2}} \quad \text{(Rotor Current)}$$

With the increase in the rotor current the stator current (I_1) also increases. Now the heat produced is given by $I_1^2 * R_1 * t$, where t is time and R_1 is stator resistance. This heat produced when increases much so as to cause motor heat-up causes motor overload.

Overloading does not cause any damage to the rotor or stator but damages the insulation. When overload occurs the insulation temperature will not instantly reach the dangerous limit, however the temperature will gradually increase. The motor therefore, should be immediately disconnected or proper protection scheme must be employed for protection.

The thermal withstand characteristics curve of the Induction motor is shown below:

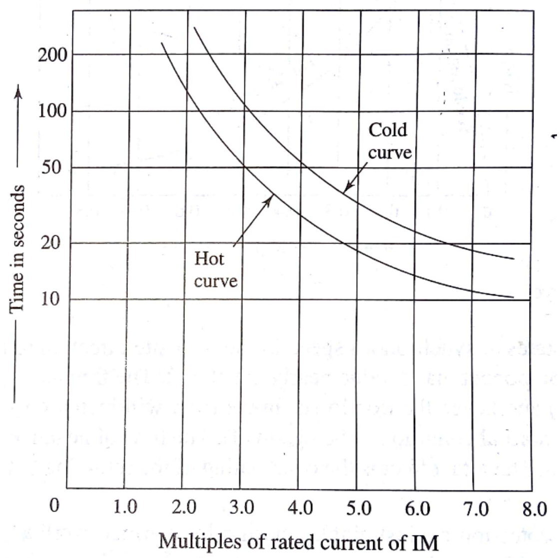

Figure. 1 Thermal Withstand Capacity of Induction motor

As seen from the graph the motor must be disconnected before the given time for respective multiple of current during overload.

Certain points must also be considered during disconnection of motor. The motor should be disconnected at the optimum time. The overload capacity of the motor will not be fully used if the motor is disconnected too early. Also care should be taken that it is not disconnected after the time limit, otherwise this will damage the motor.

Motor Start-up Supervision:

At start, the flux starting current in an induction motor is very high. This may damage the insulation of the motor windings.

To prevent the excessive starting current or rotor jam condition the motor start-up supervision is used. It ensures that the heat produced at start is within the tolerable limits. If it violates the limits then the motor is disconnected to prevent any damage. The number of start-ups in the motor are limited and is given.

For instance, consider the figure below. The X-axis denotes running time in seconds and the Y-axis denotes thermal withstand time in seconds. Suppose total thermal limit time is 30 sec that is beyond this limit the motor will be damaged because of the heat produced. Suppose each start-up requires 10sec, so total three cold start Start-up time is permissible. After two starts the motor enters into the restart inhibit zone, in which if the motor shuts down the motor cannot be restarted immediately, but some amount of time must be allotted to the motor for the heat to be dissipated. As shown below the restart function gets enabled below 19sec. So the motor can be restarted as shown.

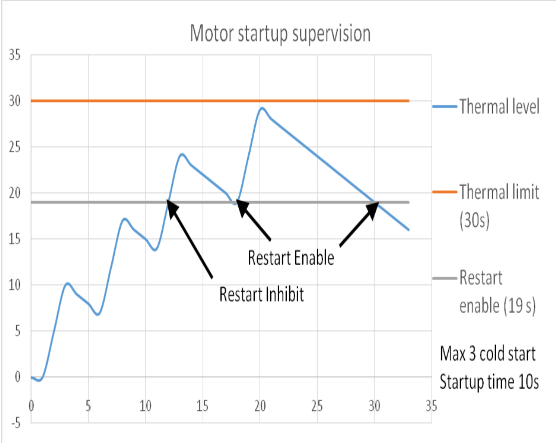

Figure 2: Motor Start-up Supervision

Relay Functionality:

Now after studying about the common faults occurring in the motor, we will now be discussing about the working of relay to protect against such faults.

Thermal Overload:

Thermal overload protection is represented by MPTTR as per IEC 61850. To understand the working consider the block diagram shown :

Function of blocks:

- Maximum current selector:

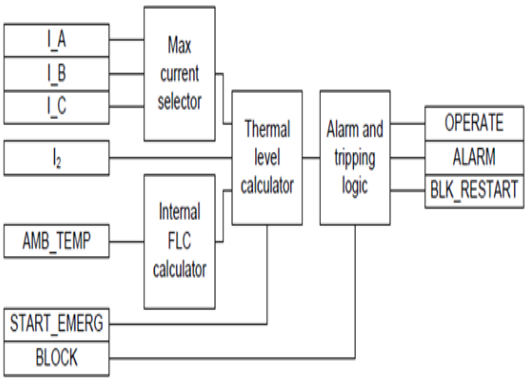

Figure 3: Function Module Diagram

As the name suggests this block selects the maximum current flowing from anyone of the three phases. It then gives the signal to the thermal level calculator.

Full load current:

The manufacturer based on the ambient temperature of 40°C defines FLC. However when the motor is operating in an ambient lesser or more than that considered by the manufacturer (here 40°C), then necessary changes has to be made in the FLC. Suppose if the motor is working in an ambient of 30°C then the motor can be allowed to be overloaded more than suggested by the manufacturer, similarly when the motor is operating at an ambient of say 50°C, then the motor will get overloaded before the time given by the manufacturer. Hence, the ambient temperature plays a crucial role in deciding the FLC.

Table 1: FLC values

Ambient Tempera-ture, $\Theta_{amb\backslash}$	**FLC Modification**
Less than 20°C	FLC*1.09
20°C to 40°C	FLC*(1.18 -Θ_{amb} x 0.09/20)
40°C	FLC
40°C to 65°C	FLC* (1 –[(Θ_{amb} -40)/100])
More than 65°C	FLC*0.75

Thermal Level calculator:

The inputs from the maximum current selector, negative phase sequence current and the FLC calculator the thermal level of the motor is calculated. This calculated value is then sent to the alarm and tripping logic where it is compared to the predefined values.

Alarm and Tripping Logic:

After processing the input from the thermal level calculator, it checks if any limit is violated and then gives the appropriate command. When the current level is at 100%, the OPERATE command is generated. When the thermal level becomes more than the thermal-alarm threshold the ALARM signal becomes active. When the restart of motor after shutting down is to be prohibited, then the BLK_RESTART signal is made high.

Sometimes there may be needs where we need to start the motor even when the fault exists. For this the START_EMERG command is given, which means emergency start of the motor. To block the tripping and alarm logic the BLOCK command is made high.

Motor start-up supervision:

Motor start-up supervision is represented by STTPMSU as per IEC61850. During operation, the relay calculates the value. $\int I^2 t$ If this calculated value increases, more than the threshold then the relay gives the trip command.

The protection is provided either by observing the RMS current of each phase or observing the condition of circuit breakers connected to the motor.

It also makes sure that the motor is not restarted multiple times within giver time period. If it's allowed then the motor will get heated up and the windings may get damaged. Once a motor shuts down from working condition there is some time allotted before the machine can be restarted. The graph is as discussed above in fig. 2.

STTPMSU also has a function of checking the rotor jam condition. Thus is done by observing the speed of rotation of the rotor. Hence, if the speed is below a certain limit, then the trip command is generated. This aspect operates after certain amount of time.

To understand the working, consider the block diagram shown below.

Function of Blocks:

Start-up Supervisor:

This block categorizes the condition of motor starting in four different cases.

- IIT- In this the block calculates only the thermal level of the motor during start.
- IIT CB- In this it calculates the thermal stress level in supplement with the CB_CLOSED input, that is CB status.
- IIT & Stall- In this it calculates the thermal level of the motor during start. It also observes for the stalling condition.
- IIT & Stall CB- In this it calculates the thermal stress along with the CB status. In this, also the motor stalling condition is checked.

Thermal Stress Calculator:

This block as in Thermal overload protection calculates the thermal level of the motor by monitoring the RMS value of currents. If the thermal level is more than the limit the OPR_IIT command is generated. The heat produced is calculated as. $\int I^2 t$

Stall Protection:

This protection is available only when IIT & Stall or IIT & Stall CB cases are selected. When at start, the rotor is not rotating and hence, the STALL_IND command is high. This signal indicates that the motor is not rotating. Now when the motor is made to rotate within the Lock rotor time and is made to reach a speed greater than the threshold speed, this signal disappears, indicating that the motor has started to rotate.

Now if a condition arises such as the rotor does not attain the predefined speed within the lock rotor time then the OPR_STALL output is made high.

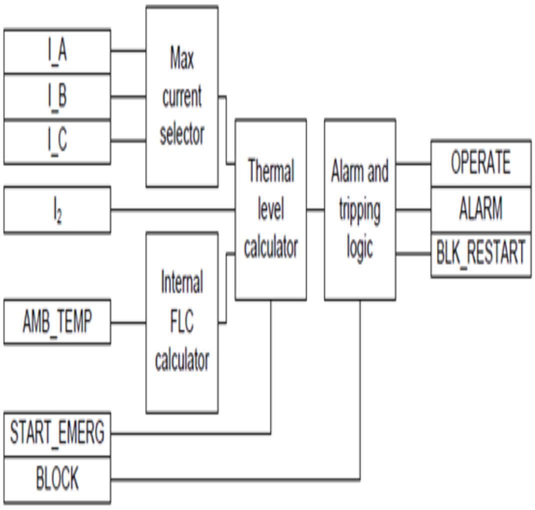

Figure 4: Function Module Diagram

Cumulative start-up protection:

Each time the motor is stated the running time is added to the memory T_ST_CNT. When the value in this memory grows beyond the cumulative time limit, the LOCK_START signal is generated. Hence, this prevents restarting of motor. Once enough time is provided so that the count T_ST_CNT reduces below the cumulative limit, the LOCK_START signal goes low and the motor now can be restarted.

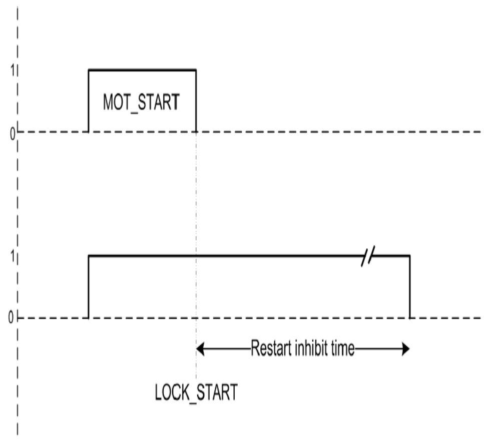

Figure 5: Lock_Start and Inhibit Time

Protection Circuits:

Power Circuit:

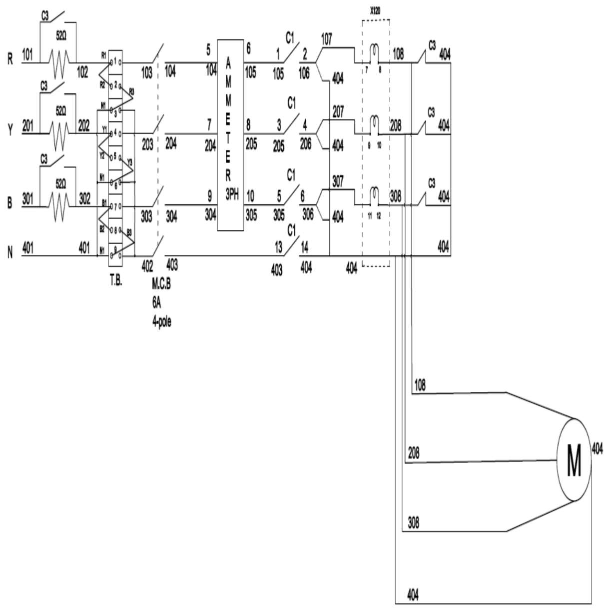

Figure 6: Power Circuit

Control circuit:

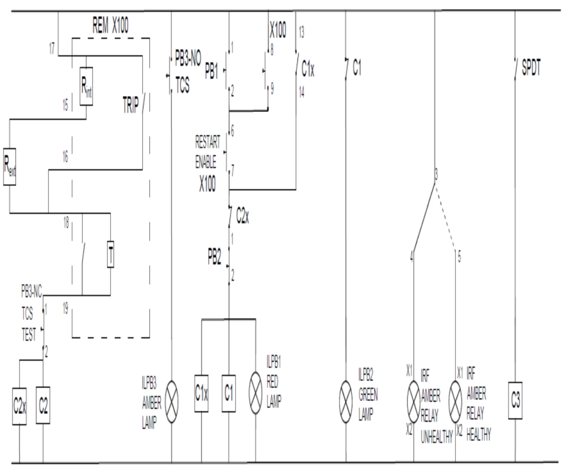

Figure 7: Control Circuit

III. IMPLEMENTATION:

For implementing the protection scheme using REM615, the following power circuit and control circuit has been designed.

A power circuit is a circuit, which is used to supply power to all the connected devices in the system. The load (Motor in this case) is connected in the circuit. The control circuit controls the control of power flow in the power circuit as the name suggest.

Construction: and Working

Power Ciruit:

The power circuit on the other hand is supplied power from a 3-phase Variac, The connections in both the circuit is simple and is similar to as shown in the circuit diagrams. The key thing to be noted in the power circuit is that instead of motors the coils of 1.1kW 50ohms is used that represent the windings of the induction motor. The coils are connected just after the supply to prevent any large short circuit conditions during single phasing operation or while placing the line on maintenance using the terminal blocks. Provision is provided in the panel for the connection and testing of actual motors. A SPDT (Singe Pole Double Throw)(near to the motor) switch is provided for this particular purpose. When SPDT is in OFF condition, coils are in the circuit whereas the motor terminals are disconnected from the circuit. When the SPDT is turned ON the contactor is energised as per the control circuit(last line) and the coils are bypassed by the contactors NO contacts. And the NC become open and hence the supply passes to the terminals of the motor. This setup thus not only is useful for laboratory experiments but also useful for testing and protection of motors in industries. It also ensures the protection of equipment and personnel for experimenting at laboratory level. It should also be noted that the contactors used in the circuit represent the operation of a circuit breaker.

The SPDT away from the motor is used to bypass a phase after relay and connect it to the neutral. Switching on the supply the Green lamp in the control circuit turns ON, indicating that the power is not flowing to the motor. Now when ILPB-1 is pushed the contactor C1 coil is energised and so it picks up and hence contacts C1 operates closing the Power circuit. As seen, the C1 also provides latching operation in the control circuit, so that when the pressure on ILPB-1 is withdrawn the circuit does not break but remains connected. Hence, the Red lamp turns ON, indicating that the power flow is available to the motor. As the Red lamp lights up the Green lamp turns off, this is done by means of interlocking provided by the contactor C1.

Control Circuit:

The control circuit is supplied AC power directly from the socket. The first section in the circuit is used for trip coil supervision (TCS). If any of the circuit breakers or in our case contactors are not getting the auxiliary supply then the relay will signal a fault of TCS. This indicates that circuit breaker will not operate if any fault occurs. It becomes crucial when there is only one trip circuit. Its work is to generate alarm signal in case there is any interruption in the tripping circuit or failure of the trip circuit because of any reasons. It hence alerts the operator that the operation of the trip circuit is compromised and that it might not operate. The programming for the trip coil supervision is done using PCM600 software. TCS function is used to monitor the trip circuit.

The second and third sections are used for switching the power circuit ON or OFF. As seen in the second section there is restart enable contact of the relay in series. This is used to implement the permissive action if any. That is this contact will close only when all the conditions to start the motor are satisfied. The relay starting contact in the ILPB11 section enables user to perform switching of the contactors through relay directly.

The 1st section is used for TRIP COIL SUPERVISION. When the PB TCS Test is held pressed for certain amount of time, it disconnects the auxiliary supply to the contactor C2. When the time for which the auxiliary supply is interrupted becomes more than that set in relay the alarm signal is generated. The alarm signal generated can be LatchedAck F-S, Follow-S, Latched-Sor Follow-F. The time duration for pressing the PB TCS Test and the signal type all can be done using PCM600 software.

A special provision is made using RTD's which will sense the temperature of the motor windings. These temperatures are then displayed on the relay. The RTD's are connected to X130 terminals, as per the pin diagram of relay.

Details of components used in the circuit:

Coil – 1.1kW 50Ohms

MCB – 6Amps, 4pole

Ammeter - 3Phase Ammeter

Contactors – 6Amps, 230V and AC operated

Terminal Box – 40 quantity

ILPB (Illuminated Light Push Button) – 230V Green, Red and Amber with NO and NC blocks.

RTD's – PT100 where PT is platinum and shows 100ohms at 0^{o}C.

IV. RESULT

The practical implementation of the power and control circuit is shown below. The supply is turned ON and the fault conditions simulated. This is done by starting the power circuit with variac set at full rated voltage. Hence, like practical condition high starting current flows. The variac is then slowly reduced which is same as the practical condition wherein the high starting current then gradually decreases. This way simulating the high starting current the Relay operates and disconnects the motor from supply by opening the contactors C1.Thus, the operation, simulation of fault and operation of protection scheme all is found to work as designed. Thus, the protection of motor from these faults is ensured.

V. CONCLUSION

Thus, the protection scheme of 3-Ø Induction motor using REM615 relay is designed. This is found to be reliable, efficient and economical design. The method discussed above of simulating high starting current can be used in laboratory rather than actually creating short-circuit condition. The latter being dangerous the former method may be used. Satisfactory operation, monitoring and protection is observed in laboratory using the setup. Thus, the purpose of motor protection is achieved.

REFERENCES:

[1] Application Manual of REM615 relay version 5 of ABB motors.

[2] Technical Manual of REM615 relay version 5 of ABB motors.

[3] Trip Circuit Supervision relay manual ABB motors.

[4] Electrical Machines – 2nd Edition by Ashfaq Husain – Dhanpat Rai and Co. Publication.

[5] Power System Protection and Switchgear by Bhuvanesh A Oza | Nirmal Kumar C Nair | Rashesh P Mehta | Vijay H Makwana – Mc Graw Hill Publication.

[6] Analysis of 3 phase Induction Motor Protection Using Numerical Relay – Journal by Dr. S Prabakaran and S M. Venkatesan. International Journal of Engineering and Techniques - Volume 4 Issue 2, Mar-Apr 2018, ISSN: 2395-1303

[7] Microcontroller based Numerical Relay for Induction Motor Protection –Research Paper

[8] By Vikramsinh N. Kathad Rashesh P. Mehta and Ankit Shah.

[9] Proc. of Int. Conf. on Control, Communication and Power Engineering 2010, ACEEE

* * * * *