

SIMES ENGINEERING LIMITED PARTNERSHIP

Tel. 081-9146766, 02-8828968

TEST REPORT

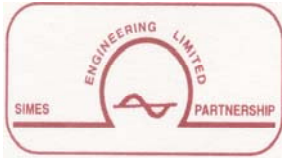
GENERATOR IMPACT WHEN PARALLEL TO PEA SYSTEM

POWER QUALITY MEASUREMENT AND FAULT RECORD

CUSTOMER: บริษัท กลุ่มปาล์มธรรมชาติ จำกัด

BY: SIMES ENGINEERING LIMITED PARTNERSHIP.

DATE: AUGUST - NOVEMBER, 2013



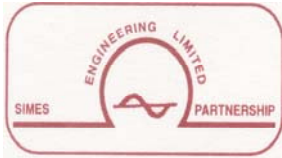
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TEST DEVICE

1. POWER QUALITY ANALYZER

: HIOKI 3196





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SUMMARY REPORT

รายงานนี้เป็นผลของการบันทึก ระบบ 22 KV ที่บริษัท กลุ่มปาล์มธรรมชาติ จำกัด ด้วย Fault Recorder HIOKI

ตั้งแต่วันที่ 15-8-2013 to 17-11-2013 จากการบันทึก มี Fault ที่ระบบ 22 KV ด้าน PEA สามารถแบ่งเหตุการณ์ที่เกิดขึ้นเป็น 5 ชนิด คือ

1. Normal Operation
2. Single line to Ground Fault
3. Double Line to Ground Fault
4. Earth Fault Relay Operate when Energize Transformer
5. Loss of Synchronism

1. เมื่อเกิด Single Line To Ground Fault : Phase Current ยังคงปกติ , Earth Fault Current เป็นศูนย์ . มีแต่ Zero Sequence Voltage ปรากฏ

ข้อเสนอแนะ : ควรใช้ Zero Sequence Voltage Function Detect Single Line To Ground Fault

2. เมื่อเกิด Line to Line Fault : ไม่มี Earth Fault Current , มีแต่การเกิด Under Voltage และ Over Current

ข้อเสนอแนะ : ควรใช้ Under Voltage และ Over Current Function Detect Line to Line Fault

3. Earth Fault Relay ทำงานขณะ Energize Transformer สาเหตุเกิดจาก CT Saturation

ข้อเสนอแนะ : ควรเปลี่ยนการ Detect Earth Fault จาก Summation CT เป็น Core Balance CT

4. PEA Feeder Reclosing ไม่ Synchronize กับ Generator เกิดขึ้นเมื่อ PEA Feeder ปลด แต่ 52 B ยังคงจ่ายไฟฟ้าอยู่หลังจากนั้นประมาณ 1-3 วินาที PEA Feeder จะสับเข้ามาทำให้เกิด LOSS OF SYNCHRONISM มีผลทำให้ Generator ชำรุด

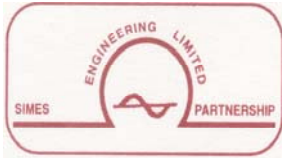
ข้อเสนอแนะ : ควรทำให้ 52B Trip ก่อน 1 Second ทุกกรณีของ Fault และควรติดตั้ง Inter Tripping ระหว่าง PEA กับ

NATURAL PALM

Chanvit Crukeao

Engineering Manager

081-8228835



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SUMMARY REPORT

From Fault Record at 52B VCB in PEA Side Since 15-8-2013 to 17-11-2013 . After considering the recorded data, all recorded events were categorized into 5 conditions to the following . 1.normal condition , 2.single line to ground fault, 3.double line fault, 4.Energize transformer (both tripping and not tripping during energize Transformer) and 5.the reclosing of another generator unit.

In condition 2 single line to ground fault it can be observed that there is no operating of over current and earth fault functions, but the voltage function operate .

Recommendation : For this reason, the threshold of Voltage Relay Function should be reduced.

In condition 3 double line fault, it can be observed that there is no operating of earth fault functions, but the voltage function and Over Current Relay operate .

Recommendation : For this reason, the threshold of Current Relay and Voltage Relay Function should be reduced.

In condition 4 The Earth Fault Relay Some Time Trip During Energize Transformer . In Practical current may flow through this residual circuit because of the unequal outputs of the phase-CT. This may be due to unequal burdens on the current transformers, the difference in the CT characteristics due to variations in manufacturing, or CT saturation caused by high starting currents. Because these unbalanced currents are present

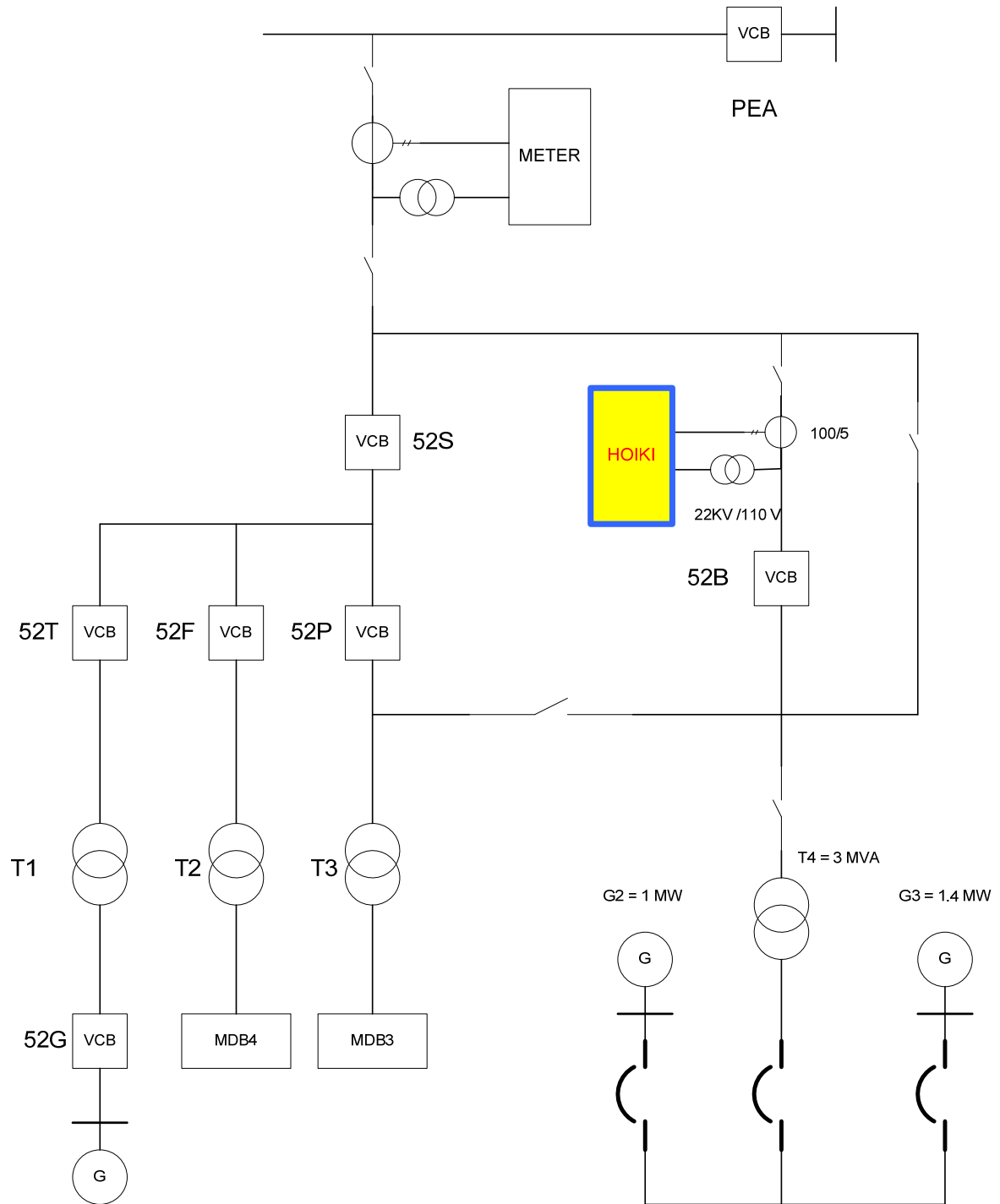
Recommendation : The Earth Fault Should be Detected by Core Balance CT . The Existing Scheme is Summation CT

In condition 5 the reclosing of PEA Feeder , the oscillation and magnitude of voltage and current could be more dangerous, if the PEA Feeder reclosing not Synchronize to Generator

Recommendation : To make sure that 52B circuit breaker was disconnected, the inter trip unit should be installed. Moreover, for avoiding that situation, the operating time of protection function should be set below 1 second. (Less Than First Shot Timing of Reclosing Relay)

Chanvit Crukeao

Engineering Manager



NATURAL PALM SINGLE LINE DIAGRAM AND FAULT RECORDER

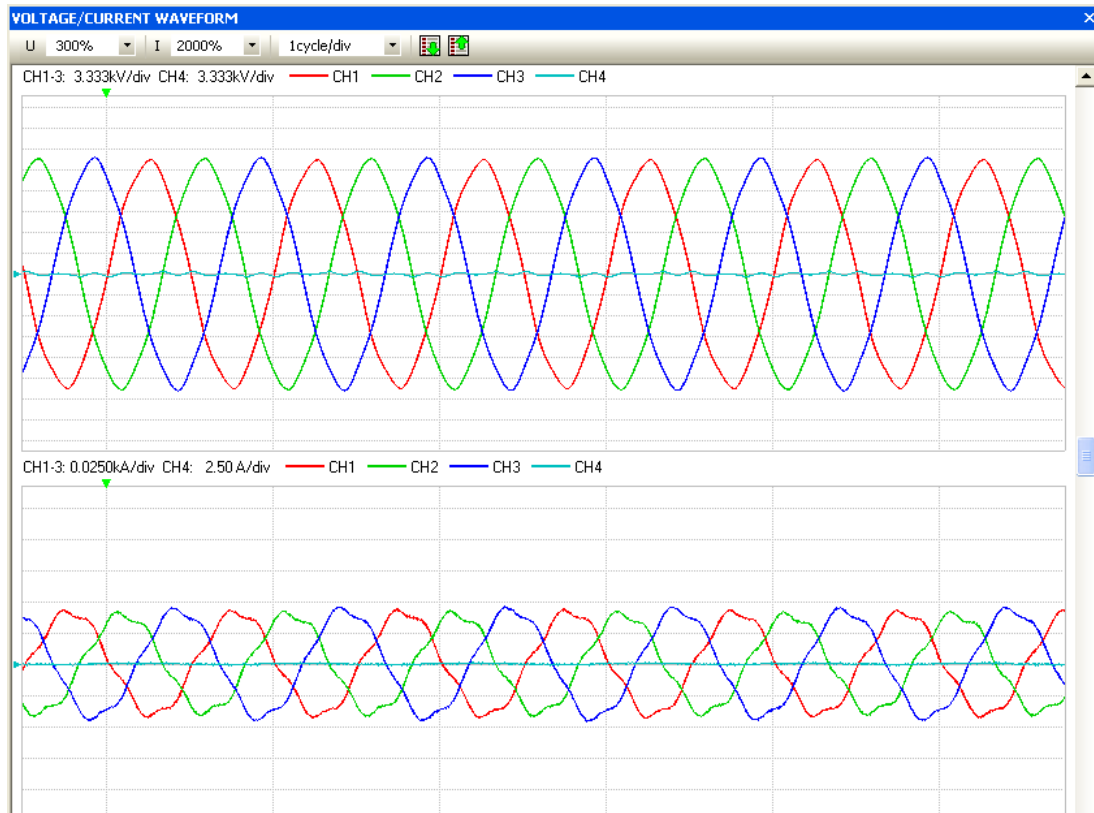
Note

1. In this report, timing was written in "hour.minute.second.millisecond"
2. * means that event was developed to be double line to ground fault later.

1. Normal Condition

Date: 16/08/2556

Time: 09.41.08.347



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.008 Hz				
P1	- 0.364Mw	U1	12.685kV	I1	0.0293kA
P2	- 0.355Mw	U2	12.765kV	I2	0.0281kA
P3	- 0.388Mw	U3	12.702kV	I3	0.0308kA
Psum	- 1.11Mw	U4	0.201kV	I4	0.00 A
S1	0.372MVA	THD-U1	2.77 %	THD-I1	8.87 %
S2	0.358MVA	THD-U2	2.14 %	THD-I2	9.59 %
S3	0.391MVA	THD-U3	2.69 %	THD-I3	7.39 %
Ssum	1.12MVA	THD-U4	----- %	THD-I4	29.36 %
Q1	- 0.075Mvar	Upk+1	18.323kV	Ipk+1	0.0447kA
Q2	- 0.049Mvar	Upk+2	18.485kV	Ipk+2	0.0433kA
Q3	- 0.047Mvar	Upk+3	18.654kV	Ipk+3	0.0465kA
Qsum	- 0.17Mvar	Upk+4	0.426kV	Ipk+4	0.24 A
PF1	-0.9792	Upk-1	-18.309kV	Ipk-1	-0.0429kA
PF2	-0.9907	Upk-2	-18.474kV	Ipk-2	-0.0421kA
PF3	-0.9926	Upk-3	-18.658kV	Ipk-3	-0.0454kA

Figure.1

Meaning :

1.	Frequency	:	50	Hz
2.	Active Power Phase "A"	:	0.364	MW Flow From NP to PEA
3.	Active Power Phase "B"	:	0.355	MW Flow From NP to PEA
4.	Active Power Phase "C"	:	0.391	MW Flow From NP to PEA
5.	Total Active Power	:	1.11	MW Flow From NP to PEA
6.	Reactive Power Phase "A"	:	75	MVAR Flow from NP to PEA
7.	Power Factor "A"	:	0.9792	Lagging
8.	Voltage Phase "A" to Ground	:	12.685	KV
9.	Zero Sequence Voltage (U4)	:	201	V (This Voltage Depend on Ground Fault Condition)
10.	Current Phase "A"	:	29.30	A
11.	Ground Fault Current	:	0.0	A

2. Event: Single line to ground fault (Phase “A” to Ground)

Date: 27/08/2556 Fault start: 06.06.11.698 Figure.2

Circuit breaker status: Trip Tripping time: 06.06.11.899 Duration: 201 ms

Relay trip by function: Ground over voltage Figure.3

Detail (Phase rotation: ABC)

Over voltage: 18.221 kV Phase: B

Under voltage: 2.122 kV Phase: A

Ground over voltage 14.591 kV

PEA Circuit breaker: Trip Tripping time: 06.06.13.652 AM Duration: 1.954 second

Figure.4

PEA reclosing time: 06.06.18.672 Duration from tripping to reclosing: 5.02 second

Figure.5

Similar event:

Date: 18/08/2556 Time: 06.22.02.486

Date: 18/08/2556 Time: 07.16.04.316

Date: 18/08/2556 Time: 14.37.14.818

Date: 18/08/2556 Time: 18.28.28.952

Date: 19/08/2556 Time: 11.49.07.391

Date: 19/08/2556 Time: 20.33.12.373

Date: 21/08/2556 Time: 13.10.11.485

Date: 22/08/2556 Time: 12.03.28.124

Date: 23/08/2556 Time: 17.42.14.580

Date: 25/08/2556 Time: 08.52.47.591

Date: 25/08/2556 Time: 15.44.32.402

Date: 27/08/2556 Time: 06.06.11.899

Date: 09/09/2556 Time: 19.39.54.203

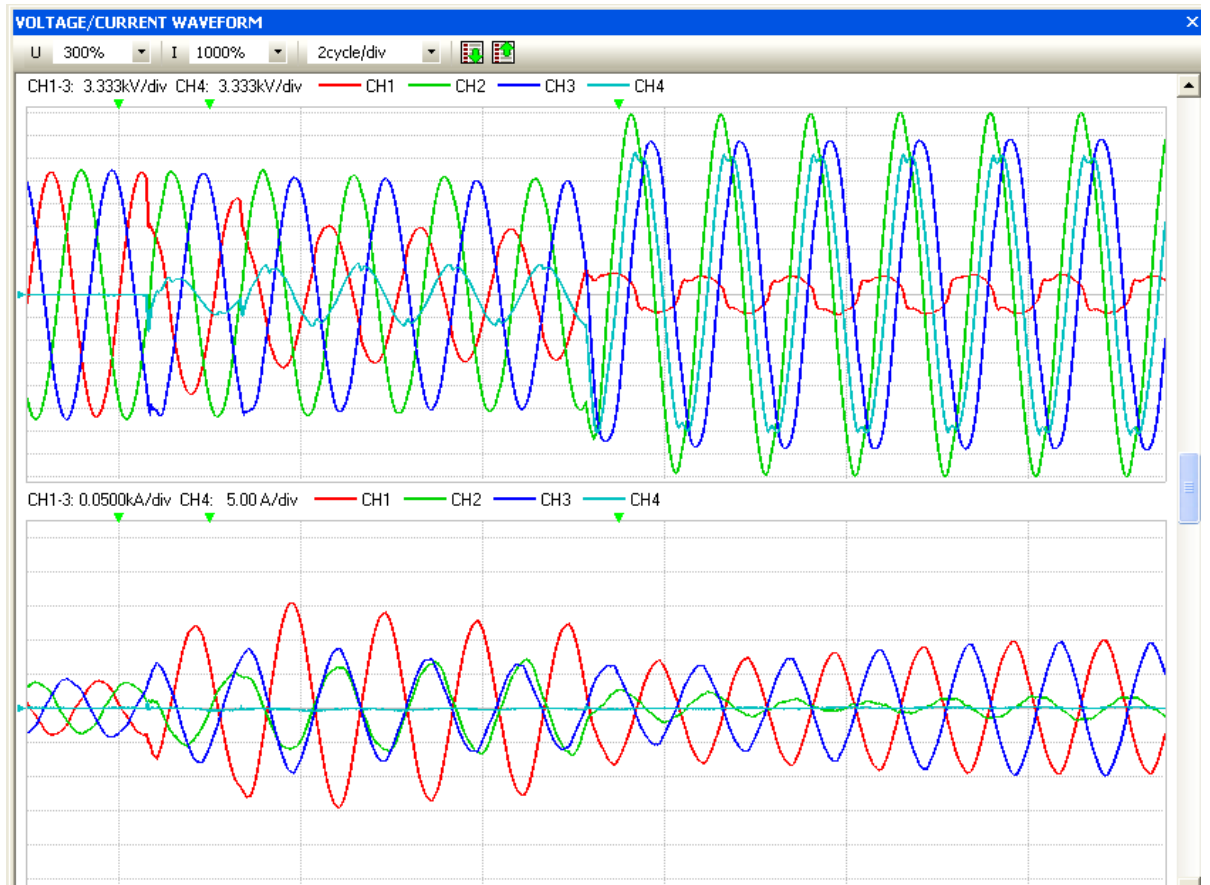
Date: 20/09/2556 Time: 12.05.50.948

Date: 20/09/2556 Time: 13.28.55.098

Date: 20/09/2556 Time: 13.37.27.742

Date: 20/09/2556	Time: 13.44.28.652
Date: 20/09/2556	Time: 15.08.55.148
Date: 20/09/2556	Time: 18.47.55.666
Date: 20/09/2556	Time: 19.18.13.647
Date: 20/09/2556	Time: 19.18.22.438
Date: 22/09/2556	Time: 14.35.54.009
Date: 22/09/2556	Time: 15.23.20.884
Date: 22/09/2556	Time: 21.59.17.683
Date: 28/09/2556	Time: 03.40.29.677
Date: 3/10/2556	Time: 14.26.35.838
Date: 5/10/2556	Time: 10.17.18.457*
Date: 6/10/2556	Time: 06.49.17.139
Date: 6/10/2556	Time: 21.17.47.387
Date: 7/10/2556	Time: 01.42.59.832*
Date: 7/10/2556	Time: 02.02.37.898
Date: 7/10/2556	Time: 02.06.12.821*
Date: 7/10/2556	Time: 03.37.28.451*
Date: 7/10/2556	Time: 03.47.24.282*
Date: 7/10/2556	Time: 04.20.59.576
Date: 7/10/2556	Time: 04.32.50.133
Date: 7/10/2556	Time: 04.44.14.759
Date: 7/10/2556	Time: 04.46.08.969*
Date: 7/10/2556	Time: 05.58.30.738
Date: 8/10/2556	Time: 02.55.09.211
Date: 9/10/2556	Time: 11.58.55.933
Date: 10/10/2556	Time: 15.37.31.025
Date: 10/10/2556	Time: 19.06.40.214
Date: 11/10/2556	Time: 13.53.14.065
Date: 17/10/2556	Time: 02.52.20.221*
Date: 17/10/2556	Time: 15.02.45.721
Date: 18/10/2556	Time: 06.50.10.258
Date: 18/10/2556	Time: 06.52.12.172
Date: 18/10/2556	Time: 23.32.08.639
Date: 21/10/2556	Time: 11.35.33.679

Date: 22/10/2556	Time: 12.20.08.641
Date: 22/10/2556	Time: 12.22.45.892
Date: 23/10/2556	Time: 07.05.07.087
Date: 23/10/2556	Time: 07.05.18.108
Date: 23/10/2556	Time: 08.13.38.382



DMM					
POWER		VOLTAGE		CURRENT	
Freq	49.893 Hz				
P1	- 0.357MW	U1	6.112kV	I1	0.0764kA
P2	0.090MW	U2	15.508kV	I2	0.0317kA
P3	- 0.700MW	U3	14.187kV	I3	0.0521kA
Psum	- 0.97MW	U4	10.490kV	I4	0.00 A
S1	0.467MVA	THD-U1	10.42 %	THD-I1	4.92 %
S2	0.491MVA	THD-U2	3.09 %	THD-I2	7.07 %
S3	0.739MVA	THD-U3	3.47 %	THD-I3	5.08 %
Ssum	1.70MVA	THD-U4	7.89 %	THD-I4	32.12 %
Q1	- 0.301Mvar	Upk+1	17.879kV	Ipk+1	0.1546kA
Q2	- 0.483Mvar	Upk+2	26.650kV	Ipk+2	0.0721kA
Q3	- 0.237Mvar	Upk+3	22.668kV	Ipk+3	0.0946kA
Qsum	- 1.02Mvar	Upk+4	20.916kV	Ipk+4	1.08 A
PF1	-0.7642	Upk-1	-14.570kV	Ipk-1	-0.1458kA
PF2	-0.1824	Upk-2	-26.631kV	Ipk-2	-0.0693kA
PF3	-0.9471	Upk-3	-22.591kV	Ipk-3	-0.0977kA

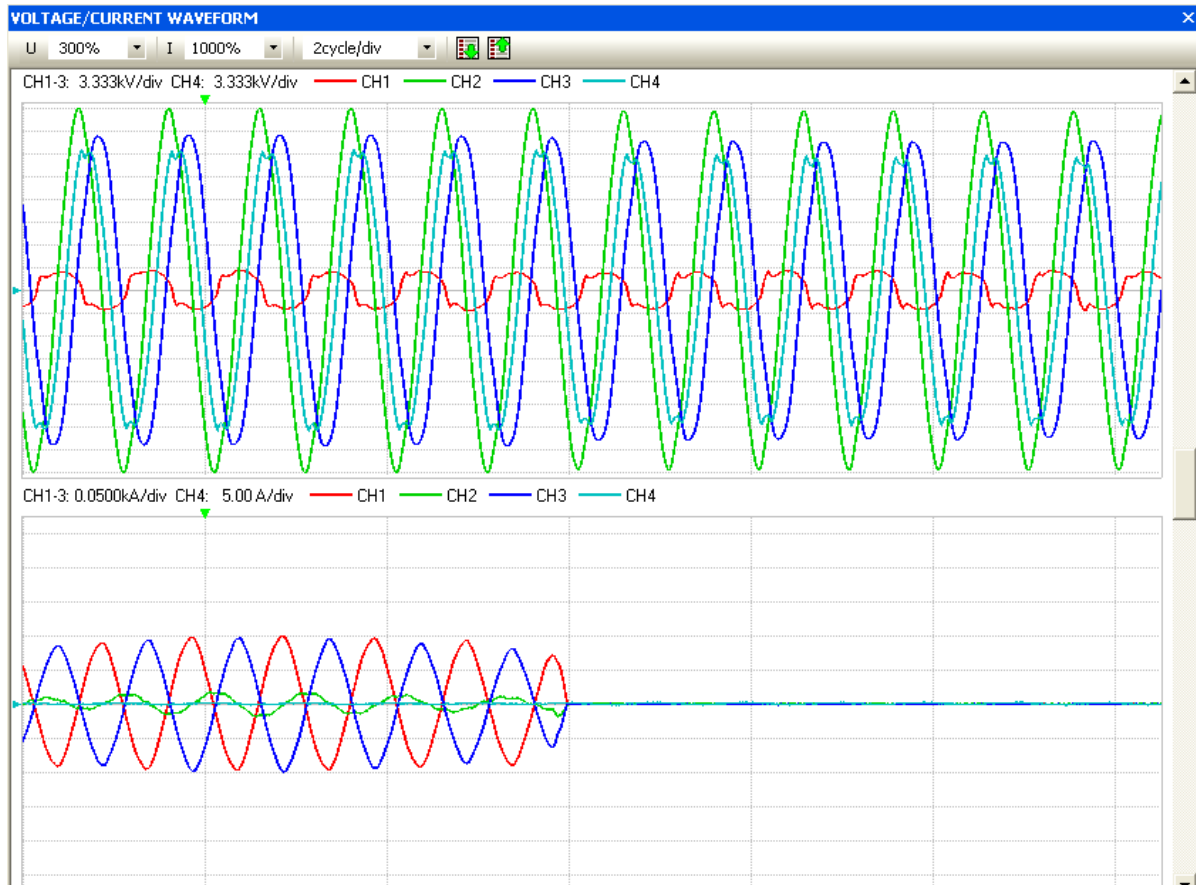
Figure.2 Fault start (06.06.11.698)

Meaning :

1. Frequency : 49.89 Hz
2. Voltage Phase "A" to Ground : 6.11 KV Faulty Phase "A"
3. Voltage Phase "B" to Ground : 15.50 KV Healthy Phase "B"
4. Voltage Phase "C" to Ground : 14.18 KV Healthy Phase "C"
5. Zero Sequence Voltage (U4) : 201 V (This Voltage Depend on Ground Fault)
6. Current Phase "A" : 29.30 A
7. Ground Fault Current : 0.0 A

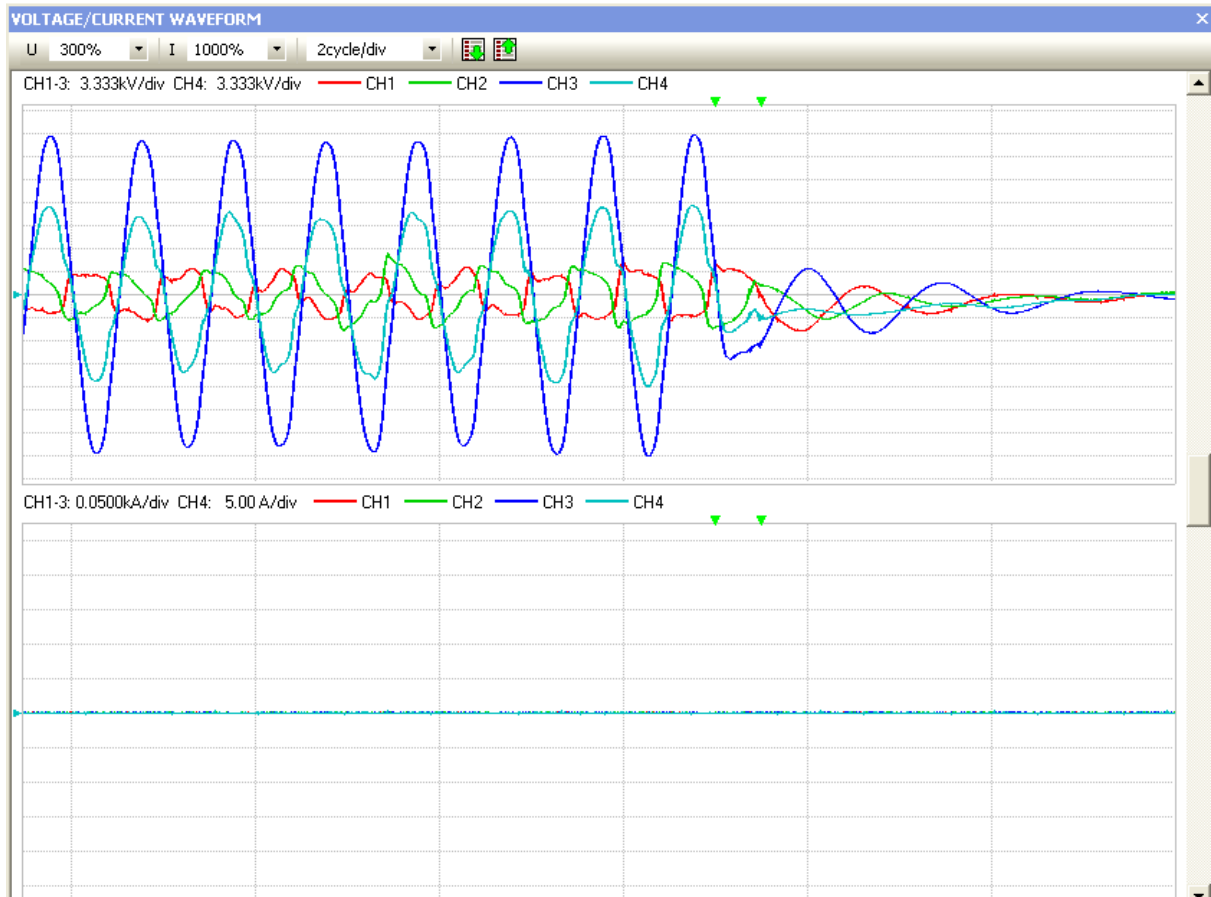
Summary : When Single Line to Ground Fault Occur : The Voltage Level in Healthy Phase More Than Rated Voltage , Phase Current Still Normal . No Earth Fault Current , Zero Sequence Voltage Appear

Detection : Use Zero Sequence Voltage Function to Detect Ground Fault in 22 KV System .



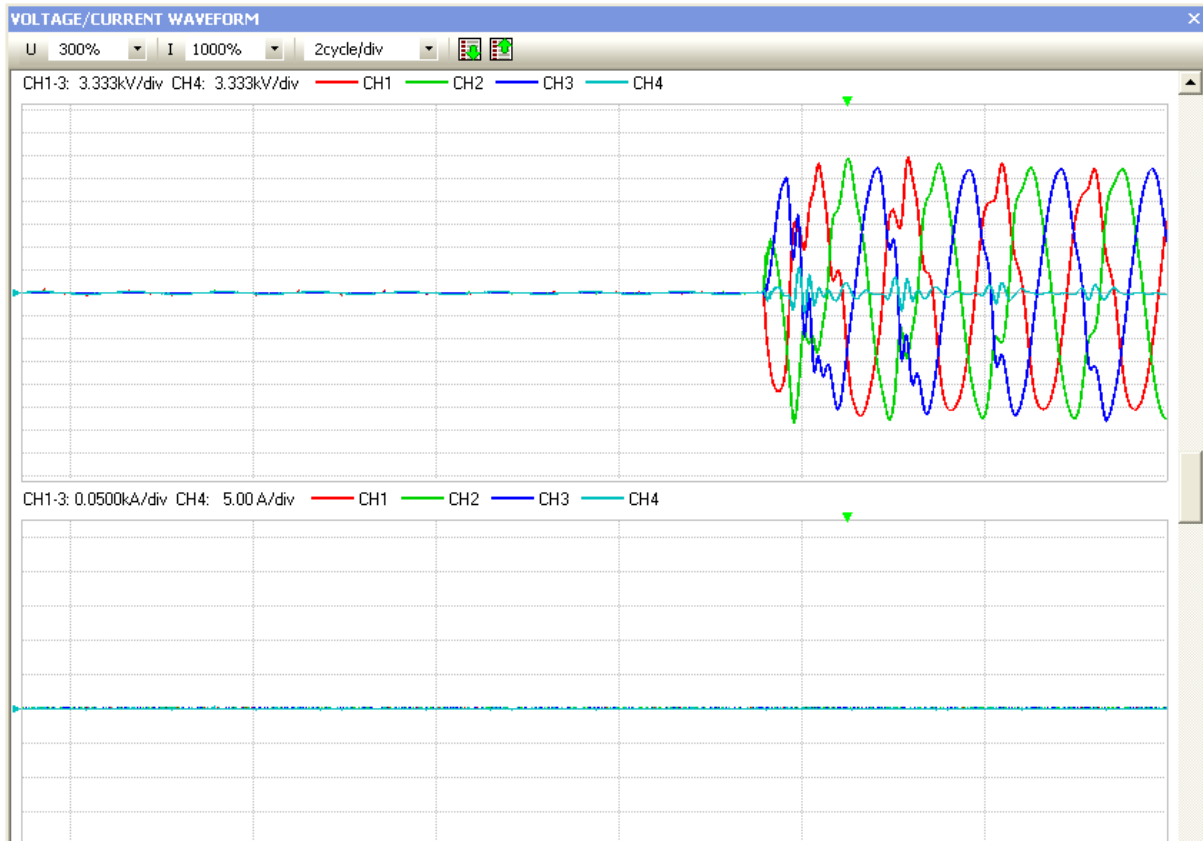
DMM					
POWER		VOLTAGE		CURRENT	
Freq	49.971 Hz				
P1	- 0.052MW	U1	2.212kV	I1	0.0399kA
P2	- 0.056MW	U2	18.221kV	I2	0.0063kA
P3	- 0.363MW	U3	15.758kV	I3	0.0379kA
Psum	- 0.47MW	U4	14.591kV	I4	0.16 A
S1	0.088MVA	THD-U1	23.39 %	THD-I1	8.69 %
S2	0.115MVA	THD-U2	2.21 %	THD-I2	17.34 %
S3	0.597MVA	THD-U3	3.25 %	THD-I3	9.44 %
Ssum	0.80MVA	THD-U4	5.15 %	THD-I4	31.33 %
Q1	0.071Mvar	Upk+1	3.012kV	Ipk+1	0.1005kA
Q2	- 0.101Mvar	Upk+2	26.738kV	Ipk+2	0.0178kA
Q3	- 0.474Mvar	Upk+3	22.756kV	Ipk+3	0.0972kA
Qsum	- 0.50Mvar	Upk+4	20.634kV	Ipk+4	0.36 A
PF1	0.5933	Upk-1	- 2.971kV	Ipk-1	-0.0961kA
PF2	-0.4856	Upk-2	-26.712kV	Ipk-2	-0.0183kA
PF3	-0.6074	Upk-3	-22.694kV	Ipk-3	-0.0989kA

Figure.3 52B tripping (06.06.11.899)



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.000 Hz				
P1	0.000MW	U1	2.601kV	I1	0.0000kA
P2	0.000MW	U2	2.654kV	I2	0.0000kA
P3	0.000MW	U3	13.704kV	I3	0.0000kA
Psum	0.00MW	U4	7.240kV	I4	0.00 A
S1	0.000MVA	THD-U1	35.56 %	THD-I1	---- %
S2	0.000MVA	THD-U2	23.58 %	THD-I2	---- %
S3	0.000MVA	THD-U3	4.20 %	THD-I3	331.74 %
Ssum	0.00MVA	THD-U4	8.20 %	THD-I4	122.25 %
Q1	0.000Mvar	Upk+1	4.962kV	Ipk+1	0.0022kA
Q2	-0.000Mvar	Upk+2	5.965kV	Ipk+2	0.0019kA
Q3	-0.000Mvar	Upk+3	23.091kV	Ipk+3	0.0017kA
Qsum	0.00Mvar	Upk+4	12.935kV	Ipk+4	0.34 A
PF1	1.0000	Upk-1	-5.296kV	Ipk-1	-0.0015kA
PF2	-1.0000	Upk-2	-5.197kV	Ipk-2	-0.0009kA
PF3	-1.0000	Upk-3	-23.403kV	Ipk-3	-0.0008kA

Figure.4 PEA CB tripping (06.06.13.652)



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.000 Hz				
P1	0.000MW	U1	5.772kV	I1	0.0000kA
P2	0.000MW	U2	5.655kV	I2	0.0000kA
P3	0.000MW	U3	5.692kV	I3	0.0000kA
Psum	0.00MW	U4	0.509kV	I4	0.00 A
S1	0.000MVA	THD-U1	29.27 %	THD-I1	276.78 %
S2	0.000MVA	THD-U2	32.63 %	THD-I2	310.92 %
S3	0.000MVA	THD-U3	22.59 %	THD-I3	----- %
Ssum	0.00MVA	THD-U4	----- %	THD-I4	462.80 %
Q1	0.000Mvar	Upk+1	19.848kV	Ipk+1	0.0024kA
Q2	-0.000Mvar	Upk+2	19.620kV	Ipk+2	0.0019kA
Q3	-0.000Mvar	Upk+3	18.287kV	Ipk+3	0.0018kA
Qsum	0.00Mvar	Upk+4	3.812kV	Ipk+4	0.33 A
PF1	1.0000	Upk-1	-17.912kV	Ipk-1	-0.0013kA
PF2	-1.0000	Upk-2	-18.933kV	Ipk-2	-0.0006kA
PF3	-1.0000	Upk-3	-17.736kV	Ipk-3	-0.0009kA

Figure.5 PEA CB reclosing (06.06.18.672)

1. Event: Double line fault (Phase A- B)

Date: 30/08/2556 Fault start: 13.12.49.511 Figure.6

Circuit breaker status: Trip Tripping time: 13.12.50.682 Duration: 1.171 ms

Relay trip by function: Under voltage Figure.7

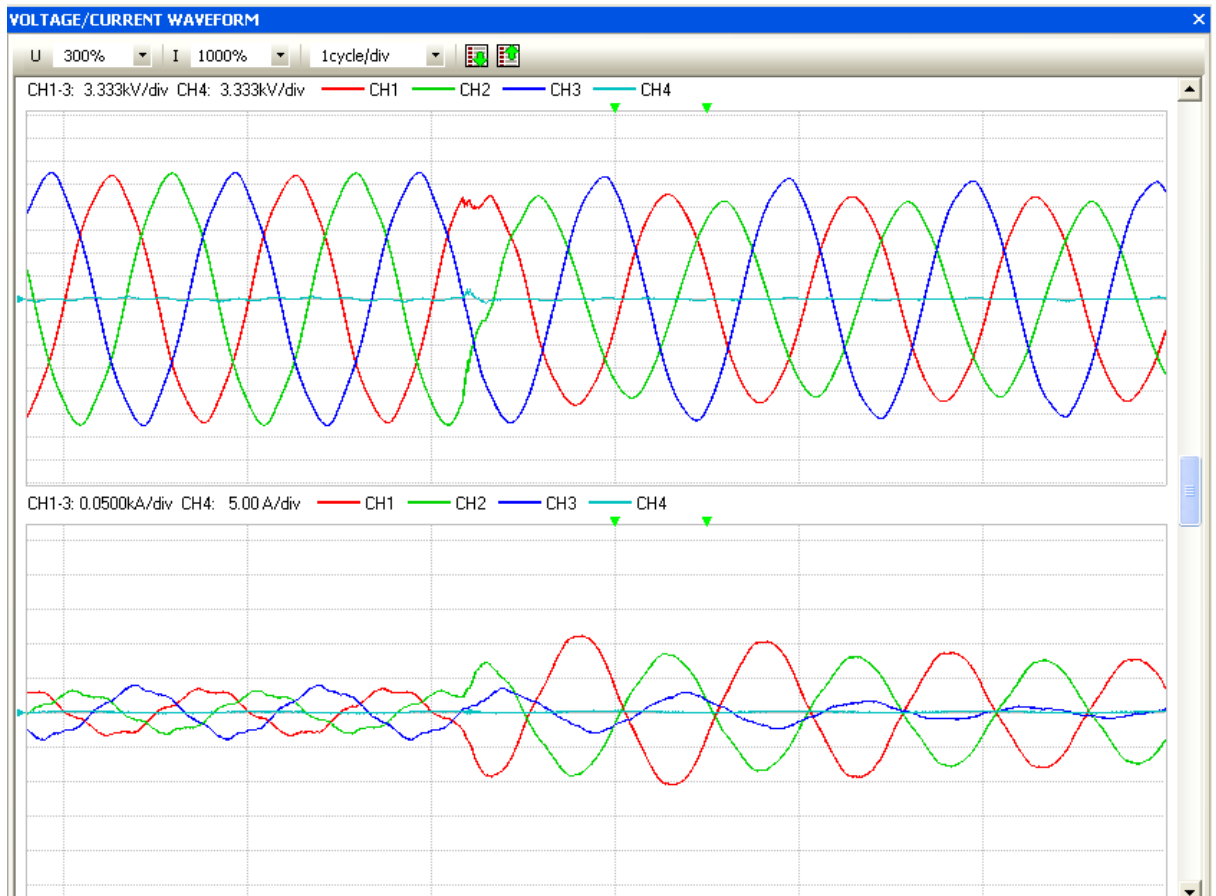
Detail (Phase rotation: ABC)

Under voltage: 9.8, 9.2 kV Phase: AB

Fault current: 70 A Approximately Phase: AB

Similar event:

Date: 28/08/2556	Time: 01.07.01.587
Date: 28/08/2556	Time: 01.07.31.668
Date: 20/09/2556	Time: 09.38.26.399
Date: 20/09/2556	Time: 10.40.55.976
Date: 20/09/2556	Time: 18.47.49.518
Date: 1/10/2556	Time: 02.03.16.490
Date: 4/10/2556	Time: 20.37.27.735*
Date: 09/10/2556	Time: 02.32.00.205
Date: 18/10/2556	Time: 23.28.04.744



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.046 Hz				
P1	0.000MW	U1	9.808kV	I1	0.0000kA
P2	0.000MW	U2	9.200kV	I2	0.0000kA
P3	0.000MW	U3	11.269kV	I3	0.0000kA
Psum	0.00MW	U4	0.152kV	I4	0.00 A
S1	0.000MVA	THD-U1	2.37 %	THD-I1	166.21 %
S2	0.000MVA	THD-U2	3.65 %	THD-I2	178.29 %
S3	0.000MVA	THD-U3	2.23 %	THD-I3	108.24 %
Ssum	0.00MVA	THD-U4	---- %	THD-I4	446.96 %
Q1	- 0.000Mvar	Upk+1	14.496kV	Ipk+1	0.0025kA
Q2	- 0.000Mvar	Upk+2	13.986kV	Ipk+2	0.0020kA
Q3	- 0.000Mvar	Upk+3	16.825kV	Ipk+3	0.0019kA
Qsum	- 0.00Mvar	Upk+4	0.599kV	Ipk+4	0.37 A
PF1	-1.0000	Upk-1	-14.496kV	Ipk-1	-0.0014kA
PF2	-1.0000	Upk-2	-14.136kV	Ipk-2	-0.0006kA
PF3	-1.0000	Upk-3	-16.876kV	Ipk-3	-0.0006kA

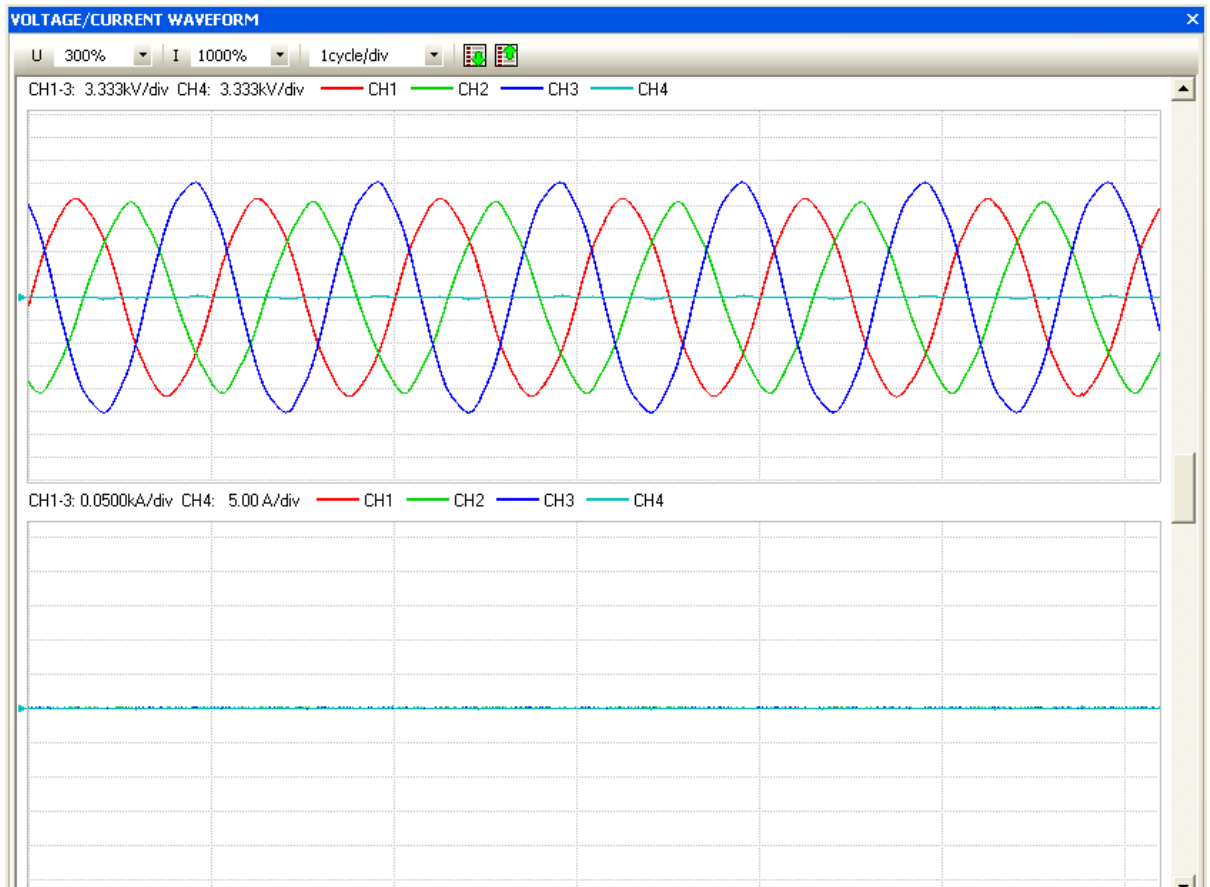
Figure.6 Fault start (13.12.49.511)

Meaning :

1. Frequency : 50.04 Hz
2. Voltage Phase "A" to Ground : 9.808 KV Faulty Phase "A"
3. Voltage Phase "B" to Ground : 9.20 KV Faulty Phase "B"
4. Voltage Phase "C" to Ground : 11.26 KV Healthy Phase "C"
5. Zero Sequence Voltage (U4) : 152 V (This Voltage Depend on Ground Fault)
6. Current Phase "A" : 0.0 A
7. Ground Fault Current : 0.0 A

Summary : When Line to Line Fault Occur : The Voltage Level in Faulty Phase Less Than Rated Voltage , Phase Current More Than Rated Current . No Earth Fault Current , No Zero Sequence Voltage

Detection : Use Under Voltage Function and Over Current Function to Detect Phase to Phase Fault in 22 KV System .



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.046 Hz				
P1	0.000MW	U1	9.808kV	I1	0.0000kA
P2	0.000MW	U2	9.200kV	I2	0.0000kA
P3	0.000MW	U3	11.269kV	I3	0.0000kA
Psum	0.00MW	U4	0.152kV	I4	0.00 A
S1	0.000MVA	THD-U1	2.37 %	THD-I1	166.21 %
S2	0.000MVA	THD-U2	3.65 %	THD-I2	178.29 %
S3	0.000MVA	THD-U3	2.23 %	THD-I3	108.24 %
Ssum	0.00MVA	THD-U4	----- %	THD-I4	446.96 %
Q1	- 0.000Mvar	Upk+1	14.496kV	Ipk+1	0.0025kA
Q2	- 0.000Mvar	Upk+2	13.986kV	Ipk+2	0.0020kA
Q3	- 0.000Mvar	Upk+3	16.825kV	Ipk+3	0.0019kA
Qsum	- 0.00Mvar	Upk+4	0.599kV	Ipk+4	0.37 A
PF1	-1.0000	Upk-1	-14.496kV	Ipk-1	-0.0014kA
PF2	-1.0000	Upk-2	-14.136kV	Ipk-2	-0.0006kA
PF3	-1.0000	Upk-3	-16.876kV	Ipk-3	-0.0006kA

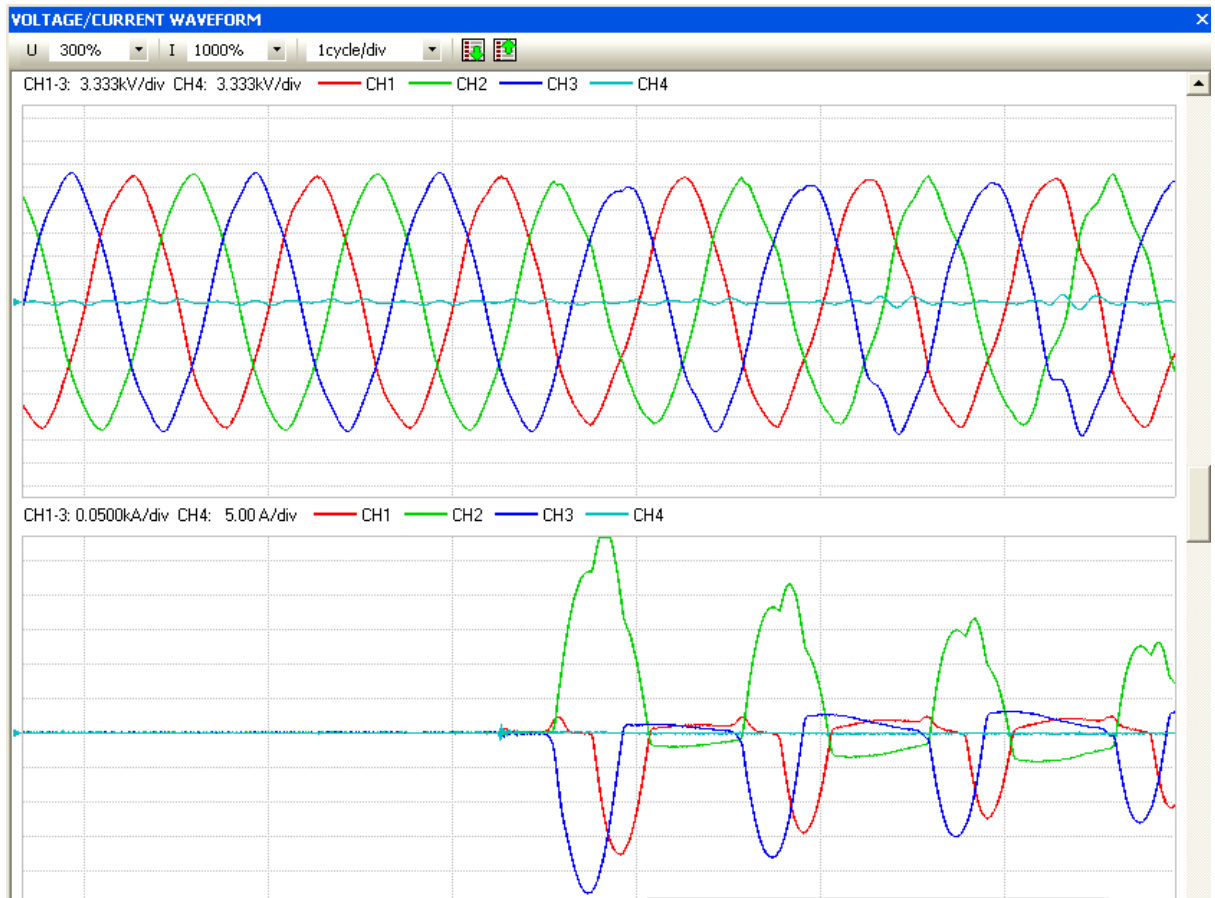
Figure.7 52B trip (13.12.50.682)

a. Transformer Energization: (No trip)

Date: 16/08/2556

Time: 12.00.44.260

Figure.8



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.027 Hz				
P1	0.148Mw	U1	12.452kV	I1	0.0394kA
P2	0.115Mw	U2	12.354kV	I2	0.0708kA
P3	-0.128Mw	U3	12.499kV	I3	0.0546kA
Psum	0.13Mw	U4	0.355kV	I4	0.00 A
S1	0.490MVA	THD-U1	6.52 %	THD-I1	82.54 %
S2	0.875MVA	THD-U2	6.26 %	THD-I2	43.44 %
S3	0.683MVA	THD-U3	6.87 %	THD-I3	75.51 %
Ssum	2.05MVA	THD-U4	---- %	THD-I4	73.99 %
Q1	0.468Mvar	Upk+1	18.294kV	Ipk+1	0.0261kA
Q2	0.868Mvar	Upk+2	18.794kV	Ipk+2	0.2988kA
Q3	0.670Mvar	Upk+3	18.749kV	Ipk+3	0.0355kA
Qsum	2.01Mvar	Upk+4	1.234kV	Ipk+4	1.21 A
PF1	0.3008	Upk-1	-18.250kV	Ipk-1	-0.1763kA
PF2	0.1313	Upk-2	-18.581kV	Ipk-2	-0.0486kA
PF3	0.1881	Upk-3	-19.389kV	Ipk-3	-0.2325kA

Figure.8

b. Transformer Energization: (Trip)

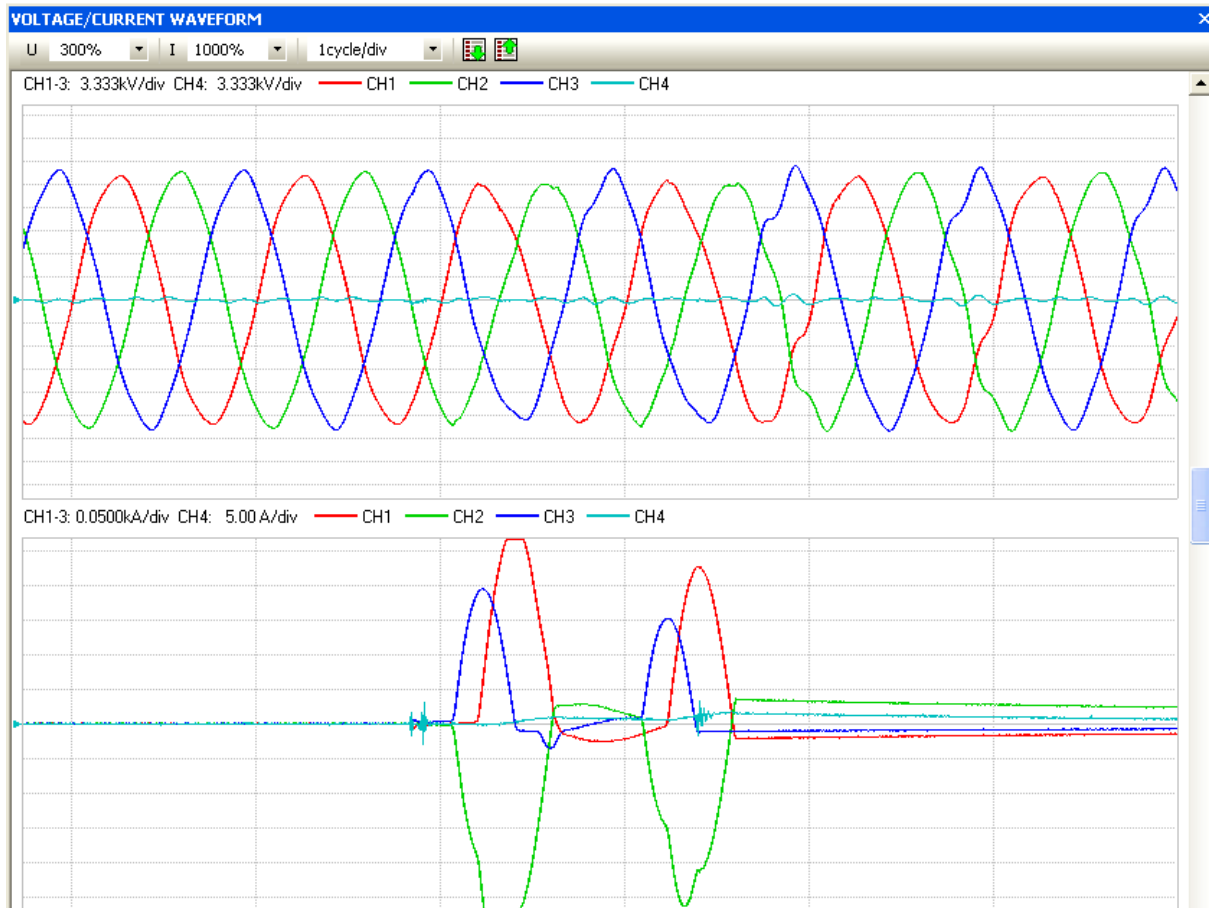
Date: 17/08/2556

Time: 07.36.59.975

Figure.9

Similar event

Date	Time	Ia peak(A)	Ib peak(A)	Ic peak(A)
17/08/2556	07.36.59.975	288	-360	195
18/08/2556	06.24.09.025	185	260	-315
19/08/2556	11.51.24.881	-268	121	264
20/09/2556	15.11.51.007	121	-200	200
03/10/2556	14.42.43.810	895	483	686
03/10/2556	23.16.35.656	248	124	-247
06/10/2556	06.52.33.545	308	311	-421
06/10/2556	21.20.17.552	400	208	-400
07/10/2556	06.06.21.743	438	-431	173
10/10/2556	19.10.48.882	-299	457	-339
11/10/2556	13.54.50.660	-407	-263	456
11/10/2556	18.08.06.576	-189	-302	319
11/10/2556	18.09.01.827	-362	-229	395
11/10/2556	18.09.34.060	-782	543	489
11/10/2556	18.10.50.314	104	236	-231
11/10/2556	18.12.24.819	-237	233	-115



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.039 Hz				
P1	0.118MW	U1	12.525kV	I1	0.0515kA
P2	0.000MW	U2	12.724kV	I2	0.0675kA
P3	0.000MW	U3	12.730kV	I3	0.0321kA
Psum	0.12MW	U4	0.219kV	I4	0.47 A
S1	0.645MVA	THD-U1	3.35 %	THD-I1	58.88 %
S2	0.859MVA	THD-U2	2.42 %	THD-I2	36.70 %
S3	0.409MVA	THD-U3	3.46 %	THD-I3	77.89 %
Ssum	1.91MVA	THD-U4	----- %	THD-I4	58.02 %
Q1	0.634Mvar	Upk+1	18.221kV	Ipk+1	0.2881kA
Q2	0.859Mvar	Upk+2	18.492kV	Ipk+2	0.0370kA
Q3	0.409Mvar	Upk+3	19.370kV	Ipk+3	0.1955kA
Qsum	1.90Mvar	Upk+4	0.830kV	Ipk+4	3.31 A
PF1	0.1837	Upk-1	-18.081kV	Ipk-1	-0.0255kA
PF2	0.0000	Upk-2	-18.489kV	Ipk-2	-0.3607kA
PF3	0.0000	Upk-3	-18.768kV	Ipk-3	-0.0355kA

Figure.9

Meaning :

1.	Frequency	:	50.039	Hz
2.	Voltage Phase "A" to Ground	:	12.52	KV
3.	Voltage Phase "B" to Ground	:	12.72	KV
4.	Voltage Phase "C" to Ground	:	12.73	KV
5.	Zero Sequence Voltage (U4)	:	0	V
6.	Current Phase "A"	:	51	A
7.	Current Phase "B"	:	67	A
8.	Current Phase "C"	:	32	A
9.	Ground Fault Current	:	0.47	A

Summary : When Energize Transformer : The Voltage Level Still Normal , Phase Current More Than Rated Current . Some Time Vacuum Circuit Breaker be Tripped by Earth Fault Current Function , No Zero Sequence Voltage

Improvement : The Existing Earth Fault Detection Method use Summation Current . It Should Replace to Core Balance CT .

The Objective is Neglect CT Saturation Effect .

10. Event: Reclosing of another generator unit.

Date: 16/11/2556

Time: 11.52.35.241

Figure.10

Description: Double line fault occurred.

Date: 16/11/2556

Time: 11.52.35.440

Figure.11

Description: It was temporary fault because it happened only 2 cycles. After that power swing occurred.

Date: 16/11/2556

Time: 11.52.40.436

Figure.12

Description: Another generator unit has been disconnected after the temporary fault event, then it reclosed.

Similar event

Date: 9/11/2556

Time: 00.16.00.653

Date: 9/11/2556

Time: 08.30.28.426

Date: 16/11/2556

Time: 11.52.40.437

Date: 16/11/2556

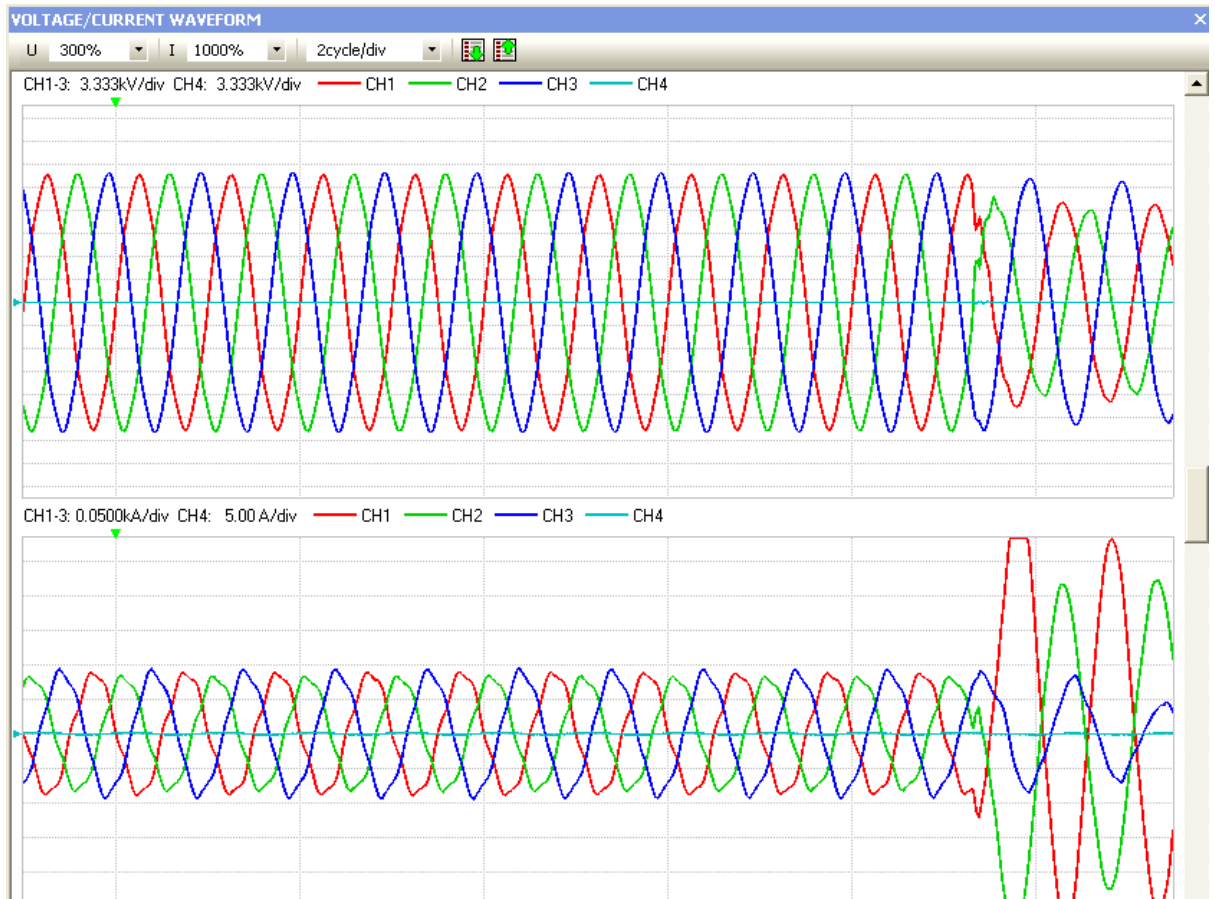
Time: 13.25.27.107

Date: 16/11/2556

Time: 13.42.01.189

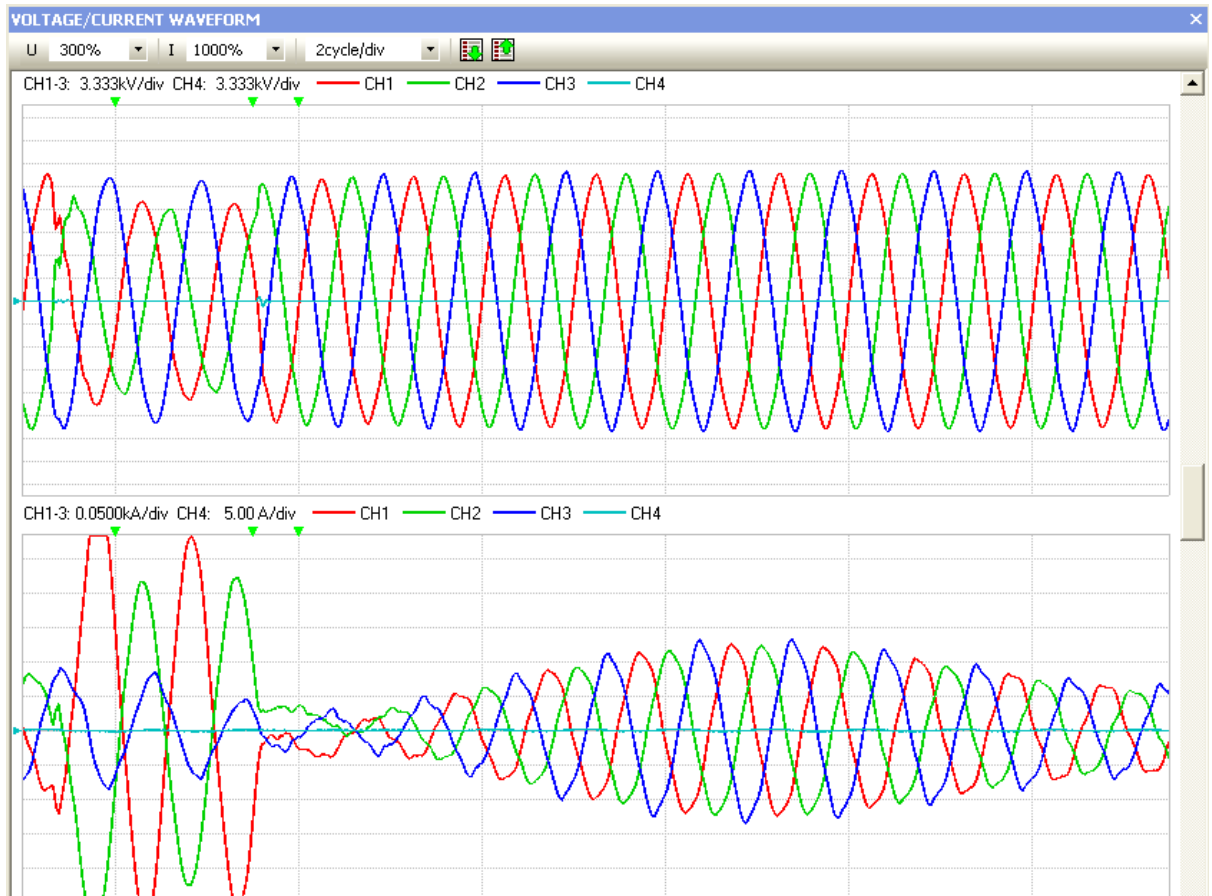
Date: 16/11/2556

Time: 17.15.43.275



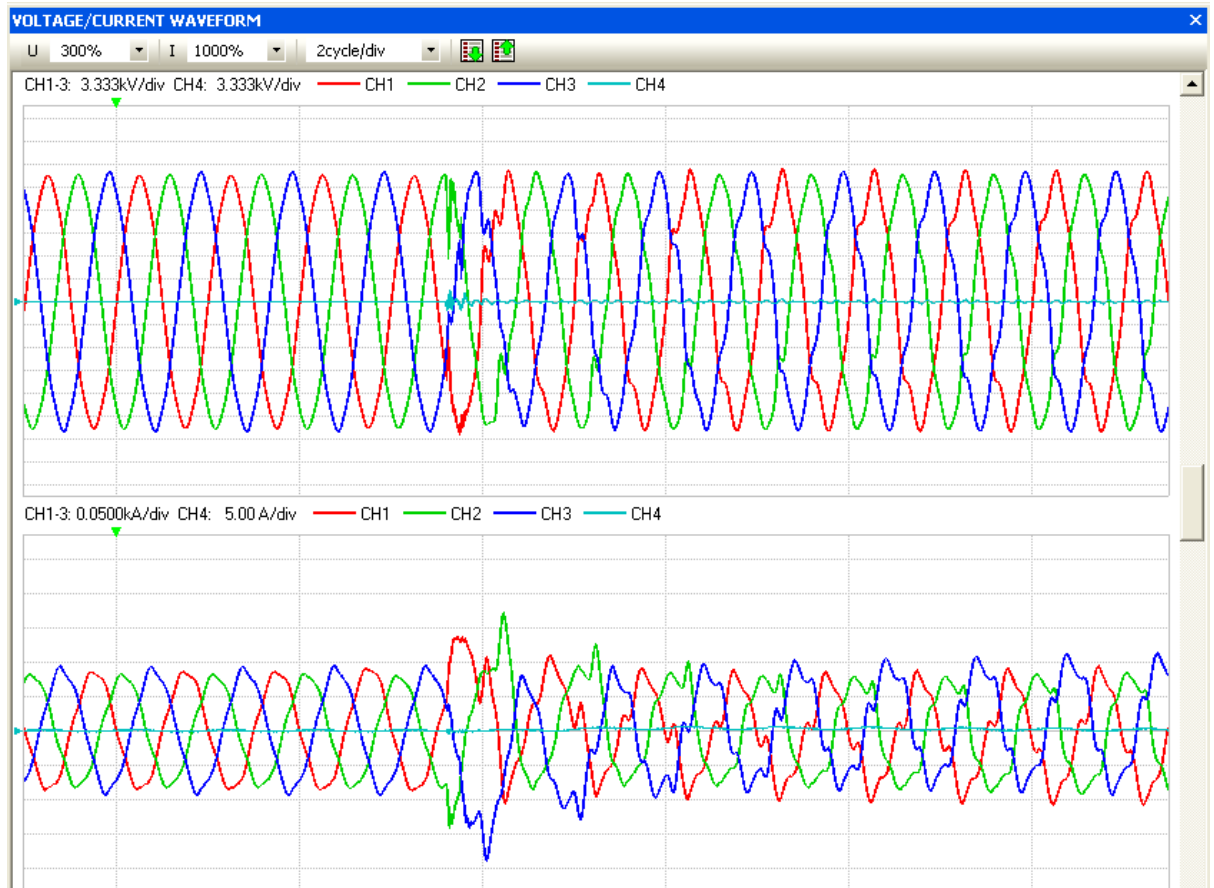
DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.047 Hz				
P1	- 0.879MW	U1	12.701kV	I1	0.0817kA
P2	- 0.740MW	U2	12.733kV	I2	0.0736kA
P3	- 0.801MW	U3	12.889kV	I3	0.0624kA
Psum	- 2.42MW	U4	0.000kV	I4	0.00 A
S1	1.038MVA	THD-U1	3.65 %	THD-I1	12.21 %
S2	0.938MVA	THD-U2	2.87 %	THD-I2	13.68 %
S3	0.804MVA	THD-U3	1.98 %	THD-I3	6.45 %
Ssum	2.78MVA	THD-U4	---- %	THD-I4	12.66 %
Q1	- 0.552Mvar	Upk+1	18.492kV	Ipk+1	0.3393kA
Q2	- 0.576Mvar	Upk+2	18.632kV	Ipk+2	0.0850kA
Q3	0.069Mvar	Upk+3	18.805kV	Ipk+3	0.0951kA
Qsum	- 1.06Mvar	Upk+4	0.191kV	Ipk+4	0.31 A
PF1	-0.8470	Upk-1	-18.503kV	Ipk-1	-0.1212kA
PF2	-0.7894	Upk-2	-18.658kV	Ipk-2	-0.2847kA
PF3	0.9964	Upk-3	-18.812kV	Ipk-3	-0.0949kA

Figure.10 Double line fault occurred.



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.089 Hz				
P1	- 0.916MW	U1	12.365kV	I1	0.0952kA
P2	- 0.619MW	U2	12.279kV	I2	0.0835kA
P3	- 0.747MW	U3	12.768kV	I3	0.0641kA
Psum	- 2.28MW	U4	0.052kV	I4	0.00 A
S1	1.177MVA	THD-U1	2.61 %	THD-I1	9.17 %
S2	1.025MVA	THD-U2	2.31 %	THD-I2	10.58 %
S3	0.818MVA	THD-U3	2.03 %	THD-I3	4.98 %
Ssum	3.02MVA	THD-U4	---- %	THD-I4	18.49 %
Q1	- 0.739Mvar	Upk+1	18.525kV	Ipk+1	0.2825kA
Q2	- 0.817Mvar	Upk+2	18.566kV	Ipk+2	0.2238kA
Q3	0.332Mvar	Upk+3	18.996kV	Ipk+3	0.1332kA
Qsum	- 1.22Mvar	Upk+4	0.716kV	Ipk+4	0.27 A
PF1	-0.7784	Upk-1	-18.547kV	Ipk-1	-0.2762kA
PF2	-0.6044	Upk-2	-18.599kV	Ipk-2	-0.2257kA
PF3	0.9139	Upk-3	-18.996kV	Ipk-3	-0.1348kA

Figure.11 It was temporary fault because it happened only 2 cycles. After that power swing occurred.



DMM					
POWER		VOLTAGE		CURRENT	
Freq	50.014 Hz				
P1	- 0.729MW	U1	12.677kV	I1	0.0619kA
P2	- 0.766MW	U2	12.726kV	I2	0.0632kA
P3	- 0.794MW	U3	12.659kV	I3	0.0683kA
Psum	- 2.29MW	U4	0.156kV	I4	0.28 A
S1	0.784MVA	THD-U1	8.13 %	THD-I1	20.76 %
S2	0.805MVA	THD-U2	7.10 %	THD-I2	18.53 %
S3	0.864MVA	THD-U3	7.56 %	THD-I3	16.44 %
Ssum	2.45MVA	THD-U4	----- %	THD-I4	20.14 %
Q1	- 0.291Mvar	Upk+1	19.422kV	Ipk+1	0.1386kA
Q2	- 0.245Mvar	Upk+2	18.937kV	Ipk+2	0.1725kA
Q3	- 0.342Mvar	Upk+3	18.996kV	Ipk+3	0.1090kA
Qsum	- 0.88Mvar	Upk+4	1.590kV	Ipk+4	0.70 A
PF1	-0.9289	Upk-1	-19.466kV	Ipk-1	-0.1054kA
PF2	-0.9525	Upk-2	-18.610kV	Ipk-2	-0.1426kA
PF3	-0.9185	Upk-3	-18.933kV	Ipk-3	-0.1885kA

Figure.12 Another generator unit has been disconnected after the temporary fault event, then it reclosed.

Reference

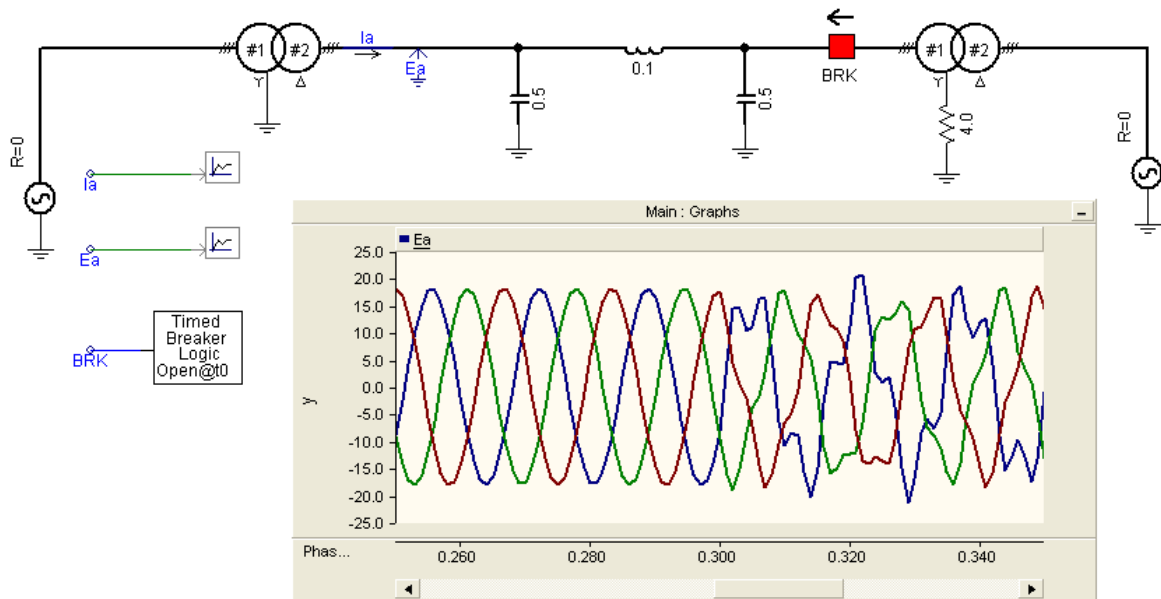


Figure.13 Simulation circuit and voltage waveform during breaker reclosing (at $t=0.3$ second)

