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A Non-Invasive Tunable Current Circuit Breaker (TCCB) For Motor Protection in Industries

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Abstract--In the case of industries, once a power system is established, it is essential to protect the equipment from faults. The major portion in total load is occupied by motor load and protection of motor by Motor Protection breakers from faults is mandatory. Generally, Motor Protection breakers cannot be adjusted to match the rated current of the motor being protected. They usually made with fixed ratings which can be chosen according to the requirement. The proposed Tunable Current Circuit breaker (TCCB) can be adjusted for the different value of rated current. High tension (HT) transformers are critical and expensive equipment in the power system. Due to the long lead time for repair and replacement of the motor and HT transformers, there is a need of protection to avoid damage. Any extended operation of the motor under abnormal condition like faults or overloads reduces the life of the motor. Adequate protection should be provided for earlier isolation of the motor under such conditions. The TCCB can be used for single phase and star or delta connection of three phase motors. When the motor consumes more than the fixed value, immediately TCCB will be tripped. Since it measures current Non-invasively, the power consumption is low and easy to connect. Because of usage of Analog method, the cost becomes low. It provides safe disconnection in the event of a short circuit and protect load from overloading without usage of any electromagnetic component.

Keywords--Tunable protection, Circuit breaker, MPCB, Overload relay

I. INTRODUCTION

The functional safety and the service life of a motor depend mainly on protection. Motor-protective electronic circuit-breakers with wide-range overload protection offer an interesting alternative to the bimetal solutions. They provide the highest level of flexibility featuring a compact and modular design with its plug-in control unit. Control units are also available for system protection applications. Power system automation has many benefits such as saves labor wages, energy, improves quality, accuracy and precision. Circuit breaker is one of the important protecting devices which protect the circuit from abnormal conditions by opening the contacts and takes very minimum time for fault clearing. The function of a circuit breaker is to isolate the faulty part of the power system in case of abnormal conditions. The main idea behind the project is to provide protection to the motor using Relays with tunable control. TCCB assures complete protection for electric circuits and motors with high breaking capacity through thermal and magnetic releases, where the thermal release may be set to protect against overloads and is equipped with a differential mechanism with phase-loss sensitivity. Potentiometer transistor combination is used for short-circuit and overload protection. It has trip indication, which allows the operator to visualize the status of the breaker. The main features are wide adjustment ranges, low heat losses, precise and extremely long-time stable tripping characteristic curves.

II. LITERATURE SURVEY

For achieving excellent protection, switches like pressure switch and flow switch, circuit breakers like Motor Protection Circuit Breaker[2] and Molded Case Circuit Breaker are used for protect the equipment from faults. For monitoring the temperature PT 100 is used [5, 6]. When any fault occurs there is a provision made for audio-visual indication. Motor Protection Circuit Breakers (MPCB) is used in multi motor applications with Variable Frequency Drives (VFD). Devices positioned load side of a drive may fail after only several months through thermal degradation. Investigations showed that MPCBs rated lower than 10 A suffer most. Similar designs of different brands were compared and showed with respect to same parameter. Steep slopes of the DC voltage pulses in combination with the surge impedance of the motor and MPCB are responsible for excessive heat generation in the switchgear destroying the short circuit protection function [4]. A paper reviews the application of multi-function motor protection relays to motors that are connected by Variable Frequency Drives (VFD). Typical VFD internal motor protection functions are reviewed to understand the required roles of external motor protection relays [6].

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III. PROPOSED TUNABLE CURRENT CIRCUIT BREAKER

Motors play a significant role in industries. The main concern with Motor protection is protecting the winding against internal faults and ensuring safety scheme for external faults. Overloading of transformers and motors beyond the nameplate rating can cause a rise in temperature of both transformer oil and windings. A Motor consists of a set of windings around a core. The windings are insulated from each other and the core. If temperature rise of the winding exceeds the limits, the insulation may deteriorate and fail prematurely. Prolonged thermal heating weakens the insulation over time, resulting in accelerated loss of life. Hence protection of the motor is essential as it may hamper the production. The circuit-breakers for motor protection are furthermore, preset for using the wide range of accessories, terminals available for motors and transformers. A fundamental choice exists when selecting overcurrent protection in a power system fuses or circuit breakers. Recent claims by fuse manufacturers about the simplicity of design and benefits of high interruption and coordination have reignited the debate of using breakers over fuses. Recent changes to the National Electric Code (NEC) have made the review of circuit breaker advantages. It is important to evaluate factors such as protection, reliability, and use of capital when making a choice between breakers and fuses. This proposal highlights some of the advantages of using circuit breakers over fuses. The Circuit breaker consist of a Non-Invasive Current Transformer (CT) which measures current continuously. The output reference signal is fed into potentiometer that can be tunable. According to the value of resistance which is fixed by user, the reference output getting varies. When the resistance drop is made equal to the reference signal from the current transformer, the output will be zero volts. Because of more current consumption the current transformer output will be somewhat more than that of the usual voltage. The excess voltage bias the transistor circuit which is connected to the potentiometer. Since biasing of NPN transistor, the relay will be tripped. The relay consists of two NC and NO terminals. All the input pins are connected to the NC pins that mean circuit breaker is normally closed. When the motor consumes more current than the fixed current, immediately NC becomes NO. Simultaneously the potentiometer also bias the another transistor circuit which is connected to the indicator. Whenever the relay tripped, immediately the indicator starts to glow. The relay and indicator takes power from transformer which can be either 220/12V or 440/12V depends on single phase or three phase respectively. A change over switch can be connected to both transformers for choosing single phase or three phase according to the requirement. It can be used for both star connections and delta connections of the motor. It is more suitable to cooperate with all type of starters which are used for 3 phase motors. Thermal relay also can be attached within this circuit breaker. The current sensor continuously monitors the current consumption of motor. When phase failure taking place at the 3phase wires, immediately the potentiometer sends signal to the relay that trips the connections. The phase failure causes consumption of more current than usual in 3phase. The block diagram Shows that the overall components of this Fixable current circuit breaker. The current sensor is normally connected with neutral or any one of the phase non-invasively. The remaining pins are connected to the relay directly. On the input side of power supply a transformer is connected to power relay and indicator. The potentiometer is powered by current sensor which generally produces about 12 V. The transistors biased by voltage and the relay by transformer voltage. When fault occurs in the protected circuit, the relay connected to the CT detects the fault current and sends the tripping signal to the circuit breaker. After receiving the trip command from the relay, the circuit breaker isolates the faulty part of the power system.

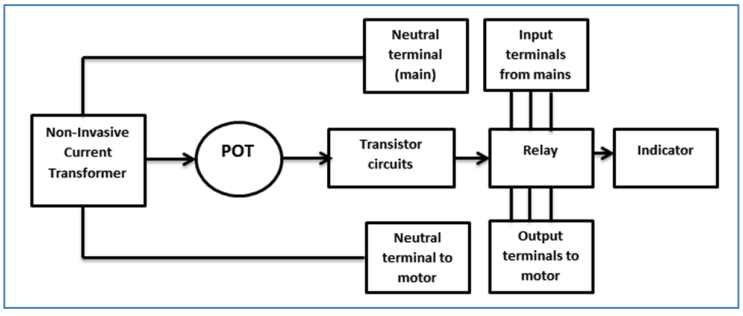
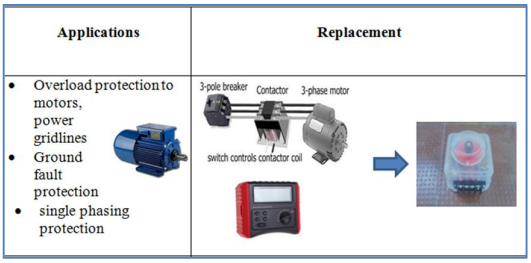


Fig.1. Block Diagram of TCCB

The TCCB can be used for DC motors. So far Motor protecting circuit breakers are not available for DC motors. DC motors also one of the salient components in Industries. By replacing AC current transformer by DC sensor, the same TCCB can be used. It can also be used for power cables. When the power cable carries more than that of the rated value, we can make TCCB to either indicate or trip the power supply. By using a change over switch, it can be used for both AC and DC machines. The motor circuit protector is designed with adjustable setting to allow the operator to set the breaker's protection level just above

the inrush level of the motor. Overload protection for the motor is supplied in the starter's overload relay similarly by TCCB with tunable option. This combination offers the ultimate in protection for the motor without causing nuisance trips. This Motor Protector breaker can be used with a contactor for a complete motor starting and protection package.



A. System Unbalance And Single Phase Prevention

The majority of faults in an electrical system are phase to ground. Single phasing is caused when only one phase to ground fault. The fuse interrupts in a circuit during a phase to ground fault. The amperage in the other two phases will typically increase by 173 percent. This is a problem when using fuses. Motors are often oversized and in these cases, the load is not large enough to blow the other two fuses. Conductors and motor winding can eventually burn up due to the heating caused by only two phases turning the motor.

This also creates a dangerous situation since the motor acts like a generator, back feeding the fault to approximately four times the full load current of the motor on the phase which the fuse has blown. Circuit breakers and motor circuit protectors are designed to open all three phases at once, thus preventing the damaging effects of single phasing.

B. Enhanced Safety

As greater demands are placed on electrical systems, more power is required to ensure reliable operation. Along with greater power comes an increase in the amount of electrical energy available at various points in the electrical system. To ensure the safety of people working around high current systems, circuit protection devices need to not only act rapidly to clear faults, but also to reduce the amount of energy available to a safe level. The current limiting arc design of circuit breakers reduces arc flash energy, requiring only Category 1 Personal Protective Equipment for maintenance personnel. Although personnel should never work on live equipment, faults are often caused by someone contacting a tool with a live uncovered part, such as a fusible switch, older design starter or bus bar. Circuit breakers are self-contained, dead front units that increase personnel safety by protecting from exposure to these live parts.

C. Effects Of Ground Faults In Motor

Another safety concern is motor ground faults. These faults are below the melting point of fuses, yet severe electrical damage can result. TCCB can be used for internal ground fault and earth leakage protection. With these protective features, the circuit breaker will trip on a ground fault according to user-selectable settings, isolating the fault before it propagates throughout the system. This safety feature protects personnel and equipment from low level arcing currents. Normally fused devices will only interrupt a high level ground fault that exceeds the fuse overload "blow" point and require external sensors, relays and remote switching devices to detect and clear ground faults.

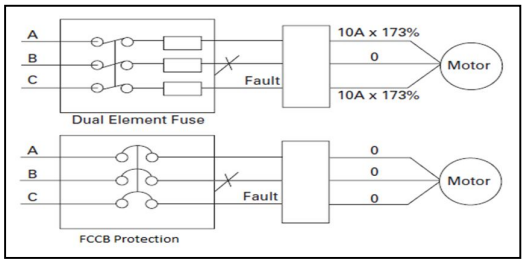


Fig.2. Phase failure



Fig.3.Motor winding damage due to ground fault

Circuit breakers are resettable, guaranteeing system coordination based on the original system design. Replacement of fuses of different types or from different manufacturers voids coordination and system protection. In addition, fuses of different ratings can look similar and be erroneously placed into the same fuse holder. The resettable nature of breakers removes the need to search for replacement fuses during a downtime situation. Circuit breakers offer the widest range of internal and external accessories. The safety benefits of externally mounted handle mechanisms and motor operators have already been mentioned. Others include shunt trips, under voltage releases, auxiliary switches, alarm switches, terminal shields, and lock offs, interlocking devices, etc. These accessories provide diagnostic information to the user and consume no additional panel space and are not available in fuses. The installed cost of the circuit breaker distribution equipment is generally less than equivalent

fused equipment plus fuses. An added cost advantage results from the reset ability of circuit breakers reducing downtime in all installations, and eliminating the need for maintenance fuse inventories in industrial settings.

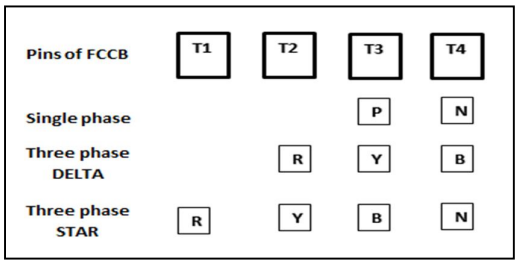


Fig.4. TCCB circuit configuration

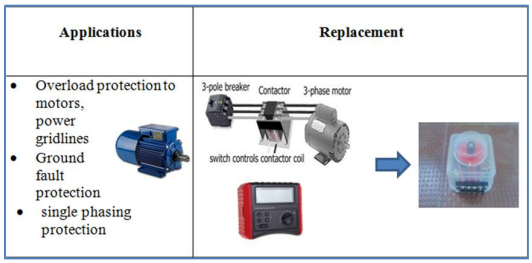


Fig.5. Applications of TCCB

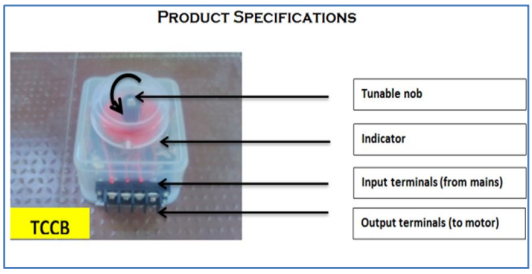


Fig.7 Circuit Diagram of TCCB

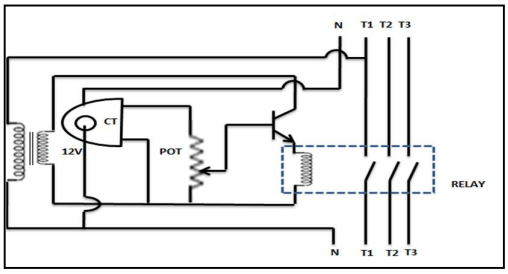


Fig.7 Circuit Diagram of TCCB

The ultimate aim is to make circuit breaker tunable, multipurpose, low cost, safe and accurate. The considerable advantages are resettable, dead front, no exposed live parts, prevents single phasing, adjustable motor protection, ability to protect from ground faults, testable, Space saving, Prevents downtime and cost-effective over the life of equipment.



Fig.8 .Prototype model of TCCB

As in growth of electrical engineering the power generation is important, also power transmission, distribution and utilization makes the power system complete. If power system is not secure and stable, then economic cost for power delivery also increases. So use of some protecting and sensing devices can protect the circuit under abnormal conditions Therefore, circuit breakers is considered as, the major component of the power system. Using of modern circuit breakers for motor protection, electrical power distribution and control panels makes sense.

IV. CONCLUSION

Generally whenever a power system is established in industries, it is always necessary to protect it from faults with the help of circuit breakers. Especially in industries, protection of motors and HT transformers is important from faults. Proper chosen of relay elements is important to care the transformer and motors thermal state to provide both short and long term benefits. Commonly, Protection breakers cannot be adjusted to match the rated current or voltage of the device being protected. They usually made with fixed ratings which can be chosen according to the need. The proposed Tunable Current Circuit breakers (TCCB) can be adjusted for the different value of rated current and voltage. TCCB can protect motors from overload and short circuit issues by automatic system without any human intervention. The ultimate aim is to make circuit breaker tunable, multipurpose, low cost, safe and accurate. The proposed circuit breakers have remarkable advantages are resettable, dead front, no exposed live parts, prevents single phasing, adjustable motor protection, ability to protect during ground faults, testable, compact, prevents downtime and cost-effective over the life of the equipment. A potentiometer and transistors are the basis of a new generation apparatus which can be perfectly integrated with the best solutions in terms of performances and reliability, as

well as of the maximum simplicity system.

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BIOGRAPHY



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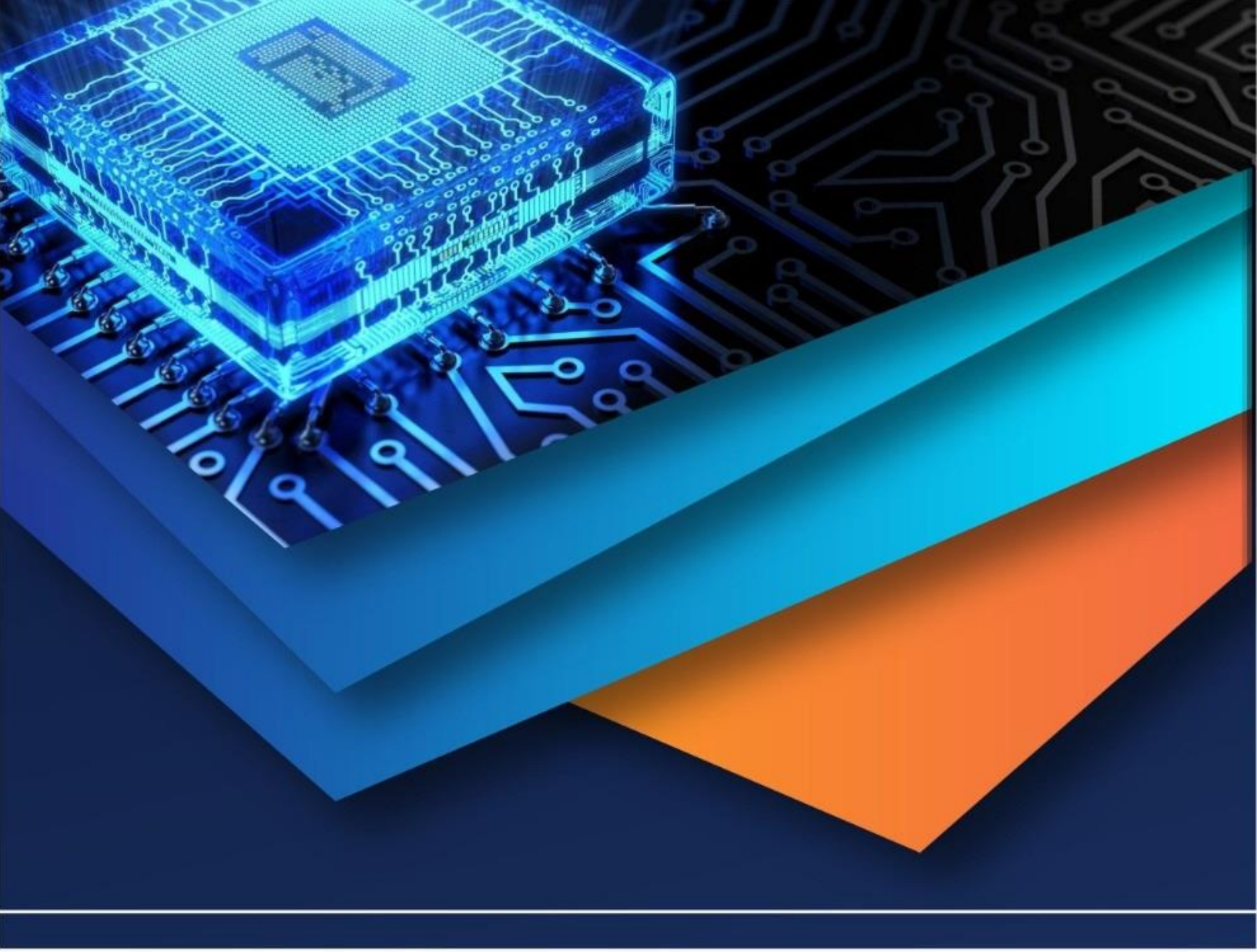
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