APPENDIX A

MATLAB CODE FOR CALCULATION OF MOTOR TORQUE

Table 1 MATLAB code for calculating motor torque[1]

```
%Definition of Motor Parameters
V=4000/sqrt(3);  %Phase voltage
NoPh=3;          %Number of Phase
NoPo=2           %Number of Pole
f=50;            %Frequency
R1=0.02;         %Stator Resistance
X1=0.01;         %Stator Reactance
X2=0.405;        %Rotor Reactance
Xm=0.6;          %Magnetization Reactance



%Calculation of Synchronous speed
w=4*pi*f/ NoPo;
nSyn=120*f/ NoPo;

%Calculation of Thevenin equivalent circuit
Z1Th=j*Xm*(R1+j*X1)/(R1+j*(X1+Xm));
R1Th=real(Z1Th);
X1Th=imag(Z1Th);
V1Th=(abs(V*j*Xm/(R1+j*(X1+Xm))));

%The loop for Resistance 0.05;0.11;0.2;0.3
for rr=1:4

if rr==1
    R2=0.05;
elseif rr==2
    R2=0.11;
elseif rr==3
    R2=0.2;
else
    R2=0.3;
end


%The loop for Slip
for n= 1:200
Slip(n)=n/200;
rpm(n)=nSyn*(1-Slip(n));
I2=abs(V1Th/(Z1Th+j*X2+R2/Slip(n)));
Tor(n)=(NoPh*I2^2*R2/(Slip(n)*w))/1000; %Calculate the mechanical
torque
end

%Plot
plot(rpm,Tor)
if rr==1
hold
   end
end
hold
xlabel('Speed [rpm]')
ylabel('Machenical Torque [kN.m]')
```

APPENDIX B

MOTOR DATA SHEET

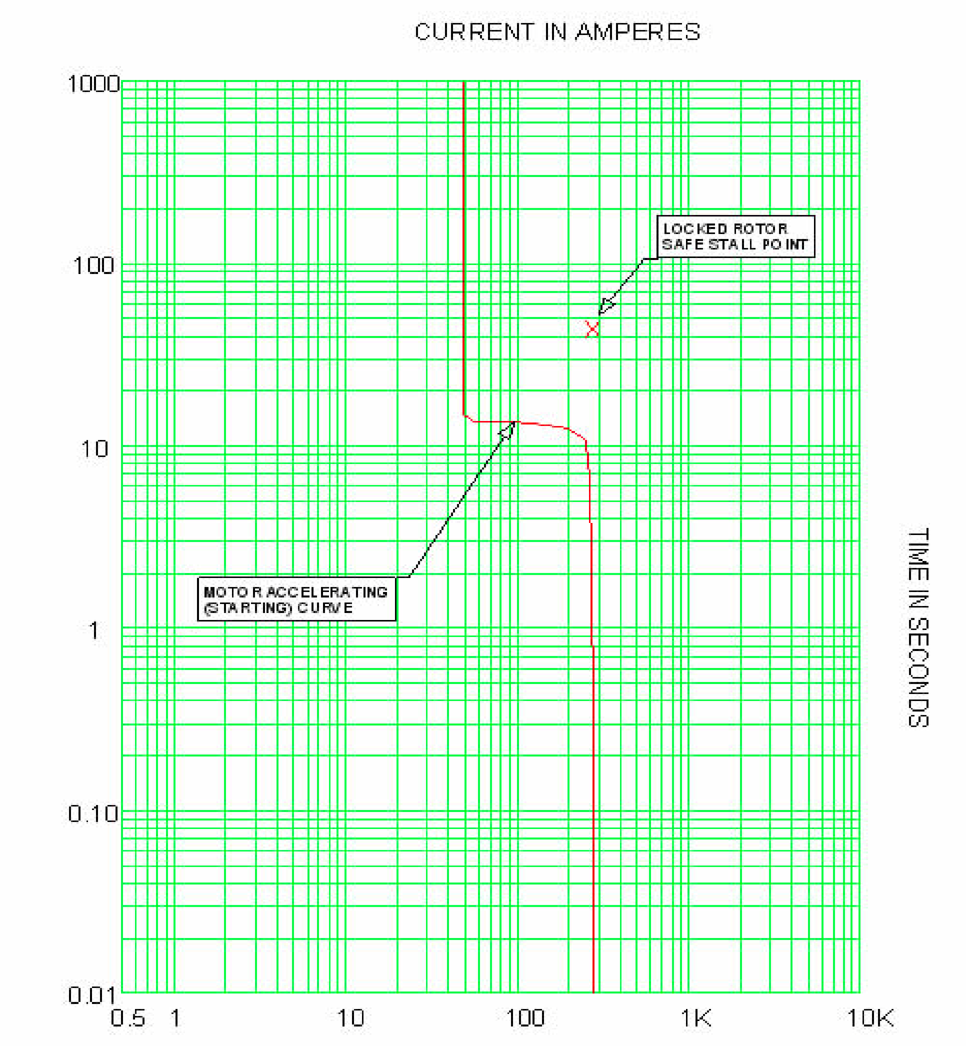

Figure 1 Low voltage induction motor

Table 2 Low voltageindcution data sheet

Low Voltage Induction Motor Data		
Rated Horse Power	HP	40 HP
Rated Voltage	Nv	460 V
Number of Pole	#P	4
Full Load Current	FLA	49.4 A
Locked Rotor Current	LRA	275.3 A
Rate Service Factor	SF	1.15
Hot Safe Stall Time at 100% volts		44 sec
Equivalent Circuit Parameters		
Stator Resistance	Rs	0.057 p.u
Stator Reactance	Xs	0.01 p.u
Mag. Reactance	Xm	2.16 p.u
Rotor resistance	Rr	0.03 p.u
Rotor Reactance	Xr	0.22 p.u

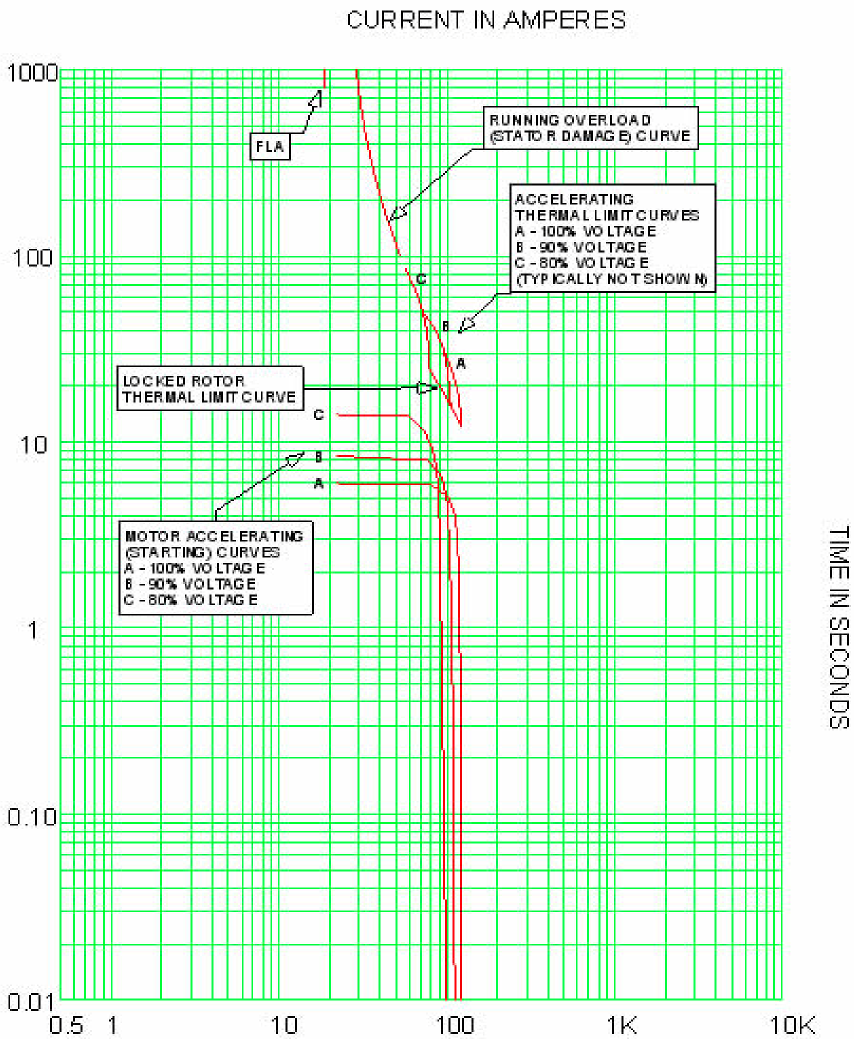

Figure 2 Medium voltage induction motor

Table 3 MV induction motor data sheet

Medium Voltage Induction Motor Data		
Rated Horse Power	HP	1500 HP
Rated Voltage	nV	4000 V
Rated Current	nA	187 A
Number of Pole	#P	2
Equivalent Circuit		
Stator Resistance	Rs	0.02 p.u
Stator Reactance	Xs	0.01 p.u
Mag. Reactance	Xm	0.6 p.u
Rotor resistance	Rr	0.11 p.u
Rotor Reactance	Xr	0.405 p.u

Starting and Thermal Limit Characteristics for MV Induction motor		
Motor Starting Curve	**Current (%)**	**Time(Sec)**
Full Load Curve	155	1000
	180	400
	282	100
Rotor Damage Points at 100% Voltage	520	30
	600	25
	660	12
Accelerating Time	Voltage (%)	Time(sec)
	100	6

APPENDIX C

SEL701 SETTING DATA SHEET

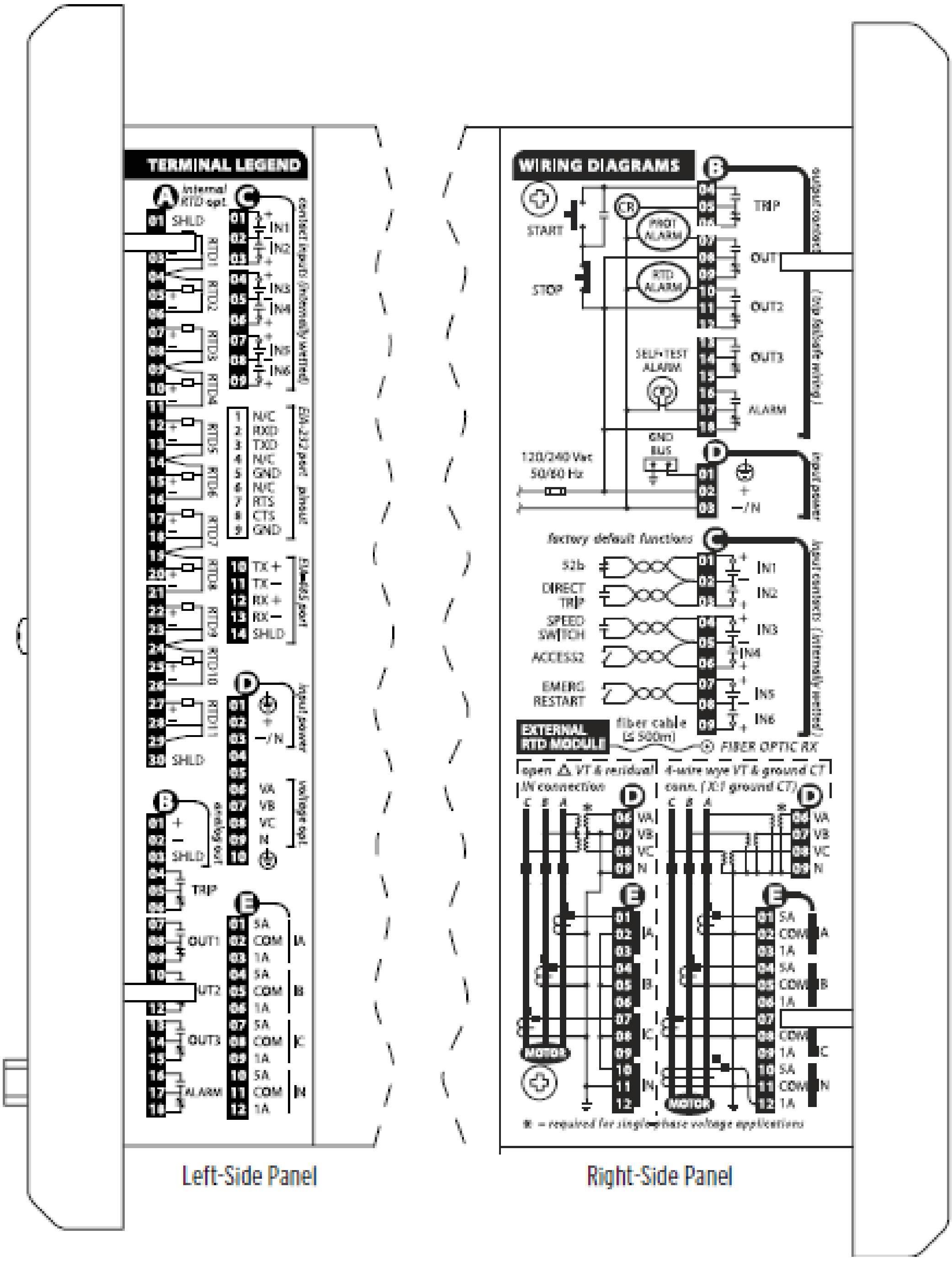

Figure 3 SEL-701 relay left-and right-side panel drawings

Table 4 Generic Thermal Limit Curve from 1 to 9

Multiples of full load Amps	Curves								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.01	311.4	622.7	934.1	1245.4	1556.8	1868.1	2179.5	2490.8	2802.2
1.1	138.9	277.7	416.6	555.4	694.3	833.1	972	1110.8	1249.7
1.15	111.9	223.8	335.7	447.6	559.4	671.3	783.2	895.1	1007
1.2	94	188	282	376	470	564	658	752	846
1.3	71	142	213.1	284.1	355.1	426.1	497.2	568.2	639.2
1.4	56.6	113.2	169.8	226.4	283	339.6	396.2	452.7	509.3
1.5	46.6	93.2	139.8	186.4	233	279.6	326.2	372.8	419.4
1.7	33.7	67.3	101	134.7	168.4	202	235.7	269.4	303
2	22.8	45.6	68.4	91.2	114	136.9	159.7	182.5	205.3
2.5	14.4	28.8	43.2	57.6	72	86.4	100.8	115.2	129.6
3	10	20	30	40	50	60	70	80	90
3.5	7.3	14.7	22	29.4	36.7	44.1	51.4	58.8	66.1
4	5.6	11.2	16.9	22.5	28.1	33.7	39.4	45	50.6
4.5	4.4	8.9	13.3	17.8	22.2	26.7	31.1	35.6	40
5	3.6	7.2	10.8	14.4	18	21.6	25.2	28.8	32.4
6	2.5	5	7.5	10	12.5	15	17.5	20	22.5
7	1.8	3.7	5.5	7.4	9.2	11	12.9	14.7	16.5
8	1.4	2.8	4.2	5.6	7	8.4	9.8	11.3	12.7
9	1.1	2.2	3.3	4.4	5.5	6.6	7.7	8.8	10
10	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1
50	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1

Table 5 Generic Thermal Limit Curve from 10 to 45

Multiples of full load Amps	Curves							
	10	15	20	25	30	35	40	45
1.01	3113.6	4670.3	6227.1	7783.9	9340.7	10897.4	12454.2	14011
1.1	1388.5	2082.8	2777.1	3471.3	4165.6	4859.9	5554.1	6248.4
1.15	1118.9	1678.3	2237.8	2797.2	3356.7	3916.1	4475.6	5035
1.2	940	1410.1	1880.1	2350.1	2820.1	3290.2	3760.2	4230.2
1.3	710.2	1065.4	1420.5	1775.6	2130.7	2485.9	2841	3196.1
1.4	565.9	848.9	1131.9	1414.8	1697.8	1980.8	2263.7	2546.7
1.5	466	699.1	932.1	1165.1	1398.1	1631.2	1864.2	2097.2
1.7	336.7	505.1	673.4	841.8	1010.1	1178.5	1346.8	1515.2
2	228.1	342.1	456.2	570.2	684.3	798.3	912.4	1026.4
2.5	144	216	288	360	432	504	576	648
3	100	150	200	250	300	350	400	450
3.5	73.5	110.2	146.9	183.7	220.4	257.1	293.9	330.6
4	56.2	84.4	112.5	140.6	168.7	196.9	225	253.1
4.5	44.4	66.7	88.9	111.1	133.3	155.6	177.8	200
5	36	54	72	90	108	126	144	162
6	25	37.5	50	62.5	75	87.5	100	122.5
7	18.4	27.6	36.8	45.9	55.1	64.3	73.5	82.7
8	14.1	21.1	28.1	35.2	42.2	49.2	56.3	63.3
9	11.1	16.7	22.2	27.8	33.3	38.9	44.4	50
10	9	13.5	18	22.5	27	31.5	36	40.5
50	9	13.5	18	22.5	27	31.5	36	40.5

APPENDIX D

MODELLING OF SEL701 RELAY

1. Introduction

The *DIgSILENT PowerFactory* model of the SEL701 provides the following 'Protection Elements';

- Thermal Overload Protection Element 49
- Instantaneous Phase Protection Element 50P
- Instantaneous Ground Protection Element 50G
- Instantaneous Negative Sequence Protection Element 50Q
- Instantaneous Under/Over Voltage Protection element 27/59

The *DIgSILENT* Pacific PowerFactory model of the SEL701 contains the complete list of defined 17 generic curves.

2. PowerFactory Protection Functionality

The graphic below is the *PowerFactory Frame.* The *Frame* shows the *blocks* used in the *PowerFactory* model.

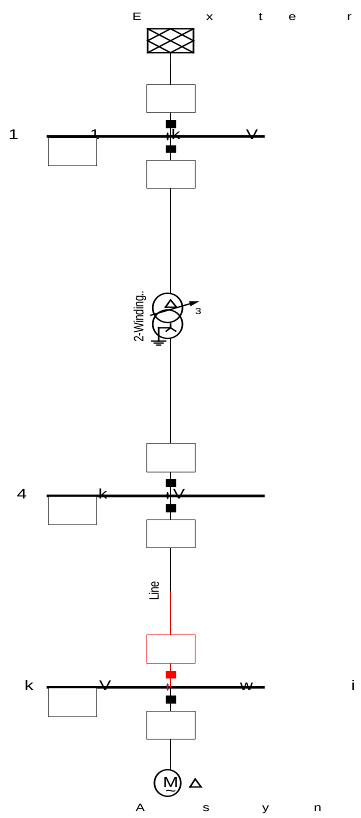

Figure 4 SEL701 PowerFactory Frame

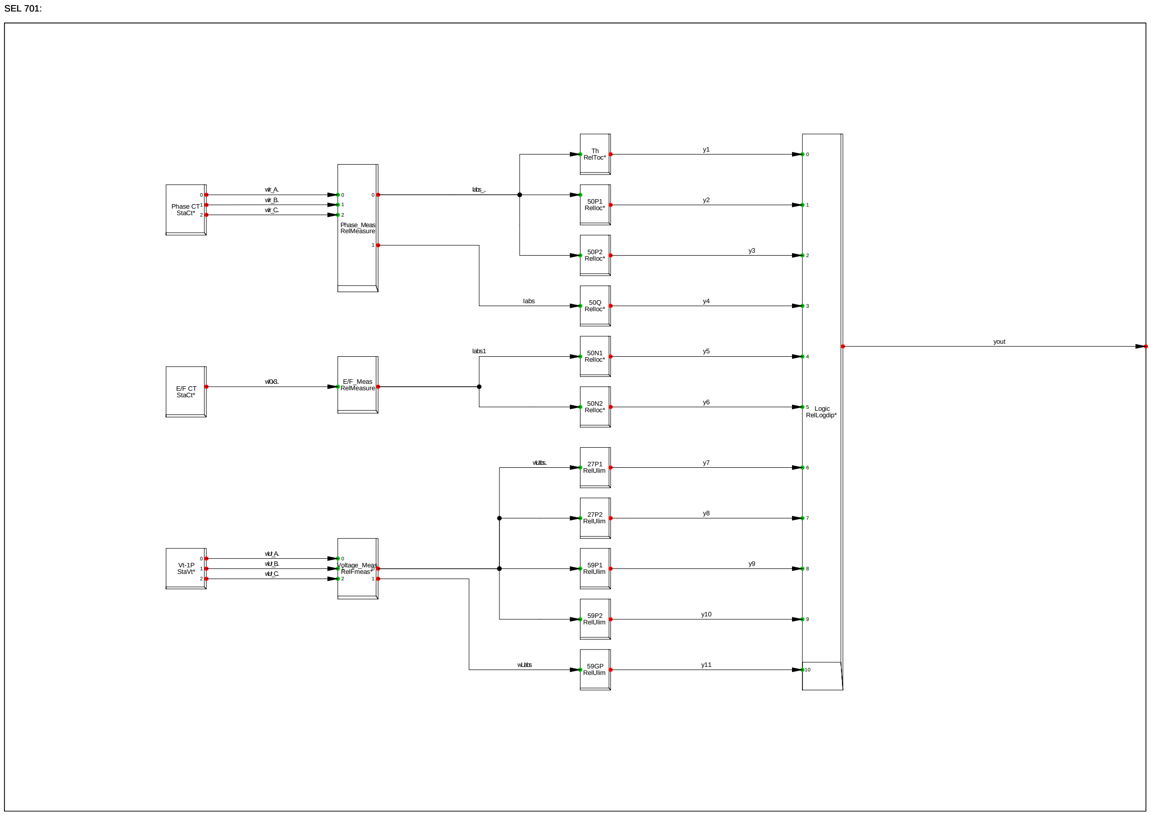

Figure 5 Block diagram

Each of the blocks modelled in the *PowerFactory Frame* (see Figure 5) represents one function of the relay, as follows;

Protection Measurement Transformer Blocks

- The CT block requires a CT ratio of 200/1.
- The VT block requires a VT ratio of 4000/240

Measurement Blocks

- Measurement Sequence / Phase: Nominal current and Nominal Voltage are set to 1A.
- Measurement Voltage Frequency: *Nominal Voltage* is set to 240V.

Time Overcurrent Protection Blocks(49)

The Time Overcurrent (TOC) block allows the user to select *Characteristic, Time Dial*, *Time Adder* and the *Min Response Time*. All Protection Curves have a maximum current multiplier of 30p.u.

- Phase / Earth / Negative Sequence: *Pickup Current* has a range from 0.2-1.6A.

Instantaneous Overcurrent Protection Setting blocks

Instantaneous Overcurrent (IOC) protection is only available for Phase, NPS and Earth Protection. IOC blocks are also used to represent Sensitive Ground Protection which operates with a definite time characteristic. The IOC block allows the user to select the *Pickup Current* and *Time Setting*. The IOC protection can be set with a time delay if required. The IOC *Time Setting* is the same value as used in the TOC blocks from the *Min Response Time*.

- Phase / Earth / Negative Sequence Trip IOC 1-4: *Pickup Current* has a range from 0.05-20A. *Time Setting* range is 0-400s.

Voltage Protection

- Over Voltage /Under Voltage: *Pickup voltage* range is from 1-300p.u.

APPENDIX E

LOAD FLOW CALCULATION

SHORT CURRENT CALCULATION

Table 6 Load flow calculation in the MV Motor

```
-------------------------------------------------------------------------------------------------------------------------------------
|     Murdoch     |               School of Engineering and Energy                |  DIgSILENT   | Project: Thesis                  |
|     Course      |   Electrical Power,Instrumentation and Control Engineering    | PowerFactory |----------------------------------
|                 |                  Calculation by Sungmin Cho                   |   14.0.515   | Date:  1/11/2010                 |
-------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------------------------------
| Load Flow Calculation                                  Complete System Report: Substations, Voltage Profiles, Grid Interchange |
-------------------------------------------------------------------------------------------------------------------------------------
|     AC Load Flow, balanced, positive sequence          |    Automatic Model Adaptation for Convergency           Yes        |
|     Automatic Tap Adjust of Transformers          No   |    Max. Acceptable Load Flow Error for                            |
|     Consider Reactive Power Limits                No   |       Nodes                                            1.00 kVA   |
|                                                       |       Model Equations                                  0.10 %     |
-------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                System Stage: Grid           | Study Case: MV Motor                   | Annex:                / 1  |
-------------------------------------------------------------------------------------------------------------------------------------
|          rated                              Active Reactive Power                  |                                               |
|         Voltage     Bus-voltage              Power   Power   Factor Current Loading|                 Additional Data               |
|          [kV]  [p.u.]    [kV]   [deg]     [MW]   [Mvar]    [-]    [kA]    [%]   |                                               |
-------------------------------------------------------------------------------------------------------------------------------------
|11kV                                                                                |                                               |
|         11.00    1.03   11.33    0.00                                             |                                               |
|   Cub_2  /Xnet     External Grid          1.16     0.78   0.83    0.07            |Sk":    10.00 MVA                             |
|   Cub_3  /Tr2      2-Winding Transfor     1.16     0.78   0.83    0.07    90.75    |Tap:     3.00      Min:      1      Max:     5   |
|                                                                                    |                                               |
|4kV with relay                                                                      |                                               |
|          4.00    0.97    3.88   28.15                                             |                                               |
|   Cub_3  /Asm      Asynchronous Machi     1.12     0.69   0.85    0.20    95.91   |Slip:    2.08 %    xm:    5.60 p.u.              |
|   Cub_1  /Lne      Line                  -1.12    -0.69  -0.85    0.20    97.90   |Pv:     40.24 kW   cLod:  0.00 Mvar L:    0.50 km|
|                                                                                    |                                               |
|4kV                                                                                 |                                               |
|          4.00    1.00    3.99   27.50                                             |                                               |
|   Cub_1  /Tr2      2-Winding Transfor    -1.16    -0.70  -0.86    0.20    90.75   |Tap:     3.00      Min:      1      Max:     5   |
|   Cub_2  /Lne      Line                   1.16     0.70   0.86    0.20    97.90   |Pv:     40.24 kW   cLod:  0.00 Mvar L:    0.50 km|
|                                                                                    |                                               |
-------------------------------------------------------------------------------------------------------------------------------------
```

Table 7 Load flow calculation in the LV Motor

```
-----------------------------------------------------------------------------------------------------------------------------------
|     Murdoch      |               School of Engineering and Energy                |  DIgSILENT   | Project: Thesis                  |
|     Course       |   Electrical Power,Instrumentation and Control Engineering    | PowerFactory |-----------------------------------
|                  |                  Calculation by Sungmin Cho                   |   14.0.515   | Date:  1/11/2010                 |
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
| Load Flow Calculation                                         Complete System Report: Substations, Voltage Profiles, Grid Interchange |
-----------------------------------------------------------------------------------------------------------------------------------
|     AC Load Flow, balanced, positive sequence              |    Automatic Model Adaptation for Convergency           Yes        |
|     Automatic Tap Adjust of Transformers           No      |    Max. Acceptable Load Flow Error for                            |
|     Consider Reactive Power Limits                 No      |       Nodes                                            1.00 kVA   |
|                                                            |       Model Equations                                  0.10 %     |
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                System Stage: Grid           | Study Case: LV Motor                | Annex:                  / 1  |
-----------------------------------------------------------------------------------------------------------------------------------
|           rated                             Active Reactive Power                  |                                                  |
|          Voltage     Bus-voltage            Power    Power   Factor Current Loading|              Additional Data                     |
|           [kV]  [p.u.]    [kV]   [deg]     [MW]    [Mvar]    [-]    [kA]    [%]   |                                                  |
-----------------------------------------------------------------------------------------------------------------------------------
|11kV                                                                                |                                                  |
|          11.00    1.00   11.00    0.00                                              |                                                  |
|   Cub_1  /Xnet     External Grid          0.03     0.02   0.80    0.00            |Sk":     0.40 MVA                                 |
|   Cub_2  /Tr2      2-Winding Transfor     0.03     0.02   0.80    0.00    3.76   |Tap:     0.00      Min:      0      Max:     0    |
|                                                                                   |                                                  |
|0.46kV Terminal                                                                    |                                                  |
|           0.46    1.00    0.46   30.06                                            |                                                  |
|   Cub_3  /Asm      LV Motor               0.03     0.02   0.80    0.05   94.82   |Slip:    0.79 %    xm:    1.79 p.u.               |
|   Cub_1  /Lne      Line                  -0.03    -0.02  -0.80    0.05   38.63   |Pv:      0.15 kW   cLod:  0.00 Mvar L:    0.03 km|
|                                                                                   |                                                  |
|0.46kV                                                                             |                                                  |
|           0.46    1.00    0.46   29.95                                            |                                                  |
|   Cub_1  /Tr2      2-Winding Transfor    -0.03    -0.02  -0.80    0.05    3.76   |Tap:     0.00      Min:      0      Max:     0    |
|   Cub_2  /Lne      Line                   0.03     0.02   0.80    0.05   38.63   |Pv:      0.15 kW   cLod:  0.00 Mvar L:    0.03 km|
|                                                                                   |                                                  |
-----------------------------------------------------------------------------------------------------------------------------------
```

Table 8 Short-Circuit Calculation of LV Motor : Single Phase to Ground Fault on Bus with Relay

```
-----------------------------------------------------------------------------------------------------------------------------------
|     Murdoch      |                School of Engineering and Energy                  |  DIgSILENT   | Project: Thesis                 |
|     Course       |   Electrical Power,Instrumentation and Control Engineering      | PowerFactory |---------------------------------
|                  |                 Calculation by Sungmin Cho                       |   14.0.515   | Date:  1/11/2010               |
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
| Relays Detailled                                                                                                                |
| Short-Circuit Calculation according to IEC60909                          Single Phase to Ground   / Max. Short-Circuit Currents |
-----------------------------------------------------------------------------------------------------------------------------------
| Asynchronous Motors                     | Grid Identification                      | Short-Circuit Duration                      |
|    Always Considered                    |    Automatic                             |    Break Time                      0.10 s   |
|                                         |                                          |    Fault Clearing Time (Ith)       1.00 s   |
|                                         | Conductor Temperature                    | c-Voltage Factor                            |
|                                         |    User Defined             No           |    User Defined                    No       |
|                                         |                                          |                                             |
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                System Stage: Grid            | Study Case: LV Motor                  | Annex:                  / 1  |
-----------------------------------------------------------------------------------------------------------------------------------
| SEL 701                         Relay Type : SEL701                                                                              |
|   Phase CTPhase CT              Location   : Busbar       : 0.46kV with Relay   /                  Ratio       : 50A/1A         |
|                                              Branch       : Line                                    Connection  : Y              |
|                                                           :                                                                      |
|   E/F CT: E/F CT                Location   : Busbar       : 0.46kV with Relay   /                  Ratio       : 50A/1A         |
|                                              Branch       : Line                                    Connection  : Y              |
|                                                           :                                                                      |
|   Vt-1P : VT                    Location   : Busbar       : 0.46kV with Relay   /                  Ratio       : 460V/120V      |
|                                              Branch       : Line                                    Connection  : Y - Y          |
-----------------------------------------------------------------------------------------------------------------------------------
|   50P1    : 50P1                ( IEC: I>>   ANSI: 50   )        Current  [sec.A]       [pri.A]          Tripping Time        |
|     Pickup Current  :   9.080 sec.A    454.00 pri.A   9.080 p.u.      A :     6.338        316.91           9999.999 s          |
|     Time Setting    :   0.050 s                                       B :     2.835        141.76                               |
|     Total Time      :   0.070 s                                       C :     2.835        141.76                               |
|   50N1    : 50N1                ( IEC: IE>>  ANSI: 50N  )        Current  [sec.A]       [pri.A]          Tripping Time        |
|     Pickup Current  :   0.500 sec.A     25.00 pri.A   0.500 p.u.             12.009        600.43              0.040 s          |
|     Time Setting    :   0.020 s                                                                                                  |
|     Total Time      :   0.040 s                                                                                                  |
|   Th      : Th                  ( IEC: I>t   ANSI: 51   )        Current  [sec.A]       [pri.A]          Tripping Time        |
|     Current Setting :   1.000 sec.A     50.00 pri.A   1.000 p.u.      A :     6.338        316.91             33.627 s          |
|     Time Dial       :   1.000     Time Shift :   1.000                B :     2.835        141.76                               |
|     Characteristic  :   C15                                           C :     2.835        141.76                               |
-----------------------------------------------------------------------------------------------------------------------------------
```

Table 9 Short-Circuit Calculation of MV Motor : Single Phase to Ground fault on Bus with Relay

```
-------------------------------------------------------------------------------------------------------------------------------------
|     Murdoch      |               School of Engineering and Energy                 |  DIgSILENT   | Project: Thesis                 |
|     Course       |   Electrical Power,Instrumentation and Control Engineering     | PowerFactory |---------------------------------
|                  |                  Calculation by Sungmin Cho                    |   14.0.515   | Date:  1/11/2010                |
-------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------------------------------
| Relays Detailled                                                                                                                  |
| Short-Circuit Calculation according to IEC60909                                   Single Phase to Ground   / Max. Short-Circuit Currents |
-------------------------------------------------------------------------------------------------------------------------------------
| Asynchronous Motors                     | Grid Identification                       | Short-Circuit Duration                      |
|    Always Considered                    |    Automatic                              |    Break Time                         1.00 s |
|                                         |                                           |    Fault Clearing Time (Ith)          5.00 s |
|                                         | Conductor Temperature                     | c-Voltage Factor                             |
|                                         |    User Defined             No            |    User Defined                       No     |
|                                         |                                           |                                              |
-------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                System Stage: Grid           | Study Case: MV Motor                 | Annex:                   / 1  |
-------------------------------------------------------------------------------------------------------------------------------------
| SEL 701                          Relay Type : SEL 701                                                                             |
|   Phase CTPhase CT               Location   : Busbar       : 4kV with relay      /                  Ratio       : 200A/1A        |
|                                                Branch       : Line                                   Connection  : Y              |
|                                                             :                                                                      |
|   E/F CT: E/F CT                 Location   : Busbar       : 4kV with relay      /                  Ratio       : 200A/1A        |
|                                                Branch       : Line                                   Connection  : Y              |
|                                                             :                                                                      |
|   Vt-1P : VT                     Location   : Busbar       : 4kV with relay      /                  Ratio       : 4000V/240V     |
|                                                Branch       : Line                                   Connection  : Y - Y          |
-------------------------------------------------------------------------------------------------------------------------------------
|   50P1    : 50P1                ( IEC: I>>   ANSI: 50   )        Current  [sec.A]       [pri.A]          Tripping Time        |
|     Pickup Current  :  10.180 sec.A   2036.00 pri.A  10.180 p.u.      A :     7.079       1415.73           9999.999 s          |
|     Time Setting    :   0.100 s                                       B :     2.284        456.86                               |
|     Total Time      :   0.120 s                                       C :     2.284        456.86                               |
|   50N1    : 50N1                ( IEC: IE>>  ANSI: 50   )        Current  [sec.A]       [pri.A]          Tripping Time        |
|     Pickup Current  :   0.500 sec.A    100.00 pri.A   0.500 p.u.            11.638       2327.50              0.510 s          |
|     Time Setting    :   0.500 s                                                                                                |
|     Total Time      :   0.510 s                                                                                                |
|   Th      : Th                  ( IEC: I>t   ANSI: 51   )        Current  [sec.A]       [pri.A]          Tripping Time        |
|     Current Setting :   1.000 sec.A    200.00 pri.A   1.000 p.u.       A :     7.079       1415.73              7.229 s          |
|     Time Dial       :   1.000     Time Shift :   1.000                 B :     2.284        456.86                               |
|     Characteristic  :   C4                                            C :     2.284        456.86                               |
-------------------------------------------------------------------------------------------------------------------------------------
```

APPENDIX F

RESULT OF ON-LINE TEST IN THE LV MOTOR

OFF LINE TEST

STEADY STATE TEST

DYNAMIC TEST

1. Off-line test

1) Thermal Protection Element (49)

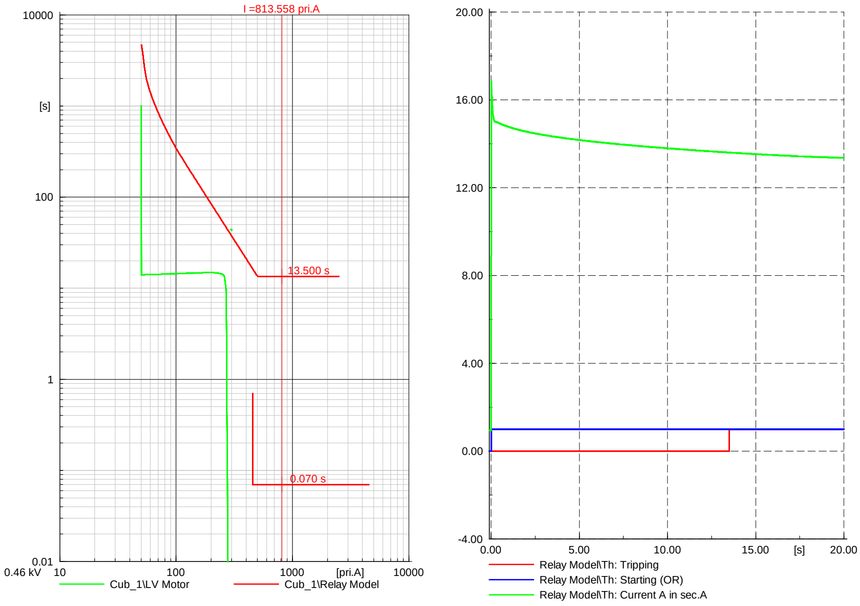

Figure 6 Time – overcurrent plot with single phase to ground fault on the bus

2) Instantaneous Protection Element (50P and 50N)

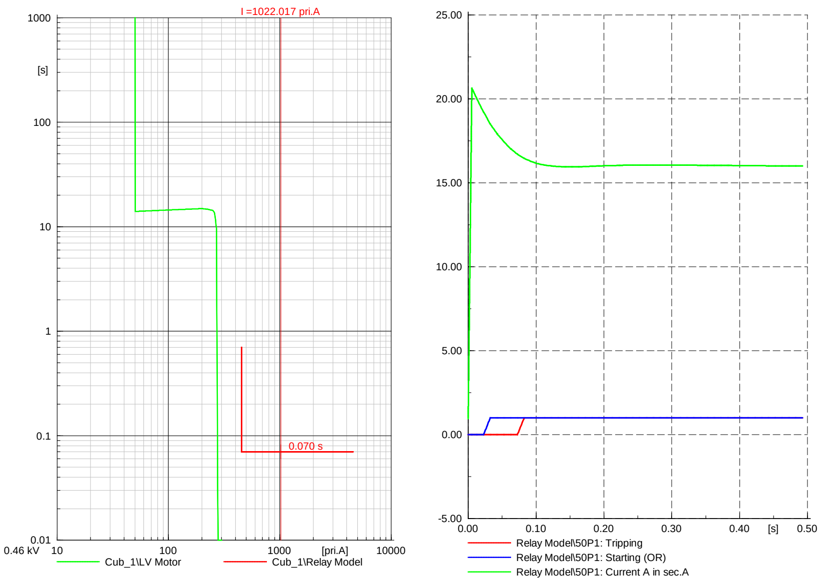

Figure 7 Time– overcurrent plot with two phases to ground fault on the bus (50P)

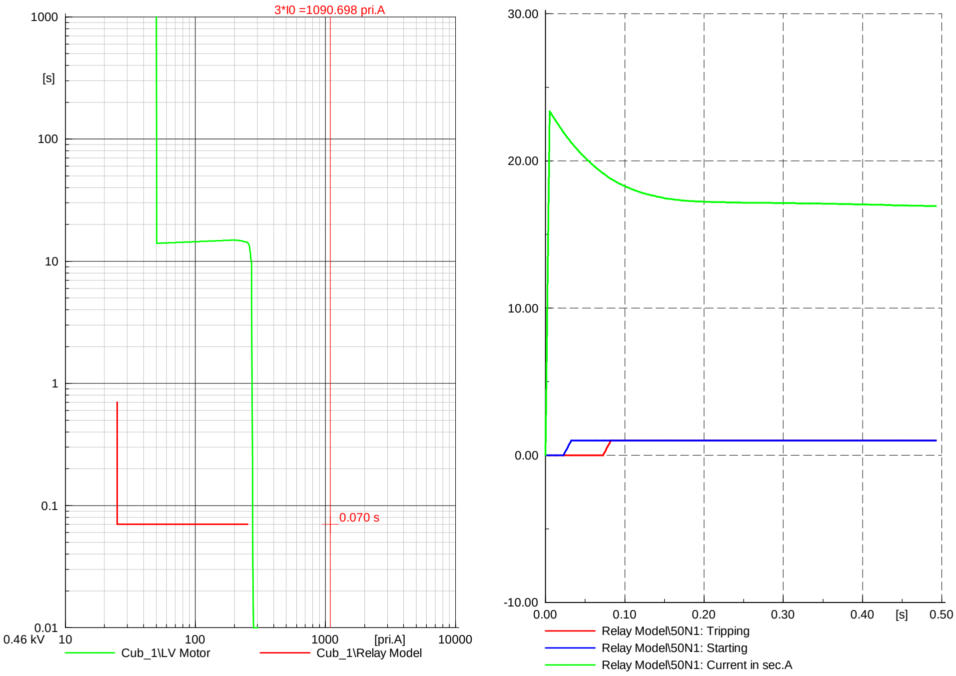

Figure 8 Time– overcurrent plot with single phase to ground fault on the bus (50G)

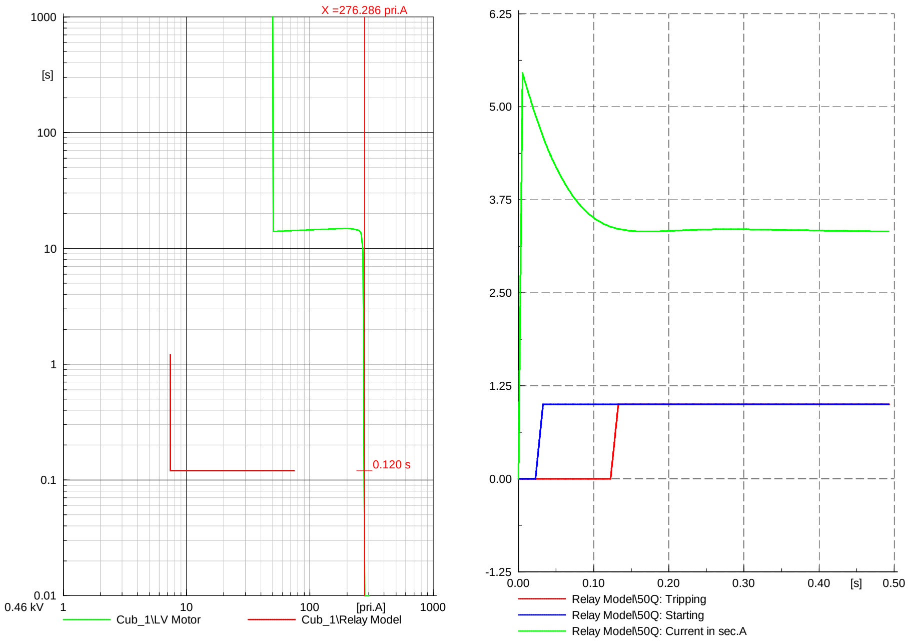

Figure 9 Time– overcurrent plot with two phase to ground fault on the bus (50Q)

2. On-line - Steady state test

1) Thermal Protection Element (49)

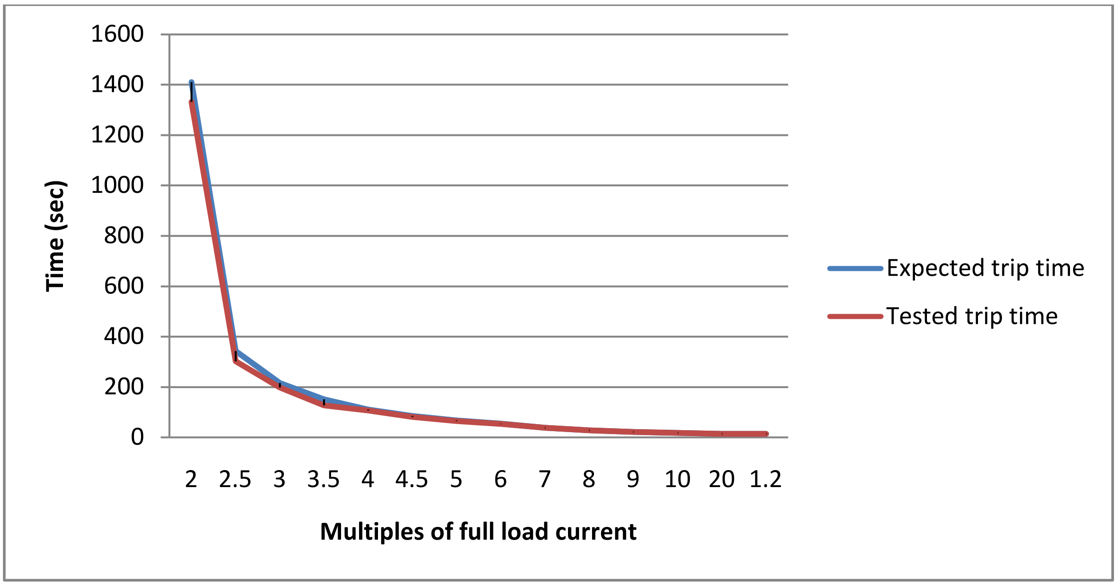

Figure 10 Plot of trip time versus multiples of full load current (curve 4 for LV motor)

Table 10 Test sheet of the thermal curve 4 for LV motor

Multiples of Full Load Amps	Expected tripping time(s) from data sheet	Tested Trip Value(s)	Error (%)
0.95	**Non**	**Non**	**0%**
1.2	1410.1	1331	-6%
2	342.1	301.12	-12%
2.5	216	197.34	-9%
3	150	126.8	-15%
3.5	110.2	105.64	-4%
4	84.4	81.27	-4%
4.5	66.7	63.67	-5%
5	54	53.04	-2%
6	37.5	37.6	0%
7	27.6	27.63	0%
8	21.1	21.15	0%
9	16.7	16.77	0%
10	13.5	13.5	0%
20	**13.5**	**13.5**	**0%**
		Total	4%

Table 11 Test sheet of the instantaneous phase protection (50P) for LV motor

Multiples of Full Load Amps	Expected tripping time(s) from data sheet	Tested Trip Value(s)	Error (%)
7	Non	Non	0%
8	Non	Non	0%
9.534	**0.1**	**0.1**	**0%**
15	0.1	0.1	0%
20.44	**0.1**	**0.1**	**0%**
		Total	0%

Table 12 Test sheet of the instantaneous E/F protection (50N) for MV motor

Multiples of Full Load Amps	Expected tripping time(s) from data sheet	Tested Trip Value(s)	Error (%)
0.1	Non	Non	0%
0.3	Non	Non	0%
0.525	**0.05**	**0.05**	**0%**
2	0.05	0.05	0%
21.8	**0.05**	**0.05**	**0%**
		Total	0%

1. On-line - Dynamic test

1) Instantaneous phase protection(50P)

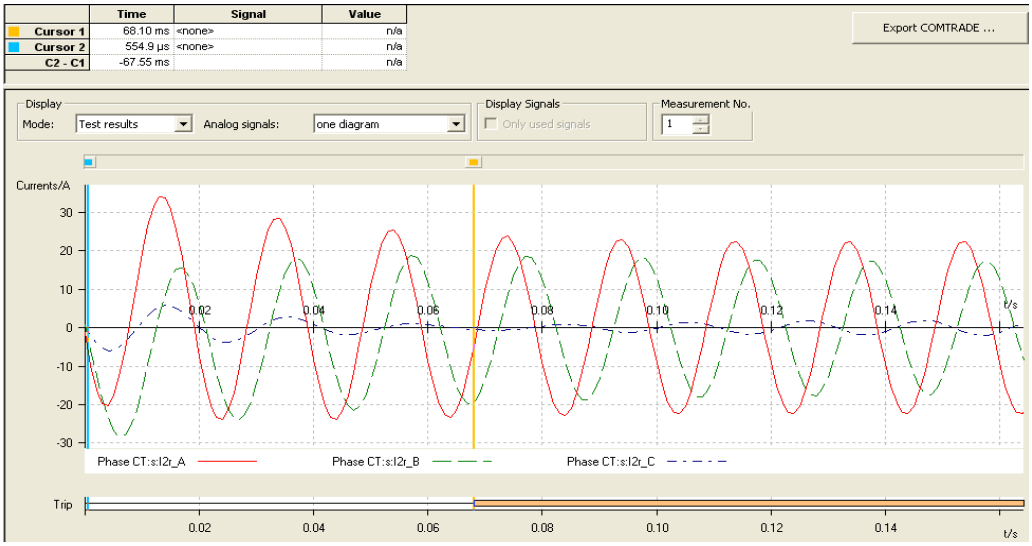

Figure 11Test result of instantaneous phase element (50P) with two phases to ground fault

2) Instantaneous E/F protection(50N)

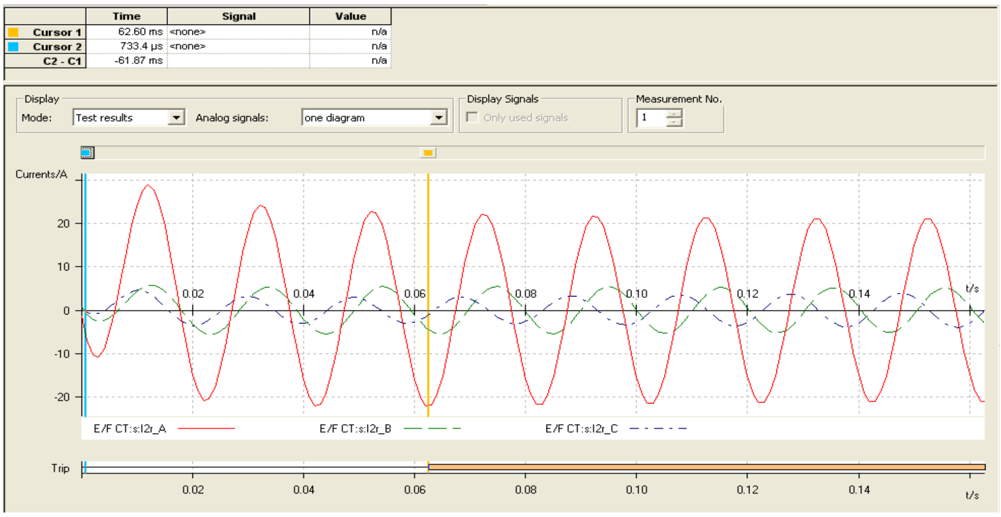

Figure 12Test result of instantaneous phase element (50G) with single phases to ground faul

3) Instantaneous negative sequence protection(50Q)

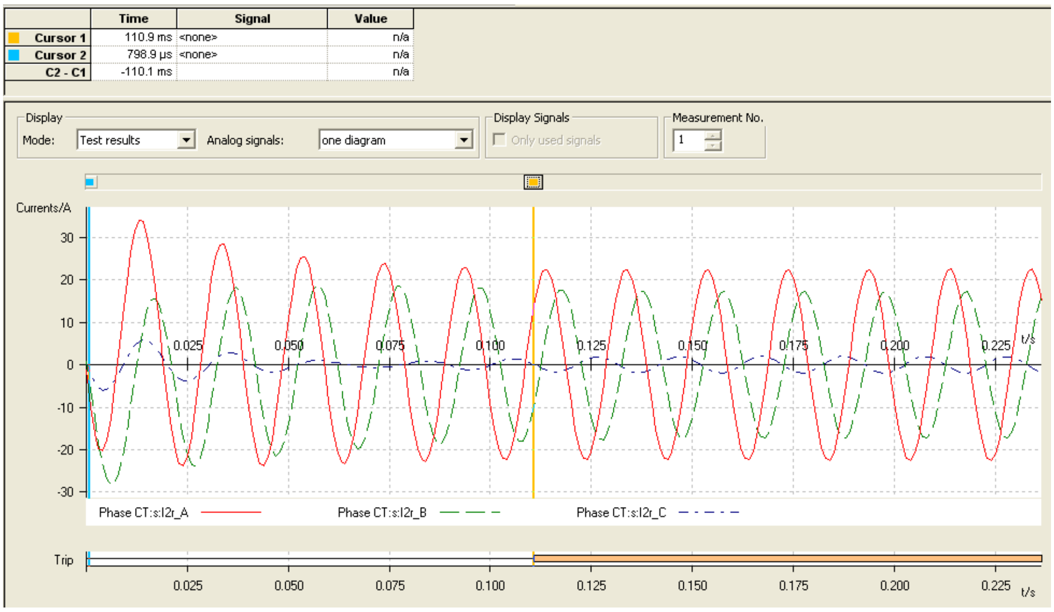

Figure 13 Test result of instantaneous phase element (50Q) with two phases to ground fault