Power System and Utilization
EEB5033

Power System Protection

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E0557

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1 Introduction

Electrical Energy is one of the most useful forms of energy in the world today. Clean and can be transformed to many other forms, electrical energy posses both advantages and dangers. Electrical Power System protection is essential for protection of both user and the system equipment itself from fault. Protection System is so crucial in Electrical Power System is not allowed to operate without any protection devices installed.

1.1 Fault Defined

Power System fault is defined as undesirable condition that occurs in the power system. These undesirable conditions are such as Short Circuit, Current Leakage, Ground Short, over current, under current, Frequency drift and Power Factor drifts. All the fault condition causes the Electrical Power System to enter the unstable region that can impose danger to both Electric Power Systems itself and the users.

1.2 Why the Protection System is required?

As described in the introduction, Fault impose hazard to both user and the system itself. When it comes to user, life is the concern and when it concern the system it is merely to provide stable electrical power system on top of that prevent damage to the expensive equipment used. In summary, the needs of power protection are:

Area of Interest	Purpose
User/Personnel Safety	Prevent injury and accident.
Equipment	Safe guard the equipment from over current, over voltage and frequency drift that can cause damage
General Safety	Prevent secondary accident that result from power system fault such as fire
Power Supply Stability	Ensure that continuous and stable electrical power supplied by the system/grid
Operation Cost	Ensure that the system is operating at optimal efficiency and reduce equipment maintenance and replacement cost

Table 1 – Power System Protection area of interest

1.3 Danger of Electricity to Human

Human body is partially resistive with resistance about 1000Ω-100KΩ. This value is considered pretty low for most electrical circuit. There are two form of electrical energy that are commonly in use Direct Current (DC) and Alternating Current (AC). AC Voltage is more hazardous to Human as compared to DC Voltage because more current from AC Voltage can flow though human body. There are about three main hazards caused by electricity namely: electrocution (fatal), electric shock, burns and falls

Electrocution

This is an event when human body nerves system became over stimulated by the electrical current. Death can occur if human body became the main path of the current

flow especially if the heart is in the pathway. Non fatal effect of electrocution is numbness and temporary paralysis

Electrical Shock
Shock Phenomenon is almost similar to electrocution. High voltage above 500V can cause human skin rupture. The effect of this is the decrease of human body resistance. In certain condition, the resistance may drop down to about 500Ω. At 500V from Ohms law, I=V/R therefore,
I=500/500 = 1A
Typically 16mA is considered hazardous to human. The following table shows the effect of current on human at 60Hz, AC

Current	Effect on Human
1 mA	Barely perceptible
16 mA	Maximum current an average man can grasp and "let go"
20 mA	Paralysis of respiratory muscles
100 mA	Ventricular fibrillation threshold
2 Amps	Cardiac standstill and internal organ damage
15/20 Amps	Common fuse or breaker opens circuit*

Table 2 – Effect of live current on human

It is very important to realize that it is the current that is hazardous not the voltage. Again, on the other hand high voltage is usually accompanied by high current as well.

Burns
Direct contact with high voltage source can cause skin burns and flash. Electricity arcs (an arc is a flow of high voltage electrons through a gas, such as air) can provide flash burns that will cause combustion to clothing and other non electrical material. Also arc can start fire in an environment where flammable liquid such as petrol methane exist. Arc also can cause skin external and internal flash burn. Other than above examples, high voltage arcs can also cause instant muscular contraction that can lead to other accident such as falls from elevated level which of course will lead to skulls or bone fracture.

1.4 Danger of Electricity to Equipments

Although a machine is designed to operate based on electrical energy however most machine can only take or require as much current or voltage to operate correctly – These parameters are also known as the equipment rating. Excessive supply of current & voltage to equipment can result in equipment damages and burns. Modern electronic equipments specially operate at very low voltage margin are very susceptive to voltage fluctuation and can be easily damaged by over voltage or over currents. Besides actually causing hazards, electrical fault in the electrical system can cause the equipment to malfunction or functioning at lower efficiency. For example, phase fault and phase to ground fault in electrical transmission system causes the system to deliver less electrical energy then it suppose to deliver to the destination.

1.5 Secondary Accident resulting from Power System Fault

Electrical system failure not will only interrupt the electrical supply on the receiving side but also can cause fire hazard in the case of short circuit or some event can cause the high current and voltage to burns. Immediate results of an intense electric shock on small cables are fire and sparks. These events can possible cause fabric and wooden material nearby starts to burns as well. In the existence of highly flammable liquid such as gasoline and petrol, explosions are more likely to take place. Local example of such an accident is the fire in Taping most likely caused by sparks form the fluorescent lighting installation that finally result in facility and equipment damages summing over RM100,000.00

1.6 Faulty system less power delivered

Faulty power system also can result in less efficient power delivery system to the end user. Phase to ground of phase-to-phase fault causes power loss such that the utility company needs to "pump-in" more power in order to be able to deliver sufficient power to the end user. Besides that, various forms of fault will also increase the capacitance or the reactance of the whole power delivery system thus causing the power factor at the delivery system become lower thus requires more active power supply at the generation sides.

2 Power System Protection

The main objective of power protection system is to define maximum sensitivity of the protection devices to operate on the permissible conditions. From here we then need to know what are the electrical power system protection devices and equipments are.

2.1 Power System Protection devices and equipment

The whole idea of an Electrical Power System Protection is to isolate the faulty circuit from the whole system to remove the faults. The isolation can be done by mean of disconnecting or opening the circuits that are connected to the faulty sections. There are passive types of protection devices such as fuse and circuit breaker or isolator. This type of protection requires maintenance personnel to manually service the system, once the fault occurs. Often enough active devices that can automatically are required because some fault is tolerable if it is occurring for a very short period of time. The most common device that can serve the purpose is relay. Relay is a device that response to an input and causes circuit connection to close or open. There are various types of relays. However from these many devices, relay can be categorized into 3 major types, namely:

- Instantaneous (Instant reaction)
- Time Delay (Tripping will only occurs after certain settable time)
- Numerical Relay (Static relay uses microprocessor and operate based on numerical method calculation)

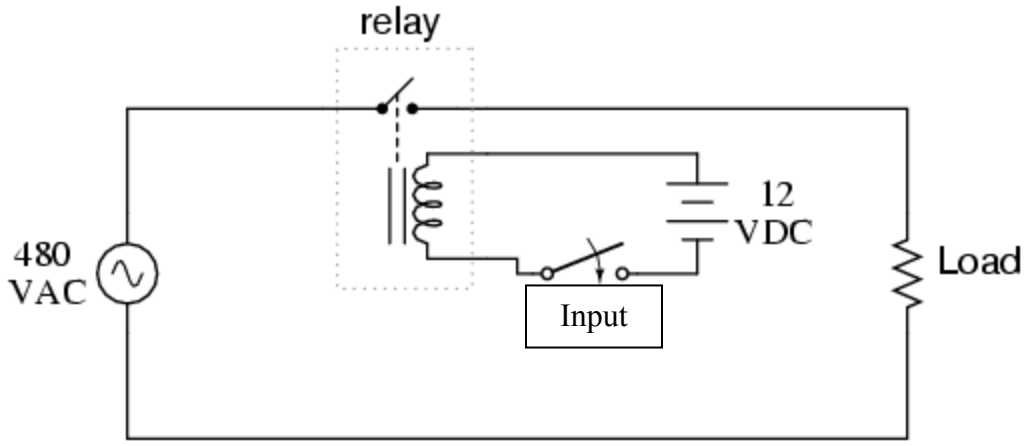


Figure 1 – Basic operation principle of a relay

The circuit diagrams above show the basic principle of a relay and how it would be used in electrical circuit. The high voltage is connected to the load via the relay such that automatic disconnection of the load can happen in the case of fault occurrences. Relay is a passive device that can only be ON or OFF state by default. As such it does not actually know if when it should start to operate and when it should not. Active device that can actually "see" or sense the fault is required to instruct the relay on what to do. These devices are then connected to the relay input to make a mini protection scheme that can actually monitor faults and take necessary action. To be able to do a good job, the protection scheme should be able to eliminate the fault condition on the smallest portion of the circuit in the shortest time possible.

			
Microprocessor Based Relay	Time Delay Relay	Numerical Relay	Electro mechanical Relay

Figure 2 – Various type of protection relay

Besides relay, important equipment used in Power System Protection is current transformer and voltage transformer. These two equipments act as sensor to sense current and voltage in the power system. Current transformer is used to sense current flowing through a cable or a bus bar. The basic operation of current transformer is induced voltage due to current flow through a conductor. Voltage Transformer on the other hand senses the voltage flowing though a conductor.

	
Oil Immersed Resin Cast Coil High Voltage Current Transformer	Low voltage air gap Current Transformer

Figure 3 – Current Transfomers

3 Protective Relay

3.1 The purpose of protective relay

In a Power System Protection, the system engineer would need to a device that can monitor current, voltage, frequency and in some case over power in the system. Thus a device called Protective Relay is created to serve the purpose. The protective relay is most often relay coupled with Circuit Breaker such that it can isolate the abnormal condition in the system.

Protective relay itself can be categorized as instantaneous and time delayed relay. From the construction perspective, relay can be build using electromechanical device and also preferred modern solid state relay. Electromechanical relay are first used for Protective relay due to technology time line as well as cost effectiveness in today's application. Solid state relay are build of electronics devices and even have microprocessor in later version nowadays. These relays are more sophisticated and feature rich with the penalty of price.

Electromechanical Relay	Static Digital relay
	
784-4C-120A	**SEL 421** (Scheweitzer Engineering Lab, Inc)
Basic Electromechanical Cube relay,	Protection, Automation, and Control System for high-speed distance and directional protection and complete control of a two-breaker bay.
Max Voltage 120VAC Contact rating 15A LED indicator	5 Zones protection capability Graphical user interface Logic functionality High speed fault clearing
Price: **$8.00**	Price: **$6,600**

Table 3 - Price Comparison of Electromechanical Relay and Digital relay

Protective relay that monitor fault current are usually operated by the current transformer. When a cable or bus induced large enough current (usually about 5A), the signal is then used to open or close a circuit. These high current and voltage relay are usually mechanical relay.

Voltage monitoring protection relay sense the voltage via the line voltage divider more efficiently by the Potential Transformer (PT). The purpose of the PT is to step down the input voltage from few kilo volts to about 120V. This voltage is then used to signal internal operation of the relay

Protective relays are usually designed for specific purpose. This allow the relay to emphasize more on certain function only because designing multi functions relays are very costly. There several standards designated for protection type relays. These standards are ANSI governed standard.

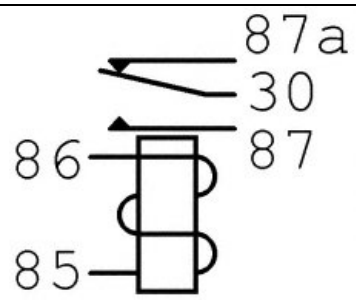
ANSI Code	Protection Relay Purpose
12	Overspeed
24	Overexcitation
25	Syncrocheck
27	Bus/Line undervoltage
32	Reverse power (anti-motoring)
38	Stator overtemp (RTD)
39	Bearing vibration
40	Loss of excitation
46	Negative sequence undercurrent (phase current imbalance)
47	Negative sequence undervoltage (phase voltage imbalance)
49	Bearing overtemp (RTD)
50	Instantaneous overcurrent
51	Time overcurrent
51V	Time overcurrent -- voltage restrained
55	Power factor
59	Bus overvoltage
60FL	Voltage transformer fuse failure
67	Phase/Ground directional current
79	Autoreclose
81	Bus over/underfrequency

Table 4 – ANSI Protection relay code

3.2 How Protective relay works?

Basically, the operation of a relay is pretty basic, that is to open or close a circuit when certain condition is met. As described before, instantaneous relay will open or close a circuit immediately when a condition is met. Time Delay – Inverse Definite Minimum Time (IDMT) relay on the other hand, will allow the fault to continuously happen till certain specified time before it actually close and open a circuit. If the fault does not last for the specified time delay, the relay will reset itself. IDMT relay functionality is slightly complex but will be discussed further later. Every mechanical relay will have moving contact that can be open or closed. The operation of the open and close itself is done by the contact coil (electromagnetic coil – usually energize to close). Static relay on the other hand, uses the semiconductor diode for switching on and off.

Electro mechanical relay internal



Circuit Diagram	Actual Relay

Figure 4 – Electromechanical Relay internal

The figure shows the internal diagram of an electromechanical relay. The coil has 2 input 86, 85. These two terminals are connected to usually 125VDC for operation. Once the voltage is supplied to the coil, the core will turn into an electromagnet hence pull the contact on terminal 30. Pulling down the terminal will cause the contact to connect to terminal 87 or on the other hand disconnect from terminal 87a. The operation of the above relay is instantaneous.

IDMT relay is constructed with almost the similar principle however, IDMT relay has delay mechanism.

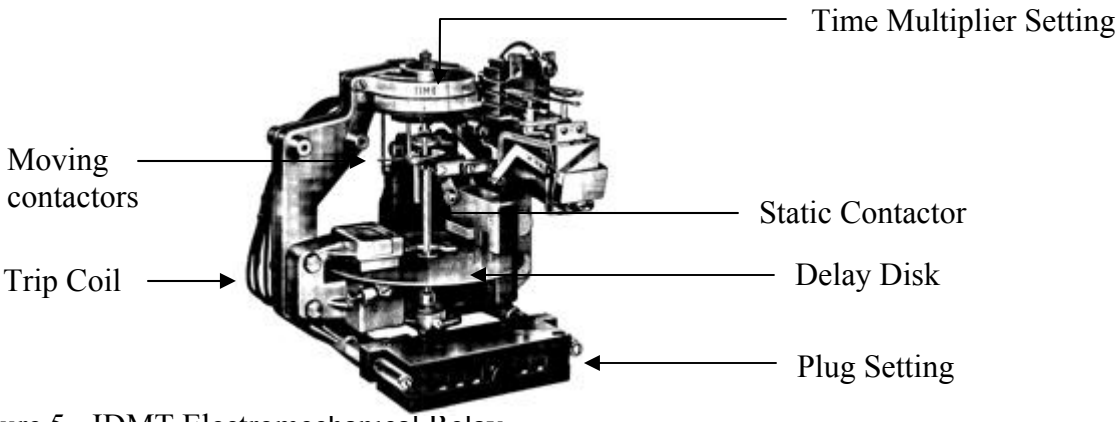


Figure 5 - IDMT Electromechanical Relay

IDMT Relay respond to the as the instantaneous relay does, however the difference is that upon receiving excitation from PT or CT, the delay disk will start to turn. The turn of the disk will also cause the moving contactor starts to travel as well. The slow transversal create sufficient delay before the moving contactor finally touches the static contactor to actually causes circuit open or circuit closing.

Static Relay Operation

Static relay as oppose to mechanical relay does not contain any moving part. Most common, it has two separate sides within the relay itself. The following diagram shows the internal of a static relay.

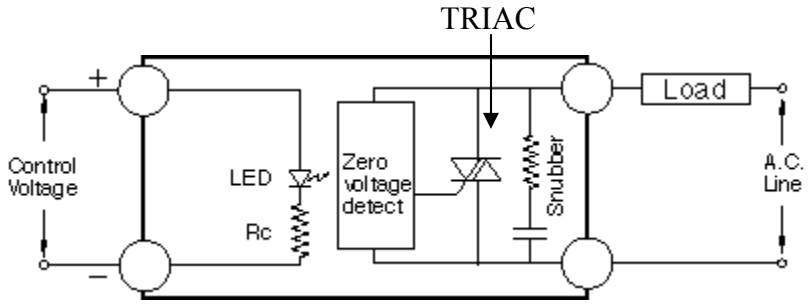


Figure 6 – Static Relay Internal

The low voltage side is equivalent to the tripping coil for electromechanical relay and the high voltage side, equivalent to the contactor on the electromechanical relay. The open and close operation is done by the TRIAC. The switching is controlled by the Zero Voltage Detect that is usually opto - coupled to the low voltage side. Difference from Electromechanical relay, Static relay is more sensitive to over current and over voltage that can cause damage to the TRIAC.

There is various type of Static Relay, namely:

Analog Relay

Static Analog Relay uses analog component for operation. The common components used are resistor, capacitor and operational amplifier. Analog relay can be constructed as instantaneous relay also IDMT relay.

 ATC Series 409 (Analog Relay)	Analog Time Delay relay 24VDC Operation voltage 10A rated 20/240VAC Contactor

Figure 7 – Analog static relay

Digital Relay – Non-Numerical

With the advancement of electronics industry, relay manufactures start to use integrated circuit (IC) and microprocessor to make more feature-rich protection relay.

Implementation of IDMT function such as delay timer and timer setting are more accurate with the use of various type of integrated circuit. Digital relay also have the capability to store fault value such that maintainer can actually obtained the fault current value, fault voltage and even capture waveform of the fault current and voltage.

 BE1-50/51B Time Overcurrent Relay	Over current IDMT Digital Relay

Figure 8 – Digital Relay (Non numerical)

Digital Relay – Numerical

Digital numerical relay is a special type of digital relay that actually uses the capability of the modern microprocessor to actually calculate the fault value and perform analysis such as Fourier Analysis on the fault data before even making decision to trip the system or not. Similar to Non-Numerical Digital Relay, the Numerical Relay also usually has the capability to record the faults value for analysis. Most often these relays are also equipped with communication port that allow maintainer to download information form the relay after the fault has occurs or just for system health analysis purposes.

 BE1-700V Digital Voltage/Frequency Protective Relay	Voltage and Frequency protection Communication Port

Figure 9 – Numerical Electromechanical relay and Static Relay

Comparison between analog and digital protection relay

Electromechanical Relay	Static Relay
Operated by tripping coil	Semiconductor switches
Moving parts for time delay and contacts	No moving parts, "contacts" are electronic switches
Usually higher operating voltage	Very low operating voltage
Not sensitive to over current or over voltage	Very susceptive to over current and over voltage
High burden to sensors (CT,PT)	Very low burden to sensors
Slow reset time	Fast reset
No logging capability	Fault value and waveform capture for fault
No logic nor analysis capability	Able to do logic comparison and data analysis before tripping
One time operation	Capable of re-connect opened circuit

Table 5 – Comparison between analog

3.3 How Protection Relay sense a Fault

Most of the Protection Relay operation relies on current measurement. Current measurement is often done by the Current Transformer. Feeding raw input from the Current Transformer can cause the relay to trip even because small noise in the system. This scenario will cause the system to be oversensitive. Therefore, proper current measurement techniques need to be employed to be able to obtain proper fault current value. There are methods that are in use for current detection namely:

Peak Detection

Input is rectified and maximum value is obtained by "smoothed" from the Low Pass Filter. This method can be erroneous because of the input signal harmonics

True RMS

True RMS methods take care of distortion from the input signal harmonics.

Fundamental Frequency

The fundamental frequency method can only be done by Numerical Static relay and it is the most accurate method to detect input current since it is able to take care of more then 1st input signal harmonics.

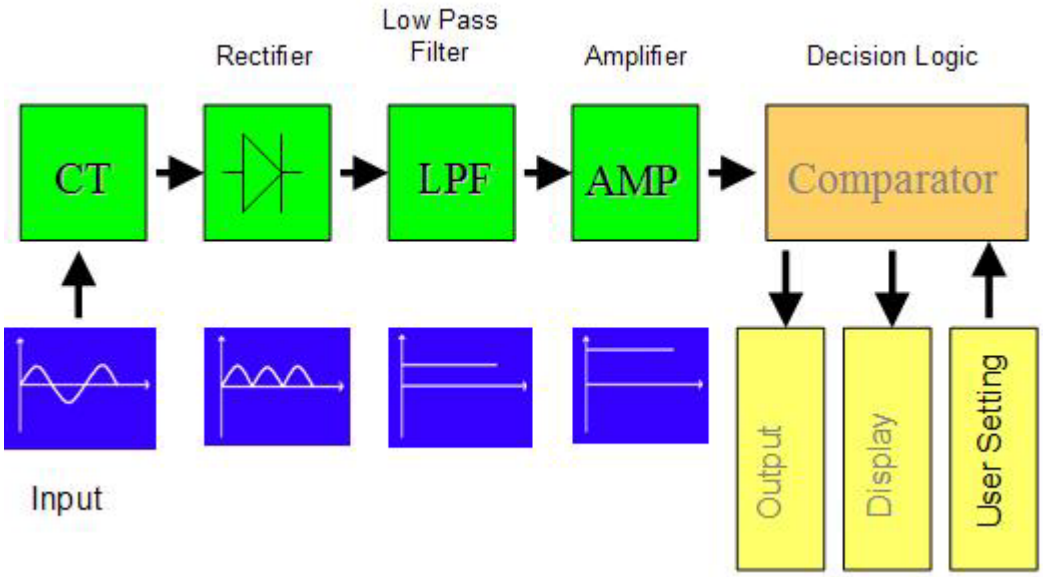


Figure 10 – Block diagram of a digital relay

The above figure shows some basic building block for a Static Protection Relay. The filters and decision logic varies from Analog Relay to Non Numerical and Numerical Relays. Advanced Numerical relay have anti-aliasing filter as well as microprocessor and digital signal processing circuit that can do complex numerical methods analysis on the input signal.

4 Overcurrent Relay, Earth Fault Relay & Earth Leakage Protection

Protection relay are general type of relay, the protection relay itself can be further categorized to twenty (20) different ANSI classifications.

4.1 Overcurrent Relay

Overcurrent relays are classified under code 5x (ie: 50, 51) in ANSI relay code. The main purpose of overcurent relay are exactly is the name suggested – to operate based on the overcurent flowing into a system and prevent such scenario from taking place. Overcurrent relay can also be constructed as IDMT and instantaneous relay.
Example of overcurrent relays are:

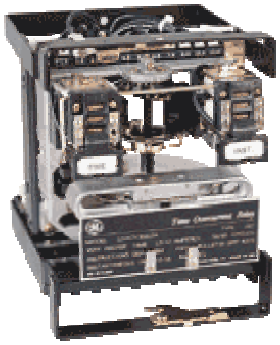
Relay	Applications and Protection Provided
 GE IAC50 Time Overcurrent Relay (electromechanical)	*Applications:* • Feeder and Transmission Line • AC machines (Motors) • Transformers *Protection Provided:* • Ground and phase time overcurrent or undercurrent • Overload motor protection
 MIC 8050 N 011 G 00C Microprocessor multifunction relay	*Application:* • Used AC Circuit • Feeders and transmission line • Motors, and other AC Machines • Transformers • Rapid Short Circuit Detection *Protection Provided:* • Instantaneous and time overcurrent • Phase and ground faults

Table 6 – Overcurrent relay and applications

Most overcurrent electromechanical relay can utilize the overcurrent to power its operation.

4.2 Earth Fault Relay (ELR)

ELR (ANSI Code 64) is a very specialized overcurrent relay that specifically designed to handle earth faults. Compared to phase-phase fault, earth fault can generate very high fault current. Earth fault current must have CT installed on the feeder or cable it needs to protect. The operation principle of the earth fault relay is to trigger whenever the current inducted in the current transformer is not zero.

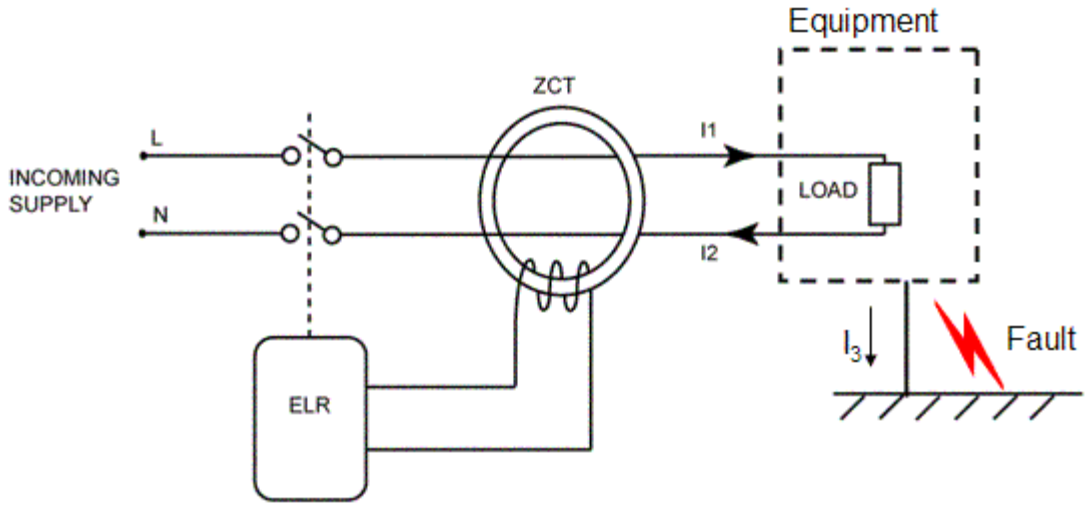


Figure 11 – Earth Leakage Detection Circuit

During normal operation, the current flowing into the load is equal to the current flowing out of the load. This of course obeys kirchoff current law. However, when earth fault occurs, the net current flow then equal to

$I_1=I_2+I_3$, where I_3 is the fault current

Therefore, the net current induced in the CT. This induced current is then detected by the ELR that will then open the circuit to stop the fault.

There are several types of ELR exist in the industry.

Relay	Applications and Protection Provided
 PFRD-99A1 ELR	*Applications* • Protection against loss of wires insulation • Spark prevention • Industrial process • Prevent human electrical shocks • Preventive maintenance for: - Motors - Light system - Ovens *Protection Provided* • Earth leakage Protection

 RCR-V25/RCR-F030	*Applications* - Earth leakage current - Overcurrent comparison to preset value - Shut down a system or operate an alarm under fault conditions. (Aux) *Protection Provided* - Earth Leakage Current - Overcurrent

Table 8 – Earth Fault Relays and applications

4.3 Earth Leakage Protection

AC voltages are usually earthed at the substation to complete the circuit. However, when a conductive or partially conductive object is come to contact with the transmission line of the exposed feeder cable, current will flow via the shortest distance to the ground. There are few source of earth leakage

Source	Description
Human or animal	Touching the live or exposed feeder or transmission line. (Birds that land on one transmission line will not cause earth leakage because it does not have contact with ground)
Dampness, degraded insulation	Dampness reduces the insulator insulating capability thus allow significant amount of current to flow through the insulator.
Surge Protector	The purpose of surge protector is to create a short circuit path whenever a very high voltage or high current enters the system to protect the rest of the system. If the surge protector does not function properly, it will always cause current to flow to the ground.
Power Line Filters	Power line filter uses the capacitor to attenuate line noise, however, the power line harmonics can cause the filter turn into alternate path for earth leakage current. Therefore, as the harmonics goes higher, thus the amount of earth leakage current.

Table 9 – Source of earth leakages

The most common devices used for earth leakage current protection is Earth Leakage Circuit Breaker (ELCB) and ELR. The ELR requires proper CT installation to operate correctly and able to detect the earth the leakage current.

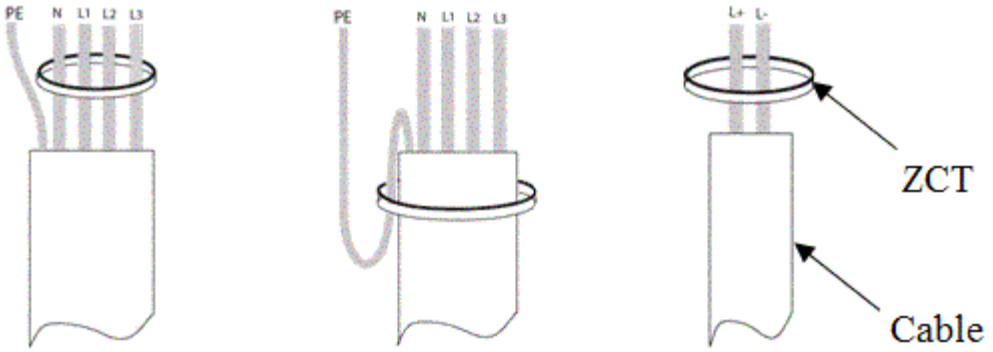


Figure 12 – Current Transformer installation on a feeder

The CT Loop must not include the earth conductor because that will cause the CT not be able to detect of there's any earth leakage current flowing in the system.

5 Unit and Non-Unit Protection

Power Protection System can be implemented in two ways, namely: 'Unit Schemes' and the 'Non-Unit Schemes'. Each of the implementation has its own advantage over the other.

5.1 Non-Unit Protection

The Non-Unit protection scheme work on the system and it might overlap with another protection device in the systems. The use of this mode of protection is usually to isolate the whole circuit when a fault occurs.

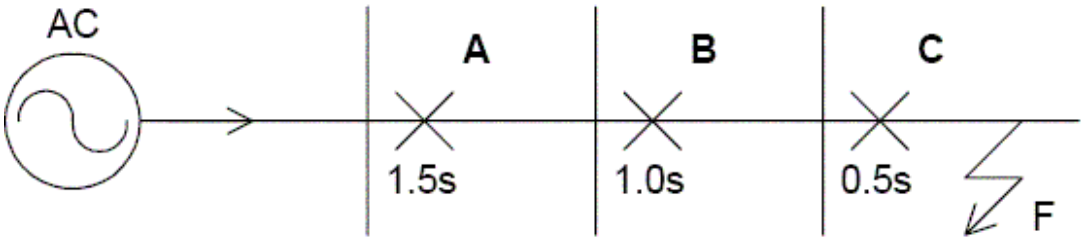


Figure 13 – One line diagram of a typical Non Unit Protection

There are 3 protection relay installed in the system to provide protection for the system. If instantaneous relay is used, fault accruing at C will cause the whole system to trip because all the relays A, B and C will see the fault. Therefore the system engineer will use IDMT Protection Relays instead to be able to discriminate the fault such that the smallest section of the system is disconnected if a fault occurs. With the scheme in the figure above, the protection system will be able to only isolate C when the fault at the end of the one-line diagram. However, if section C is comprised of several loads and devices, fault on any devices will cause the whole section to trip. It is important to note that the protection relay B will only trigger after 1.0s after the fault take place and only occur when Protection Relay C failed to isolate the fault from the system.

Advantage
This mode of protection has the backup capability such that it almost guarantees that the fault will be removed by at least one of the protection relay in the system.

Disadvantage
The operation relies on time/current/impedance grading. Other then that, the system also cannot isolate individual device in a situation that the machines is overload.

5.2 Unit Protection

The main purpose of the unit protection scheme is to protect a defined or discrete zone of location that is usually the zone bounded by the 2CT used for differential current measurement. Relay used in Unit Protection scheme are usually Differential Protection relay.

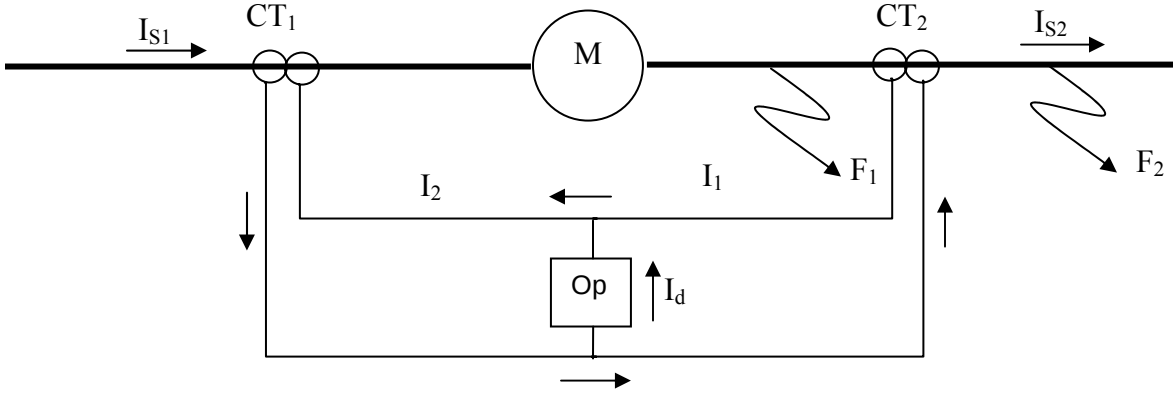


Figure 15 – Differential fault current measurement

The figure above shows the operation of a unit protection. The two CT is used to measure the incoming and outgoing current into the protected load M. Under normal operating condition, IS1 will be equal to IS2, therefore, I1 = I2, thus result in Id=0. However, when I1 ≠ I2 (Fault at F1), then Id will have the value of I1-I2. The current is then detected by the relay that will then cause trip in the system. For this protection scheme, if the fault occurs at F2, the protection system will not be able to detect the fault because it is happening outside the protection zone of the system. The following diagram show the complete circuit of unit protection using the Digital Differential Protection Relay

Figure 16 - RFL 9300 Digital Differential Protection relay

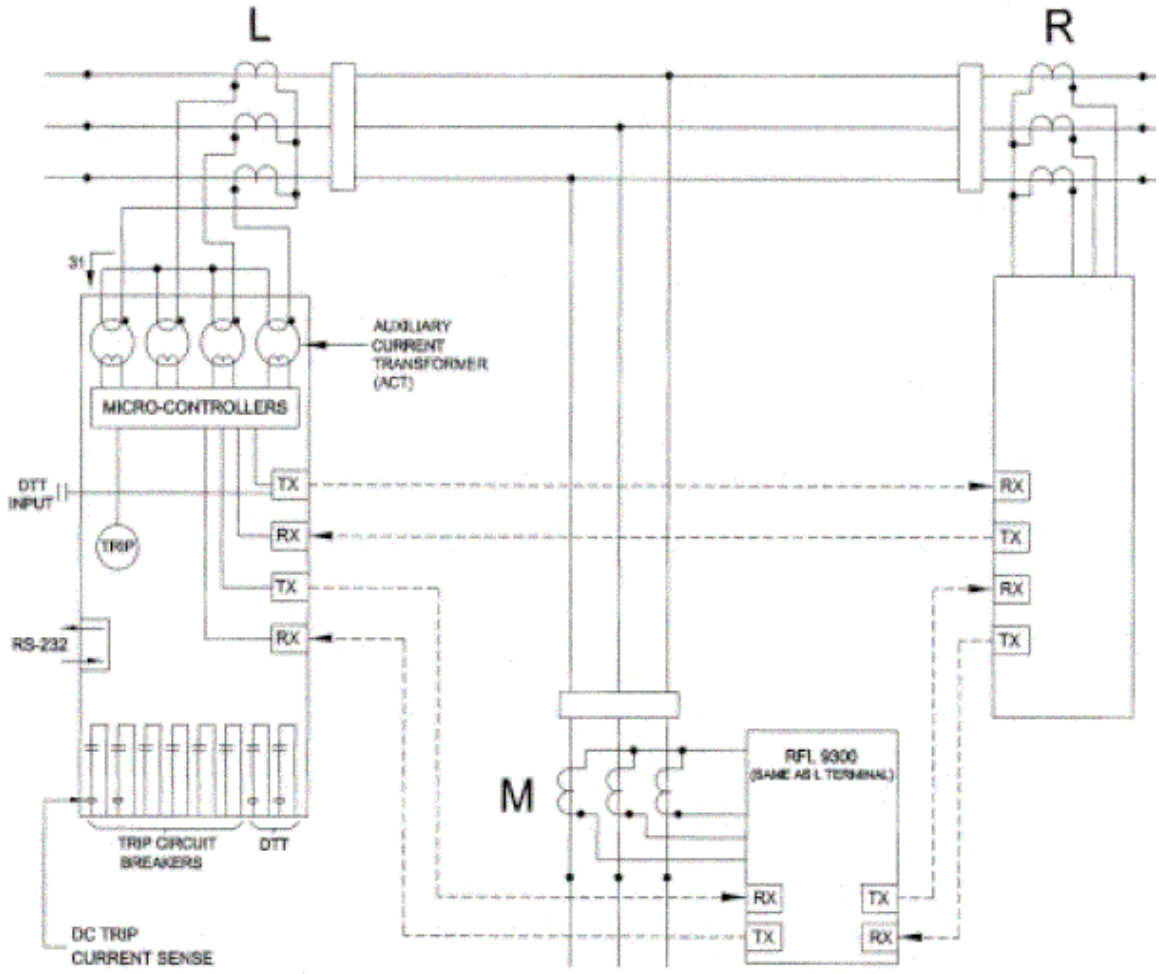


Figure 17 - Actual Circuit Diagram of the Unit Protection from one-line diagram. Implementation using RFL 9300 differential Protection Relay

Advantage

No grading is required. This mean, the unit protection system is independent of other unit protection in the system.

Since there is no grading required, the reaction of the protection system is very fast

By only focus on a particular zone, unit protection is more sensitive as compared to non-unit protection scheme.

Disadvantages

One major draw back of a unit protection system is that it is lacking of backup functionality against other unit protection system. The back functionality can only be provided by the non-unit protection.

Exist blind spot in the system, if fault occurs at the blind spot the unit protection system will not be able to respond.

Therefore, to have a complete protection system, both unit and non-unit protection system must be employed. By having both protection scheme installed, the system can

respond faster to fault while ensure that fault that happen on any segment of the system can be detected and cleared or isolated.

5.3 Comparison between Unit and Non-Unit Protection

Having known the features, advantages and disadvantages of both Unit and known unit protection we can compare and choose which protection scheme is suitable for which type of applications.

Feature	Unit Protection	Non-Unit Protection
Fault isolation speed	Can react as fast as 20-30miliseconds. The minimum reaction time of the circuit breaker/isolator the protection relays is installed with	Minimum time usually set for discrimination is about 0.5seconds. The second stage discrimination will take about 1s. When fault occurs near the power generation source, it will take much longer time to isolate because at that point, longer discrimination time is usually set
Backup Feature	Unit Protection only provides protection for its zone of protection only. Therefore it would not be able to protect other equipments outside its protection boundary. Another bad feature is that it would not be able to sense fault is the overall system in overcurrent	System wide protection against all the downstream of the position at which the protection relay is installed
Cost	Unit protection is expensive specially when inter – station signaling is required. (CT are located at remote located)	Cheaper implementation because it can use various types of protection relay to build the system
Applications	Usually used at the Transmission level due to cost	Used at smaller system level such as substation
Equipments Protected	Pilot Wire or Line Differential Transformer Differential Bus Protection (High Impedance, Medium Impedance, Low Impedance) Phase Comparison	Feeder Overcurrent Transformer Overcurrent Bus Overload Earth Leakage Protection Distance Protection without associated signaling Fuses

	Distance Protection with Associated Signaling Directional Comparison Restricted Earth Fault	

Table 10 – Comparison between unit and non-unit protection

6 Discussion

Protection of Power System is the most basic requirement before the power system is put into operation; it is equivalent to the certificate of fitness (CF) of a building before it can be occupied. Electrical energy have eminent dangers both human and machines. Protection system is mainly controlled by the protection relay. It is the brain of the protection system that monitors input from it sensor as current transformer and signals the circuit breaker to open/close high voltage/current circuits. Power protection system can be implemented at various stages and various types of protection devices

Protection Device	Level of protection	Description
Fuse	Equipment	Provide protection for the equipment preventing overcurrent to the equipment. Cannot protect against over voltage and frequency change
ELCB	Residential Building Unit	Protect against earth leakage within the unit. Help in occupancy safety
Protection relay	Power System Protection	Various type of protection relay that can be configured as unit or non-unit protection scheme to provide large system protection

Table 11 – Level of protection and devices used

Momentary power loss in a house or residential area might be a common tolerable situation. However, other unmanaged electrical fault such as short circuit can easily lead to secondary accident such as fire and electrocution

Industrial operation on the other hand requires continuous stable power for its operation. Even, 30 seconds power interruptions can cause million of ringgit worth of loss in a factory operation. Most medium and small factory in this country operates on 415V 3Phase incoming feeder from the utility company. For most of the company in Kulim Hi-Tech park itself, they have a backup generator that can provide backup power in case of there is interruption from the incoming feeder. With the complex implementation of the power system and delicate expensive equipments in use as well as top priority on the human and occupational safety, factory like Intel®, invest significant amount money to put up a fool proofed Power protection system for the factory. It would be good to review the Protection System and the overall system from bottom up to be able to follow through how protection on the smaller scale affects the overall system.

Protection Level	Description/Benefits
Personnel	• All personal operating machinery and electrical live voltage are required to wear a fully qualified protection suits that include ESD protection footwear and smog • No food and drinks are allow in the working area to avoid accidents and spills that can lead to electrical short circuit or earth leakage
Small machine/equipments	• All machine is fuse fitted and periodical maintenance (usually 3-6months). Power cords used for equipment that has different voltage rating are usually designed such that it will not fit on other power plugs. This method can help to minimize fault due to overcurrent because the equipment is hooked into a wrong power outlet. • Usage of extension cord is strictly prohibited to avoid high burden on the power outlet.
Medium /Large Machine	• All the medium and high voltage machine such as the tester and production assembly machines are equipped with emergency stop panic button that is made accessible to enable personnel intervention to stop the system in case of visible accident or fault take place.
Lab/Factory Line	• Each of the Labs is equipped with its own segment MCCB to allow smallest unit protection within the factory. It would be certainly not a good idea to trip the whole production floor if a small segment of the floor is having fault.
Factory Building	• The whole factory building receives its power from the 3Phase 415V incoming feeder from the in house substation. The incoming feeder is connected to the building switch boards. This is the point on which the power is then supplied to the smaller segment of the factory building such as the labs, factory floor and office area. Most of the protection relay installed in the stage is IDMT type relay to provided system wide non-unit protection.

Table 12 – Plant Power Protection System

At almost all of the protection stage except the smaller MCCB, uses protection relay to actually operate powerful electromechanical circuit breaker capable of handling high voltage/current. Therefore, protection relay only act as the brain of the protection and actual switching work are done by the circuit breakers and isolators

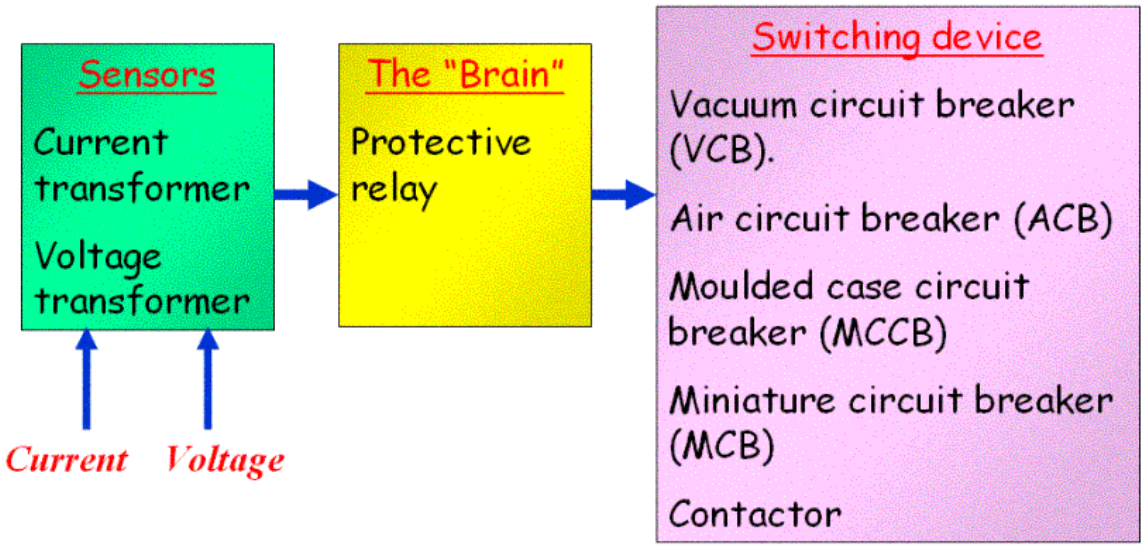


Figure 18 – Building block of a protection system

Of all the notions of the Power System Protection, one must note that the whole idea of protection is to prevent accident from happening thus it not implies that it make sure that accident will not happen at all. There can be one thousand and one way things can go wrong and the best measure against all these is to put safety first.

7 References

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