CHAPTER 4

The Study Results

4.1 Analysis System Results

4.1.1 Results of conditional contingency analysis

The WAP can protect by many the methods. This case study analyzed the system problem by setting the proper OC relay together with conditional the CA in the abnormal network (N-1). The network will support the outage problem on a wide area in the future if it has occurrence event such as the overloading problem and the fault occurrence the network in Figure 4.1.

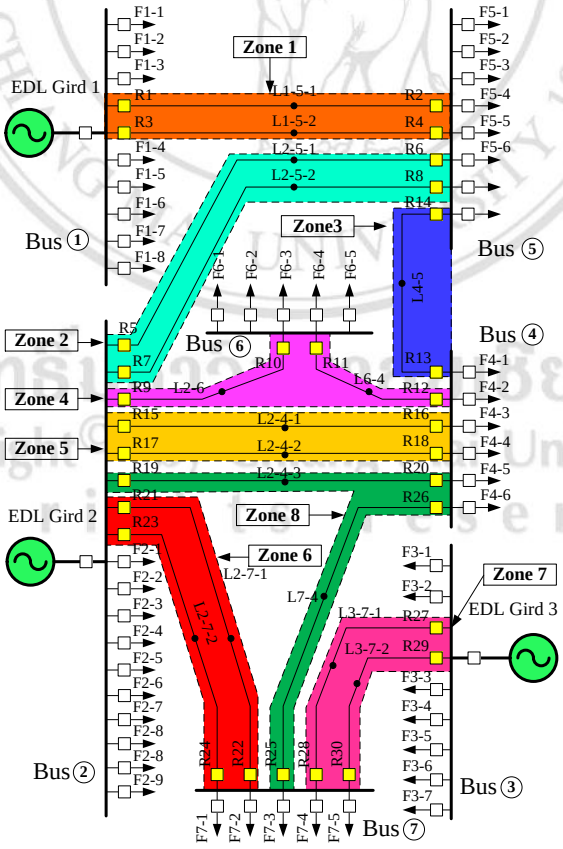

Figure 4.1 Single line diagram of the distribution system

4.1.1.1 Analysis system before improvement the network

The analysis result shows the load flow and CA in conditional (N-1) the networks in Table 4.1.

Table 4.1 Result of analysis before improvement the system

Networks No	Load flow			Contingency Analysis Condition [%]	
	P [MW]	Q [MVAR]	I [kA]	Normal Load	Overloading [N-1]
L1-5-1	1.947779	1.848663	0.073047	13.91378	21.39162
L1-5-2	1.821554	2.149041	0.076615	14.59334	22.43781
L2-5-1	8.749882	3.440262	0.253838	48.35018	67.0068
L2-5-2	8.647043	2.359335	0.241993	46.09388	64.61646
L4-5	9.500603	2.088256	0.268505	51.14387	73.02277
L2-6	14.60112	3.799829	0.407224	77.56651	101.3466
L6-4	-4.44865	-0.09396	0.123315	23.48863	103.3527
L2-4-1	17.87925	7.479876	0.523182	49.82685	66.22072
L2-4-2	17.87925	7.479876	0.523182	49.82685	66.22072
L2-7-1	6.215479	2.869343	0.184859	35.21131	52.18937
L2-7-2	6.156457	3.696549	0.193907	36.93471	52.18937
L3-7-1	8.289597	-0.33075	0.223336	42.54025	56.18056
L3-7-2	8.681845	0.594659	0.234266	44.62205	56.18056
L2-4-3	17.87925	7.479876	0.523182	49.82685	66.22072
L7-4	1.414203	-1.05995	0.048856	9.305954	19.21956

From the analysis results of the networks in Table 4.1 show the overloading problem in conditional (N-1) that are more than 90 %. The overloading feeders consist L2-6 and L6-4 that are equal to 101.34% and 103.35 % respectively. These networks will not support the outage problem with a wide area in the future if it has an

event occurrence such as the overloading problem and the fault occurrence in the network. Therefore, the model built line thesis can be upgraded the new feeder NL2-6 for carrying out the complete relay coordination for substation in Figure 4.2.

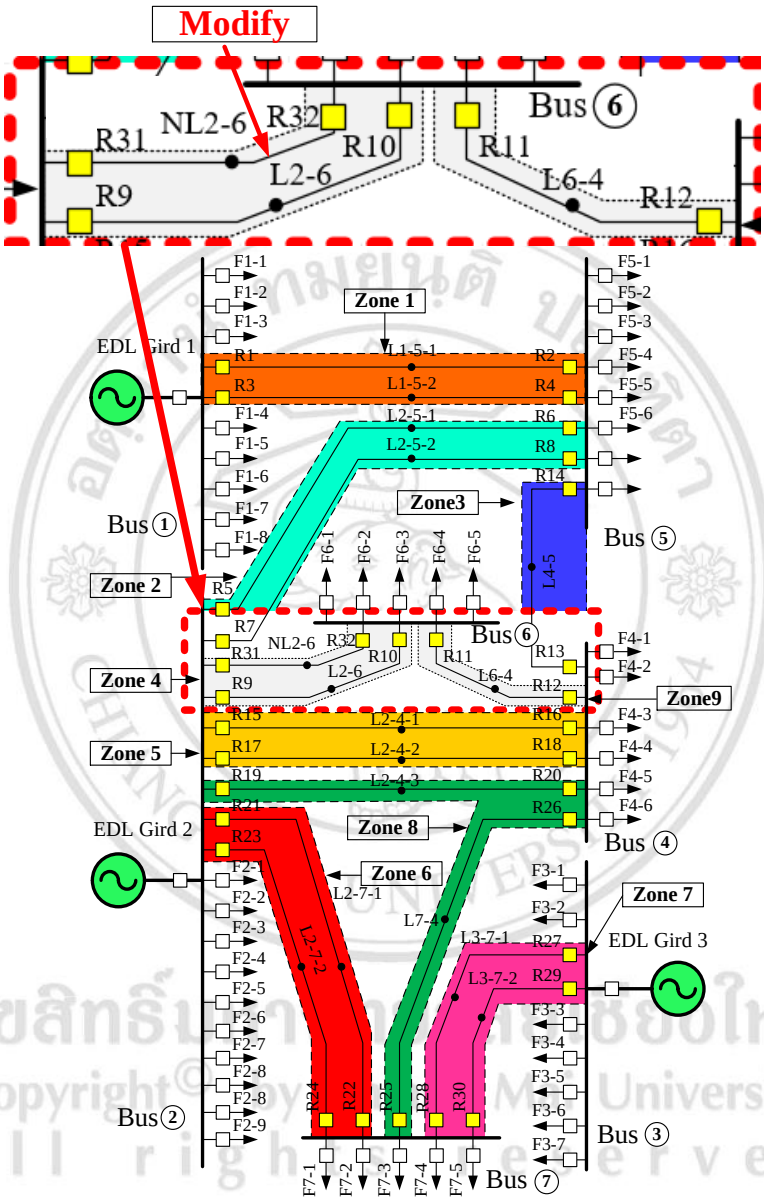

Figure 4.2 New single line diagram, after improvement of the distribution system

4.1.1.2 Contingency analysis after improvement the network

The analysis result after the network was improved in Figure 4.2, shows the load flow and over-loading in the conditional (N-1) in the feeder L2-6 and L6-4 in Table 4.2.

Table 4.2 Result of analysis after improvement the system

Networks No	Load flow			Contingency Analysis Condition [%]	
	P [MW]	Q [MVAR]	I [kA]	Normal Load	Overloading [N-1]
L1-5-1	1.874036	1.826744	0.071204	13.56259	21.38382
L1-5-2	1.747137	2.117828	0.074681	14.22493	22.42963
L2-5-1	8.591051	3.374508	0.249191	47.46498	67.01001
L2-5-2	8.48974	2.31337	0.237562	45.24998	63.88289
L4-5	9.957146	2.224426	0.281221	53.5659	75.09909
L2-6	9.33538	1.974987	0.257558	49.05866	78.12639
NL2-6	9.511276	3.117305	0.270166	51.46012	78.12639
L6-4	-0.16295	1.239115	0.034483	6.568158	22.85444
L2-4-1	16.72176	7.024605	0.489605	46.62905	61.38059
L2-4-2	16.72176	7.024605	0.489605	46.62905	61.38059
L2-7-1	6.051258	2.825105	0.180331	34.3488	50.89151
L2-7-2	5.990217	3.631812	0.189157	36.02997	50.89151
L3-7-1	8.22469	-0.35682	0.22161	42.21141	55.73859
L3-7-2	8.617112	0.560124	0.232455	44.27711	55.73859
L2-4-3	16.72176	7.024605	0.489605	46.62905	61.38059
L7-4	0.968694	-1.18436	0.042275	8.052336	15.83408

❖ Figure 4.3 shows the result from CA before and after improvement the feeder L2-6 and L6-4.

❖ Before improvement, the overloading in conditional (N-1) which is more than 90 %, consists L2-6 and L6-4 that are equal to 101.34 % and 103.35 % respectively.

❖ After improvement, the network was improved by building new feeder NL2-6 in Figure 6. The feeder L2-6, NL2-6 and L6-4 have less than 90 % of overloading in conditional (N-1) that are equal 78.12 %, 78.12 % and 22.85 % respectively.

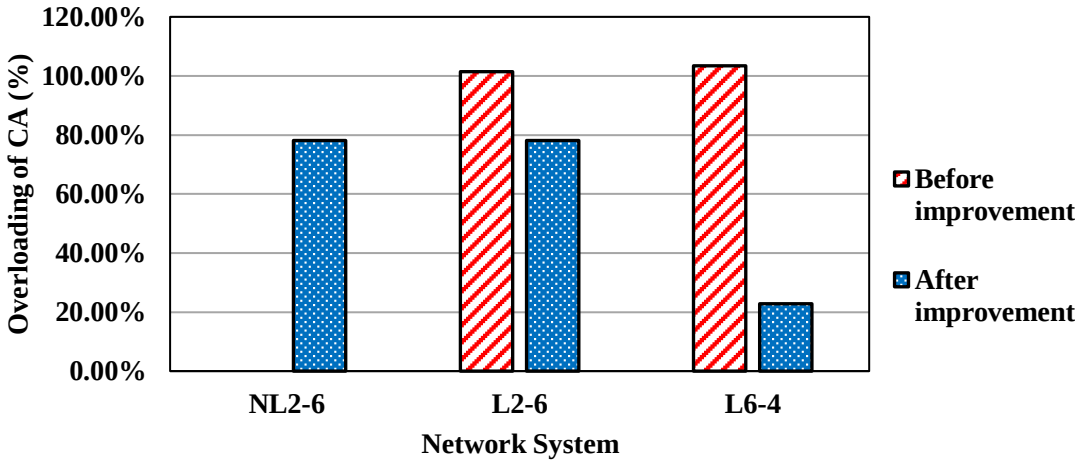

Figure 4.3 Overloading of contingency analysis (CA) before and after improvement the network

4.2 Result Protection Zones

4.2.1 The coordination time in the case 3 phase fault

4.2.1.1 The protection in zone 1

The protection zone 1 which consists OC relay as follows R1, R4, R3, and R2 that will operate the operating time of relays respectively. If the feeder L1-5-1 and L1-5-2 occur on the fault current in protection zone 1. The results of the coordination of R1, R4, R3, and R2 are shown in Figure 4.4 and Figure 4.5.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R1, R4, R3, and R2 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.4 and Figure 4.5.

Figure 4.4 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L1-5-2, which operate as follows:

1) The backup OC relay R1 operates at the fault current to reaching predestined value that is equal approximately 1930.896 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec. A and 1.70 respectively. The operation time (t) of the OC relay R1 is equal 0.604s.

2) The primary OC relay R4 operates on the fault current reaching predestined value that is equal approximately 16405.329 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec.A and 1.56 respectively. The operation time (t) of the OC relay R4 is equal 0.327s. Therefore, the CTI of R1 with R4 is equal 0.277s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

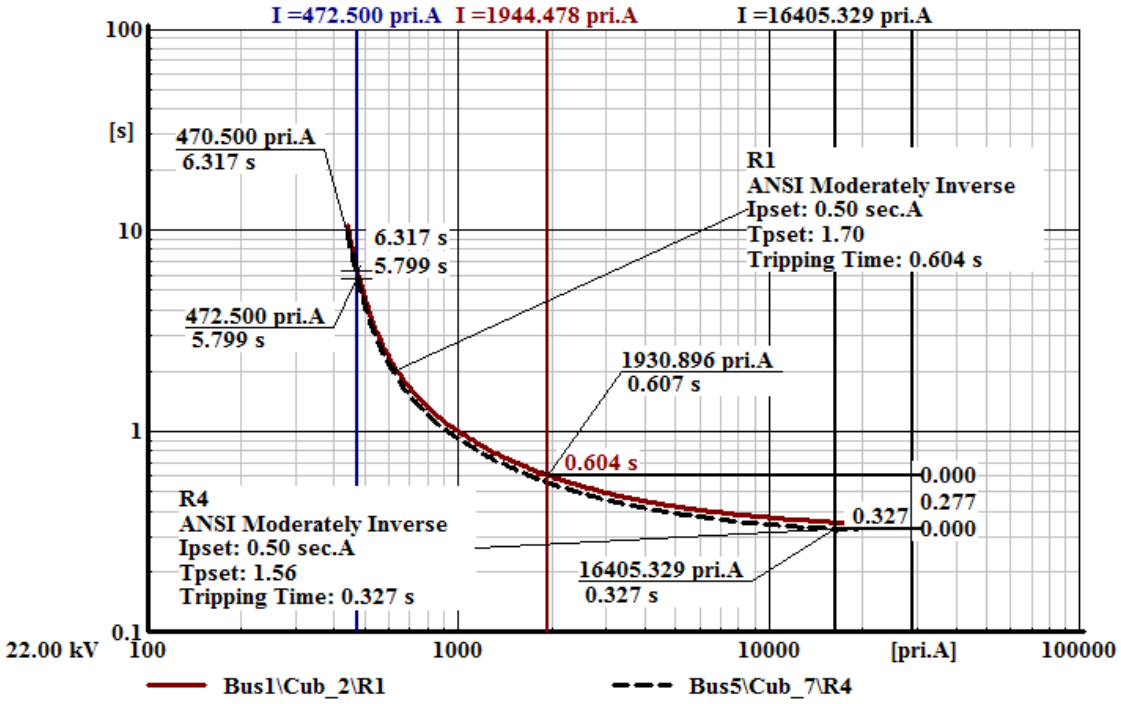

Figure 4.4 The coordination time of OC relay R1 and R4

Figure 4.5 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L1-5-1, which operate as follows:

1) The backup OC relay R3 operates at the fault current to reaching predestined value that is equal approximately 2039.662 pri. A. The current settings of I

pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec. A and 1.70 respectively. The operation time (t) of the OC relay R3 is equal 0.589s.

2) The primary OC relay R2 operates on the fault current reaching predestined value that is equal approximately 16474.883 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec.A and 1.48 respectively. The operation time (t) of the OC relay R2 is equal 0.312s. Therefore, the CTI of R3 with R2 is equal 0.277s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

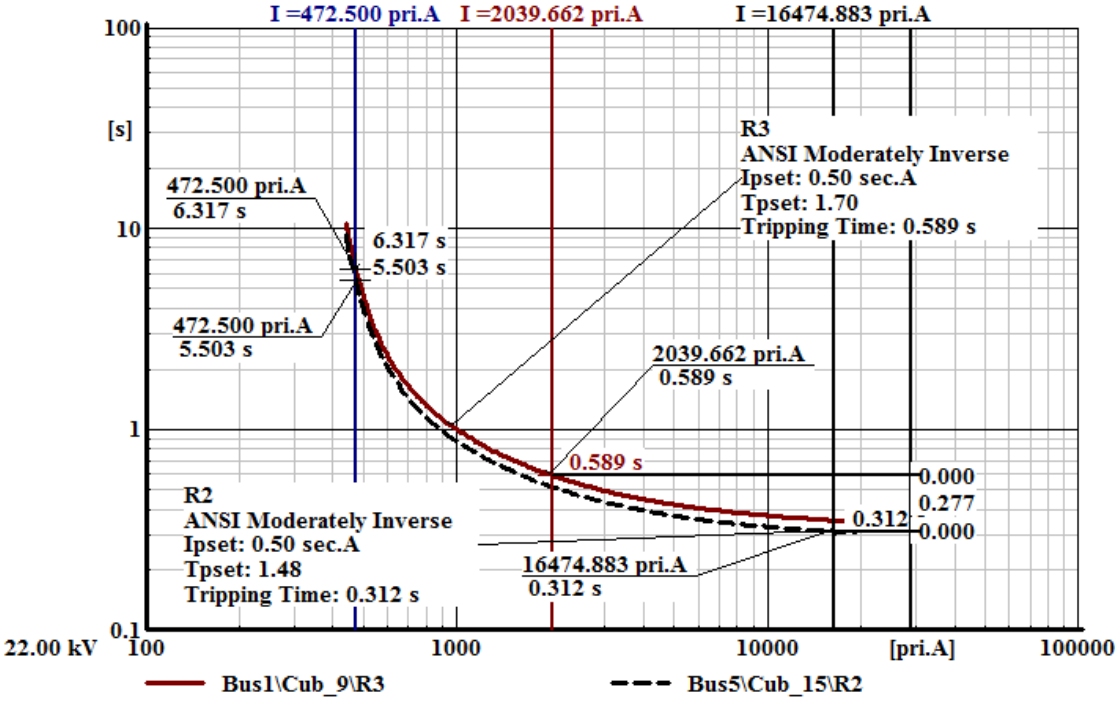

Figure 4.5 The coordination time of OC relay R3 and R2

4.2.1.2 The protection in zone 2

The protection zone 2 which consists OC relay as follows R5, R8, R7, and R6 that will operate the operating time of relays respectively. If the feeder L2-5-1 and L2-5-2 occur on the fault current in protection zone 2. The results of the coordination of R5, R8, R7, and R6 are shown in Figure 4.6 and Figure 4.7.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R5, R8, R7, and R6

operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.6 and Figure 4.7.

Figure 4.6 shows the coordination of OC relay at the protection zone 2 that occur on the fault at network L1-5-2, which operate as follows:

1) The backup OC relay R5 operates at the fault current to reaching predestined value that is equal approximately 3504.232 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.30 respectively. The operation time (t) of the OC R5 is equal 0.623s.

2) The primary OC relay R8 operates on the fault current reaching predestined value that is equal approximately 15086.416 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.03 respectively. The operation time (t) of the OC relay R8 is equal 0.418s. Therefore, the CTI of R5 with R8 is equal 0.205s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

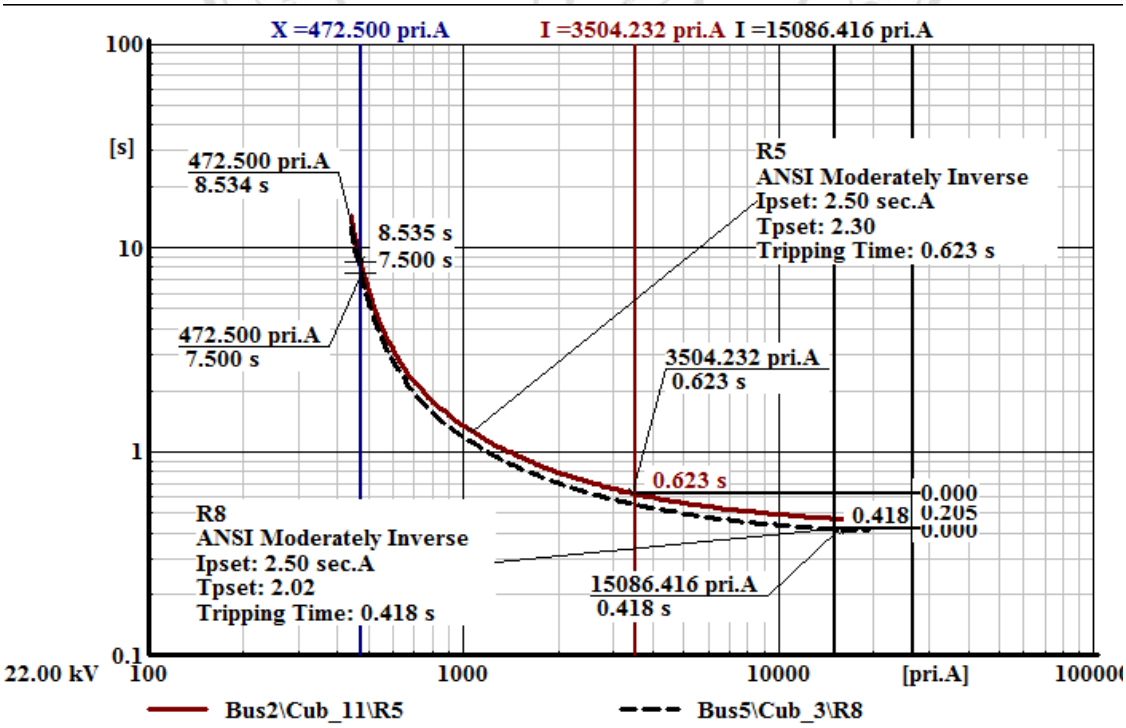

Figure 4.6 The coordination time of OC relay R5 and R8

Figure 4.7 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L2-5-1, which operate as follows:

1) The backup OC relay R7 operates at the fault current to reaching predestined value that is equal approximately 3340.703 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.30 respectively. The operation time (t) of the OC relay R7 is equal 0.633s.

2) The primary OC relay R6 operates on the fault current reaching predestined value that is equal approximately 14915.484 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.03 respectively. The operation time (t) of the OC relay R6 is equal 0.431s. Therefore, the CTI of R7 with R6 is equal 0.202s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

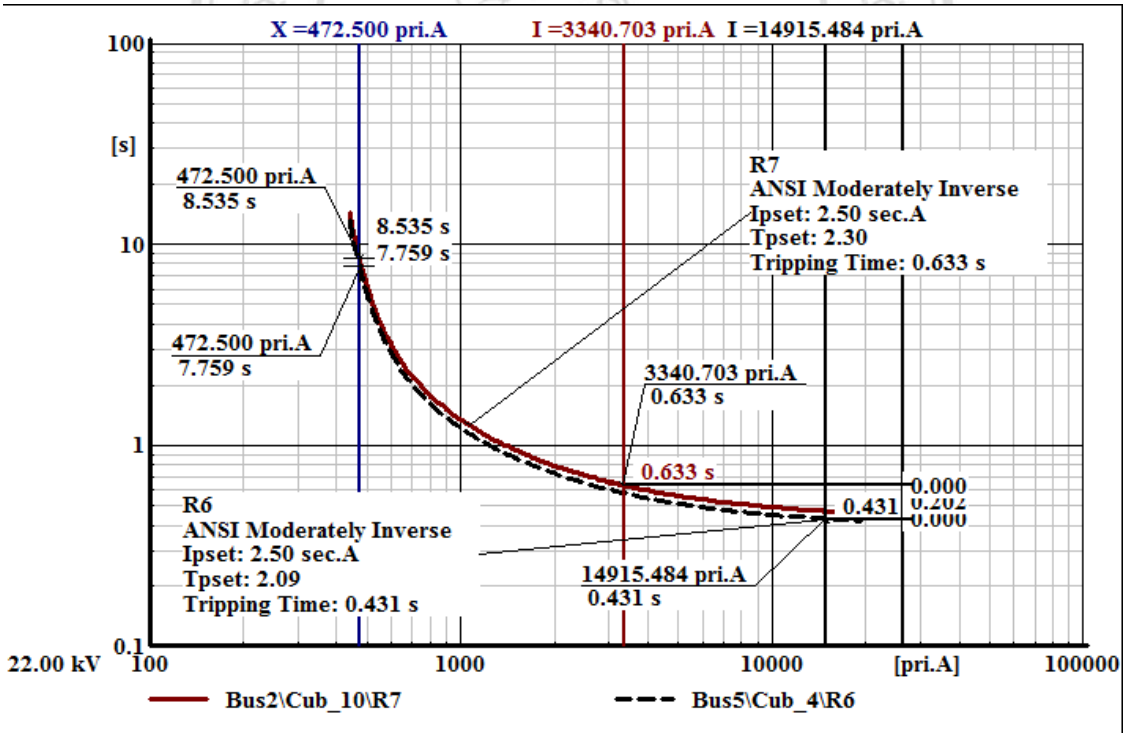

Figure 4.7 The coordination time of OC relay R7 and R6

4.2.1.3 The protection in zone 3 and zone 9

The protection zone 3 and zone 9 which consists OC relay as follows R11, R13, R14, and R12 that will operate the operating time of relays respectively. If the

feeder L4-5 and L6-4 occur on the fault current in protection zone 3 and zone 9. The results of the coordination of R11, R13, R14, and R12 are shown in Figure 4.8 and Figure 4.9Figure 4.5.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R11, R13, R14, and R12 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.8 and Figure 4.9.

Figure 4.8 shows the coordination of OC relay at the protection zone 3 and zone 9 that occur on the fault at network L4-5, which operate as follows:

1) The backup OC relay R11 operates at the fault current to reaching predestined value that is equal approximately 3379.488 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec. A and 1.95 respectively. The operation time (t) of the OC relay R11 is equal 0.549s.

2) The primary OC relay R13 operates on the fault current reaching predestined value that is equal approximately 28877.664 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec.A and 1.95 respectively. The operation time (t) of the OC relay R13 is equal 0.299s. Therefore, the CTI of R11 with R13 is equal 0.250s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

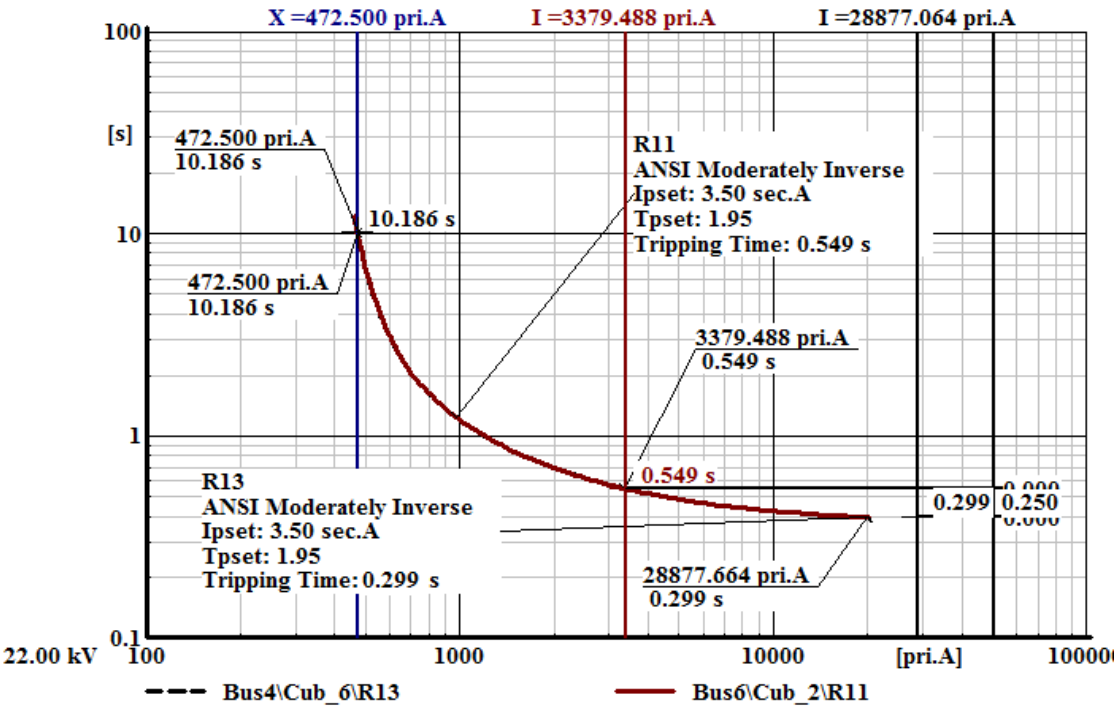

Figure 4.8 The coordination time of OC relay R11 and R13

Figure 4.9 shows the coordination of OC relay at the protection zone 3 and zone 9 that occur on the fault at network L6-4, which operate as follows:

1) The backup OC relay R14 operates at the fault current to reaching predestined value that is equal approximately 3874.106 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec. A and 2.00 respectively. The operation time (t) of the OC relay R14 is equal 0.536s.

2) The primary OC relay R12 operates on the fault current reaching predestined value that is equal approximately 30048.377 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec.A and 2.00 respectively. The operation time (t) of the OC relay R12 is equal 0.283s. Therefore, the CTI of R14 with R12 is equal 0.253s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

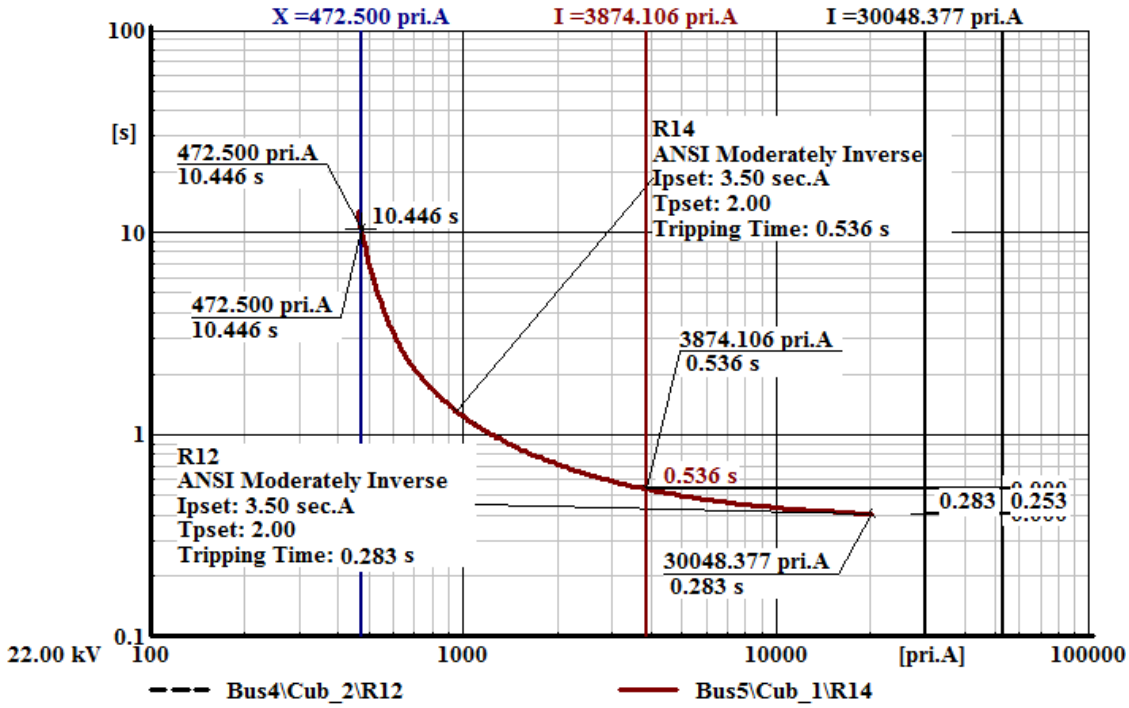

Figure 4.9 The coordination time of OC relay R14 and R12

4.2.1.4 The protection in zone 4

The protection zone 4 which consists OC relay as follows R31, R10, R9, and R32 that will operate the operating time of relays respectively. If the feeder L2-6 and NL2-6 occur on the fault current in protection zone 4. The results of the coordination of R31, R10, R9, and R32 are shown in Figure 4.10 and Figure 4.11.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R31, R10, R9, and R32 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.4 and Figure 4.5.

Figure 4.10 shows the coordination of OC relay at the protection zone 4 that occur on the fault at network L2-6, which operate as follows:

1) The backup OC relay R31 operates at the fault current to reaching predestined value that is equal approximately 5880.766 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 3.00 respectively. The operation time (t) of the OC relay R31 is equal 0.696s.

2) The primary OC relay R10 operates on the fault current reaching predestined value that is equal approximately 13449.118 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.08 respectively. The operation time (t) of the OC relay R10 is equal 0.434s. Therefore, the CTI of R31 with R10 is equal 0.262s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

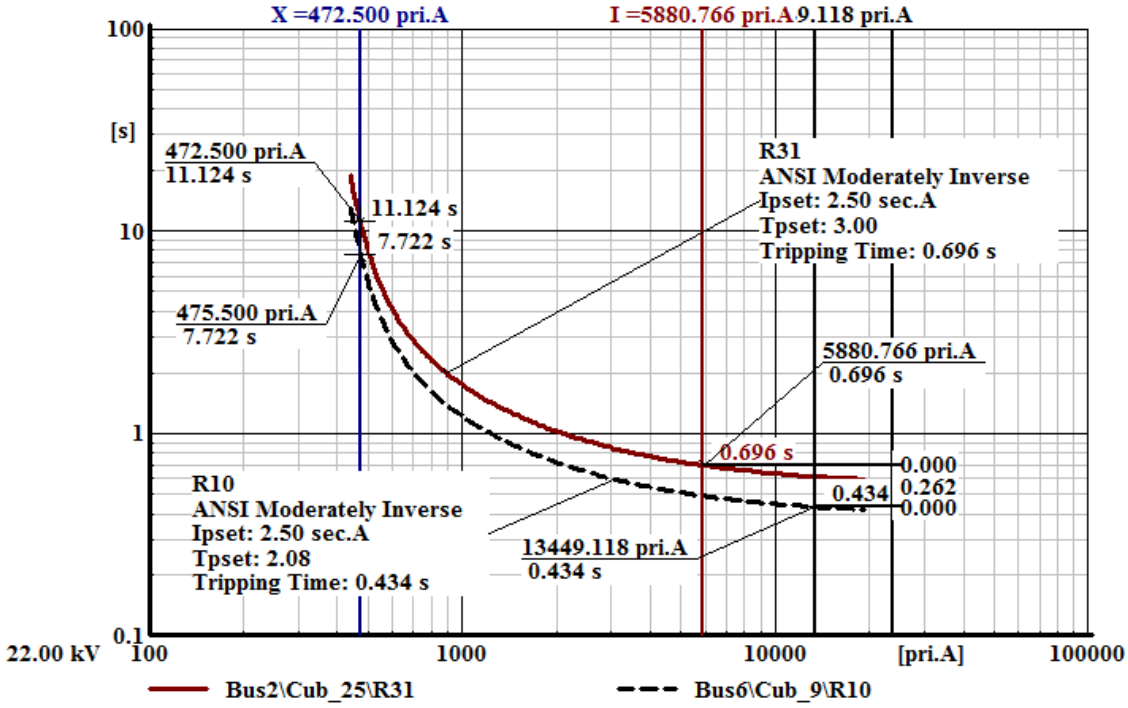

Figure 4.10 The coordination time of OC relay R31 and R10

Figure 4.11 shows the coordination of OC relay at the protection zone 4 that occur on the fault at network NL2-6, which operate as follows:

1) The backup OC relay R9 operates at the fault current to reaching predestined value that is equal approximately 6168.633 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 3.00 respectively. The operation time (t) of the OC relay R9 is equal 0.689s.

2) The primary OC relay R32 operates on the fault current reaching predestined value that is equal approximately 13731.109 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.03 respectively. The operation

time (t) of the OC relay R32 is equal 0.423s. Therefore, the CTI of R9 with R32 is equal 0.266s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

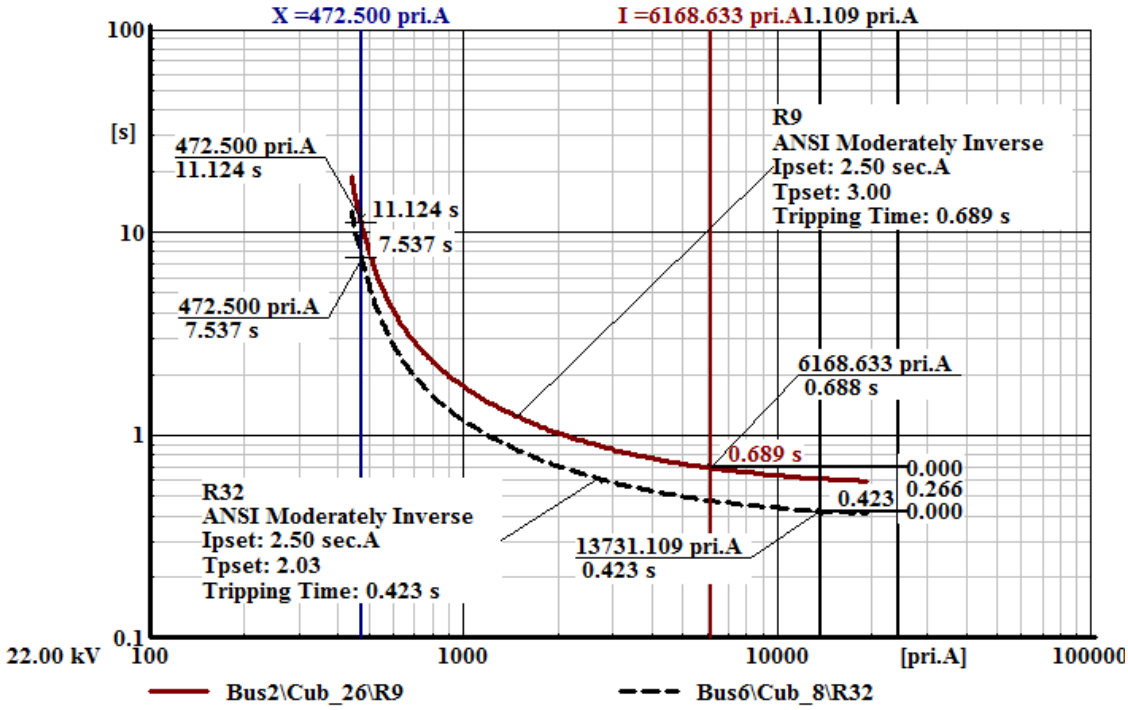

Figure 4.11 The coordination time of OC relay R9 and R32

4.2.1.5 The protection in zone 5

The protection zone 5 which consists OC relay as follows R15, R18, R17, and R16 that will operate the operating time of relays respectively. If the feeder L2-4-2 and L2-4-1 occur on the fault current in protection zone 5. The results of the coordination of R15, R18, R17, and R16 are shown in Figure 4.12 and Figure 4.13.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R15, R18, R17, and R16 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.12 and Figure 4.13.

Figure 4.12 shows the coordination of OC relay at the protection zone 5 that occur on the fault at network L2-4-2, which operate as follows:

1) The backup OC relay R15 operates at the fault current to reaching predestined value that is equal approximately 7484.493 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 3.10 respectively. The operation time (t) of the OC relay R15 is equal 0.685s.

2) The primary OC relay R18 operates on the fault current reaching predestined value that is equal approximately 26023.428 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.28 respectively. The operation time (t) of the OC relay R18 is equal 0.458s. Therefore, the CTI of R15 with R18 is equal 0.227s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

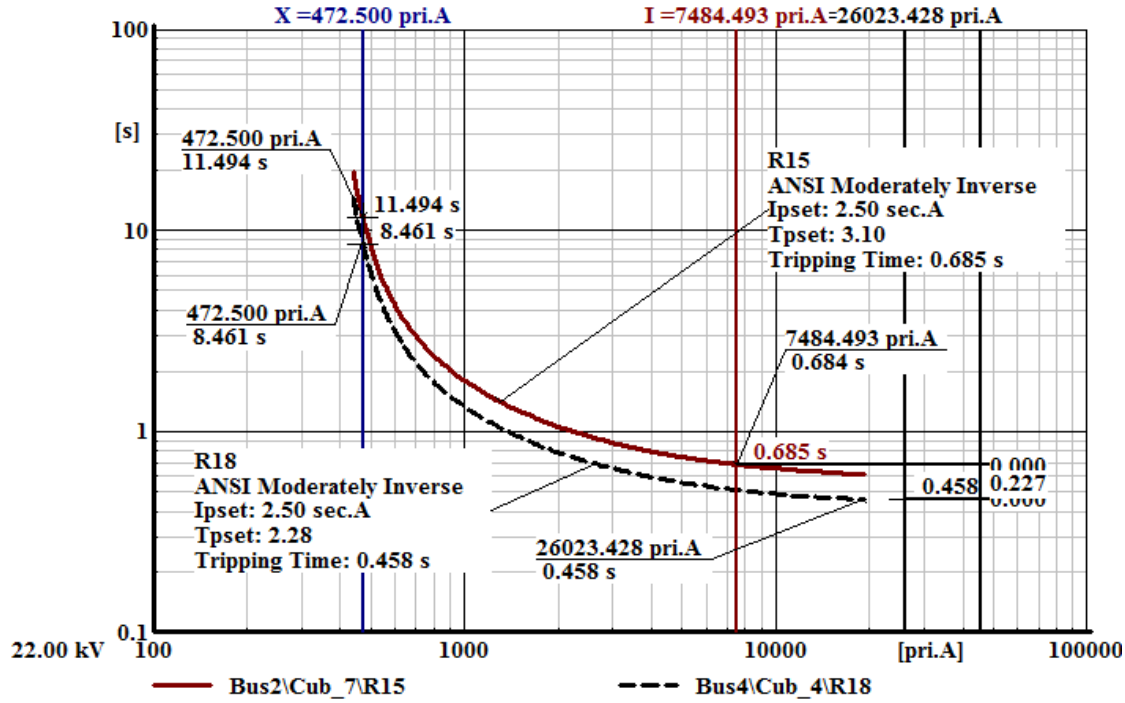

Figure 4.12 The coordination time of OC relay R15 and R18

Figure 4.13 shows the coordination of OC relay at the protection zone 5 that occur on the fault at network L2-4-1, which operate as follows:

1) The backup OC relay R17 operates at the fault current to reaching predestined value that is equal approximately 7484.493 pri. A. The current settings of I

pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 3.10 respectively. The operation time (t) of the OC relay R17 is equal 0.685s.

2) The primary OC relay R16 operates on the fault current reaching predestined value that is equal approximately 26023.428 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.28 respectively. The operation time (t) of the OC relay R16 is equal 0.458s. Therefore, the CTI of R17 with R16 is equal 0.227s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

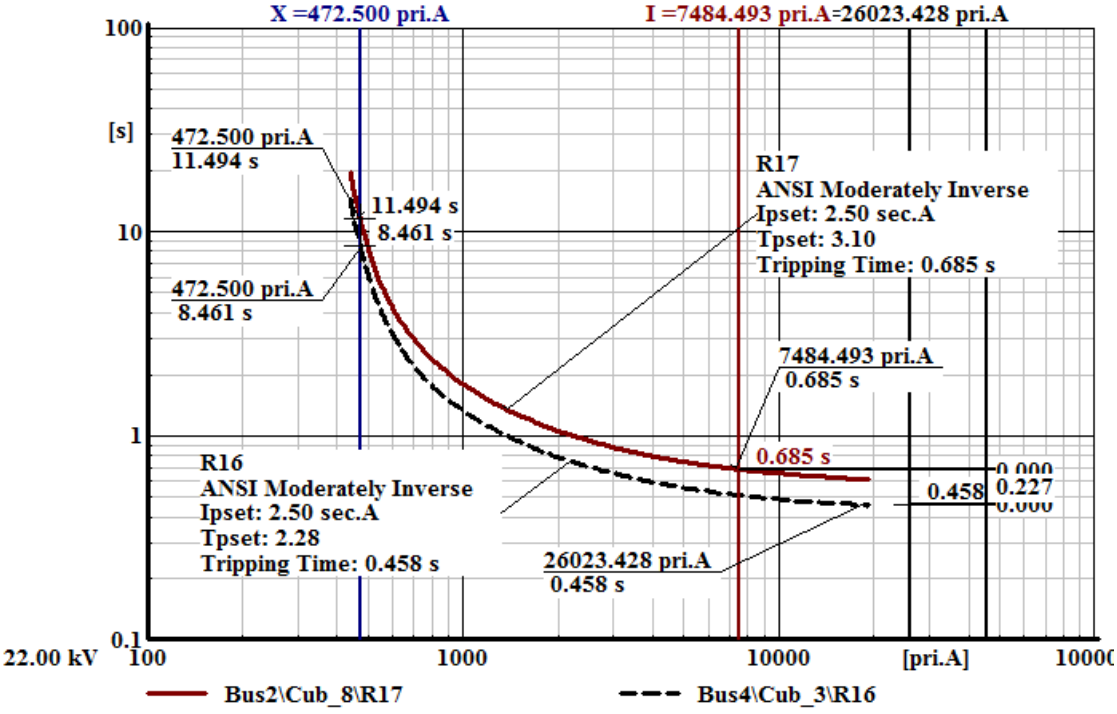

Figure 4.13 The coordination time of OC relay R17 and R16

4.2.1.6 The protection in zone 6

The protection zone 6 which consists OC relay as follows R21, R24, R23, and R22 that will operate the operating time of relays respectively. If the feeder L2-7-2 and L2-7-1 occur on the fault current in protection zone 6. The results of the coordination of R21, R24, R23, and R22 are shown in Figure 4.14 and Figure 4.15.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R21, R24, R23, and R22

operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.14 and Figure 4.15.

Figure 4.14 shows the coordination of OC relay at the protection zone 6 that occur on the fault at network L2-7-2, which operate as follows:

1) The backup OC relay R21 operates at the fault current to reaching predestined value that is equal approximately 4594.158 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 3.20 respectively. The operation time (t) of the OC relay R21 is equal 0.787s.

2) The primary OC relay R24 operates on the fault current reaching predestined value that is equal approximately 15346.400 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.20 respectively. The operation time (t) of the OC relay R24 is equal 0.451s. Therefore, the CTI of R21 with R24 is equal 0.336s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

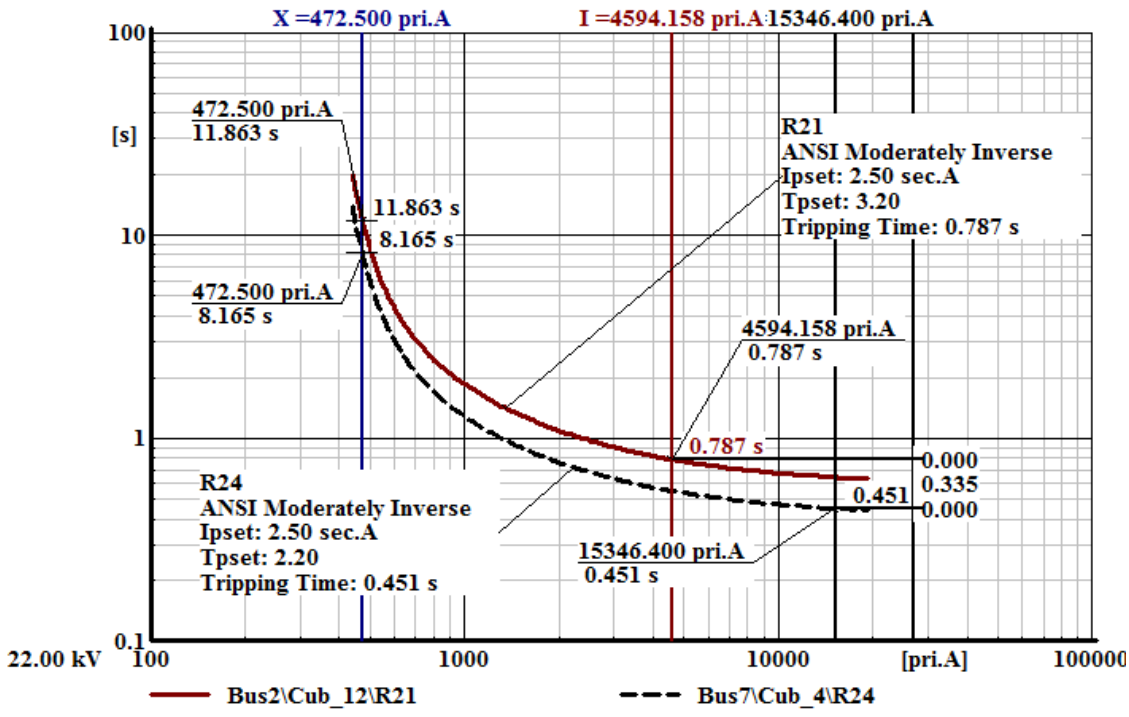

Figure 4.14 The coordination time of OC relay R21 and R24

Figure 4.15 shows the coordination of OC relay at the protection zone 6 that occur on the fault at network L2-7-1, which operate as follows:

1) The backup OC relay R23 operates at the fault current to reaching predestined value that is equal approximately 4819.044 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 3.20 respectively. The operation time (t) of the OC relay R23 is equal 0.777s.

2) The primary OC relay R22 operates on the fault current reaching predestined value that is equal approximately 15580.935 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.20 respectively. The operation time (t) of the OC relay R22 is equal 0.451s. Therefore, the CTI of R23 with R22 is equal 0.326s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

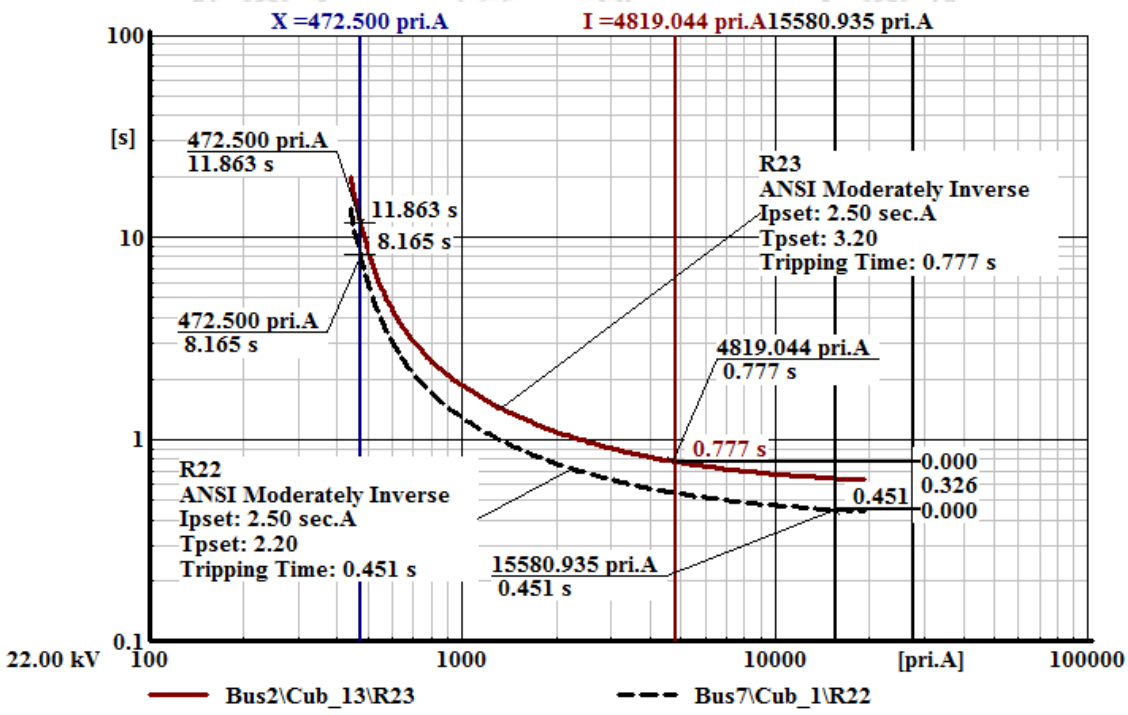

Figure 4.15 The coordination time of OC relay R23 and R22

4.2.1.7 The protection in zone 7

The protection zone 7 which consists OC relay as follows R27, R30, R29, and R28 that will operate the operating time of relays respectively. If the feeder L3-

7-2 and L3-7-1 occur on the fault current in protection zone 7. The results of the coordination of R27, R30, R29, and R28 are shown in Figure 4.16 and Figure 4.17.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R27, R30, R29, and R28 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.16 and Figure 4.17.

Figure 4.16 shows the coordination of OC relay at the protection zone 7 that occur on the fault at network L3-7-2, which operate as follows:

1) The backup OC relay R27 operates at the fault current to reaching predestined value that is equal approximately 2256.590 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.50 respectively. The operation time (t) of the OC relay R27 is equal 0.809s.

2) The primary OC relay R30 operates on the fault current reaching predestined value that is equal approximately 17817.551 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.29 respectively. The operation time (t) of the OC relay R30 is equal 0.463s. Therefore, the CTI of R27 with R30 is equal 0.346s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

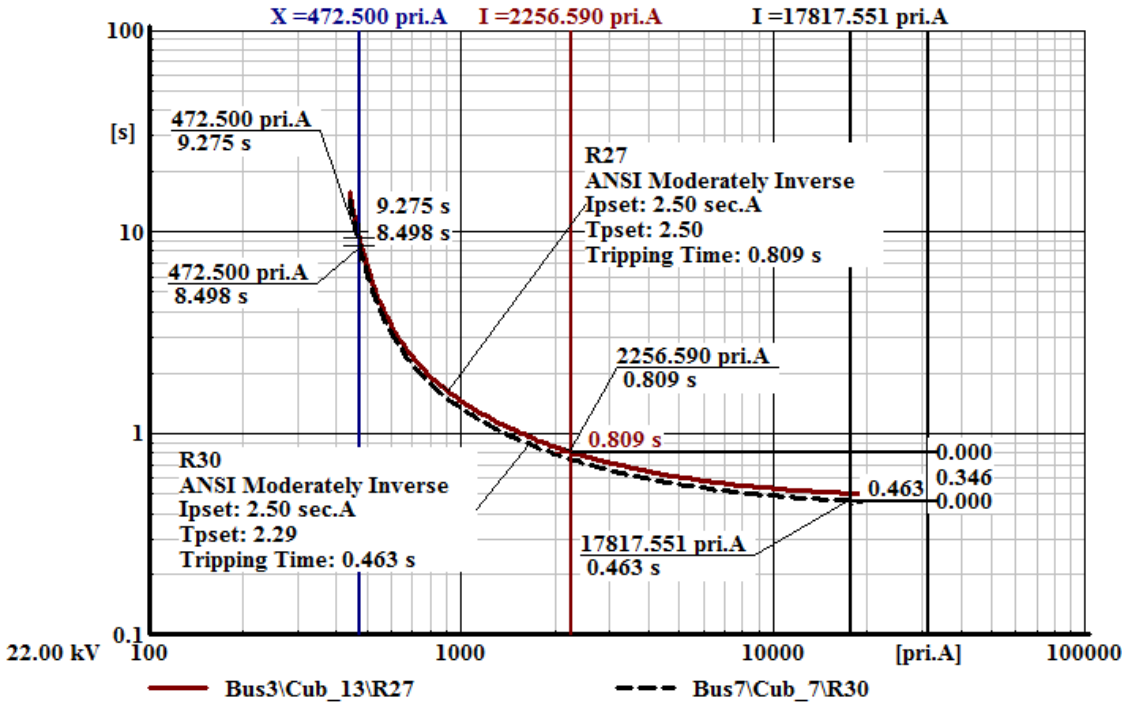

Figure 4.16 The coordination time of OC relay R27 and R30

Figure 4.17 shows the coordination of OC relay at the protection zone 7 that occur on the fault at network L3-7-1, which operate as follows:

1) The backup OC relay R29 operates at the fault current to reaching predestined value that is equal approximately 2367.051 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.50 respectively. The operation time (t) of the OC relay R29 is equal 0.790s.

2) The primary OC relay R28 operates on the fault current reaching predestined value that is equal approximately 17904.942 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.18 respectively. The operation time (t) of the OC relay R28 is equal 0.442s. Therefore, the CTI of R29 with R28 is equal 0.348s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

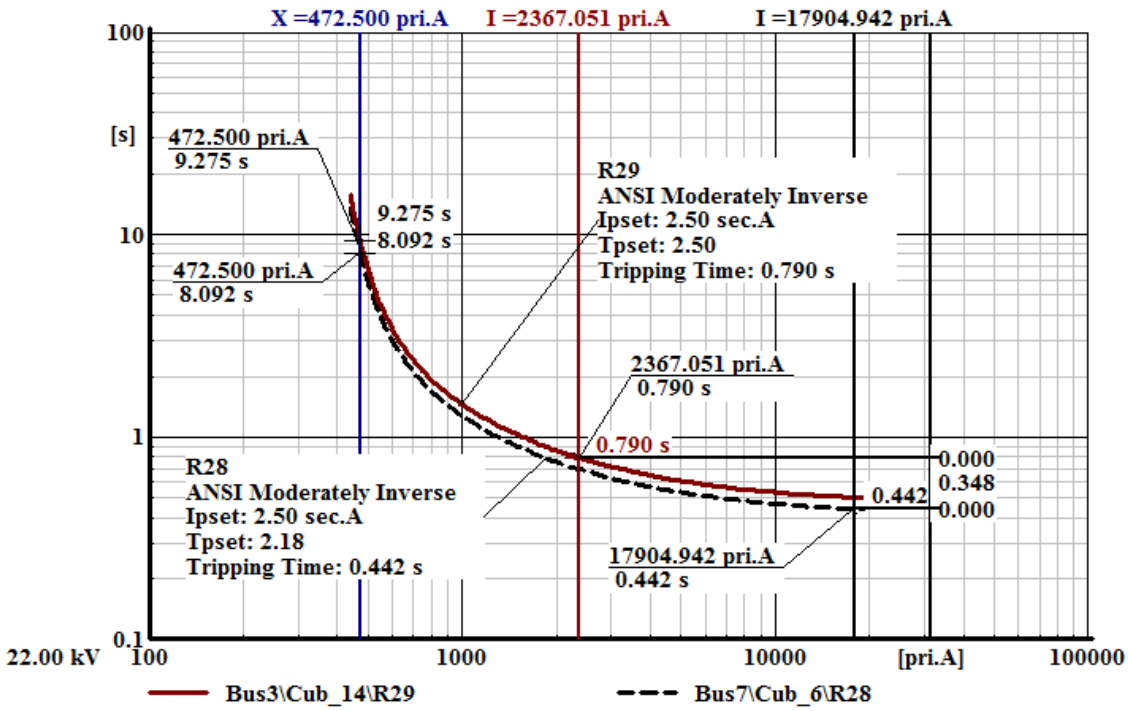

Figure 4.17 The coordination time of OC relay R29 and R28

4.2.1.8 The protection in zone 8

The protection zone 8 which consists OC relay as follows R19, R26, R25, and R20 that will operate the operating time of relays respectively. If the feeder L7-4 and L2-4-3 occur on the fault current in protection zone 8. The results of the coordination of R19, R26, R25, and R20 are shown in Figure 4.18 and Figure 4.19.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R19, R26, R25, and R20 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.18 and Figure 4.19.

Figure 4.18 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L7-4, which operate as follows:

1) The backup OC relay R19 operates at the fault current to reaching predestined value that is equal approximately 7484.493 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 3.20 respectively. The operation time (t) of the OC relay R19 is equal 0.706s.

2) The primary OC relay R26 operates on the fault current reaching predestined value that is equal approximately 29783.382 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec.A and 1.96 respectively. The operation time (t) of the OC relay R26 is equal 0.398s. Therefore, the CTI of R19 with R26 is equal 0.308s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

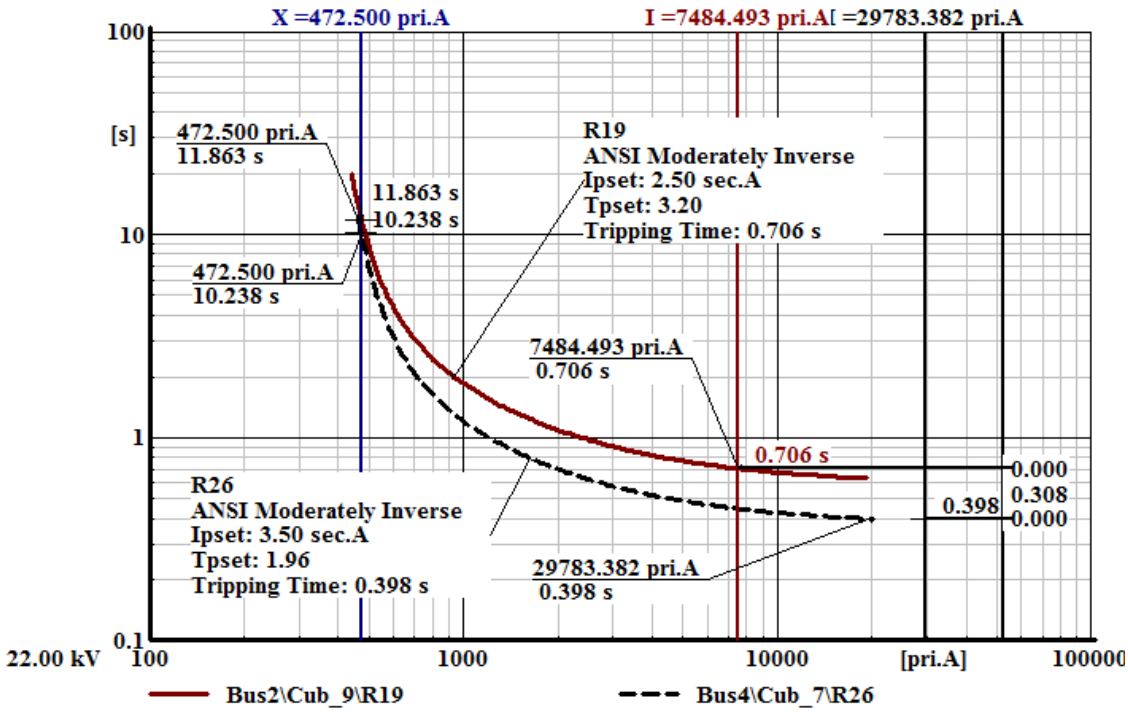

Figure 4.18 The coordination time of OC relay R19 and R26

Figure 4.19 shows the coordination of OC relay at the protection zone 8 that occur on the fault at network L2-4-3, which operate as follows:

1) The backup OC relay R25 operates at the fault current to reaching predestined value that is equal approximately 3725.640 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec. A and 2.50 respectively. The operation time (t) of the OC relay R25 is equal 0.672s.

2) The primary OC relay R20 operates on the fault current reaching predestined value that is equal approximately 26023.428 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.22 respectively. The operation

time (t) of the OC relay R20 is equal 0.447s. Therefore, the CTI of R25 with R20 is equal 0.225s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

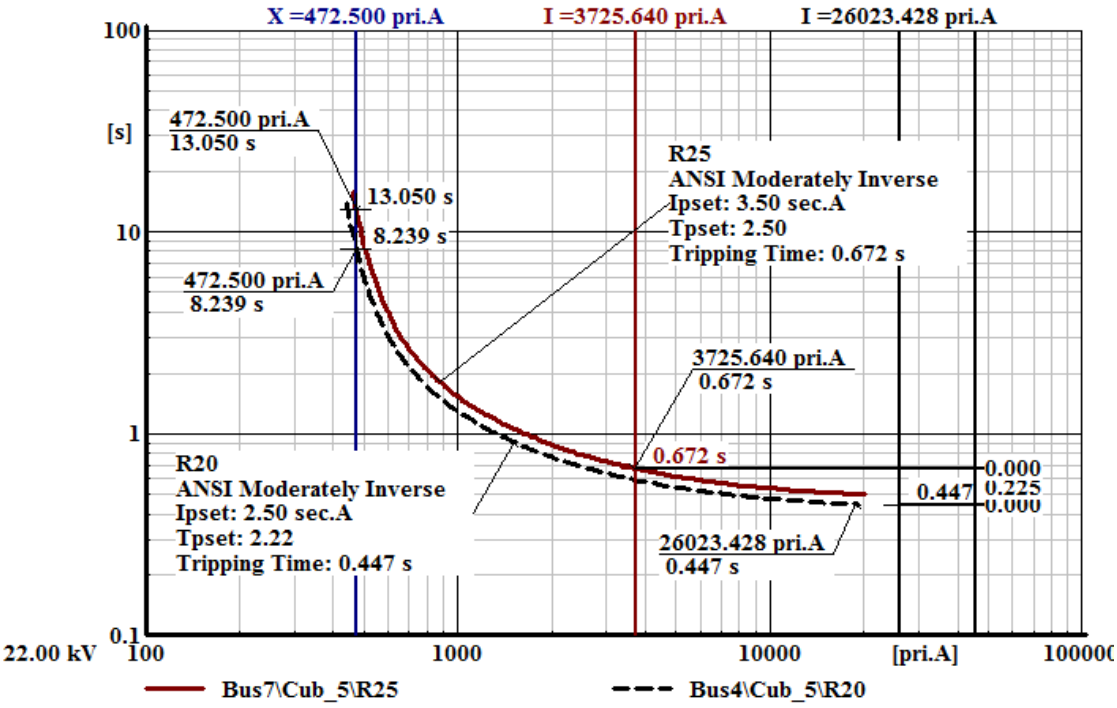

Figure 4.19 The coordination time of OC relay R25 and R20

These results have summarized the setting the proper coordination of all OC relays in the case short circuit 3 phase type in Table 4.3.

Table 4.3 Summarizing of coordination time in the case 3 phase fault

3 Phase Fault Location No	Relay	Current setting	Time dial	Relay operation time in seconds [t]		CTI [s]
		[I_{CS}]	[Tpset]	Backup (t_b)	Primary (t_p)	t_b-$t_p \geq$CTI
L1-5-2	R1	0.5	1.70	0.604	-	0.277
	R4	0.5	1.56	-	0.327	
L1-5-1	R3	0.5	1.70	0.589	-	0.277
	R2	0.5	1.48	-	0.312	
L2-5-2	R5	2.5	2.30	0.623	-	0.205

Table 4.3 Summarizing of coordination time in the case 3 phase fault (Continued)

3 Phase Fault Location No	Relay	Current setting	Time dial	Relay operation time in seconds [t]		CTI [s]
		[I_{CS}]	[Tpset]	Backup (t_b)	Primary (t_p)	t_b-$t_p \geq$CTI
L2-5-1	R8	2.5	2.03	-	0.418	
	R7	2.5	2.30	0.633	-	0.202
	R6	2.5	2.03	-	0.431	
L4-5	R11	3.5	1.95	0.549	-	0.250
	R13	3.5	1.95	-	0.299	
L6-4	R14	3.5	2.00	0.536	-	0.253
	R12	3.5	2.00	-	0.283	
NL2-6	R9	2.5	3.00	0.689	-	0.266
	R32	2.5	2.03	-	0.423	
L2-6	R31	2.5	3.00	0.696	-	0.262
	R10	2.5	2.08	-	0.434	
L2-4-2	R15	2.5	3.10	0.685	-	0.227
	R18	2.5	2.28	-	0.458	
L2-4-1	R17	2.5	3.10	0.685	-	0.227
	R16	2.5	2.28	-	0.458	
L2-7-2	R21	2.5	3.20	0.787	-	0.336
	R24	2.5	2.20	-	0.451	
L2-7-1	R23	2.5	3.20	0.777	-	0.326
	R22	2.5	2.20	-	0.451	
L3-7-2	R27	2.5	2.50	0.809	-	0.346
	R30	2.5	2.29	-	0.463	
L3-7-1	R29	2.5	2.50	0.790	-	0.348
	R28	2.5	2.18	-	0.442	

Table 4.3 Summarizing of coordination time in the case 3 phase fault (Continued)

3 Phase Fault Location No	Relay	Current setting	Time dial	Relay operation time in seconds [t]		CTI [s]
		[I_{CS}]	[Tpset]	Backup (t_b)	Primary (t_p)	t_b-$t_p \geq$CTI
L7-4	R19	2.5	3.20	0.706	-	0.308
	R26	3.5	1.96	-	0.398	
L2-4-3	R25	3.5	2.50	0.672	-	0.225
	R20	2.5	2.22	-	0.447	

4.2.1 The coordination time in the case single phase to ground fault.

4.2.1.1 The protection in zone 1

The protection zone 1 which consists OC relay as follows R1, R4, R3, and R2 that will operate the operating time of relays respectively. If the feeder L1-5-1 and L1-5-2 occur on the fault current in protection zone 1. The results of the coordination of R1, R4, R3, and R2 are shown in Figure 4.20 and Figure 4.21.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R1, R4, R3, and R2 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.20 and Figure 4.21.

Figure 4.20 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L1-5-2, which operate as follows:

1) The backup OC relay R1 operates at the fault current to reaching predestined value that is equal approximately 800.303 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec. A and 0.60 respectively. The operation time (t) of the OC relay R1 is equal 0.484s.

2) The primary OC relay R4 operates on the fault current reaching predestined value that is equal approximately 7363.637 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec.A and 0.56 respectively. The operation

time (t) of the OC relay R4 is equal 0.149s. Therefore, the CTI of R1 with R4 is equal 0.335s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

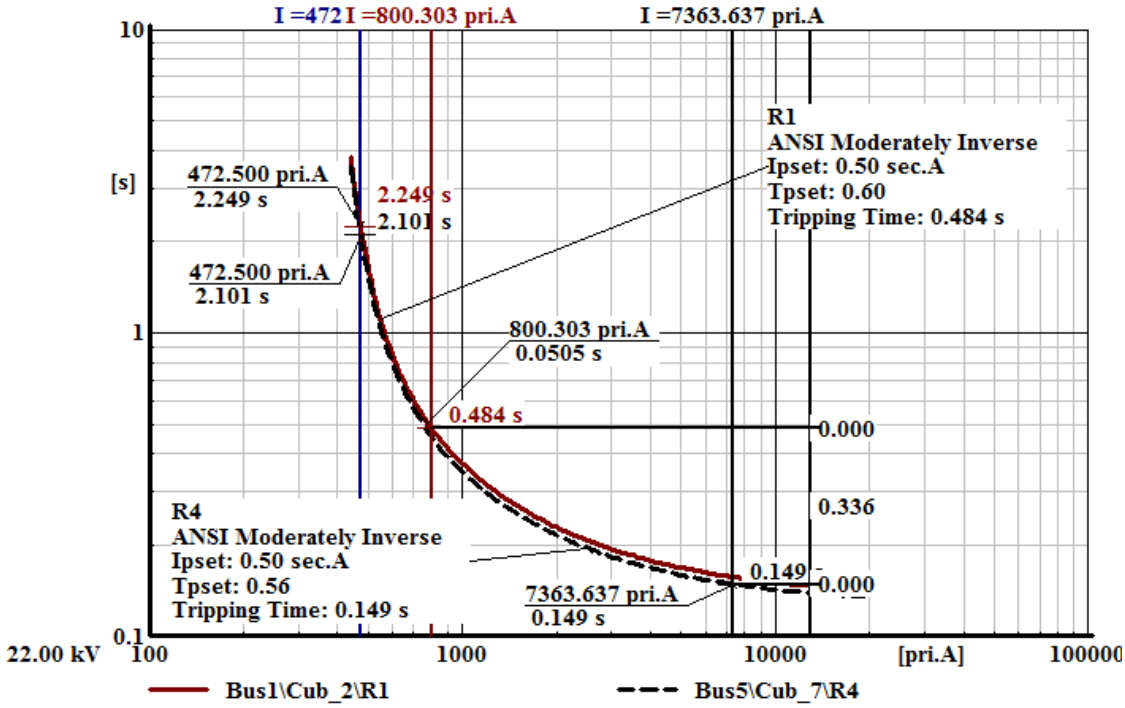

Figure 4.20 The coordination time of OC relay R1 and R4

Figure 4.21 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L1-5-1, which operate as follows:

1) The backup OC relay R3 operates at the fault current to reaching predestined value that is equal approximately 827.416 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec. A and 0.6 respectively. The operation time (t) of the OC relay R3 is equal 0.463s.

2) The primary OC relay R2 operates on the fault current reaching predestined value that is equal approximately 7384.713 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 0.5 sec.A and 0.51 respectively. The operation time (t) of the OC relay R2 is equal 0.138s. Therefore, the CTI of R3 with R2 is equal 0.325s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

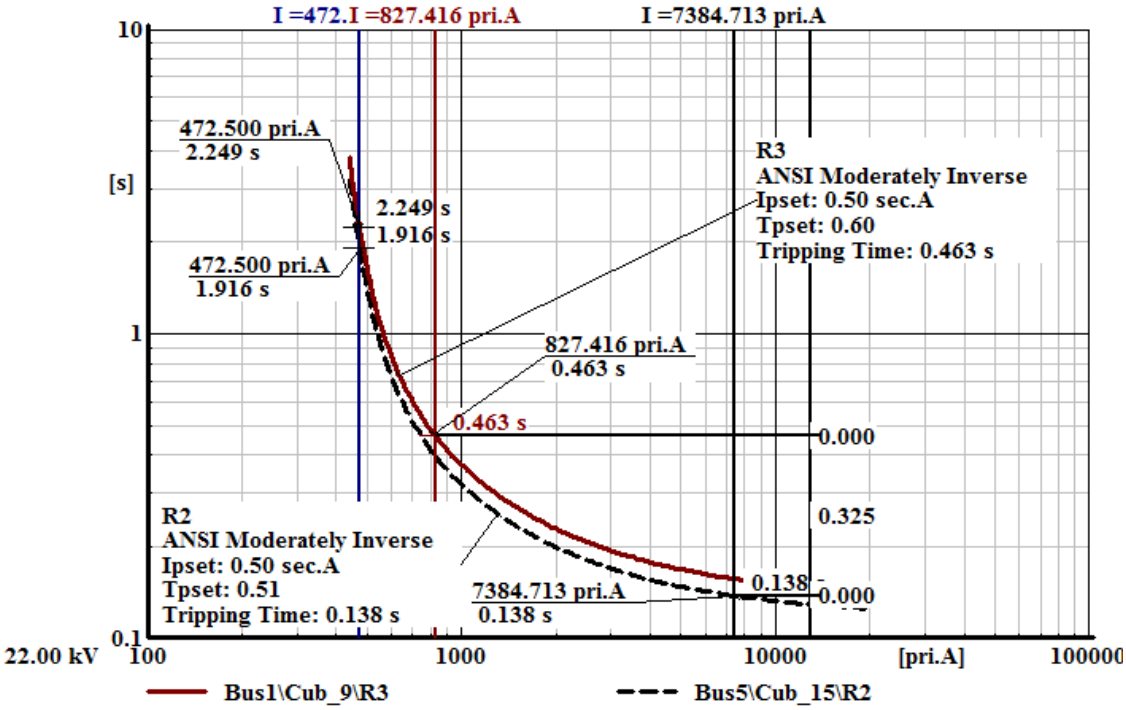

Figure 4.21 The coordination time of OC relay R3 and R2

4.2.1.2 The protection in zone 2

The protection zone 2 which consists OC relay as follows R5, R8, R7, and R6 that will operate the operating time of relays respectively. If the feeder L2-5-1 and L2-5-2 occur on the fault current in protection zone 2. The results of the coordination of R5, R8, R7, and R6 are shown in Figure 4.22 and Figure 4.23.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R5, R8, R7, and R6 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.22 and Figure 4.23.

Figure 4.22 shows the coordination of OC relay at the protection zone 2 that occur on the fault at network L1-5-2, which operate as follows:

1) The backup OC relay R5 operates at the fault current to reaching predestined value that is equal approximately 1467.784 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 1.50 respectively. The operation time (t) of the OC relay R5 is equal 0.639s.

2) The primary OC relay R8 operates on the fault current reaching predestined value that is equal approximately 6767.283 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.30 respectively. The operation time (t) of the OC relay R8 is equal 0.310s. Therefore, the CTI of R5 with R8 is equal 0.329s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

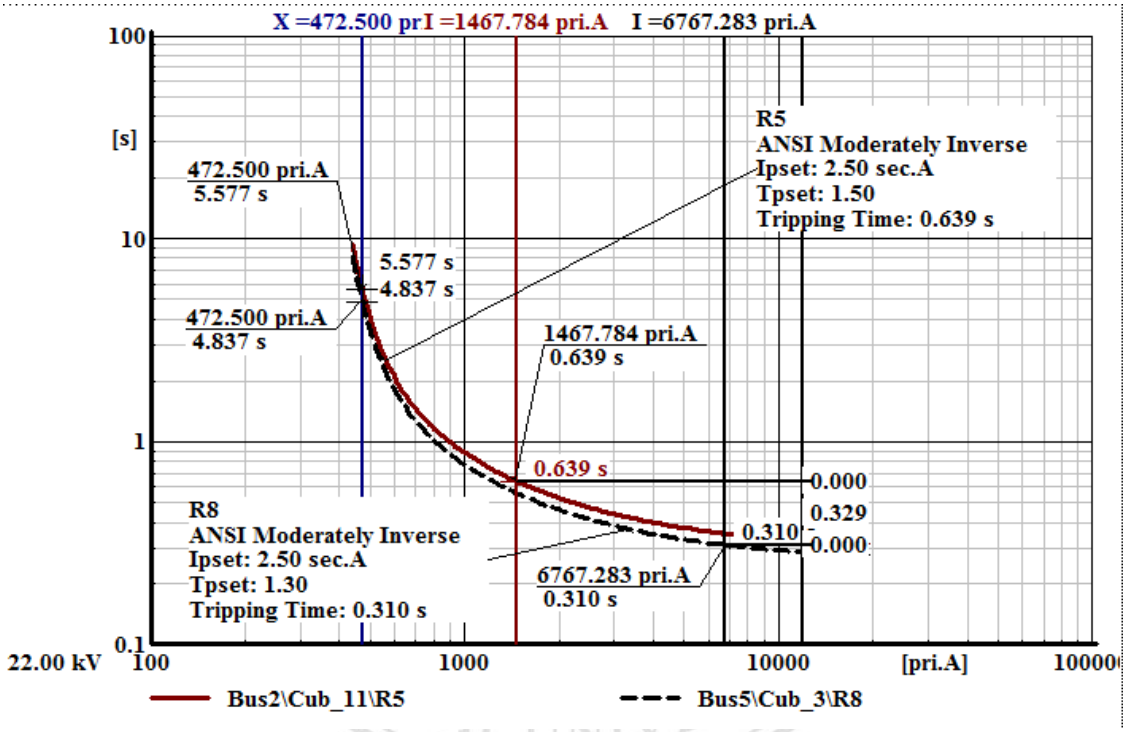

Figure 4.22 The coordination time of OC relay R5 and R8

Figure 4.23 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L2-5-1, which operate as follows:

1) The backup OC relay R7 operates at the fault current to reaching predestined value that is equal approximately 1418.874 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 1.50 respectively. The operation time (t) of the OC relay R7 is equal 0.654s.

2) The primary OC relay R6 operates on the fault current reaching predestined value that is equal approximately 6717.172 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.37 respectively. The operation

time (t) of the OC relay R6 is equal 0.325s. Therefore, the CTI of R7 with R6 is equal 0.329s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

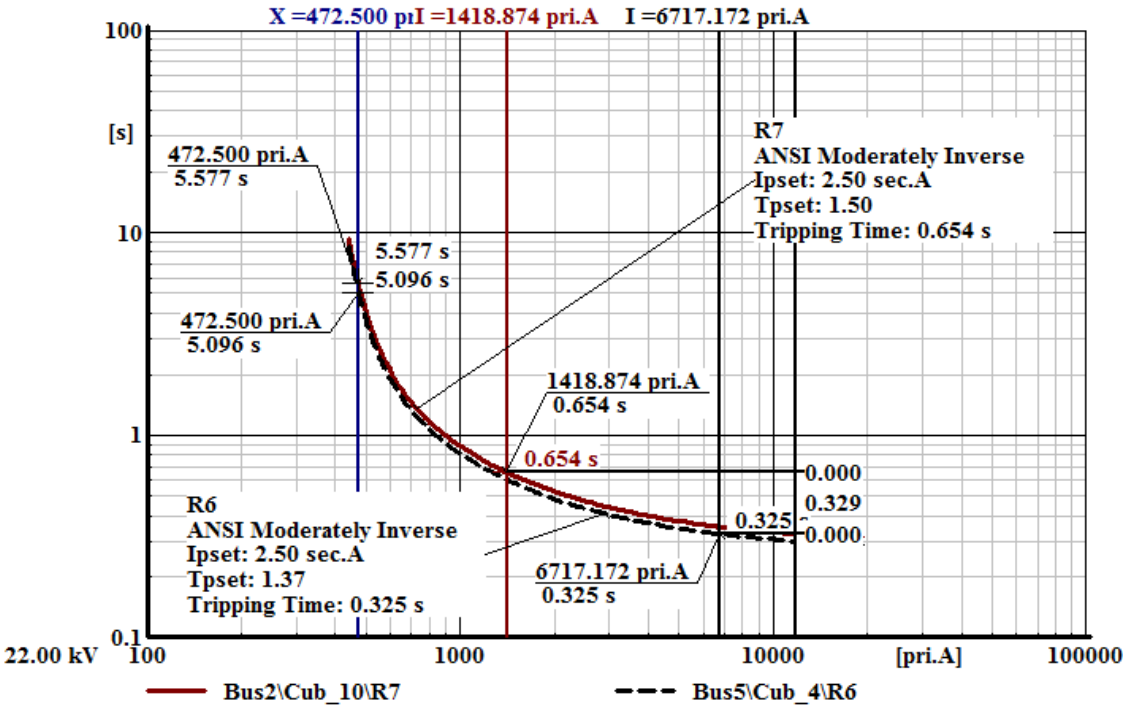

Figure 4.23 The coordination time of OC relay R7 and R6

4.2.1.3 The protection in zone 3 and zone 9

The protection zone 3 and zone 9 which consists OC relay as follows R11, R13, R14, and R12 that will operate the operating time of relays respectively. If the feeder L4-5 and L6-4 occur on the fault current in protection zone 3 and zone 9. The results of the coordination of R11, R13, R14, and R12 are shown in Figure 4.24 and Figure 4.25Figure 4.5.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R11, R13, R14, and R12 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.24 and Figure 4.25Figure 4.5.

Figure 4.24 shows the coordination of OC relay at the protection zone 3 and zone 9 that occur on the fault at network L4-5, which operate as follows:

1) The backup OC relay R11 operates at the fault current to reaching predestined value that is equal approximately 1986.513 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec. A and 1.46 respectively. The operation time (t) of the OC relay R11 is equal 0.531s.

2) The primary OC relay R13 operates on the fault current reaching predestined value that is equal approximately 15745.067 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec.A and 1.46 respectively. The operation time (t) of the OC relay R13 is equal 0.310s. Therefore, the CTI of R11 with R13 is equal 0.221s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

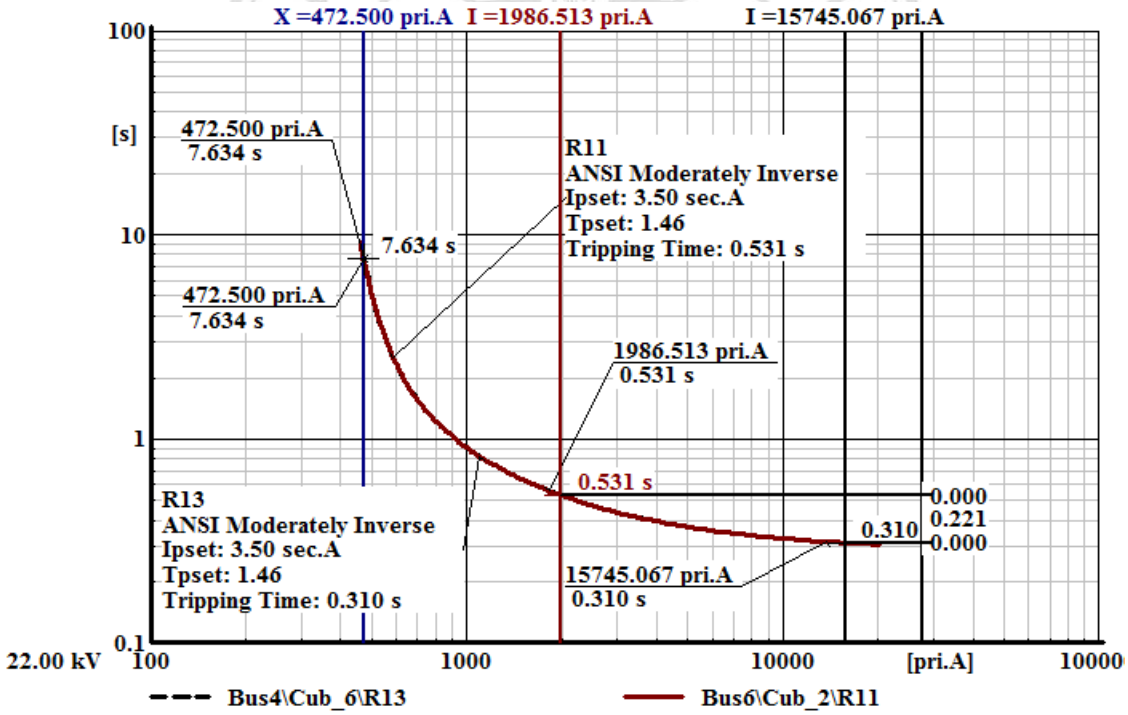

Figure 4.24 The coordination time of OC relay R11 and R13

Figure 4.25 shows the coordination of OC relay at the protection zone 3 and zone 9 that occur on the fault at network L6-4, which operate as follows:

1) The backup OC relay R14 operates at the fault current to reaching predestined value that is equal approximately 1770.204 pri. A. The current settings of I

pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec. A and 1.5 respectively. The operation time (t) of the OC relay R14 is equal 0.583s.

2) The primary OC relay R12 operates on the fault current reaching predestined value that is equal approximately 14220.142 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec.A and 1.5 respectively. The operation time (t) of the OC relay R12 is equal 0.321s. Therefore, the CTI of R14 with R12 is equal 0.262s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

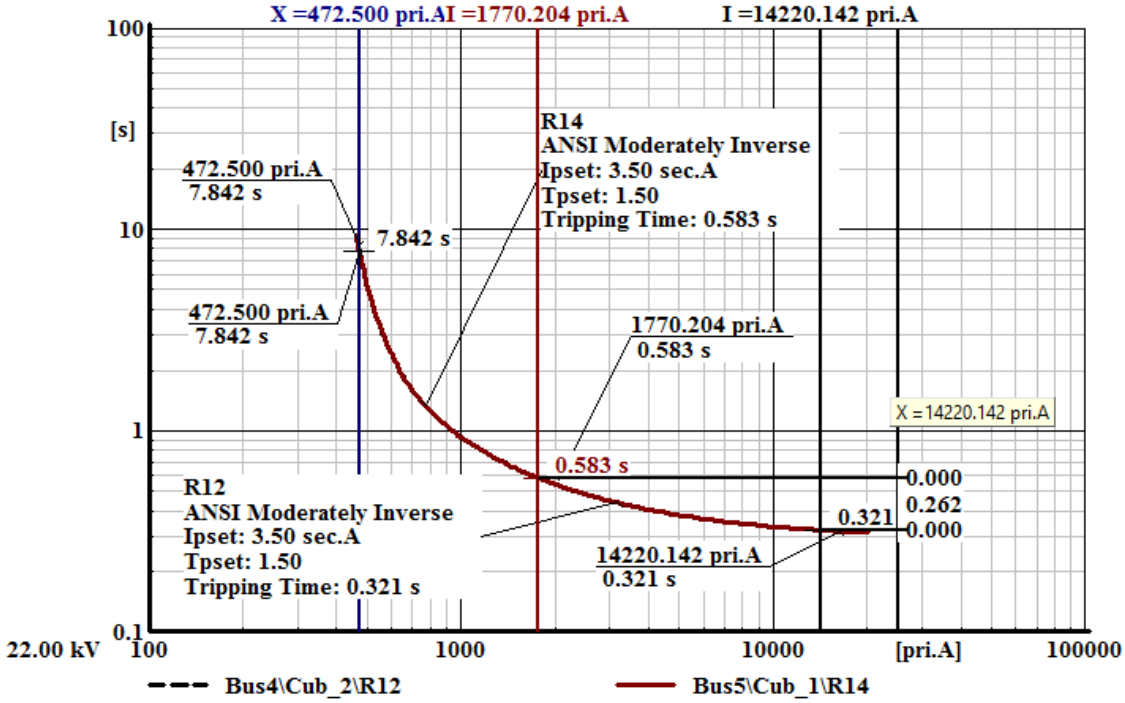

Figure 4.25 The coordination time of OC relay R14 and R12

4.2.1.4 The protection in zone 4

The protection zone 4 which consists OC relay as follows R31, R10, R9, and R32 that will operate the operating time of relays respectively. If the feeder L2-6 and NL2-6 occur on the fault current in protection zone 4. The results of the coordination of R31, R10, R9, and R32 are shown in Figure 4.26 and Figure 4.27.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R31, R10, R9, and R32

operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.26 and Figure 4.27.

Figure 4.26 shows the coordination of OC relay at the protection zone 4 that occur on the fault at network L2-6, which operate as follows:

1) The backup OC relay R31 operates at the fault current to reaching predestined value that is equal approximately 2670.038 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.00 respectively. The operation time (t) of the OC relay R31 is equal 0.605s.

2) The primary OC relay R10 operates on the fault current reaching predestined value that is equal approximately 6534.057 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.60 respectively. The operation time (t) of the OC relay R10 is equal 0.377s. Therefore, the CTI of R31 with R10 is equal 0.228s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

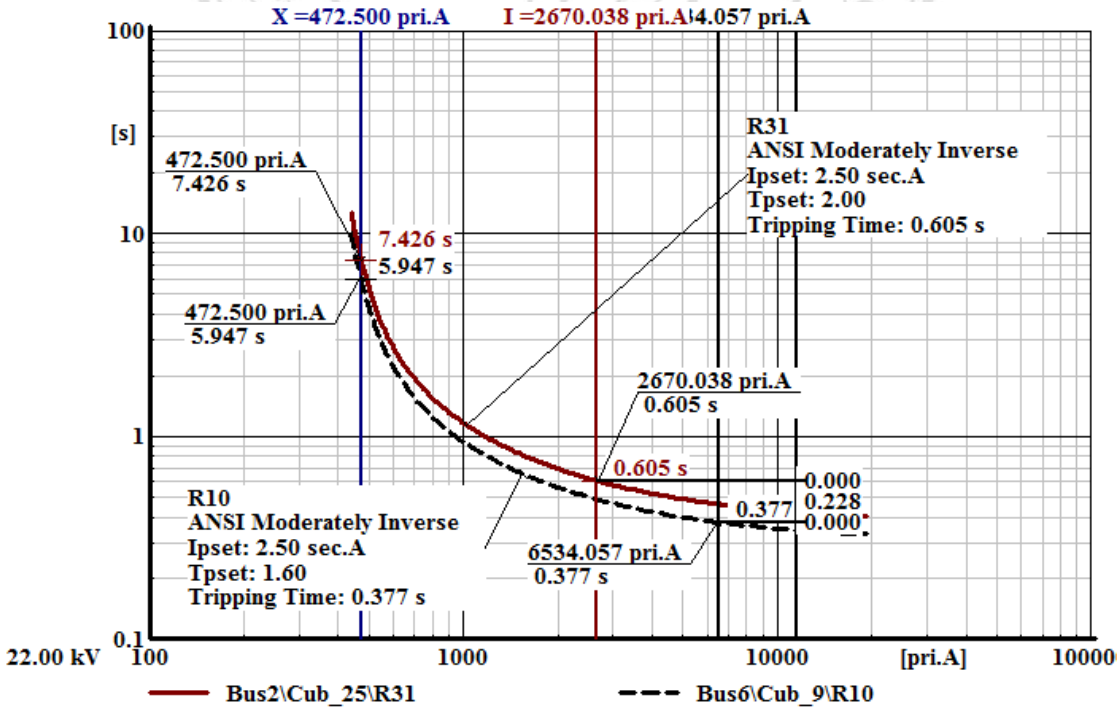

Figure 4.26 The coordination time of OC relay R31 and R10

Figure 4.27 shows the coordination of OC relay at the protection zone 4 that occur on the fault at network NL2-6, which operate as follows:

1) The backup OC relay R9 operates at the fault current to reaching predestined value that is equal approximately 2760.834 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.00 respectively. The operation time (t) of the OC relay R9 is equal 0.596s.

2) The primary OC relay R32 operates on the fault current reaching predestined value that is equal approximately 6622.811 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.55 respectively. The operation time (t) of the OC relay R32 is equal 0.365s. Therefore, the CTI of R9 with R32 is equal 0.231s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

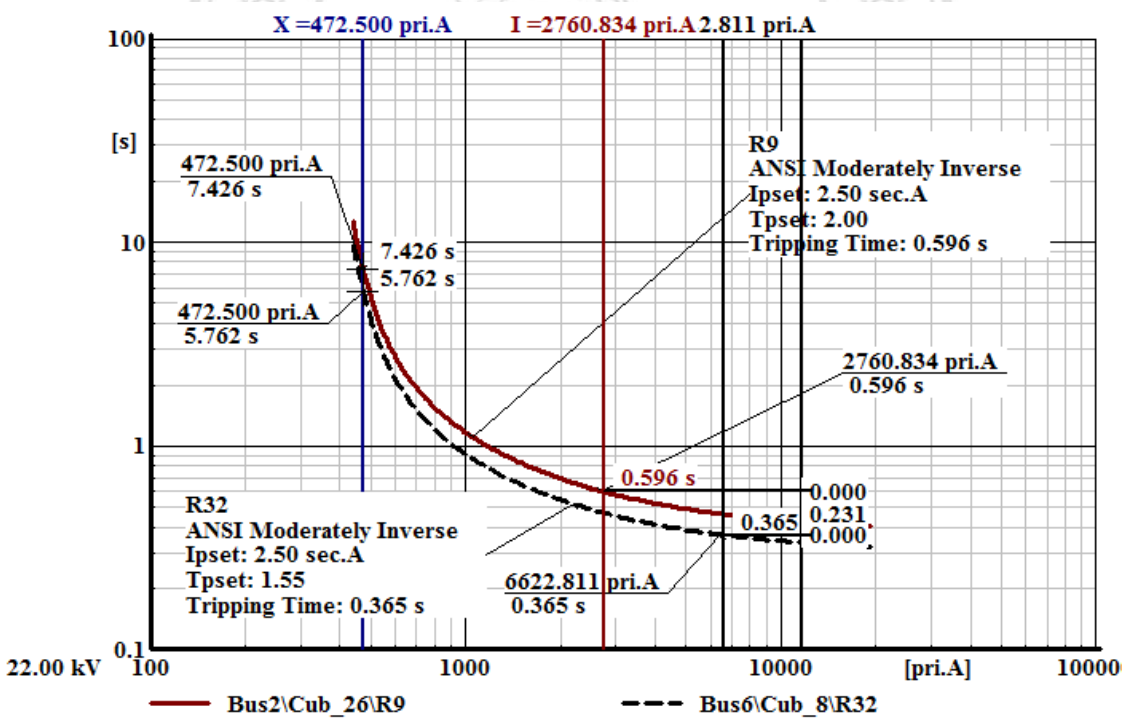

Figure 4.27 The coordination time of OC relay R9 and R32

4.2.1.5 The protection in zone 5

The protection zone 5 which consists OC relay as follows R15, R18, R17, and R16 that will operate the operating time of relays respectively. If the feeder L2-

4-2 and L2-4-1 occur on the fault current in protection zone 5. The results of the coordination of R15, R18, R17, and R16 are shown in Figure 4.28 and Figure 4.29.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R15, R18, R17, and R16 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.28 and Figure 4.29.

Figure 4.28 shows the coordination of OC relay at the protection zone 5 that occur on the fault at network L2-4-2, which operate as follows:

1) The backup OC relay R15 operates at the fault current to reaching predestined value that is equal approximately 4033.501 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.50 respectively. The operation time (t) of the OC relay R15 is equal 0.645s.

2) The primary OC relay R18 operates on the fault current reaching predestined value that is equal approximately 14274.871 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.97 respectively. The operation time (t) of the OC relay R18 is equal 0.410s. Therefore, the CTI of R15 with R18 is equal 0.235s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

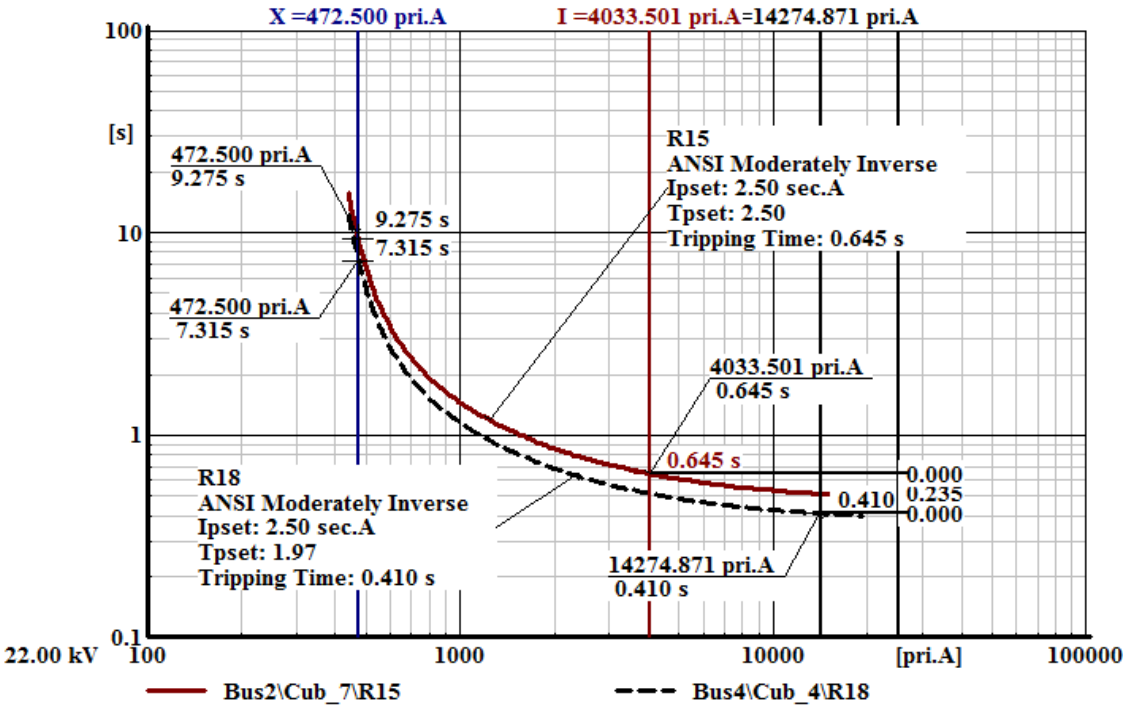

Figure 4.28 The coordination time of OC relay R15 and R18

Figure 4.29 shows the coordination of OC relay at the protection zone 5 that occur on the fault at network L2-4-1, which operate as follows:

1) The backup OC relay R17 operates at the fault current to reaching predestined value that is equal approximately 4033.501 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.50 respectively. The operation time (t) of the OC relay R17 is equal 0.645s.

2) The primary OC relay R16 operates on the fault current reaching predestined value that is equal approximately 14274.871 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.97 respectively. The operation time (t) of the OC relay R16 is equal 0.410s. Therefore, the CTI of R17 with R16 is equal 0.235s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

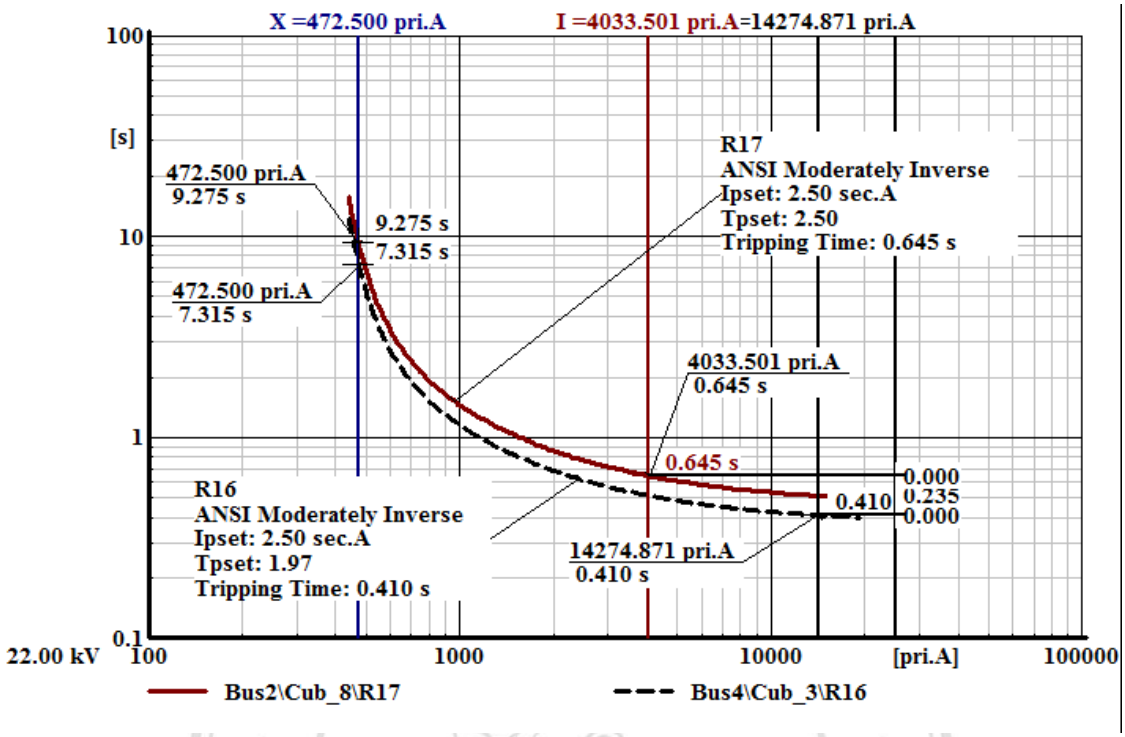

Figure 4.29 The coordination time of OC relay R17 and R16

4.2.1.6 The protection in zone 6

The protection zone 6 which consists OC relay as follows R21, R24, R23, and R22 that will operate the operating time of relays respectively. If the feeder L2-7-2 and L2-7-1 occur on the fault current in protection zone 6. The results of the coordination of R21, R24, R23, and R22 are shown in Figure 4.30 and Figure 4.31.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R21, R24, R23, and R22 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.30 and Figure 4.31.

Figure 4.30 shows the coordination of OC relay at the protection zone 6 that occur on the fault at network L2-7-2, which operate as follows:

1) The backup OC relay R21 operates at the fault current to reaching predestined value that is equal approximately 1966.059 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.00 respectively. The operation time (t) of the OC relay R21 is equal 0.701s.

2) The primary OC relay R24 operates on the fault current reaching predestined value that is equal approximately 6932.296 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.68 respectively. The operation time (t) of the OC relay R24 is equal 0.390s. Therefore, the CTI of R21 with R24 is equal 0.311s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

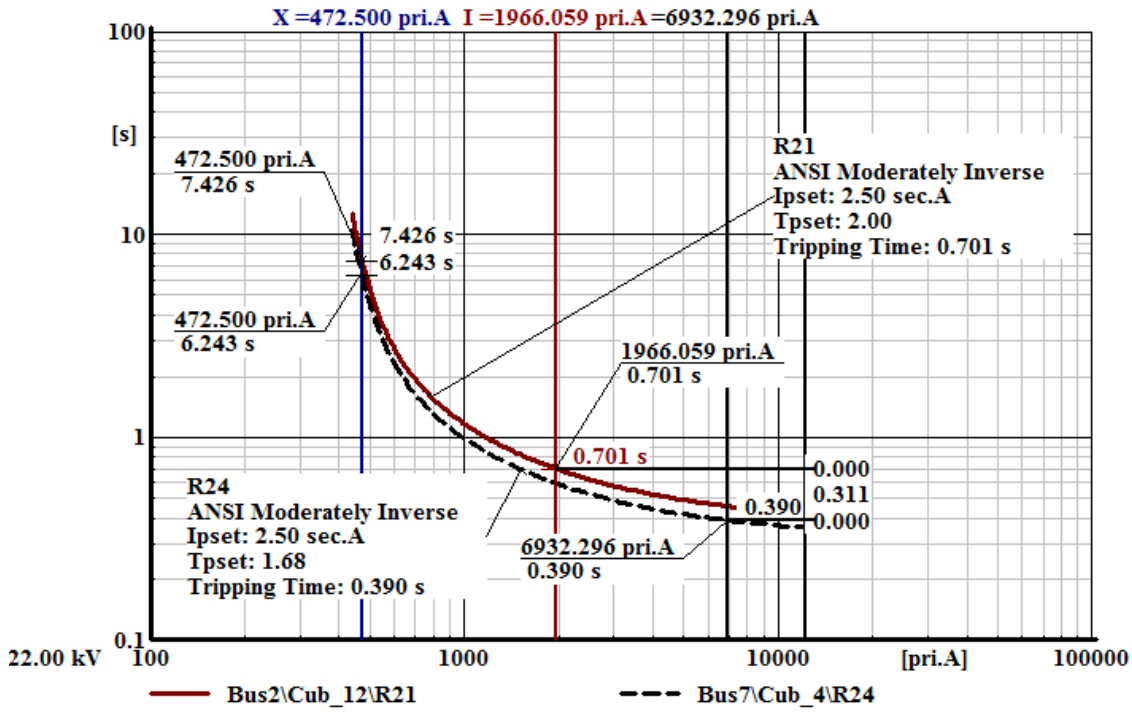

Figure 4.30 The coordination time of OC relay R21 and R24

Figure 4.31 shows the coordination of OC relay at the protection zone 6 that occur on the fault at network L2-7-1, which operate as follows:

1) The backup OC relay R23 operates at the fault current to reaching predestined value that is equal approximately 2033.064 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.00 respectively. The operation time (t) of the OC relay R23 is equal 0.689s.

2) The primary OC relay R22 operates on the fault current reaching predestined value that is equal approximately 7001.164 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 1.68 respectively. The operation

time (t) of the OC relay R22 is equal 0.389s. Therefore, the CTI of R23 with R22 is equal 0.300s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

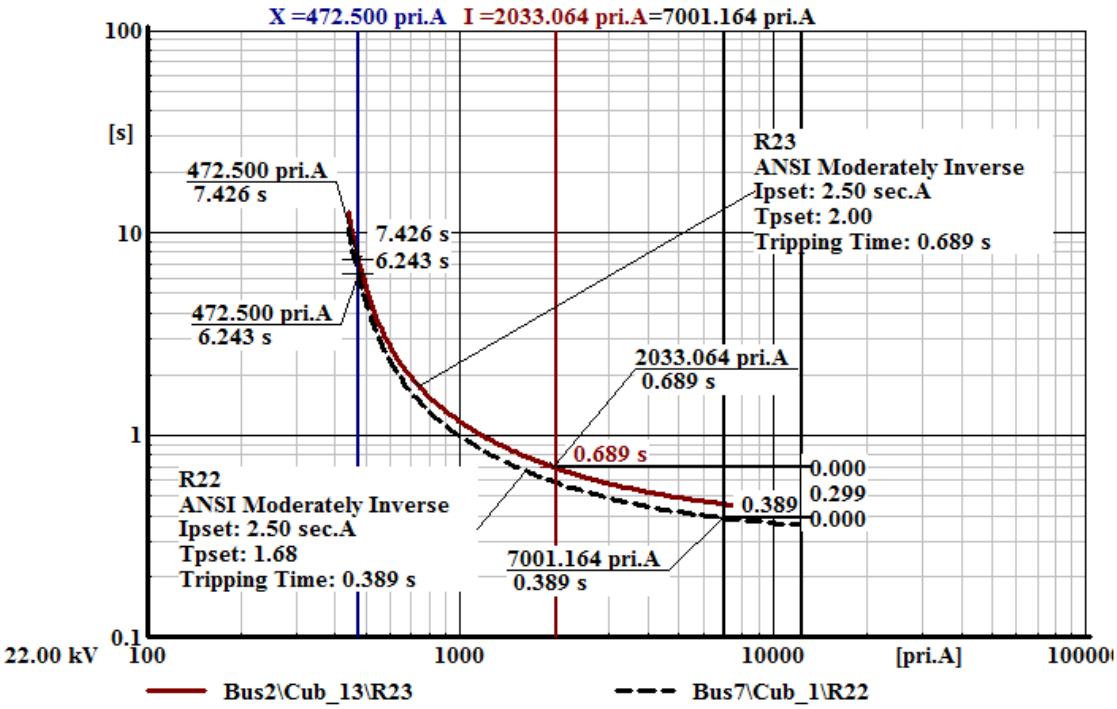

Figure 4.31 The coordination time of OC relay R23 and R22

4.2.1.7 The protection in zone 7

The protection zone 7 which consists OC relay as follows R27, R30, R29, and R28 that will operate the operating time of relays respectively. If the feeder L3-7-2 and L3-7-1 occur on the fault current in protection zone 7. The results of the coordination of R27, R30, R29, and R28 are shown in Figure 4.32 and Figure 4.33.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R27, R30, R29, and R28 operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.32 and Figure 4.33.

Figure 4.32 shows the coordination of OC relay at the protection zone 7 that occur on the fault at network L3-7-2, which operate as follows:

1) The backup OC relay R27 operates at the fault current to reaching predestined value that is equal approximately 964.487 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 0.80 respectively. The operation time (t) of the OC relay R27 is equal 0.506s.

2) The primary OC relay R30 operates on the fault current reaching predestined value that is equal approximately 7974.076 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 0.74 respectively. The operation time (t) of the OC relay R30 is equal 0.185s. Therefore, the CTI of R27 with R30 is equal 0.321s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

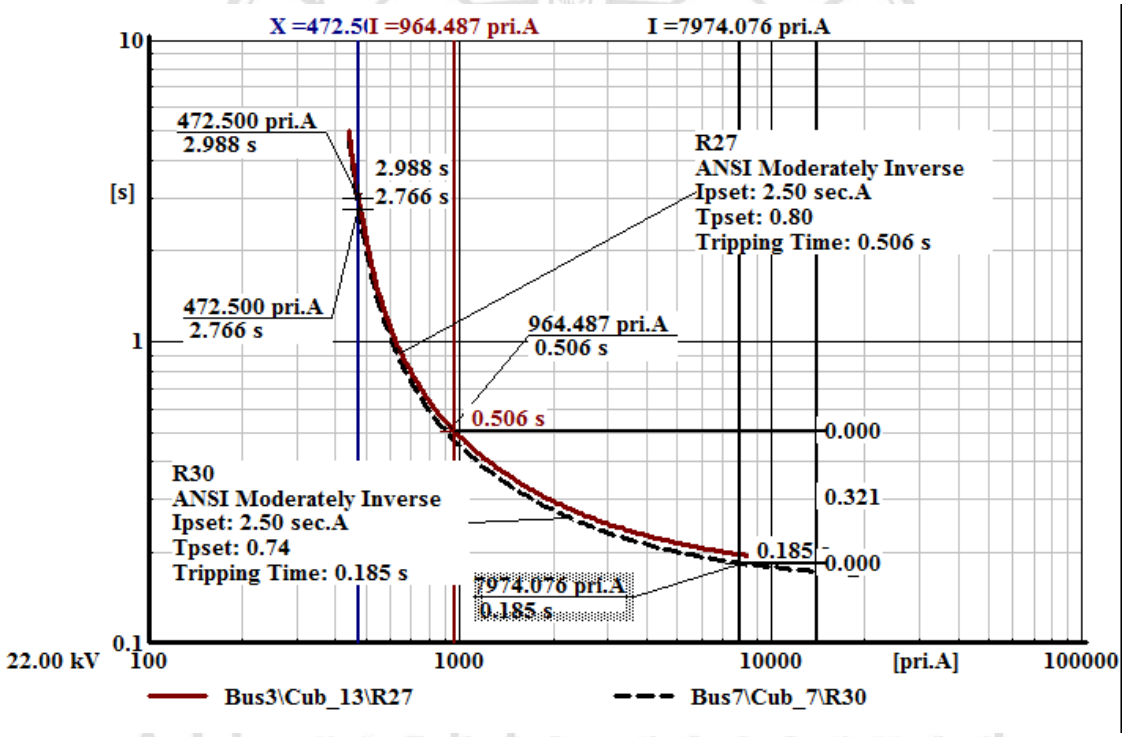

Figure 4.32 The coordination time of OC relay R27 and R30

Figure 4.33 shows the coordination of OC relay at the protection zone 7 that occur on the fault at network L3-7-1, which operate as follows:

1) The backup OC relay R29 operates at the fault current to reaching predestined value that is equal approximately 996.476 pri. A. The current settings of I

pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 0.8 respectively. The operation time (t) of the OC relay R29 is equal 0.489s.

2) The primary OC relay R28 operates on the fault current reaching predestined value that is equal approximately 8000.295 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 0.68 respectively. The operation time (t) of the OC relay R28 is equal 0.172s. Therefore, the CTI of R29 with R28 is equal 0.317s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

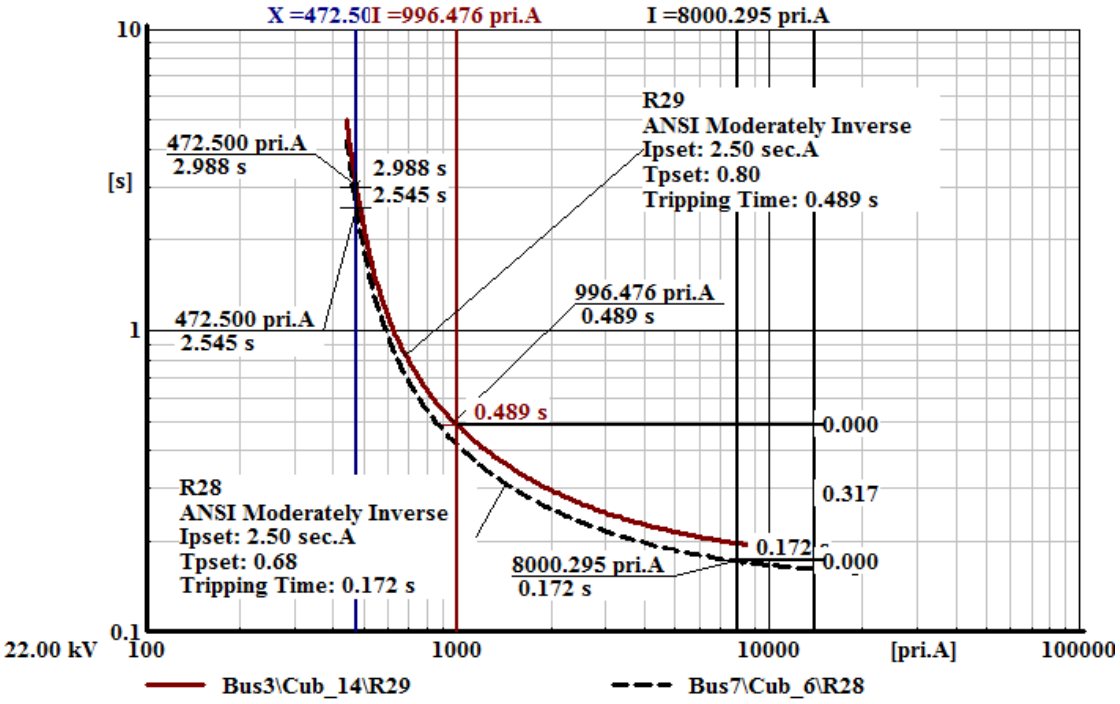

Figure 4.33 The coordination time of OC relay R29 and R28

4.2.1.8 The protection in zone 8

The protection zone 8 which consists OC relay as follows R19, R26, R25, and R20 that will operate the operating time of relays respectively. If the feeder L7-4 and L2-4-3 occur on the fault current in protection zone 8. The results of the coordination of R19, R26, R25, and R20 are shown in Figure 4.34 and Figure 4.35.

Rated current 90 percent of the line is equal 472.5 A. Which Rated current max of line (SAC 240 Sq.mm) is equal 525 A. OC relay R19, R26, R25, and R20

operate at overload current to reaching predestined value that is equal current approximately 472.5 pri.A in Figure 4.34 and Figure 4.35.

Figure 4.34 shows the coordination of OC relay at the protection zone 1 that occur on the fault at network L7-4, which operate as follows:

1) The backup OC relay R19 operates at the fault current to reaching predestined value that is equal approximately 4033.501 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec. A and 2.50 respectively. The operation time (t) of the OC relay R19 is equal 0.645s.

2) The primary OC relay R26 operates on the fault current reaching predestined value that is equal approximately 16230.809 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec.A and 1.54 respectively. The operation time (t) of the OC relay R26 is equal 0.325s. Therefore, the CTI of R19 with R26 is equal 0.320s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

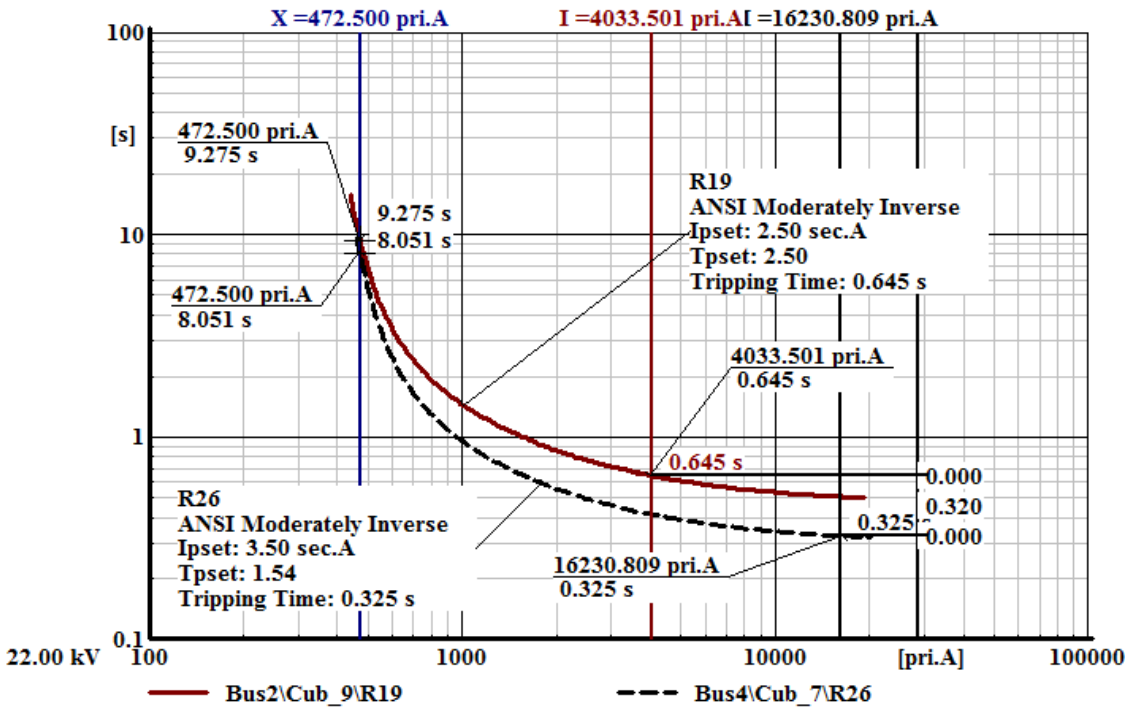

Figure 4.34 The coordination time of OC relay R19 and R26

Figure 4.35 shows the coordination of OC relay at the protection zone 8 that occur on the fault at network L2-4-3, which operate as follows:

1) The backup OC relay R25 operates at the fault current to reaching predestined value that is equal approximately 2077.925 pri. A. The current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 3.5 sec. A and 2.00 respectively. The operation time (t) of the OC relay R25 is equal 0.699s.

2) The primary OC relay R20 operates on the fault current reaching predestined value that is equal approximately 14274.871 pri. A current settings of I pick-up (I_{CS}) and Time dial (*Tpset*) are equal to 2.5 sec.A and 2.00 respectively. The operation time (t) of the OC relay R20 is equal 0.416s. Therefore, the CTI of R25 with R20 is equal 0.283s from setting values. The coordination range of CTI used between 0.2 to 0.5 s which depends on the degree of reliability system.

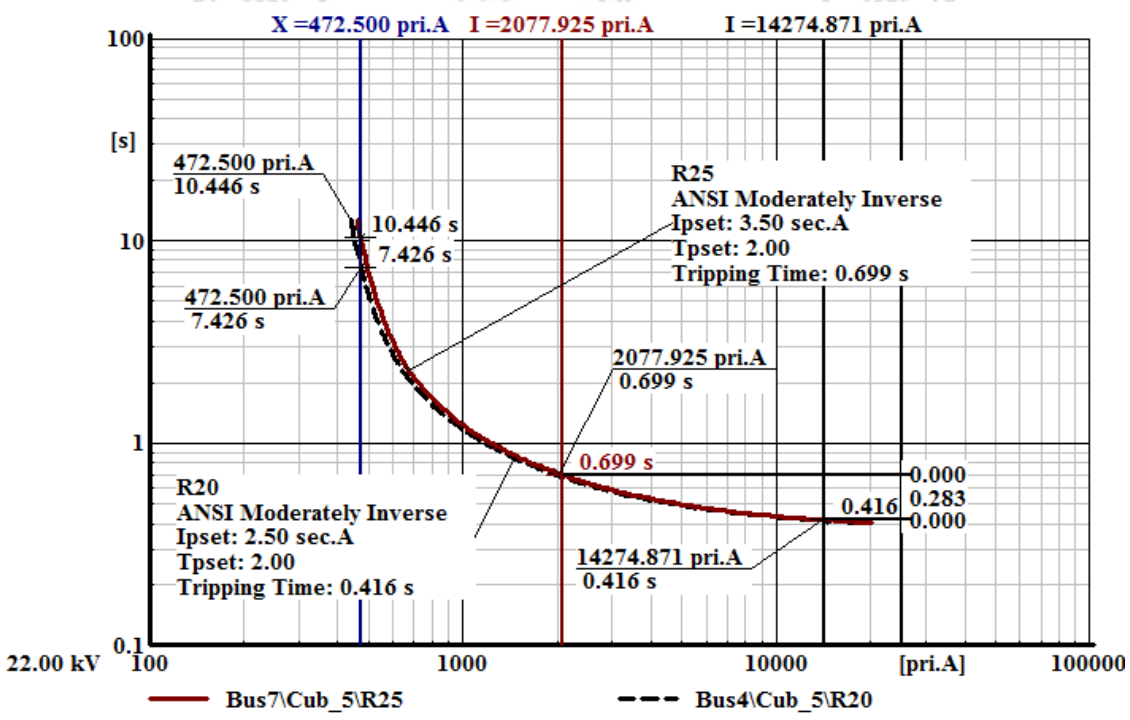

Figure 4.35 The coordination time of OC relay R19 and R26

These results have summarized the setting the proper coordination of all OC relays in the case short circuit single phase to ground type in Table 4.4.

Table 4.4 Summarizing of coordination time in the case single phase to ground fault

1 Phase to Ground Fault Location No	Relay	Current setting [I_{CS}]	Time dial [Tpset]	Relay operation time in seconds [t]		CTI [s]
				Backup (tb)	Primary (tp)	tb-tp ≥CTI
L1-5-2	R1	0.5	0.60	0.484	-	0.335
	R4	0.5	0.56	-	0.149	
L1-5-1	R3	0.5	0.60	0.463	-	0.325
	R2	0.5	0.51	-	0.138	
L2-5-2	R5	2.5	1.50	0.639	-	0.329
	R8	2.5	1.30	-	0.310	
L2-5-1	R7	2.5	1.50	0.654	-	0.329
	R6	2.5	1.37	-	0.325	
L4-5	R11	3.5	1.46	0.531	-	0.221
	R13	3.5	1.46	-	0.310	
L6-4	R14	3.5	1.50	0.583	-	0.262
	R12	3.5	1.50	-	0.321	
NL2-6	R9	2.5	2.00	0.596	-	0.231
	R32	2.5	1.55	-	0.365	
L2-6	R31	2.5	2.00	0.605	-	0.228
	R10	2.5	1.60	-	0.377	
L2-4-2	R15	2.5	2.50	0.645	-	0.235
	R18	2.5	1.97	-	0.410	
L2-4-1	R17	2.5	2.50	0.645	-	0.235
	R16	2.5	1.97	-	0.410	
L2-7-2	R21	2.5	2.00	0.701	-	0.311
	R24	2.5	1.68	-	0.390	

Table 4.4 Summarizing of coordination time in the case single phase to ground fault

(Continued)

1 Phase to Ground Fault Location No	Relay	Current setting	Time dial	Relay operation time in seconds [t]		CTI [s]
		[I_{CS}]	[Tpset]	Backup (tb)	Primary (tp)	tb-tp ≥CTI
L2-7-1	R23	2.5	2.00	0.689	-	0.300
	R22	2.5	1.68	-	0.389	
L3-7-2	R27	2.5	0.80	0.506	-	0.321
	R30	2.5	0.74	-	0.185	
L3-7-1	R29	2.5	0.80	0.489	-	0.317
	R28	2.5	0.68	-	0.172	
L7-4	R19	2.5	2.50	0.645	-	0.320
	R26	3.5	1.54	-	0.325	
L2-4-3	R25	3.5	2.00	0.699	-	0.283