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COMPARATIVE ANALYSIS OF DIFFERENT TYPES OF RELAYS

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Abstract --- Protective relays works as sensing and control devices to make system more healthy and protective. Basically relay sense the abnormalities of the system and gets operated when fault occurs. This paper deals with operational comparison of different types of Protective Relays. In this paper we have included the basic concept of relays and different between their operating principle.

Keywords --- Working of protective relays, Relay terminology, Types of relays and Data table of Relays

I. INTRODUCTION

A Power System contain various electrical components like Generator, Transformers, Transmission lines, Isolators, Circuit breakers, Bus bars, Cables, Relays, Instrument transformers, Distribution feeders, and various types of loads. Faults may occur in any part of power system, it may be Single Line to Ground, Double Line to Ground, Line to Line, three phase short circuit etc. Its level also depends on the fault impedance which depends on the location of fault referred from the source side.

The protection system operates and isolates the faulty portion. The operation of the protection system should be quick and selective i.e. it should isolate only the faulty portion in the shortest time causing minimum disturbance to the power system. Also, if main protection system fails to operate, there should be a backup protection for which proper relay co-ordination is required. Failure of a protective relay can result in equipment damage.

WHAT IS RELAY: relay is automatic device which senses an abnormal condition of electrical circuit and connects its contacts, which closes the circuit, Hence circuit breaker gets tripped for disconnecting the faulty portion of the electrical circuit from rest of the healthy circuit.

WORKING OF PROTECTIVE RELAYS

Protective relaying senses the abnormal condition in a particular portion in power system and sounds an alarm or isolates that part from healthy portion of system. Protective relaying system is a combined work of CT, PT, protective relays, time delay relays, trip circuits, circuit breakers etc.

Protective relaying has an important role in minimizing the faults and also in minimizing the damage during the faults.

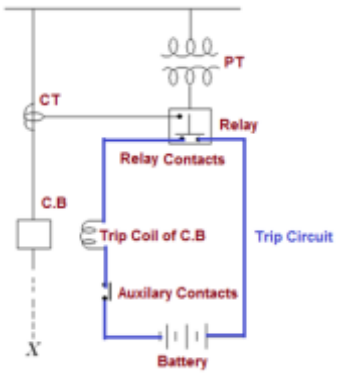

Figure1. Working principle of relay

Figure shows basic connections and operation of circuit breaker control for the opening operation. The protected circuit is shown by dashed line. When a faulty condition occurs in the protected circuit the relay connected to CT and PT actuates and closes its contacts.

Current flows from battery in the tripped circuit. As the tripped coil of circuit breaker is energized, the circuit breaker operating mechanism is actuated and it operates for the opening operation. Thus the fault is sensed and the faulty part is isolated.

II. TERMINOLOGY OF PROTECTIVE RELAY

Pickup level of actuating signal: The value of actuating voltage or current, which is on threshold above which the relay initiates to be operated. If the value of actuating voltage or current is increased, the electromagnetic effect of the relay coil is increased and above a certain level of actuating quantity the moving mechanism of the relay just starts to move.

Reset level: The value of current or voltage below which a relay disconnects its contacts and comes in original position.

Operating Time of Relay: Just after exceeding pickup level of actuating quantity the moving mechanism of relay starts moving and it close the relay contacts at the end of its journey. The time which goes by between the instant when actuating quantity exceeds the pickup value to the instant when the relay contacts are connected.

Reset time of Relay: The time which goes by between the instant when the actuating quantity becomes less than the reset value to the instant when the relay contacts returns to its normal position.

Reach of Relay: A distance relay operates whenever the distance seen by the relay is less than the pre-specified impedance. The actuating impedance in the relay is the function of distance in a distance protection relay. This impedance or corresponding distance is called reach of the relay.

III. TYPES OF RELAY BASED ON RELAY OPERATION MECHANISM

Electromagnetic Relay: Electromagnetic relays are further classified in two categories which are as follows,

Electromagnetic Attraction Relay: This Relay works on principle of Electromagnetic Attraction.

Electromagnetic Induction Relay: This Relay works on principle Electromagnetic Induction.

1. **Solid State (Static) Relay:**The working principle of the Solid Static relays is similar to that of the Electromechanical Relay, relays use analogue electronic devices instead of magnetic coils and mechanical components to create the relay characteristics

2. **Digital Relay:**In Digital relays measured ac quantities are manipulated in analogue form and subsequently converted into square-wave (binary) voltages. Logic circuits or microprocessors compare the phase relationships of the square waves to make a trip decision.

3. **Numerical Relay:**In Numerical relays measured ac quantities are sequentially sampled and converted into numeric data form. A microprocessor performs mathematical and/or logical operations on the data to make trip decisions.

IV. ELECTROMECHANICAL RELAY

Operation of Electromagnetic-attraction Relay: Figure shows electro-mechanical relay. An input voltage is applied to the coil mechanism, which magnetizes the core which pulls the arm towards it. This action causes the output contacts to touch, closing the load circuit. On removal of input voltage, the spring lever will push the contacts away from each other, breaking the load circuit connection.

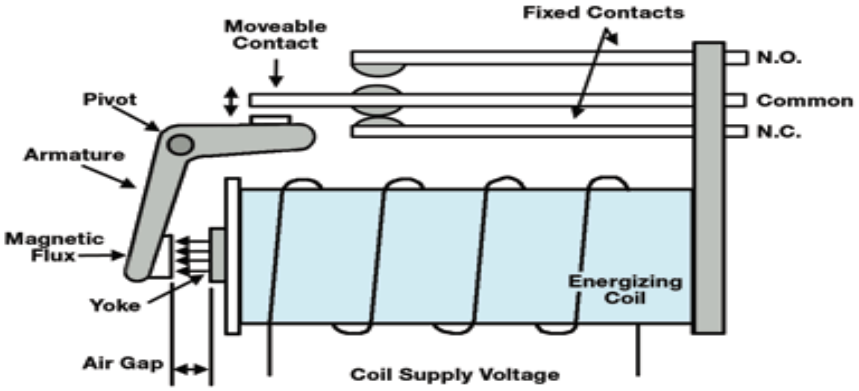

Figure2. Electromechanical Relay

Basically there are two types of Electomechanical Relays, which are

Electromagnetic-attraction Relay

Electromagnetic-Induction Relay

Limitations of Electromagnetic relays:

1. It has Low speed of operation.
2. Failure of Component may lead to relay failure.
3. Bulky equipment, due to the internal mechanical components with physical dimension restraints, the package size of an electromechanical Relay can limit the size of a PCB design. Excessive power consumption.
4. No fault data available except phase indication.
5. Isolation voltage is another area where Electromechanical Relays are limited.

V. SOLID STATE RELAY (STSTIC RELAY)

Operation of Relay: The necessary components of static relays are shown in fig. The output of CT and PT are not acceptable for static components so they are brought down to suitable level by auxiliary CT and PT. Then auxiliary CT output is given to rectifier. Rectifier rectifies the relaying quantity i.e., the output from a CT or PT or a Transducer

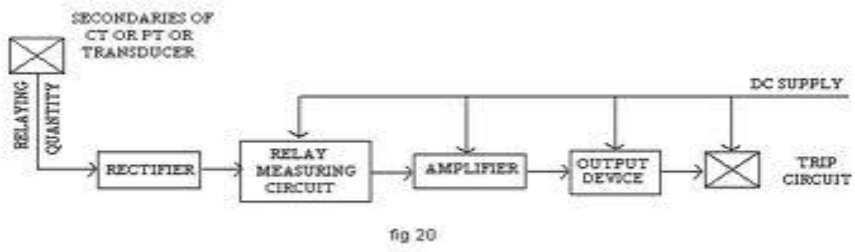

Figure3.Block Diagram of Static Relay

The rectified output is supplied to a measuring unit of comparators, level detectors, filters, logic circuits. The output is actuated when the dynamic input (i.e., the relaying quantity) attains the threshold value. This output of the measuring unit is amplified by amplifier and fed back to the output unit device, which is commonly an electro-magnetic one. The output unit energizes the trip coil only when relay operates.

Advantages of Solid State Relay:

1. Static Relay burden is less than Electromagnetic relays, Hence error is less.
2. It has Low Weight
3. It Requires Less Space which results in panel space saving.

4. Arc less switching
5. No acoustical noise.
6. It has Long life (High Reliability): more than 109 operations
7. Low Electromagnetic Interference.
8. Less power consumption.

Limitations of static relays:

1. Auxiliary voltage is required for Relay Operation.
2. Static relays are sensitive to voltage transients which are caused by operation of breaker and isolator in the primary circuit of CTs and PTs.
3. Highly reliable power supply circuits are required.
4. No availability of fault data.
5. Characteristic varies with passage of time.

VI. DIGITAL RELAY

Operation of Relay: Digital relay contain: (1) Analogue input subsystem, (2) Digital input subsystem, (3) Digital output subsystem, (4) A processor along with RAM (data scratch pad), main memory (historical data file) and Power supply

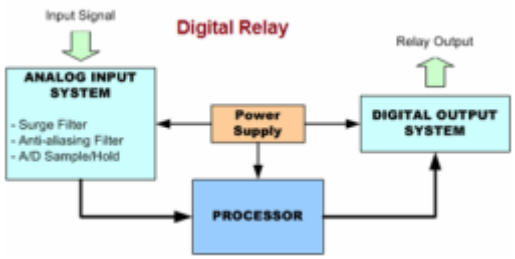

Figure4. Block Diagram of Digital Relay

Digital relaying involves digital processing of one or more analog signals in three steps which are Conversion of analogue signal to digital form Processing of digital form Boolean decision to trip or not to trip

Advantages of Digital Relay:

1. It has Functional flexibility.
2. It is Capable of working under a wide range of temperatures.
3. They can implement more complex function and are generally more accurate
4. Economical because it can be produced in volumes.
5. plane for distance relaying is possible
6. In this Signal storage is possible

Limitations of Digital Relay:

1. It has short lifetime due to the continuous development of new technologies.
2. The devices used in digital relay become obsolete rapidly.
3. Susceptibility to power system transients.

VII. NUMERICAL RELAY

Operation of Relay: A current signal from CT is converted into proportional voltage signal using Current to Voltage converter.

The ac voltage proportional to load current is converted into dc using precision rectifier and then it will given to multiplexer (MUX) which accepts more than one input and gives one output.
Microprocessor sends command signal to the multiplexer, to switch on desired channel to accept rectified voltage proportional to current in a desired circuit.

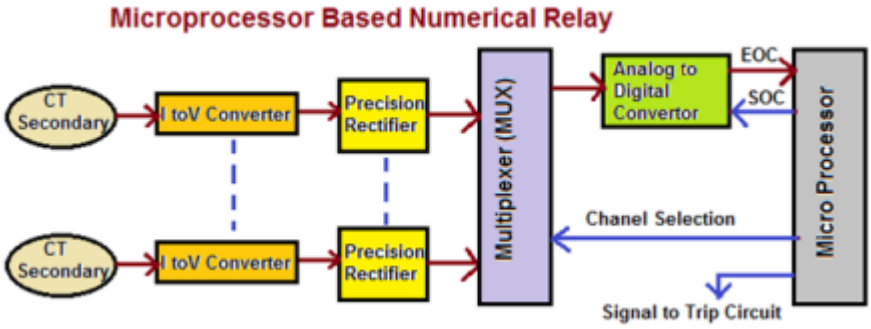

Figure4. Block Diagram of Numerical Relay

Output of Multiplexer is fed to analog to digital converter (ADC) to obtain signal in digital form. Microprocessor then sends a signal ADC for start of conversion (SOC), examines whether the conversion is completed and on receipt of end of conversion (EOC) from ADC, receives the data in digital form. The microprocessor then compares the data with pick-up value. If the input is greater than pick-up value the microprocessor send a trip signal to circuit breaker of the desired circuit.

In case of instantaneous over current relay there is no intentional time delay and circuit breaker trips instantly. In case of normal inverse, very inverse, extremely inverse and long inverse over current relay the inverse current-time characteristics are stored in the memory of microprocessor in tabular form called as look-up table.

Limitations of Numerical Relay:

1. Numerical Relay offers more functionality, and greater precision. Regrettably, it does not necessarily translate into better protection.
2. It can make faster decisions. But, in the real world, faster protection itself is of no value because circuit breakers are still required to interrupt at the direction of the protective equipment.

Table1. Comparison of Different types of relays.

Characteristic	**Electro Mechanical Relay**	**Static Relay**	**Digital Relay**	**Numerical Relay**
Technology Standard	1st generation Relays.	2nd generation Relays.	Present generation Relays.	Present generation Relays.
Operating Principle	They use principle of electromagnetic principle.	In this relays transistors and IC's r been used	They use Microprocessor. Within built software with predefined values	They use Microprocessor. Within built software with predefined values
Measuring elements/ Hardware	Induction disc, Electromagnets, Induction cup, Balance Beam	R, L, C, Transistors, Analogue ICs comparators	Microprocessors, Digital ICs, Digital Signal Processors	Microprocessors, Digital ICs, Digital Signal processors

Measuring method	Electrical Quantities converted into mechanical force, torque	Level detects, comparison with reference value in analogue Comparator	A/D conversion, Numerical algorithm techniques	A/D conversion, Numerical algorithm techniques
Surrounding Environment	Depend upon gravitation and the value changes to the surrounding magnetic fields also.	There value may vary with respect to temperature also.		
Relay Size	Bulky	Small	Small	Compact
Speed of Response	Slow	Fast	Fast	Very Fast
Timing function	Mechanical clock works, dashpot	Static timers	Counter	Counter
Time of Accuracy	Temp. Dependant	Temp. Dependant	Stable	Stable
Reliability	High	Low	High	High
Vibration Proof	No	Yes	Yes	Yes
Characteristics	Limited	Wide	Wide	Wide
Requirement of Draw Out	Required	Required	Not Required	Not Required
CT Burden	High	Low	Low	Low
CT Burden	8 to 10 VA	1 VA	<0.5 VA	<0.5 VA
Reset Time	Very High	Less	Less	Less
Auxiliary supply	Required	Required	Required	Required
Range of settings	Limited	Wide	Wide	Wide

Isolation Voltage	Low	High	High	High
Function	Single Function	Single Function	Multi Function	Single Function
Maintenance	Frequent	Frequent	Low	Very Low
Resistance	100 mille ohms	10 Ohms	10 Ohms	10 Ohms
Output Capacitance	< 1 Pico Farad	> 20 Pico Farads	> 20 Pico Farads	> 20 Pico Farads
Deterioration due to Operation	Yes	No	No	No
Relay Programming	No	Partially	Programmable	Programmable
SCADA Compatibility	No	No	Possible	Yes
Operational value indication	Not Possible	Possible	Possible	Possible
Visual indication	Flags, targets	LEDs	LEDs, LCD	LEDs, LCD
Self monitoring	No	Yes	Yes	Yes
Parameter setting	Plug setting, dial setting	Thumb wheel, dual in line switches	Keypad for numeric values, through computer	Keypad for numeric values, through computer
Fault Disturbance Recording	Not possible	Not possible	possible	possible

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