CHAPTER 2

Principle and Theory

2.1 Power distribution System

Power distribution system is a system that supports the power from the generator supply to the transmission system and distribution to the user. Electrical power distribution system that will need to be safe and efficient, can support enough power in the present and able to support the power supply may have increased in the future. For the power distribution system of state-owned enterprises EDL will reduce the levels. The voltage from high-voltage 115 kV into the distribution system, a medium high-voltage distribution system up to 12.7 to 35 kV by using a power transformer station on the high-voltage electricity to sell to power users who need a lot of power.

The structure of electric distribution systems that are generally used, it'll split 5 formats as follows: Radial Distribution System, Loop Primary Distribution System, Primary Selective Distribution System, Secondary Selective Distribution System, and Spot Network [7].

For this thesis will consider the only loop distribution system that is a model in the parallel feeder. The primary loop scheme is an even more reliable service that is sometimes offered for critical loads used in distribution systems for areas that need reliability high, which could protect the outage electricity in the wide area when occurring an event such as the over-load and the fault occurrence in the network.

2.1.1 Loop Primary Distribution System

The loop distribution systems consist the structure of the high-voltage transmission line to receive electrical power from the station to the high voltage source. Sending power to the load connected to the bus or any in electric substation. The direction makes the electricity flows in one direction, from the source to the power station the power sub-station to until the power sub-station destination that show in Figure 2.1.

The loop distribution systems provide better service continuity than radial distribution systems. However, it is more expensive than radial systems because of the additional switching equipment requirements. As a result, the loop distribution systems are an important system for the user electricity, which electrical outage problem is more likely to endanger human lives or result in property losses with the user electricity in a wide area. It may be generated inside or outside system equipment leading to equipment deterioration.

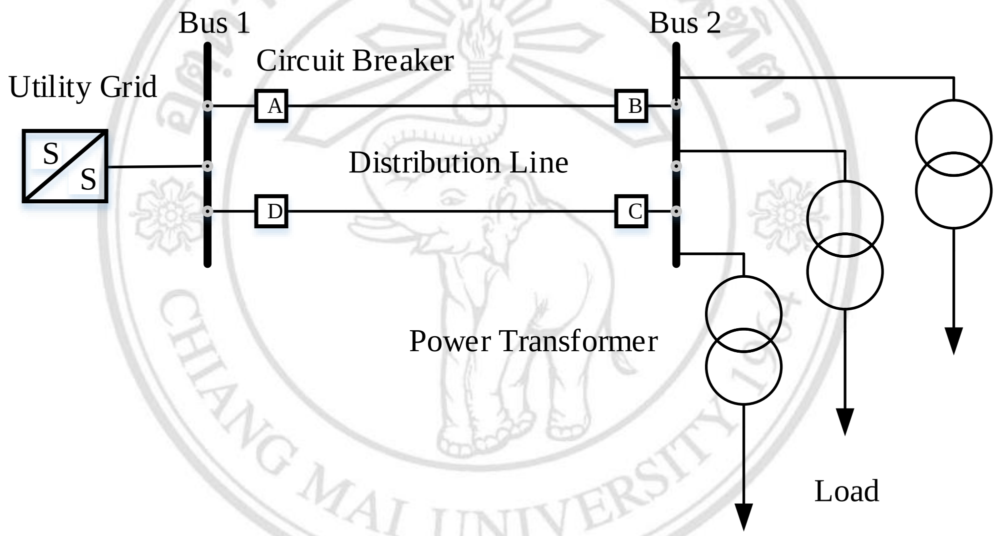

Figure 2.1 The structure of loop Electrical distribution systems

2.2 Fault in distribution system

A short circuit current has occurred in the system, it will damage the system may cause a power outage. The severity of the short circuit occurs will depend on the size of the short circuit current. If the short circuit current has a high value will cause system damage is considerable. Which is the size of the short circuit current depending on the pattern of occurrence of a short circuit and position of short circuit occurs. For a short circuit current that occurs most often is a style single phase to ground, which has up to 70 to 80 percent, [9]. A short circuit in all electrical systems. A short circuit current occurs type the section will then send the result is the most severe impact, which has the size of the maximum short circuit, it is a short circuit style three-phase. Therefore, it is taken into consideration for design protection device in an electrical distribution system.

A majority of short circuit faults make a breakdown insulation, which it caused by switching surges or lightning strikes, degradation of insulating materials due to temperature rise or internal partial discharge, and accidental electrical connection between two conductors through a foreign body (tools, animals, tree branches). A short circuit which can be separated into 2 types [8]:

1) Symmetrical

- ❖ Three-Phase Short Circuit

2) Unsymmetrical Short Circuits

- ❖ Line-to-Ground Fault (L-G Fault)
- ❖ Line-to-Line Fault (L-L Fault)
- ❖ Double Line-to- Ground Fault (2L-G Fault)

In some cases, a fault in the electrical distribution systems may not have been caused by a short circuit problem alone. A fault in the electrical distribution system may be caused by an open circuit, which a fault in this characteristic makes it not flow balance (Unbalanced Current Flow). Example in case of a fault in the electrical distribution system resulting from open circuit such as a lack of electrical wiring. For the fault in this case consists as follows:

- ❖ One Line Open (1LO)
- ❖ Two Lines Open (2LO)
- ❖ Three Lines Open (3LO)

For in this thesis is to choose a particular consideration the three-phase fault and style single phase to ground fault only. Because it is a fault. That is most affected and the most frequently occurring, respectively.

2.2.1 Three-phase Fault

A three-phase fault is a short circuit the most severe because of the size of the short circuit current is quite high. A three-phase fault is a short circuit and symmetrical (Balanced Fault), so the calculation of the short circuit current does not hassle than calculation a single-phase to ground fault. How to calculate the short-circuit current of the three-phase short circuit analysis method is used by the principle of symmetry elements.

A three-phase fault analysis method uses the symmetrical composition. The symmetrical components bring converts to three component series. When get component series and then calculate phase elements of the short-circuit current, which set as: positive-sequence components, negative-sequence components, and zero-sequence components as shown in Figure 2.2 (a), (b), and (c) [8].

❖ Positive-sequence component as shown in Figure 2.2 (a), it consists of three phases that have equal magnitude 120° angle, and rotating in the same direction as the phase under consideration in the positive direction.

❖ Negative-sequence components as shown in Figure 2.2 (b), it consists of three phases that have equal magnitude 120° angle, and rotating in the same direction as the positive-sequence phases but it is in the reverse sequence.

❖ Zero-sequence components as shown in Figure 2.2 (c), it consists of three phases that have equal magnitude in phase other, and rotating in the same direction as the positive-sequence phase.

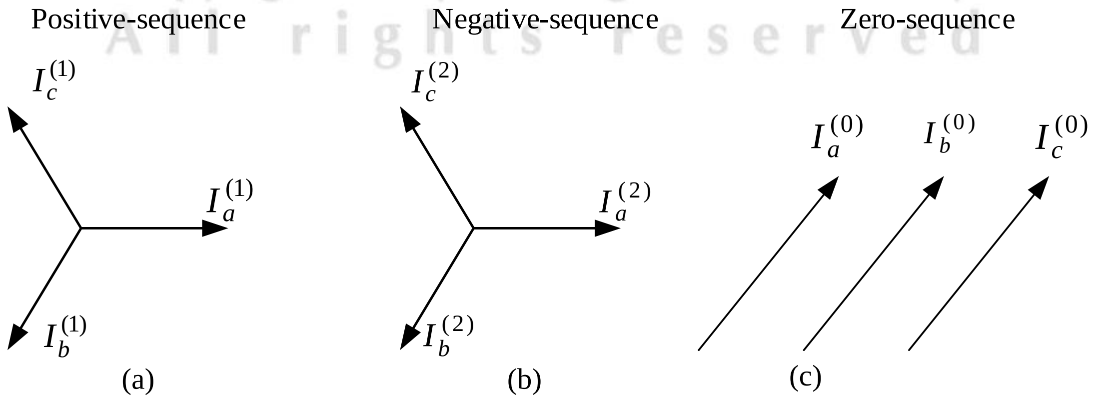

Figure 2.2 The symmetrical components of sequence (a), (b), and (c)

From the phase diagram in Figure 2.2 (a) positive-sequence component in Equations (2.1) as following.

$$\begin{aligned} I_a^{(1)} &= I_a^{(1)}\angle 0^\circ = I_a^{(1)} \\ I_b^{(1)} &= I_a^{(1)}\angle 240^\circ = a^2 I_a^{(1)} \\ I_c^{(1)} &= I_a^{(1)}\angle 120^\circ = aI_a^{(1)} \end{aligned} \tag{2.1}$$

Where

$I_a^{(1)}$ is the short-circuit current of the positive-sequence component phase a.

$I_b^{(1)}$ is the short-circuit current of the positive-sequence component phase b.

$I_c^{(1)}$ is the short-circuit current of the positive-sequence component phase c.

a is an operator value.

From the phase diagram in Figure 2.2 (b) negative-sequence components in Equations (2.2) as following.

$$\begin{aligned} I_a^{(2)} &= I_a^{(2)}\angle 0^\circ = I_a^{(2)} \\ I_b^{(2)} &= I_a^{(2)}\angle 240^\circ = a^2 I_a^{(2)} \\ I_c^{(2)} &= I_a^{(2)}\angle 120^\circ = aI_a^{(2)} \end{aligned} \tag{2.2}$$

Where

$I_a^{(2)}$ is the short-circuit current of the negative-sequence component phase a.

$I_b^{(2)}$ is the short-circuit current of the negative-sequence component phase b.

$I_c^{(2)}$ is the short-circuit current of the negative-sequence component phase c.

From the phase diagram in Figure 2.2 (c) Zero-sequence components in Equations (2.3) as following.

$$I_a^{(0)} = I_b^{(0)} = I_c^{(0)} \tag{2.3}$$

Where

$I_a^{(0)}$ is the short-circuit current of the zero-sequence component phase a.

$I_b^{(0)}$ is the short-circuit current of the zero-sequence component phase b.

$I_c^{(0)}$ is the short-circuit current of the zero-sequence component phase c.

To set an operator for easy to tell phase rotation in 120 angle by using symbol a, which is the vector unit in the same direction, it has the around the counter-clockwise as shown in Equations (2.4).

$$\begin{aligned} a &= 1\angle 120^\circ = -0.5 + j0.866 \\ a^2 &= 1\angle 240^\circ = -0.5 - j0.866 \\ a^3 &= 1\angle 360^\circ = 1 + j0 \end{aligned} \tag{2.4}$$

From the Equations (2.4) will get Equation (2.5).

$$1 + a + a^2 = 0 \tag{2.5}$$

When consider the short circuit current flowing through each phase, which will have the equation's symmetrical elements, as shown in Equations (2.6).

$$\begin{aligned} I_a &= I_a^{(0)} + I_a^{(1)} + I_a^{(2)} \\ I_b &= I_b^{(0)} + a^2 I_b^{(1)} + a I_b^{(2)} \\ I_c &= I_c^{(0)} + a I_c^{(1)} + a^2 I_c^{(2)} \end{aligned} \tag{2.6}$$

If is in the format of matrix, which show in the Equations (2.7).

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I_a^{(0)} \\ I_a^{(1)} \\ I_a^{(2)} \end{bmatrix} \tag{2.7}$$

From the Equations (2.7) will get Equations (2.8).

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \tag{2.8}$$

Therefore, we can write a new Equation (2.9) form Equations (2.7) and (2.8) as following.

$$I_{abc} = AI_a^{(012)} \tag{2.9}$$

From the Equation (2.9) can write in the format of inverse matrix A the Equation (2.10) as following.

$$I_a^{(012)} = A^{-1} I_{abc} \tag{2.10}$$

Which, inverse matrix A will have the value Equations (2.11) as following.

$$A^{-1} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \tag{2.11}$$

From the Equations (2.11) and (2.8) can write in the format of inverse matrix A the Equation (2.12) as following.

$$A^{-1} = \frac{1}{3} A^{*} \tag{2.12}$$

Bring A^{-1} value from the Equations (2.7) and (2.12) will be replaced to Equations (2.13) as following.

$$\begin{bmatrix} I_a^{(0)} \\ I_a^{(1)} \\ I_a^{(2)} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix}\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} \tag{2.13}$$

From the Equation (2.13) can write in the format symmetrical component of sequence, which show in Equations (2.14) as following.

$$\begin{aligned} I_a^{(0)} &= \frac{1}{3}(I_a + I_b + I_c) \\ I_a^{(1)} &= \frac{1}{3}(I_a + aI_b + a^2 I_c) \\ I_a^{(2)} &= \frac{1}{3}(I_a + a^2 I_b + aI_c) \end{aligned} \tag{2.14}$$

In the case occurs three-phase fault, which is short circuit symmetrical, as shown in Figure 2.3, which can write in equations in components sequence as shown in Figure 2.4.

So, will found three-phase fault occurrence. It flows in the symmetrical component of a sequence in Equations (2.15).

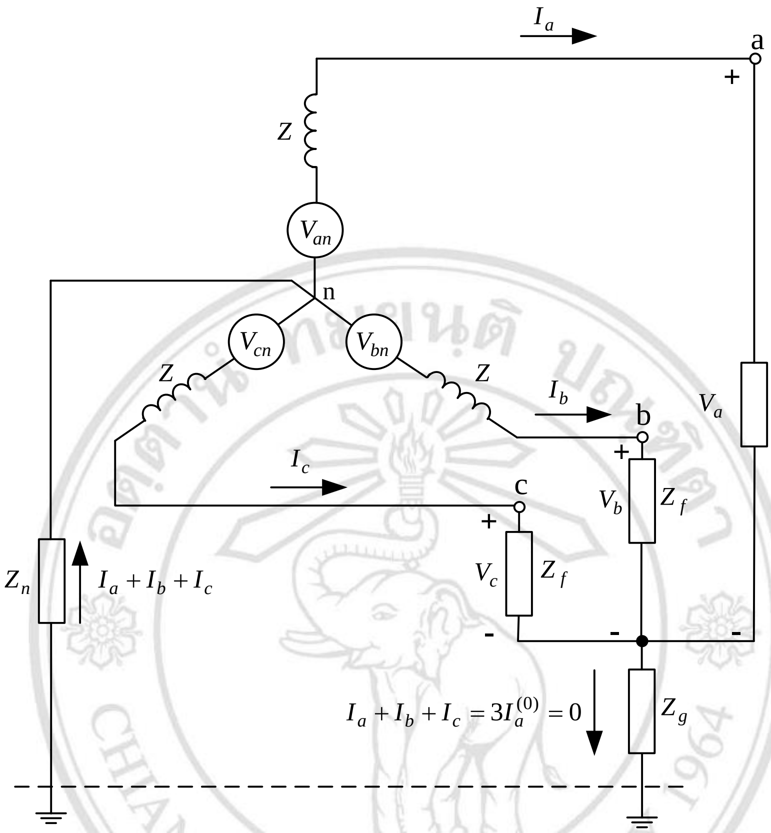

Figure 2.3 Three-phase fault occurrence

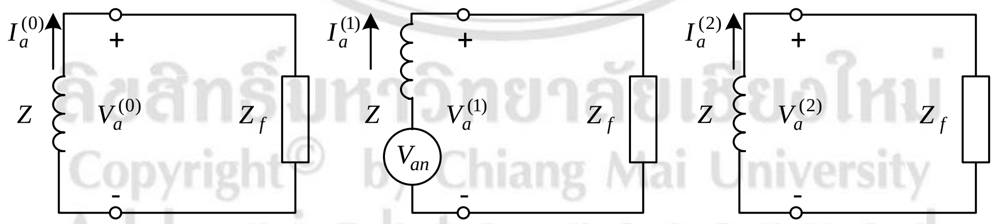

Figure 2.4 Circuit symmetrical component of sequence in three-phase fault

$$
\begin{aligned}
I_a^{(0)} &= 0 \\
I_a^{(1)} &= \frac{V_{an}}{Z + Z_f} \\
I_a^{(2)} &= 0
\end{aligned}
\qquad (2.15)
$$

Form of a matrix in the Equations (2.7), which can write a new Equations (2.16).

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} 0 \\ I_a^{(1)} \\ 0 \end{bmatrix} \tag{2.16}$$

From the Equations (2.16) can write in the format symmetrical component of sequence, which show in Equations (2.17) as following.

$$\begin{aligned} I_a &= I_a^{(1)} \\ I_b &= a^2 I_a^{(1)} \\ I_c &= a I_a^{(1)} \end{aligned} \tag{2.17}$$

From the Equations (2.17) will get the Equation (2.18) as following.

$$I_{3\phi,f} = I_a^1 = I_a = \frac{V_a^{(1)}}{Z_f} \tag{2.18}$$

Therefore, the size of three-phase fault, it will have value as shown in Equation (2.19).

$$I_{3\phi,f} = \frac{V_{an}}{Z_S + Z_f} \tag{2.19}$$

Where

$I_{3\phi,f}$ is a current in three-phase fault in the format of three phase.

Z_S is the supply impedance.

Z_f is value of short circuit impedance.

Or write in the format short-circuit current of line as shown in Equation (2.20):

$$I_{Line,f} = \frac{\sqrt{3} V_{an}}{Z_S + Z_f} \tag{2.20}$$

Where

$I_{Line,f}$ is a current in three-phase fault in the format of a phase.

2.2.2 Single phase to ground fault

Single phase to ground fault is occurring more frequently in an electrical distribution system. The circuit diagram shows single phase to ground fault (phase a) at point F is shown in Figure 2.5. The first step calculates the fault current, which has equations for phases a, b, and c in the terms of phase current and voltages to define the fault conditions. The next step is to apply the symmetrical component's method to provide the relation by which the fault current is calculated and to determine the interconnection of three sequence networks necessary to satisfy this relation.

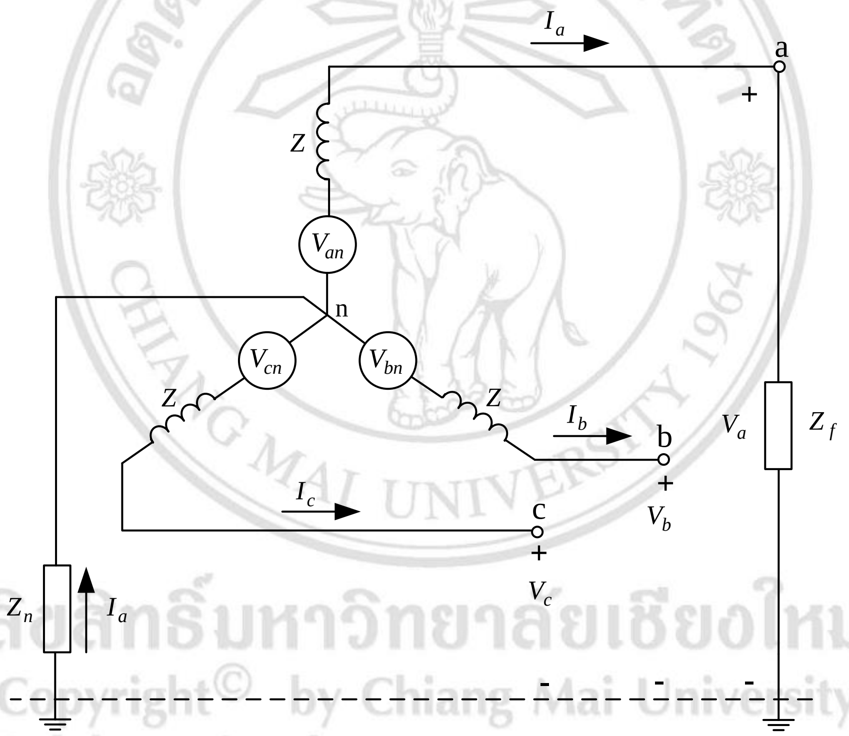

Figure 2.5 Single phase to ground fault occurrence (phase a)

Assigned Z_f is value of short circuit impedance, which shows in Equation (2.21) as following.

$$V_a = Z_f I_a \tag{2.21}$$

Which shows in Equation (2.22) as following.

$$I_b = I_c = 0 \tag{2.22}$$

From the Equations (2.16) can write in the format symmetrical component of sequence, when $I_b = I_c = 0$, will get the Equations (2.22) as following.

$$\begin{bmatrix} I_a^{(0)} \\ I_a^{(1)} \\ I_a^{(2)} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix}\begin{bmatrix} I_a \\ 0 \\ 0 \end{bmatrix} \tag{2.22}$$

Or Equation (2.23) as following.

$$I_a^{(0)} = I_a^{(1)} = I_a^{(2)} = \frac{1}{3} I_a \tag{2.23}$$

To get phase voltage values, which will be in the type of symmetrical components, we can write in Equation (2.24) as following.

$$V_a = V_a^{(0)} + V_a^{(1)} + V_a^{(2)} \tag{2.24}$$

From (Z) and (I) values, we can write in Equation (2.25) as following.

$$V_a = V_{an} - (Z^{(1)} + Z^{(2)} + Z^{(0)}) I_a^0 \tag{2.25}$$

To take an Equation (2.21) instead an Equation (2.25) and from an Equation (2.24), which will get $I_a = 3I_a^0$ instead an Equation at (2.25), it will be get an Equation (2.26) as following.

$$3Z_f I_a^0 = V_{an} - (Z^{(1)} + Z^{(2)} + Z^{(0)}) I_a^0 \tag{2.26}$$

Or from can write in Equation (2.27) as following.

$$I_a^0 = \frac{V_{an}}{Z^{(1)} + Z^{(2)} + Z^{(0)} + 3Z_f} \tag{2.27}$$

Therefore, to get value of short circuit current in the single phase to ground fault form an Equation (2.28) as following.

$$I_F = I_a = 3I_a^0 = \frac{3V_{an}}{Z^{(1)} + Z^{(2)} + Z^{(0)} + 3Z_f} \tag{2.28}$$

Therefore, we can write a circuit symmetrical component of sequence, while occurs short-circuit the single phase to ground fault, which shows in Figure 2.6.

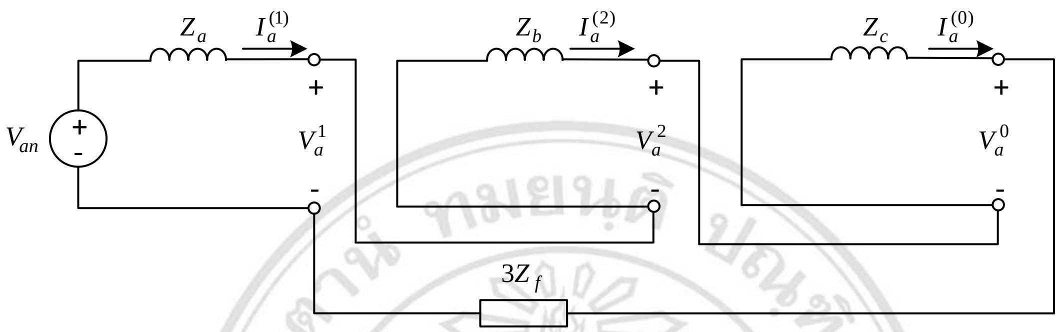

Figure 2.6 Circuit symmetrical component of sequence in single phase to ground fault (phase a)

2.3 Protection in the Distribution System

2.3.1 A fault occurrence in the electrical distribution system

When a fault occurrence in the electrical distribution system which affects the damage to electrical equipment. Especially, big power system, it has the current of a high short circuit which affects the power system such as thermal, electro-dynamic, voltage sags, and other causes [9].

1) Thermal effect where a high fault current flow result in system equipment (cables, machines, and transformer windings), so an overheating damage the insulation material and melt conductors.

2) Electro-dynamic is a cause electro-dynamic forces observed in the network equipment. The general an operator circuit breaker or the switching devices must be able to withstand the high dynamic force, while occurring the overload and fault in the system.

3) The voltage sags is lowered voltage from the normal in a short time. It is the often problem in the electrical system. It may lead to motor stopping and computer damage

The protection system must be fast enough to clear the fault at minimum operating correctly (reliable), disconnecting the minimum section of the network necessary to isolate the fault (selectivity), and ensuring coordination at cost as low as possible.

2.3.2 Components of the protection system

The protection system generally consists an important section as following [7].

1) The circuit breaker (CB) is a device that is used for the opening and closing. While, the electrical system is in normal and abnormal. To open circuit. Normally, it can make it whenever when needs to open a circuit, such as maintenance the electrical system, but when the system is in an abnormal such as a fault circuit. Circuit breaker must open quickly, but the Circuit breaker cannot be detected an abnormal itself, therefore, required must be devices to help detecting in an abnormal.

2) Protection or Overcurrent (OC) relay is a protection device that is designed for signal detector from current transformer and voltage transformer. Relay has the duty of detecting signal an animal by measuring electrical quantities at all times. When an electrical quantity measure exceeds the value. The relay to send signals to a circuit-breaker for opening the circuit out of the system.

3) Voltage transformer and current transformer (VT and CT) is a device that converts voltage or current that have high voltage or high current. It is converted into low voltage or low current, which will be to enter the call to signal with protection relay. In General, the standard output of current transformer is 1A or 5A and a voltage transformer is 110V or 120V.

4) Other protective equipment to be used for protection transmission line, motor, and generator or other protection equipment for electrical system, examples: Re-closer, fuse, and other.

2.3.3 Protection zone

In general, a power system can be divided into protection zones generators, transformers, groups of generator transformers, motors, and transmission lines.

Figure 2.7 shows a single diagram of Parallel networks in the single-end-fed system which was consisted four OC relays are used the N-1 security of the network [10].

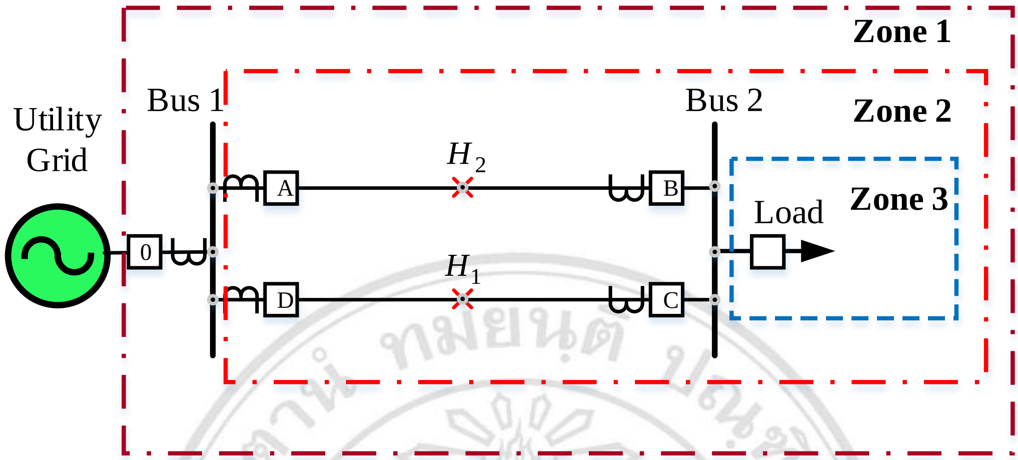

Figure 2.7 Protection zone of parallel network in the single-end-fed system

The purpose in the scope of protection is to divide the protection system into sections. Each of which is responsible for the protection of the area as a base. Called primary prevention (Primary Protection), which makes it possible to identify the location of the fault has caused problems. But when a problem occurs, the system fault protection with in the work itself does not need to be provided with protection, backup (Backup Protection). To get rid of the faults of the system. Dividing Range Input The same principle is as follows.

1) The protection covers the entire circuit system. Thus, all parts of the electrical system will be in the scope of protection and at least one zone.

2) The relay is in the scope of protection of its own. To can disconnect the circuit before the relay in the scope of protection before the backup operation. The relays are set to be in the area adjacent. It's set in the time sequence (coordinating time interval: CTI). I will be considering zone2, because the zone 2 section is part an important to power supply in the electrical distribution system. Explain the circuit in Figure 2.8.

3) Figure 2.8 shows the OC relay the setting around the clockwise loop and around the counter-clockwise loop. It will show the operating time of OC relay A, B, C, and D respectively. Relay C protected a fault occurrence at point H1 is backup from

relay A in Figure 5 and relay B protected a fault occurrence at point H2 is a backup from relay D in Figure 2.8.

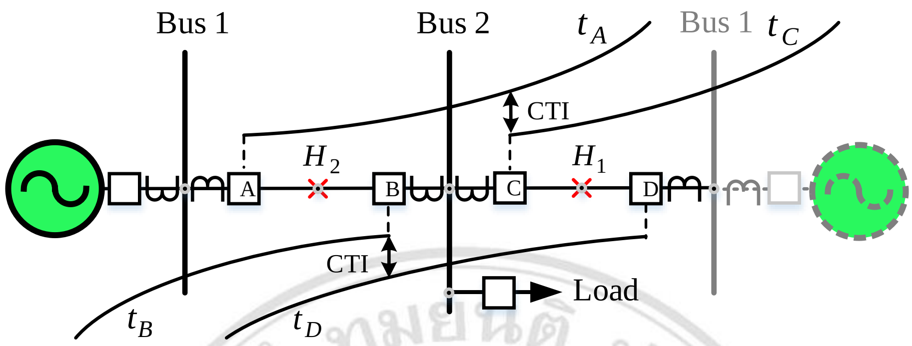

Figure 2.8 Scope protection in direction the clockwise loop and the counter-clockwise loop

CTI is operated time between two protective devices (backup and primary). The coordination range of coordinating time interval used between 0.2 to 0.5 s which depends on the degree of reliability system [9].

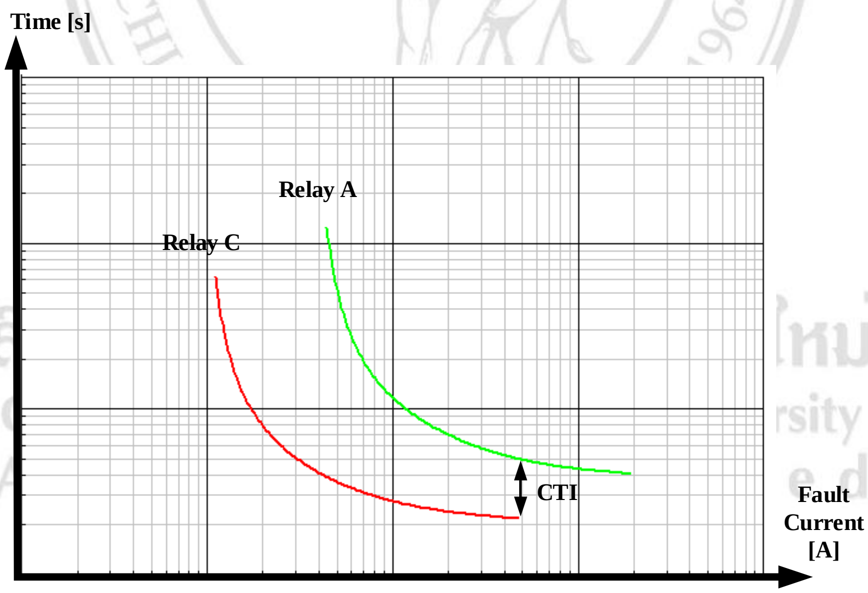

Figure 2.9 Criteria of coordination in the clockwise loop

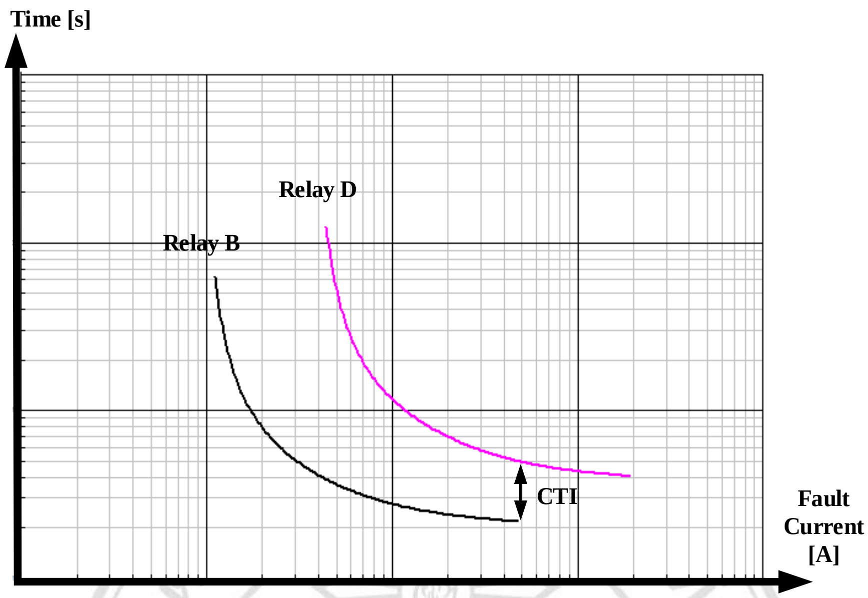

Figure 2.10 Criteria of coordination in the counter-clockwise loop

2.3.4 Case in scope the protection zone

We can separate each case in the protection zone as following.

Case 1: If occur fault in distance from F1 to H1 as Figure 2.11, a short circuit current is will flow into F1 fault point. So, the relay R_A is backup of relay R_C, it must operate to open the circuit breakers (A) at point immediately for the protection at point line 1.

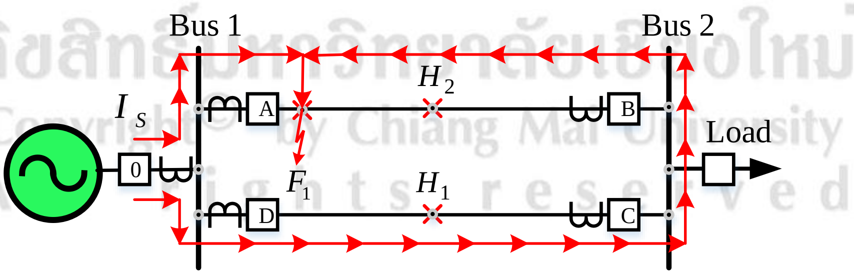

Figure 2.11 Case occur fault in distance from F1 to H1

Case 2: If occur fault in distance from F2 to H1 as Figure 2.12, a short circuit current is will flow into F2 fault point. So, the relay R_B is primary of relay R_D, it must operate to open the circuit breakers (B) at point immediately for the protection at point line 1.

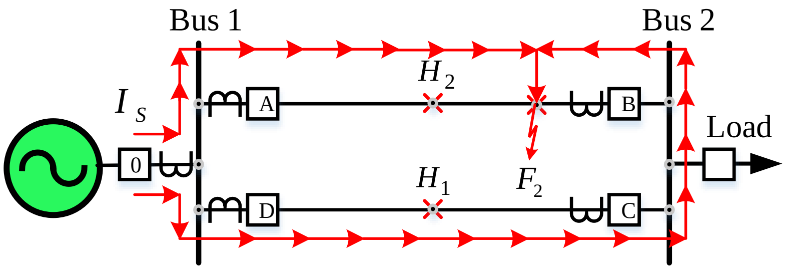

Figure 2.12 Case occur fault in distance from F2 to H1

Case 3: If occur fault in distance from F3 to H2 as Figure 2.13, a short circuit current is will flow into F3 fault point. So, the relay R_C is primary of relay R_D, it must operate to open the circuit breakers (C) at point immediately for the protection at point line 2.

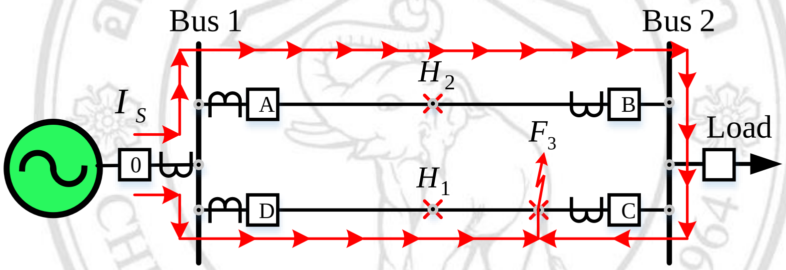

Figure 2.13 Case occur fault in distance from F3 to H2

Case 4: If occur fault in distance from F4 to H2 as Figure 2.14, a short circuit current is will flow into F4 fault point. So, the relay R_D is backup of relay R_B, it must operate to open the circuit breakers (D) at point immediately for the protection at point line 2.

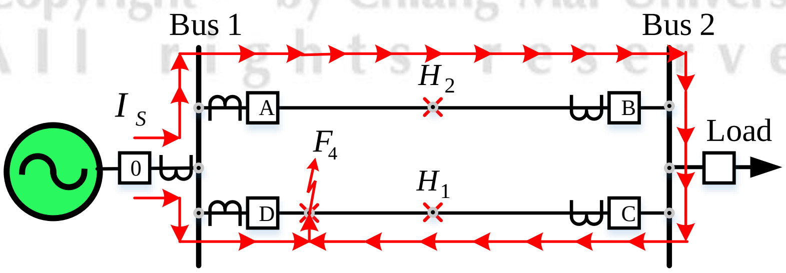

Figure 2.14 Case occur in distance from F4 to H2

Case 5: If occur fault in F_{BUS} as Figure 2.15, a short circuit current Is will flow into Bus 2 fault point. So, the relay R_B is primary of relay R_D, and R_C is primary of relay RA, they must operate to open the circuit breakers (B and C) at point immediately for the protection at Bus 2.

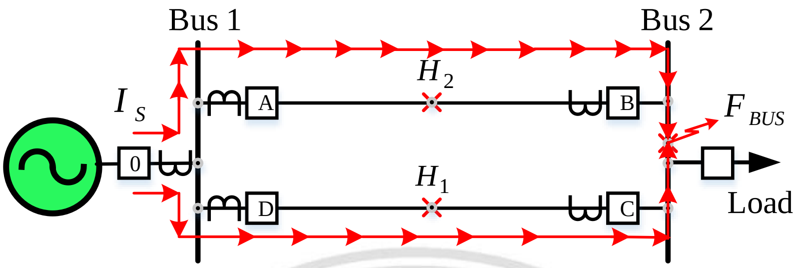

Figure 2.15 Case occur fault in F_{BUS}

2.4 Overcurrent protection devices in the power distribution system

When there was a short circuit in the electrical distribution system, which may cause damage from over-current, so to protect damage occurrence, the protection devices are mostly in the electrical distribution system consisted Fuses, (Re) closer, and OC relays.

2.4.1 Overcurrent relays

The OC is a protection device that is designed for signal detector from current transformer that has the duty of detecting signal an animal by measuring electrical quantities at all times. When an electrical quantity measure exceeds the value. The relay to send signals to a circuit-breaker for opening the circuit out of the system. The OC relays were classified into the principal 3 group as instantaneous, definite time and inverse time in Table 2.1 [11].

1) Definite-Current Protection or Instantaneous OC Relays: This relay to work immediately when the current exceeds a predetermined value. Generally, this type of relay is deployed near a sub-station that is far from source, which has the over-current low. This relay is working to disconnect the circuit immediately by without delay. The disadvantage of this type of relay. When the transmission line's impedance is low. When a short circuit in the sub-station is far away, the device for protection will operate in the area near the sub-station.

2) Definite-Time Protection: This relay is activated when the current exceeds a predetermined time. The relay will be operated the time and the overcurrent

protection in the area near the sub-station. A time set up gradually fast when away from a sub-station away. The disadvantage of this type of relay. When a short circuit near the power station and the size of the short circuit current is high. Relays may be working slowly, which may make equipment damage.

3) Inverse-Time Protection: This relay has the characteristics in working, which operate on time and as part of the currents. That is, the short circuit current is very high. Time will operate very fast. But, if the short circuit current is very low. During the work, it would be more lasting. Inverse-Time OC Relays were classified into the group by graphing feature a variety of each type is suitable for applications in various cases.

Table 2.1 Inverse-Time OC Relays [9] characteristics

The type of OC protection relays	Usage characteristics	Area protection
Moderately Inverse OC Relays	To use for systems that supply the internal resistance is not constant. Example: line protection has to supply in parallel network.	Transmission line and electrical distribution systems
Very Inverse OC Relays	To use the protection ground wire in the supply system.	
Extremely Inverse OC Relays	To use for protection in the distribution system. The relay will have to work with (Re) closer and fuse or use the system with the increases loads and may be expanded load in the future.	
Inverse OC Relays	To use as a backup protective device in a system	
Modified Inverse OC Relays	To use protect for line-phase and line grounding.	
Modified Very Inverse OC Relays	To use for systems that supply the internal resistance is constant. The relay will take advantage of this type of work less.	

The moderately inverse is used in this study because the internal resistances of the supply system are not constant. It will proper protection in the parallel network. This characteristic of the OC relay show in Table 2.2. The standard equation of the OC relay is expressed in Equation (2.29) [11].

$$t(s) = TD \times \left[\frac{a}{\left(I_{FC} / I_{CS} \right)^{c} - 1} \right] + b \tag{2.29}$$

Where

t (s) is operation time of relay in seconds,

TD or T_{pset} is time dial,

I_{FC} is fault current or I_{SC}

I_{CS} is current setting, and

a, b, c are constants of the selected curve characteristics.

Table 2.2 *a, b, c* are constants [11] of the selected curve characteristics

Characteristics of OC Relay	standard	constants		
		a	b	c
Moderately inverse	IEEE	0.0515	0.114	0.02
Very inverse	IEEE	19.61	0.491	2.0
Extremely inverse	IEEE	28.2	0.1217	2.0
Inverse	CO8	5.95	0.18	2.0
Short-time inverse	CO2	0.0239	0.0169	0.02
Standard inverse	IEC	0.14	0	0.02
Very inverse	IEC	13.5	0	1
Extremely inverse	IEC	80.0	0	2.0
Long-time inverse	UK	120	0	1.0

Type of over-current protection relay, which has characteristics of graph as shown in Figure 2.16**.**

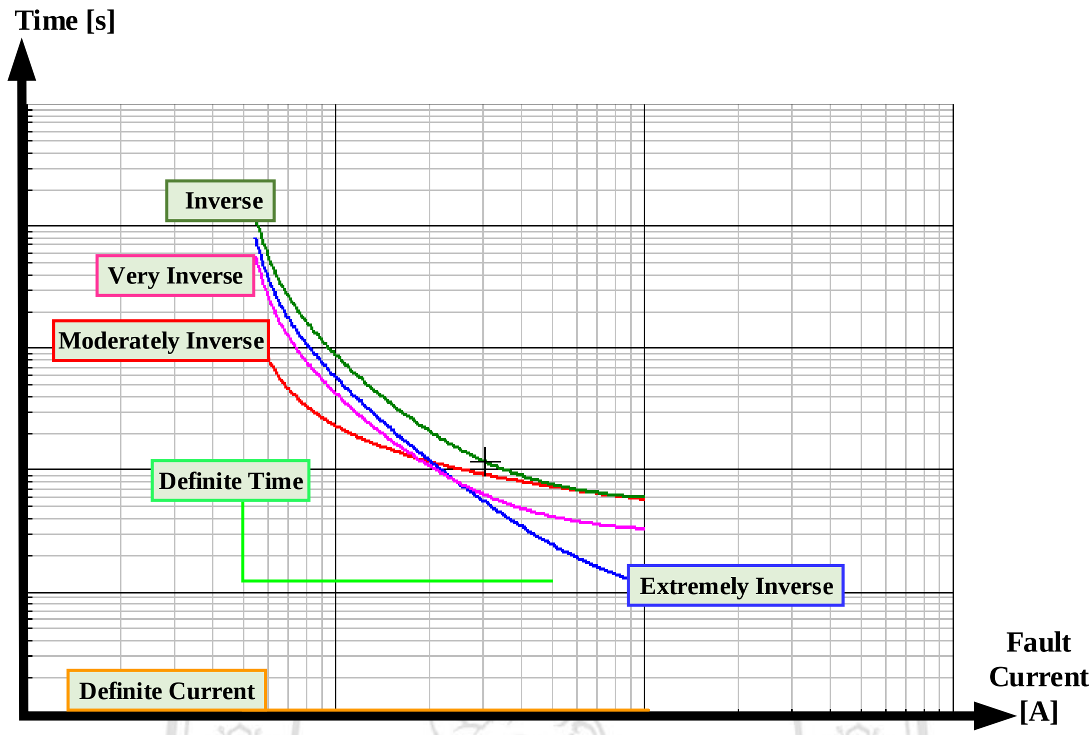

Figure 2.16 Characteristics of graph operate of the type relays

To set the operation of the OC protection relay, which show the parameters that are an important as following [11].

1) Time Dial Setting (TDS)

The adjustable distance between contacts on not moving with the contacts on moving. This value controls the contacts in both the near and far. Since the operating time of the relay is prescribed in the setting relay. If you set the number higher. The operating time of OC relay has been a long time as shown in Figure 2.17.

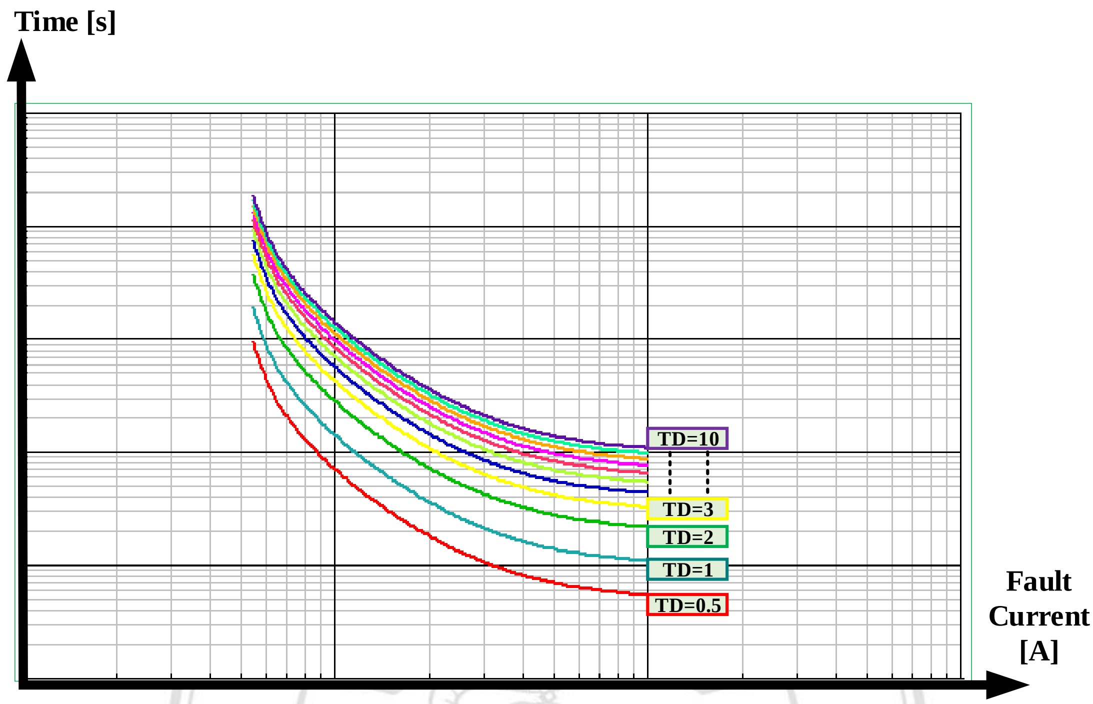

Figure 2.17 The graph shows the time dial setting of relays

2) Pick-Up Current Setting

Setting the start operation of OC relays. The current configuration of the relay starts. OC and short circuit current of the relay is detected, which is a multiple of the current work in normal conditions. This value is indicated by the ratio of short circuit currents began to work in normal conditions, which can find start operation. It will be pick-up current setting as shown in Equation (2.30).

$$I_{CS} = (OLF \times I_{nom}) \div CTR \quad (2.30)$$

Where

I_{CS} or $I_{Pick\text{-}up}$ is determined by allowing a margin for overload above the nominal current,

OLF is overload factor that depends on the element being protected,

I_{nom} is nominal circuit current rating,

CTR is CT ratio of current transformer.

2.5 Contingency Analysis

In general terms can be defined as CA evaluated the safety of the electrical system. CA typically involves the analysis of a system malfunction. This is a major problem in both the planning and operational. Common Criteria is the obligation is extinguished as of any system components (power line transformers or reactor) and assesses the state of contingency. This so-called N-1 security criteria other obligations to be considered a failure along the lines of a circuit in the building of the road. Failure of the generator, the largest in the area and contingency line will analyze any connectivity with the rest of the system [13].

2.5.1 Characteristics of Contingency analysis

Contingency analysis is used to monitor the status of network failure after one (N - 1) or component (N - k). Therefore, the load must be carried out for each of the selected contingency. In this article, involves the most basic CA, but is typically used to analyze contingency defined. Power-Factory CA module offers two ways to analyze contingency [13].

1) Single Time-Phase CA: To evaluate the effects of failure under the obligation that is defined within a single period. Here is just one load flow post-crash analysis per contingency.

2) Multiple Time-Phase CA: Impact assessment of the crash under a given obligation. It is conducted over different time periods. Each of which is defined as the time elapsed after the contingency. It is the definition of the offense after the effective.

In both cases, load current shortcomings advance, the fault is compared to the load rating, the voltage specified, and reports generated from the comparison between the load current shortcomings. Before and after the fault in PowerFactory 15.1. The word is used to determine if a defective contingency. The second concept must be defined in order to understand the function of this module [13].

Contingencies: The object of class PowerFactory function ComOutage which is used to display these commitments. They set the series of events in which the defect start time and sentenced to wash and defective operation as shown in Figure 2.18 and Figure 2.19.

Time Phases: This represents the point in time when the stability of the network under analysis calculations. Over a period of time after a user-defined contingency. In times of contingency imposed after the end of the term that is calculated in part of the network.

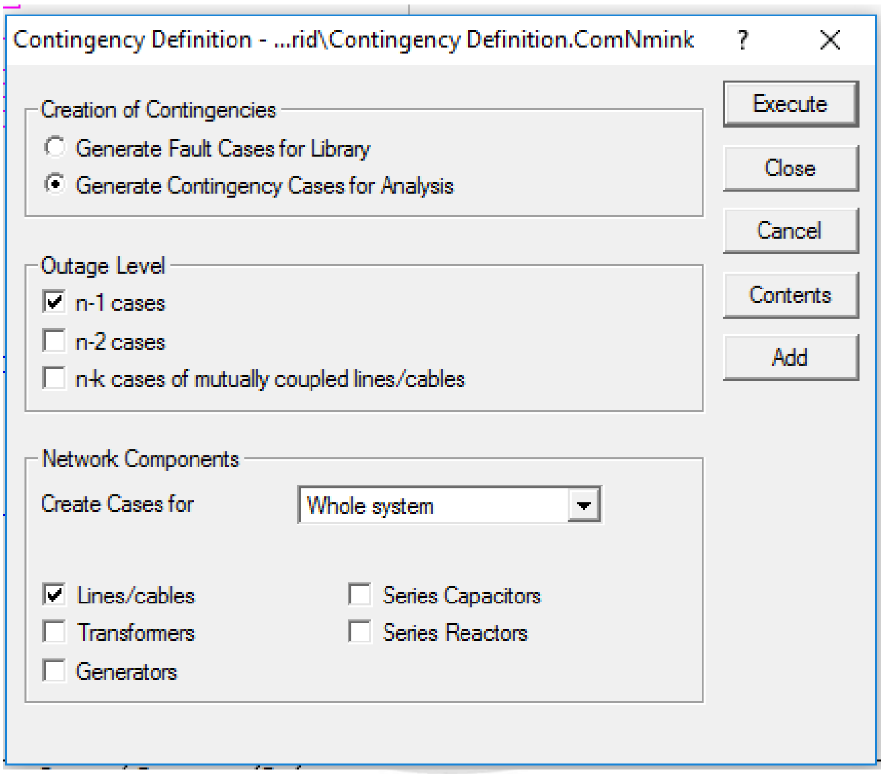

Figure 2.18 Contingency definition by used PowerFactory 15.1

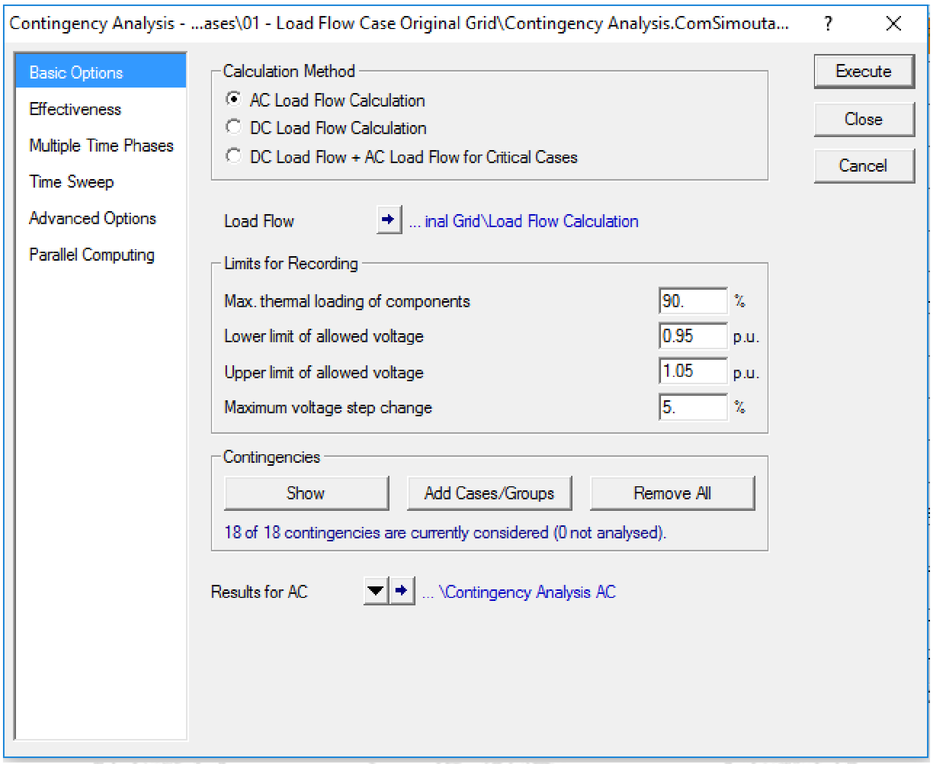

Figure 2.19 Contingency analysis by used PowerFactory 15.1

2.5.2 Outage electricity problems

From Figure 2.20 shows the electrical supply into a normal load by passing parallel network in the single-end-fed system. It is the N-1 security of the network. I_{LF} is flow current of generation supply into the network, I_{LF1} and I_{LF2}, they are flow current by passing into the network load.

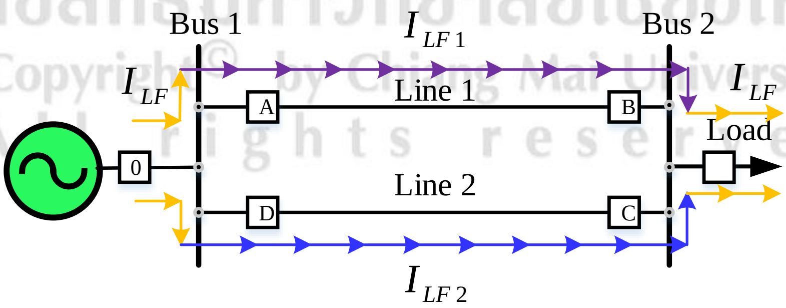

Figure 2.20 Flowing of current in parallel network

The cause of max overload in the network occurs the unexpected event. The most outage electricity problems occur from overloading of network and fault occurrence in the system, which can separate each the cause of max overload in the network as following.

Case 1: The CBs at line 1 (A and B) operate to open, because occur the unexpected event such as overloading of network and fault occurrence in the system. So this cause of flow current into max overload in the network line 2, which is continues result, the problem operate to open the CBs of line 2 (C and D). It is as shown in Figure 2.21 and Figure 2.22.

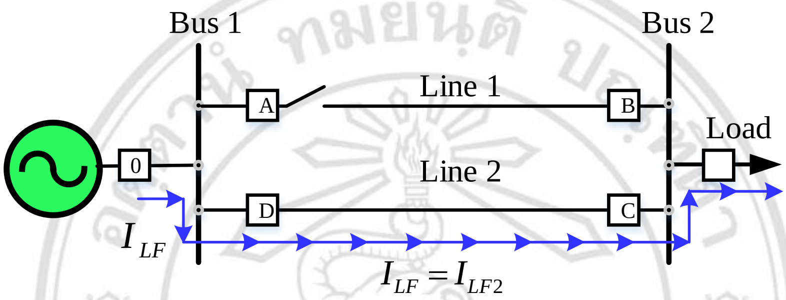

Figure 2.21 Flowing current max in the network line 2 (CBs A open)

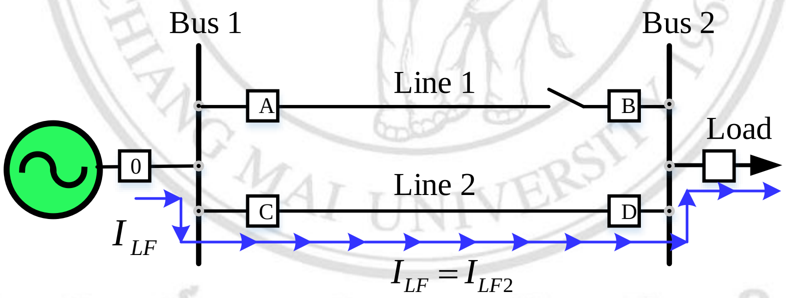

Figure 2.22 Flowing current max in the network line 2 (CBs B open)

Case 2: The CBs at line 1 (C and D) operate to open, because occur the unexpected event such as overloading of network and fault occurrence in the system. So this cause of flow current into max overload in the network line 1, which is continues result, the problem operate to open the CBs of line 1 (A and B). They are as shown in Figure 2.23 and Figure 2.24.

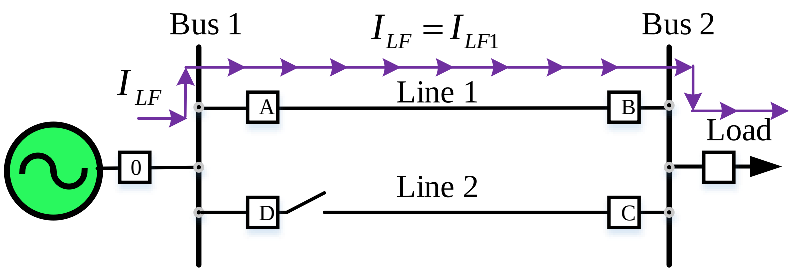

Figure 2.23 Flowing current max in the network line 1 (CBs D open)

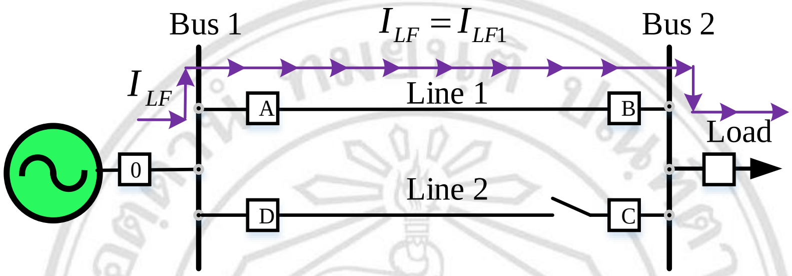

Figure 2.24 Flowing current max in the network line 1 (CBs C open)