



Network & Protection Studies

Marketing Material

From Product to System up to Solution

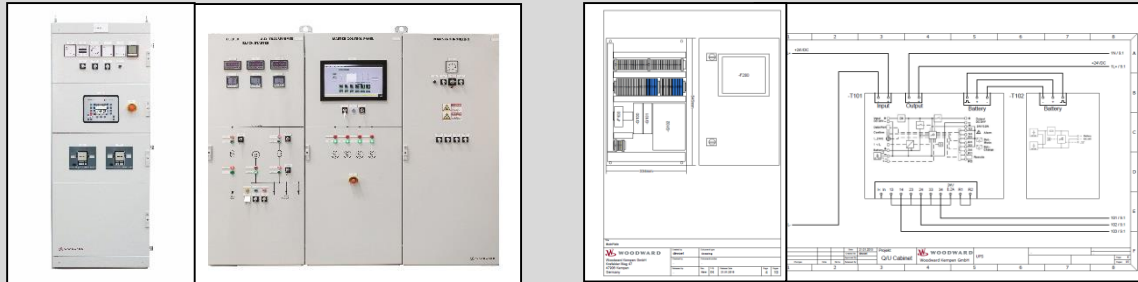
Solution



- Network Study
- Remote Access Capability
- Link to superior systems (SCADA) via bus / Ethernet
- Implementation into existing installation / customization
- Commissioning
- etc.

System

- Gen.-Set Control & Protection Panel
- Common Control & Protection Panel
- Protection Boards



Product



- Generator Protection Relay
- Feeder Protection Relay
- Transformer Protection Relay
- Motor Protection Relay
- Interconnection / Mains Decoupling Relay
- etc.

Network Study - Purpose

- Dimensioning of Network Elements, e.g.
 - Distribution Systems & Cable and Installation Systems
 - MV switchgears
 - LV switchgears
 - Power Transformers
 - Power Cables
 - Dimensioning Parameters
 - Max. Short-Circuit Current
 - Operation Current

Network Study - Purpose

- Protection of Network Elements, e.g.
 - Network Elements
 - Generators
 - Power Transformers
 - Motors & Feeders
 - Power Cables
 - Dimensioning Parameters
 - Min. Short-Circuit Current
 - Operation Current

Network Study - Content

■ Content of a Network Study

- Protection Study, CNE Tizit job.no. E03-41-110

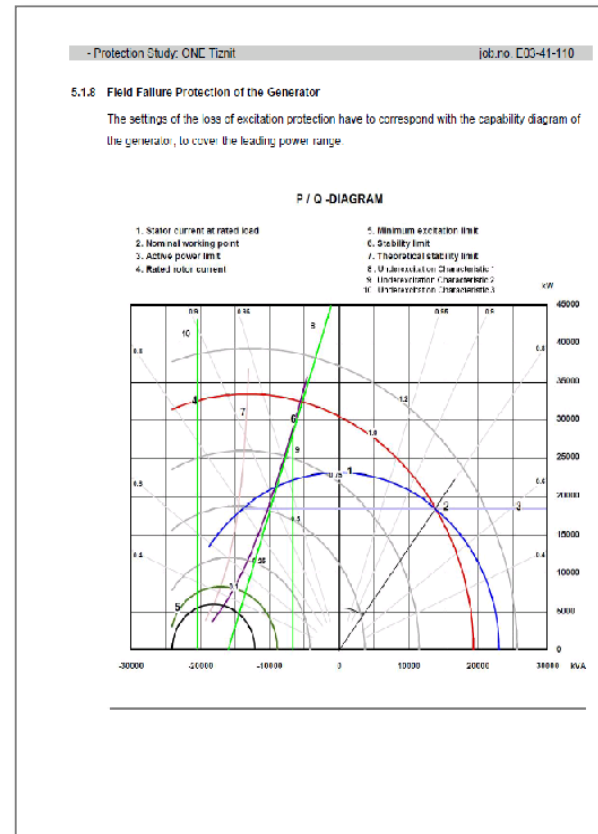
- Protection Study -

Author:
Ing. Ulrich Stratling

WOODWARD
Woodward Power Solutions
Krefelder Weg 47
47906 Kempen, Germany

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- Calculation & Verification of CCP related CTs

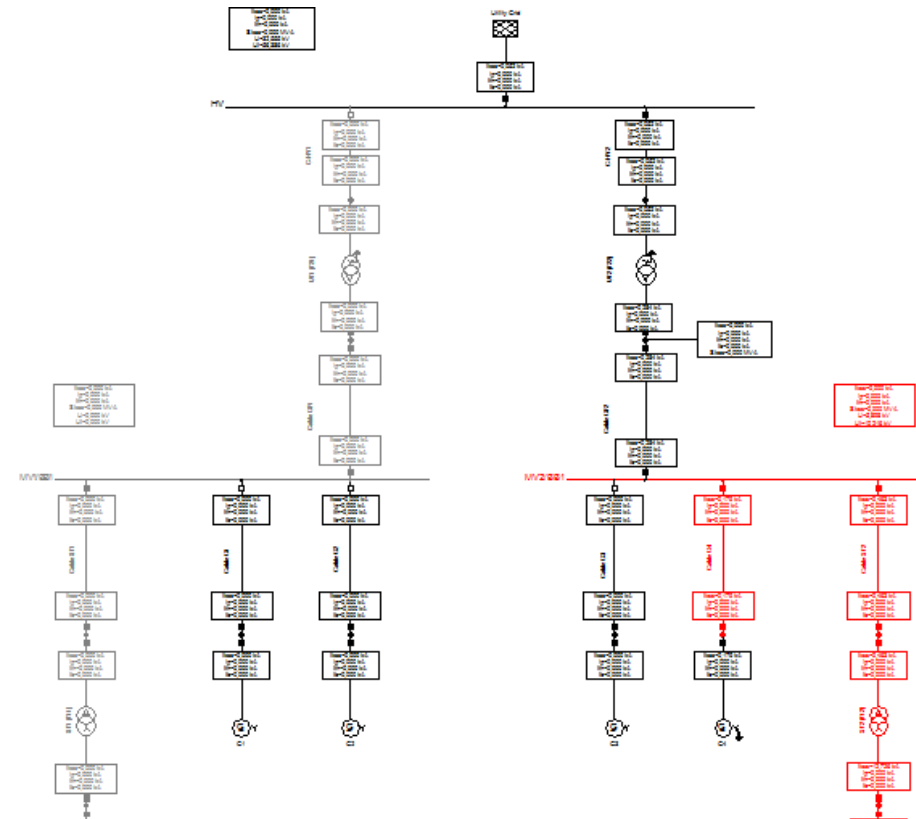
Author:
Ing. Ulrich Stratling

WOODWARD
Woodward Power Solutions
Krefelder Weg 47
47906 Kempen, Germany

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Network Study - Data Input

- Data Collection of Network Elements, e.g.
 - Generators
 - Utility Grid Connection
 - Power Transformers
 - Motors & Loads
 - Cables
- Network Topology



Network Study - Calculations

■ Load Flow Calculation

- Result: voltage & load profiles (max. operational current of each network branch)
- Basis for determination and verification of operating modes

■ Short-Circuit Calculation

- Calculation of max. 3-phase short-circuit current / Calculation of max. 1-phase short-circuit current
 - Result: maximum short-circuit currents at worst case topology
 - Basis for verification of dimensioning of network elements (e.g. switchgears, power transformers)
- Calculation of min. 2-phase short-circuit current / Calculation of min. 1-phase short-circuit current
 - Result: minimum short-circuit currents at worst case topology
 - Basis for determination of settings of protection devices

Network Study - Protection Setting Calculation

- Protection device setting calculation, e.g. Generator Protection
 - Generator differential protection
 - Three-phase overcurrent and earth fault protection
 - Stator earth fault at open generator circuit breaker
 - Voltage protection
 - Frequency protection
 - Reverse power protection
 - Negative phase sequence protection
 - Field failure protection
 - Over-excitation protection

Network Study - Protection Setting Documentation

MPU-Setting Calculation

SEG Job-No.: **A01-64-13G**
 Project Name: **Power Station**
 Date: **03.01.2013**

Determination of the undervoltage U_1 and $U_{1,CT}$ of the generator :
 To protect the generator against undervoltages (see generator data sheets) the following:
 - Undervoltages of 0,90 $\cdot U_{N,CT}$ can be withstand for continuous operation acc.
 - Undervoltages of 0,90 $\cdot U_{N,CT}$ can be withstand for short-term operation and
 To make sure that the generator is adequate protected, the following pick-up voltage
 $\Rightarrow U_1 = 0,92 \cdot U_{N,CT} \cdot U_{N,CT,perm} / U_{N,CT,perm}$
 $\Rightarrow U_1 = 101,2 \text{ V}$
 $\Rightarrow t_{1,CT} = 10,0 \text{ s}$
 $\Rightarrow U_{1,CT} = 0,90 \cdot U_{N,CT} \cdot U_{N,CT,perm} / U_{N,CT,perm}$
 $\Rightarrow U_{1,CT} = 99 \text{ V}$
 $\Rightarrow t_{1,CT} = 1,0 \text{ s}$

Determination of the overvoltage U_2 and $U_{2,CT}$ of the generator :
 To protect the generator against overvoltages (see generator data sheets) the following:
 - Overvoltages of 1,08 $\cdot U_{N,CT}$ can be withstand for continuous operation acc.
 - Overvoltages of 1,10 $\cdot U_{N,CT}$ can be withstand for short-term operation and
 To make sure that the generator is adequate protected, the following pick-up voltage
 $\Rightarrow U_2 = 1,08 \cdot U_{N,CT} \cdot U_{N,CT,perm} / U_{N,CT,perm}$
 $\Rightarrow U_2 = 118,8 \text{ V}$
 $\Rightarrow t_{2,CT} = 10,0 \text{ s}$
 $\Rightarrow U_{2,CT} = 1,10 \cdot U_{N,CT} \cdot U_{N,CT,perm} / U_{N,CT,perm}$
 $\Rightarrow U_{2,CT} = 121 \text{ V}$
 $\Rightarrow t_{2,CT} = 1,0 \text{ s}$

Determination of the underfrequency f_1 and $f_{1,CT}$ of the generator :
 To protect the generator against underfrequency (see generator data sheets) the following:
 - Underfrequencies of 0,97 $\cdot f_{N,CT}$ can be withstand for continuous operation acc.
 - Underfrequencies of 0,96 $\cdot f_{N,CT}$ can be withstand for short-term operation and
 To make sure that the generator is adequate protected, the following pick-up frequency
 $\Rightarrow f_1 = 0,97 \cdot f_{N,CT}$
 $\Rightarrow f_1 = 58,2 \text{ Hz}$
 $\Rightarrow t_{1,CT} = 10,0 \text{ s}$
 $\Rightarrow f_{1,CT} = 0,96 \cdot f_{N,CT}$
 $\Rightarrow f_{1,CT} = 57,6 \text{ Hz}$
 $\Rightarrow t_{1,CT} = 1,0 \text{ s}$

Determination of the overfrequency f_2 and $f_{2,CT}$ of the generator :
 To protect the generator against overfrequencies (see generator data sheets) the following:
 - Overfrequencies of 1,03 $\cdot f_{N,CT}$ can be withstand for continuous operation acc.
 - Overfrequencies of 1,04 $\cdot f_{N,CT}$ can be withstand for short-term operation and
 To make sure that the generator is adequate protected, the following pick-up voltage
 $\Rightarrow f_2 = 1,03 \cdot f_{N,CT}$
 $\Rightarrow f_2 = 61,8 \text{ Hz}$
 $\Rightarrow t_{2,CT} = 10,0 \text{ s}$
 $\Rightarrow f_{2,CT} = 1,04 \cdot f_{N,CT}$
 $\Rightarrow f_{2,CT} = 62,4 \text{ Hz}$
 $\Rightarrow t_{2,CT} = 1,0 \text{ s}$

Power Train - Protection Calculations and Settings_Example.xlsx
 MPU-Setting Calculation 28.01.2013

MRD-Setting Calculation

SEG Job-No.: **A01-64-13G**
 Project Name: **Power Station**
 Date: **03.01.2013**

Determination of the differential current I_{diff} ($I_0 = 0 \cdot I_N$) at no-load condition referring to
 - Calculation of the current losses at no-load condition:
 $I_0 = P_{0,CT} / S_{N,CT} = 0,007$
 - Calculation of the setting value I_{diff} ($I_0 = 0 \cdot I_N$) at no-load condition:
 no-load current losses $I_0 = 0,007$
 + safety margin (10%) = 0,100
 $\Rightarrow I_{diff} (I_0 = 0 \cdot I_N) = 0,107$
 $\Rightarrow I_{diff} (I_0 = 0 \cdot I_N) = 0,11 \cdot I_{N,CT} = 0,12 \cdot I_{N,CT}$

Determination of the differential current I_{diff} ($I_0 = 2 \cdot I_N$) caused by the power loss at double
 referring to the nominal generator current:
 - Calculation of the current losses at double load condition:
 $I_0 = 4 \cdot P_{0,CT} / S_{N,CT} = 0,041$
 - Calculation of the setting value I_{diff} ($I_0 = 2 \cdot I_N$) at double load condition:
 double load current losses $I_0 = 0,041$
 no-load current losses $I_0 = 0,007$
 + safety margin (2x10%) = 0,200
 + CT tolerances 2x (2x1,2%) = 0,048
 $\Rightarrow I_{diff} (I_0 = 2 \cdot I_N) = 0,296$
 $\Rightarrow I_{diff} (I_0 = 2 \cdot I_N) = 0,32 \cdot I_{N,CT} = 0,34 \cdot I_{N,CT}$

Determination of the differential current I_{diff} ($I_0 = 10 \cdot I_N$) caused by the power loss at ten
 referring to the nominal generator current:
 - Calculation of the current losses at ten-fold load condition:
 $I_0 = 100 \cdot P_{0,CT} / S_{N,CT} = 1,022$
 - Calculation of the setting value I_{diff} ($I_0 = 10 \cdot I_N$) at double load condition:
 ten-fold load current losses $I_0 = 1,022$
 no-load current losses $I_0 = 0,007$
 + safety margin (10x10%) = 1,000
 + CT tolerances 10x (2x1,2%) = 0,579
 $\Rightarrow I_{diff} (I_0 = 10 \cdot I_N) = 2,608$
 $\Rightarrow I_{diff} (I_0 = 10 \cdot I_N) = 2,70 \cdot I_{N,CT} = 2,85 \cdot I_{N,CT}$

Determination of the maximum permitted differential current $I_{diff,perm}$ (high set) of the block
 By using the following Inequation the setting value of the maximum differential current Idiff
 $I_{diff,perm,CT} < I_{diff,perm} < I_{diff,perm} < I_{diff,perm}$
 $458,3A < 500A < 1834A < 2787A$
 $458 \quad 500 \quad 1834 \quad 2787$
 $\Rightarrow I_{diff,perm} = 3,7 \cdot I_{N,CT} = 4,0 \cdot I_{N,CT}$

Determination of the offset of characteristic curve from static basic characteristic curve
 This factor raises the characteristic curve in case of harmonics. Harmonics can be caused by
 station transformers or from 1 side CT saturation in case of a heavy through fault current call
 in practice a setting of $\theta(I_0) = 2,1 \cdot I_{N,CT} = 2,2 \cdot I_{N,CT}$

Summary of the results

$I_{diff,perm,CT}$	=	0,11	$\cdot I_{N,CT}$	=	0,12	$\cdot I_{N,CT}$
$I_{diff,perm,CT}$	=	0,3	$\cdot I_{N,CT}$	=	0,3	$\cdot I_{N,CT}$
$I_{diff,perm,CT}$	=	2,7	$\cdot I_{N,CT}$	=	2,9	$\cdot I_{N,CT}$
$I_{diff,perm}$	=	3,7	$\cdot I_{N,CT}$	=	4,0	$\cdot I_{N,CT}$
$\theta(I_0)$	=	2,1	$\cdot I_{N,CT}$	=	2,2	$\cdot I_{N,CT}$

Power Train - Protection Calculations and Settings_Example.xlsx
 MRD-Setting Calculation 28.01.2013

MRI-Setting Calculation

SEG Job-No.: **A01-64-13G**
 Project Name: **Power Station**
 Date: **03.01.2013**

Determination of the overcurrent tripping current I_{over} of the generator :
 To protect the generator against overcurrents (see generator data sheets) the following has to be fulfilled:
 - Overcurrents of $1.1 \times I_N$ Gen. should lead to a trip after 1h later (once in 12h); acc. to IEC
 - Overcurrents of $1.5 \times I_N$ Gen. should lead to a trip after 220 s later, acc. to generator manufacturer (after 120s acc. to IEC)
 - Overcurrents of $3.0 \times I_N$ Gen. should lead to a trip after 9 s later, acc. to generator manufacturer.
 To make sure that the generator is adequate protected, the EINV current characteristic is selected,
 with $\beta = 0,666$ and $\gamma = 1 \cdot \ln,ct$ (nearest adjustable value)
 which leads to a trip at the following overcurrents (acc. to IEC 255-4):

$I_{1,1 \cdot I_N,CT}$	=	3187 s	<	3600 s	q.e.d.
$I_{1,5 \cdot I_N,CT}$	=	59,3 s	<	220 s	q.e.d.
$I_{3,0 \cdot I_N,CT}$	=	9,0 s	<	9 s	q.e.d.


Determination of the overcurrent tripping current $I_{over,perm}$ of the generator :
 The independent short-circuit stage of the overcurrent relay is also used as back-up protection in case of
 failures within the generator stator winding.
 For getting a staggering to the differential protection relay the following setting was selected:
 $\Rightarrow I_{over,perm} = 4,6 \cdot I_{N,CT} = 5,04 \cdot I_{N,CT} = 2308 \text{ A}$ (nearest adjustable value)
 $\Rightarrow t_{over,perm} = 0,6 \text{ s}$

Furthermore the following Inequation has to be checked :

$I_{diff,perm,CT} < I_{diff,perm} < I_{diff,perm} < I_{diff,perm}$	$I_{diff,perm,CT} < I_{diff,perm} < I_{diff,perm} < I_{diff,perm}$
$458,3A < 500A < 1834A < 2787A$	$458 \quad 500 \quad 1834 \quad 2787$

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 MRI-Setting Calculation 28.01.2013 page 6/31

Network Study - Protection Setting List



Setting List MRI3

Project Name: Power Station Project Job No.: A01-64-13G

Function Group: =3.GanB Location: +3Sx.TL Relay Code: -F9

Relay Function: Overcurrent, Short-Circuit and Restricted Earth Fault Protection ANSI Code: 51/50/67N

Password: ++++ Date: 03.01.2013

x = 1-12,
a = A-T, n = 1-2

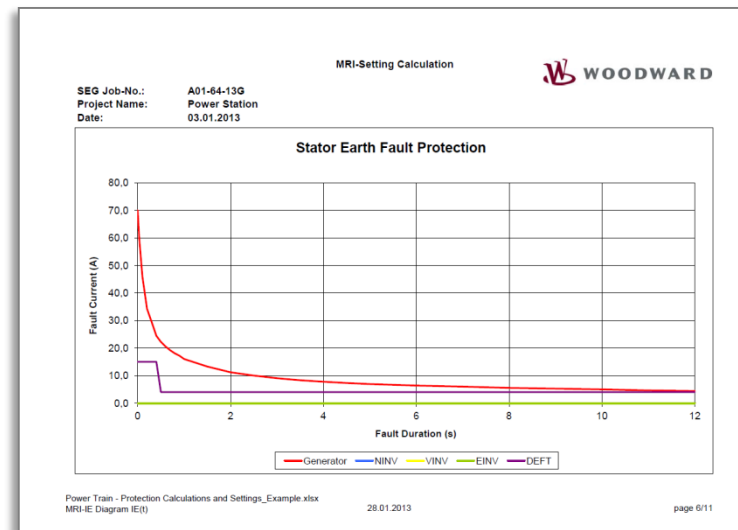
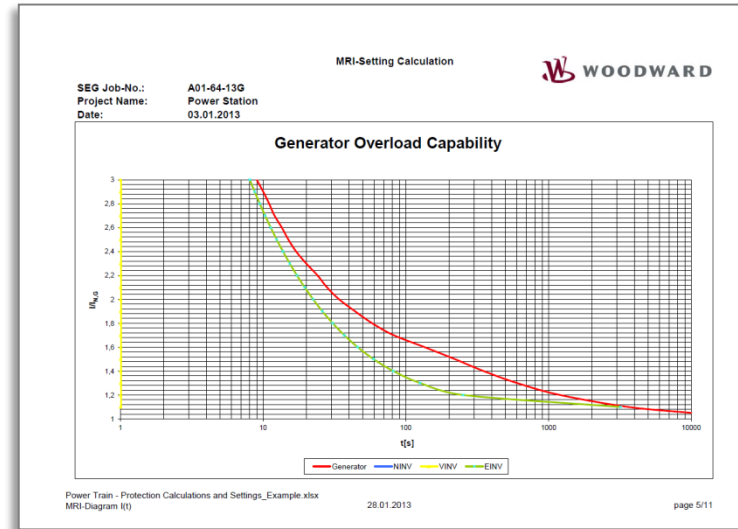
1. System Parameter

Function	Relay Type: MRI3- IER	Default Settings	Actual Settings
I _{prng} (phase) Indication as kA	X	500	
I _{prng} (earth) Indication as kA	X	50	
U _{prim} /U _{sek} (earth)	X	sek	
1:1 / 3pha / e-n	X	3pha	
50 / 60 Hz	X	60	
Indication Pickup	X	FLSH	
Parameter switch/ext.triggering for fault recorder	X	SET 1	

2. Protection Parameter

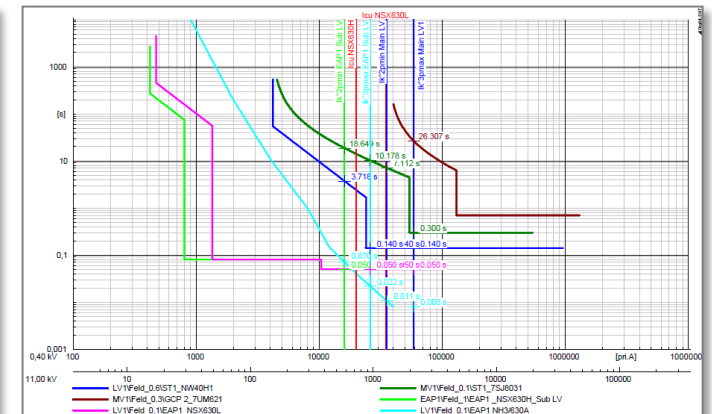
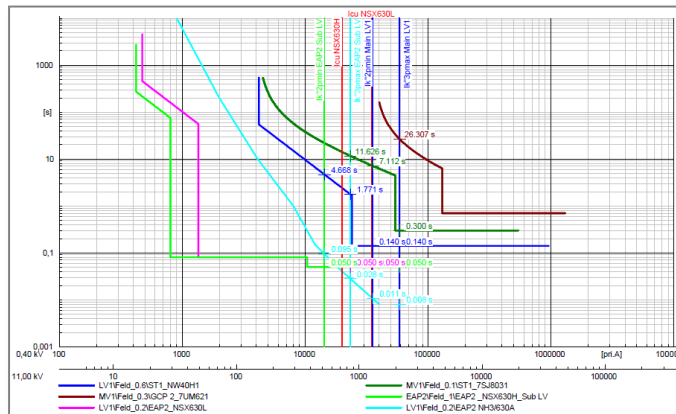
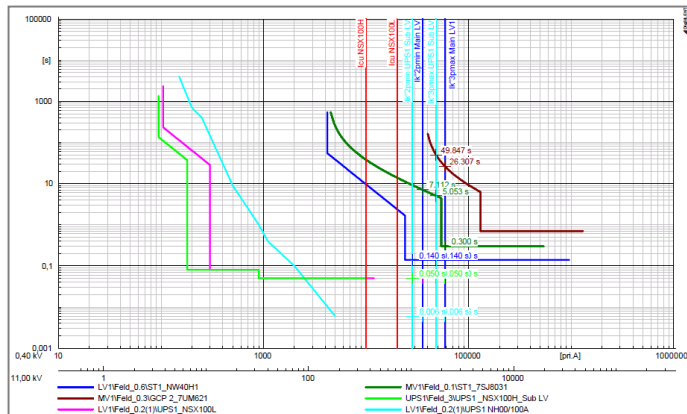
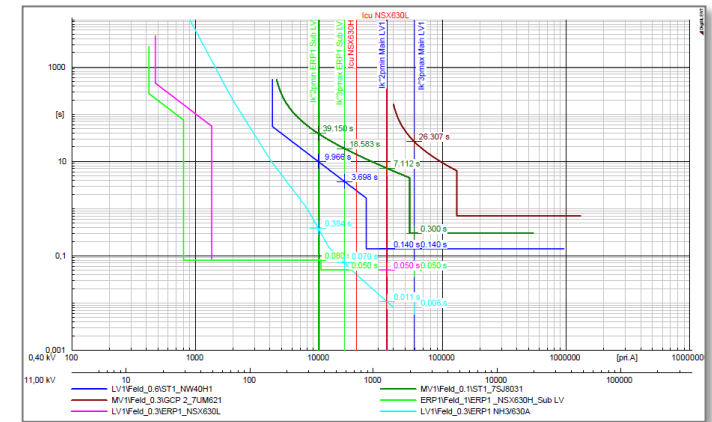
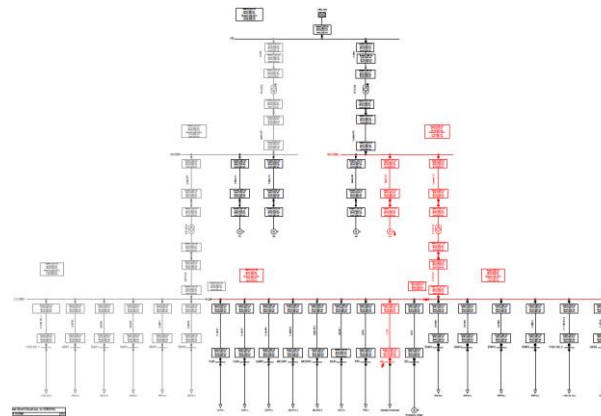
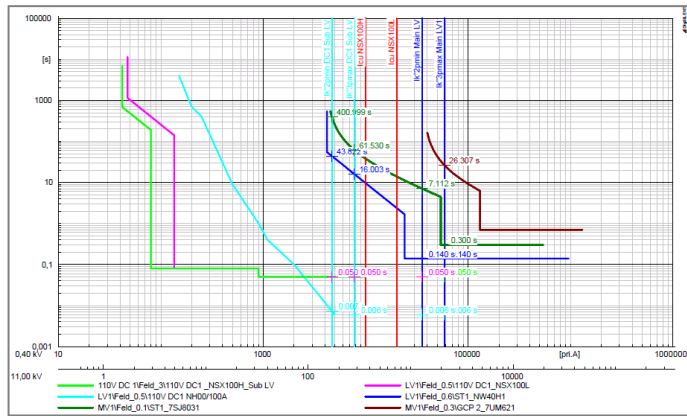
Function	Relay Type: MRI3- IER	Default Settings	Actual Settings
2 parameter sets	X	set 1	
I _{>} (=xx*IN)	X	1,00	
CHAR I _{>}	X	EINV	
t _{0p} (V) / t _{0p} (R)	X	0,66	
0s / 00s (phase)	X	60	
I _{>>} (=xx*IN)	X	4,8	
t _{0>>} (V) / t _{0>>} (R)	X	0,8	
RCA			
U _{E>}	X	11	
I _{E>} (=xx*IN)	X	0,080	
trip / warn	X	Trip	
CHAR I _E			
t _{E>} (V) / t _{E>} (R)	X	20,00 12,00	
0s / 00s (phase)			
I _{E>>} (=xx*IN)	X	0,30	
t _{E>>} (V) / t _{E>>} (R)	X	2,0 0,4	
SIN / COS	X	COS	
SOLI / RESI			
Block/trip - time	X	EXIT	
I _{case}	X	EXIT	
RS485 / Slave	X	1	
Baud-Rate (only Modbus Protocol)	X	9600	
Parity-Check (only Modbus Protocol)	X	Even	

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MRI-Setting List 28.01.2013 page 7/11



Network Study - Verification of Coordination

Verification of Selectivity



Network Study - Verification of Current Transformer

- Calculation & Verification of GCP related CTs

2. Generator Current Transformers - Rating Calculation

2.1. Objective

All current transformer protection cores shall be designed in such a way that trippings of the protection relays are guaranteed. Therefore the following requirements have to be fulfilled.

2.2. Calculation of Generator CTs

2.2.1. Calculation of Generator CTs - Requirement 1: Accuracy Limit Factor

For the verification of the CTs requirements it has to be checked, that the difference between actual and rated burden has no impact on saturation effects and resulting protection detection.

$$I_{pu} < I_{bn,CT,sec,N} = I_{F,th} \cdot \frac{I_{CT,sec,N}}{I_{CT,prim,N}} < I_{Lk}$$

with $k_{half} = k_{half} \cdot \frac{S_{CT,sec,N,load}}{S_{CT,sec,eff,load}} = k_{half} \cdot \frac{S_{CT,sec,N}}{S_{cable} + S_{relays} + S_{CT,J}}$

$$S_{cable} \approx 2 \cdot R_L \cdot I_{CT,sec,N}^2 = \frac{2 \cdot L}{\chi \cdot A} \cdot I_{CT,sec,N}^2$$

$$S_{relays} = Z_{relays} \cdot I_{CT,sec,N}^2$$

$$S_{CT,J} \approx R_{CT,J} \cdot I_{CT,sec,N}^2$$

whereby

- I_{pu} : pick-up value of the protection relay
- $I_{F,th}$: rated short-time thermal current
- $I'_{K,max,3pol}$: calculated max. primary current
- $I_{kn,CT,sec,eff}$: actual secondary current
- $I_{kn,CT,sec,N}$: rated secondary current
- $I_{CT,sec,N}$: rated secondary current
- $I_{CT,prim,N}$: rated primary current of the CT
- k_{over} : actual overcurrent factor
- k_{nar} : rated overcurrent factor
- $S_{CT,sec,eff,load}$: actual load of the CT's secondary
- $S_{CT,sec,N,load}$: rated load of the CT's secondary
- $S_{CT,sec,N}$: rated power of the CT's secondary
- S_{cable} : power consumption of the cable
- $2 R_L$: loop resistance of the cable
- L : cable length
- χ : cable conductivity
- A : cable cross-section
- S_{relays} : power consumption of the protection relays
- $S_{CT,J}$: internal power consumption of the CT's secondary
- $R_{CT,J}$: resistance of the CT's secondary

- Calculation & Verification of GCP related CTs

2.2.2. Calculation of Generator CTs - Requirement 2: Saturation

For the verification of the CTs requirements it has to be checked, that the difference between actual and rated knee point voltage has no impact on saturation effects and resulting protection detection.

$$U_{kn,CT,N} \geq U_{kn,CT} \cdot (I'_{K,max,3pol}) = 2 \cdot I'_{K,max,3pol} \cdot U_{kn,CT}$$

with $Z_{cable} \approx 2 \cdot R_L = \frac{2 \cdot L}{\chi \cdot A}$

$$Z_{relays} = \sum \frac{S_{relays}}{I_{CT,sec,N}^2}$$

$$Z_{CT,J} \approx R_{CT,J}$$

whereby

- $U_{kn,CT,N}$: rated knee point voltage
- $U_{kn,CT} \cdot (I'_{K,max,3pol})$: actual knee point voltage
- $I_{F,th}$: rated short-time thermal current
- $I'_{K,max,3pol}$: calculated max. primary current
- $I_{CT,sec,N}$: rated secondary current
- $I_{CT,prim,N}$: rated primary current of the CT
- $I_{kn,CT,N}$: secondary exciting current
- $Z_{CT,J}$: impedance of the CT's secondary
- $R_{CT,J}$: resistance of the CT's secondary
- Z_{cable} : cable impedances
- $2 R_L$: loop resistance of the cable
- L : cable length
- χ : cable conductivity
- A : cable cross-section
- Z_{relays} : relay impedances

- Calculation & Verification of GCP related CTs job.no. A01-64-13G -

3. Generator Current Transformers - Rating Verification

3.1. Objective

All current transformer protection cores shall be designed in such a way that trippings of the protection relays are guaranteed. Therefore the following requirements have to be fulfilled.

3.1.1. Verification of Generator CTs - Requirement 1: Saturation Impact - Accuracy Limit Factor

For the verification of the CTs requirements it has to be checked, that the difference between actual and rated burden has no impact on saturation effects and resulting protection detection.

$$I_{pu} < I_{bn,CT,sec,N} = I_{F,th} \cdot \frac{I_{CT,sec,N}}{I_{CT,prim,N}} < I_{Lk} = I_{CT,sec,N} \cdot k_{half}$$

3.1.1.1. Generator Star Point Phase Current Transformer

$$\Rightarrow I_{pu} = 3.51A < 67.5kA \cdot \frac{1A}{1350A} = 50A < 1A \cdot 52.9 = 52.9A \quad \checkmark \text{ q.e.d.}$$

with $k_{half} = k_{half} \cdot \frac{S_{CT,sec,N,load}}{S_{CT,sec,eff,load}} = k_{half} \cdot \frac{S_{CT,sec,N} + S_{CT,J}}{S_{cable} + S_{relays} + S_{CT,J}}$

$$\Rightarrow k_{half} = 20 \cdot \frac{15VA + 7.373VA}{1.030VA + 0.05VA + 7.373VA} = 20 \cdot 2.647 = 52.9$$

$$S_{cable} \approx 2 \cdot R_L \cdot I_{CT,sec,N}^2 = \frac{2 \cdot L}{\chi \cdot A} \cdot I_{CT,sec,N}^2 = 1.030VA \text{ (worst case)}$$

$$S_{relays} = Z_{relays} \cdot I_{CT,sec,N}^2 = 0.05VA$$

$$S_{CT,J} \approx R_{CT,J} \cdot I_{CT,sec,N}^2 = 7.373\Omega \cdot 1A^2 = 7.373VA \text{ (worst case)}$$

$$I_{pu} = 3.51A \text{ (acc. to protection setting calculation)}$$

3.1.1.2. Generator MV Switchgear Phase Current Transformer

$$\Rightarrow I_{pu} = 3.51A < 67.5kA \cdot \frac{1A}{1350A} = 50A < 1A \cdot 52.9 = 52.9A \quad \checkmark \text{ q.e.d.}$$

with $k_{half} = k_{half} \cdot \frac{S_{CT,sec,N,load}}{S_{CT,sec,eff,load}} = k_{half} \cdot \frac{S_{CT,sec,N} + S_{CT,J}}{S_{cable} + S_{relays} + S_{CT,J}}$

$$\Rightarrow k_{half} = 20 \cdot \frac{15VA + 7.373VA}{1.030VA + 0.05VA + 7.373VA} = 20 \cdot 2.647 = 52.9$$

$$S_{cable} \approx 2 \cdot R_L \cdot I_{CT,sec,N}^2 = \frac{2 \cdot L}{\chi \cdot A} \cdot I_{CT,sec,N}^2 = 1.030VA \text{ (worst case)}$$

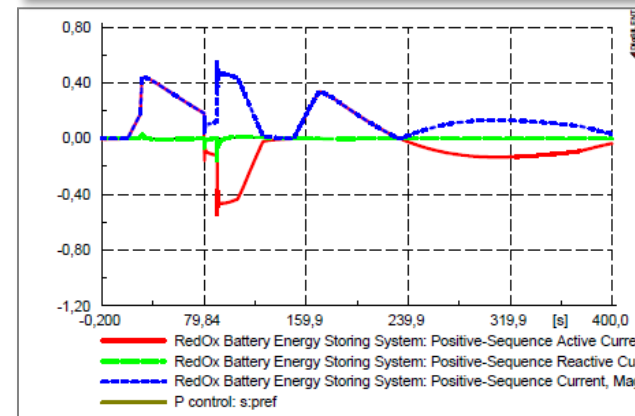
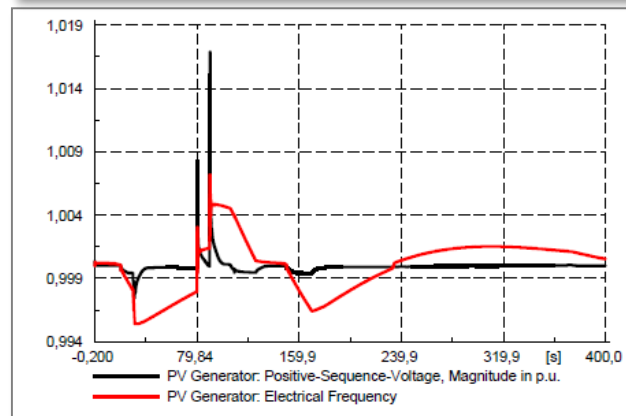
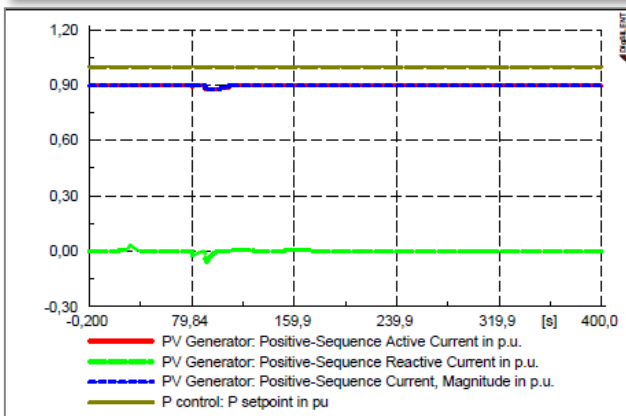
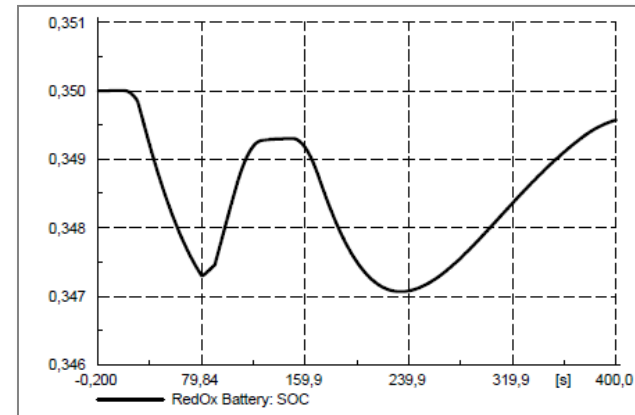
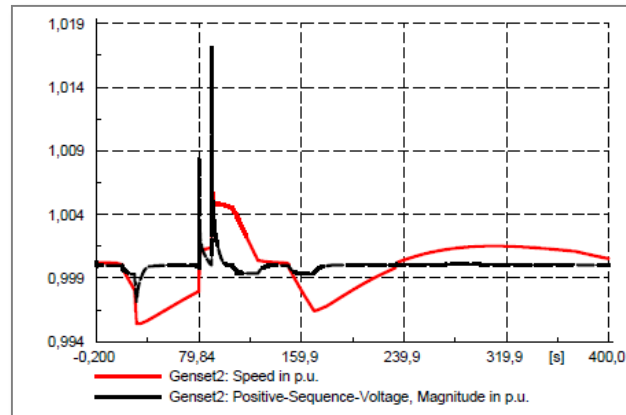
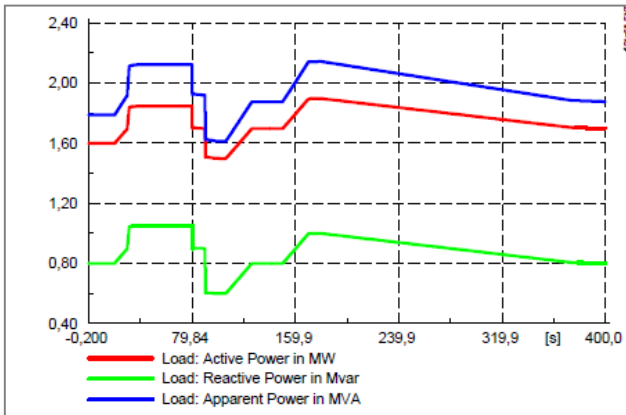
$$S_{relays} = Z_{relays} \cdot I_{CT,sec,N}^2 = 0.05VA$$

$$S_{CT,J} \approx R_{CT,J} \cdot I_{CT,sec,N}^2 = 7.373\Omega \cdot 1A^2 = 7.373VA \text{ (worst case)}$$

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Network Study - Fault Event Simulation

- Simulation of Network Stability / Investigation of Special Events (e.g. for critical load steps, loss of generator, loss of power transformer)



Network Study - Some Reference Projects

Project Name	Application	Country	Year
Cementos Progreso SA	Cement Plant	Guatemala	1993
Palma de Mallorca	Airport	Spain	1996
Sharourah Extension	Power Plant	Saudi Arabia	1998
Monte Rio	Power Plant	California	2001
Cap Verde	3x Power Plants	Cap Verde Islands	2001
US Navy Milcon	Naval Base	Bahrain	2002
Sri Lanka	Power Plant	Sri Lanka	2004
Kabul	3x Power Plants	Afghanistan	2007
Collahuasi	Copper Mine (4000m)	Chile	2008
Termomanaus	Power Plant	Argentina	2008
A3	Peak Power Plant	Brazil	2010 - 2011
Rubiales	6x Power Plant	Columbia	2008 - 2011
ONE Tiznit	Power Plant	Marocco	2011
KPS6 - KPS7 - KPS9	Power Ship	Turkey	2009 - 2013
King Abdullah Port	Power Plant	Saudi Arabia	2013
Tabuk Cement	Power Plant	Saudi Arabia	2014
Noonmati PS - Oil India	Crude Oil Power Station	India	2015
Kodda, Desh	2x Power Plants	Bangladesh	2015
Ocensa - Chiquillo	Power Plant	Columbia	2015

Service & Commissioning: Capabilities

- Erection of Protection & Control System
- Commissioning of Protection & Control System
 - Secondary injection test for validation of protection setting including
 - test of the entire signal chain up to circuit breaker trip test.
 - data logging with Omicron sec. injection test units
 - test reports
- Maintenance incl. Secondary Injection Test
- Retrofit of obsolete Protection Relays & Systems
- Training on Protection & Control Systems
 - On-site training
 - In-house training

Service & Commissioning: Protection Validation

Validation of Protection Settings with secondary Injection Tests on-site.

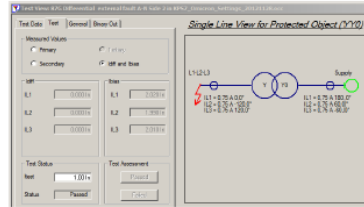


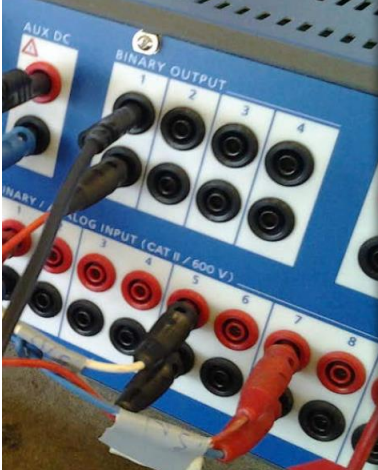
Figure 46: Test Module Diff Configuration – Test results external fault

4.5.2 Differential Operating Characteristic L1-L2-L3 – 87G

Internal fault:

- The diff operating and trip time characteristic is based on Inom as shown in the Diff Operating Characteristic test modules.
- If the relay parameter Increase of Trip Char During S normal conditions operating characteristic cannot be needs to be applied to the following test modules:

- 87G Differential operating characteristic L1-L2-L3



Settings:

Button:	Tab:	Frame:	Setting:
Test View	Test Data	Fault type	L1-L2-L3
Test View	Shot Test	Test Points	See note *
Test View	General	Prefault	Prefault time
Test View	General	Prefault	Prefault current
Test View	General	Voltage Output	Apply
Test View	General	Trigger Condition	BI 1 - Trip

*Note: test points can be created by clicking into the characteristic diagram (bias). With using the button "add" the test point is listed.

The postfault time has to be adjusted in the following folder (see Figure 47)

Test Objekt/RIO/Generator Differential → TReset = 15s

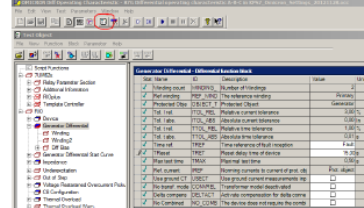


Figure 47: Test Module Diff Operating characteristic – Postfault reset time

Note: After each test point all trips have to be reset.

After testing nominal value (Nom.) and actual value (Act.) are compared deviation is within the tolerances, the testing will be passed.

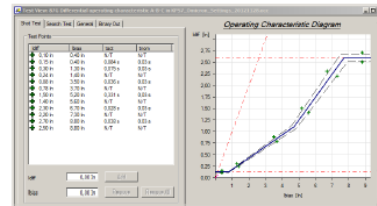


Figure 48: Test Module Diff Operating characteristic – Test results

Settings:

Button:	Tab:	Frame:	Setting:	Value
Test View	Settings	Test Model	Constant test voltage	Vn=57.73V
Test View	Settings	Times	Prefault	15s
Test View	Settings	Times	Max fault	11s *
Test View	Settings	Times	Postfault	5s
Test View	Trigger	Trip Condition	Trip	0

*: 11s > Chara. 1 Time Delay = 10s

58 Group Underexcitation Protection: Group Characteristics

No.	Settings	Value	Group
3002	Susceptance Inverted Characteristic 1	0.41	A
3003	Inclination Angle of Characteristic 1	72°	A
3004	Characteristic 1 Time Delay	10.00 ms	A
3005	Susceptance Inverted Characteristic 2	0.37	A
3008	Inclination Angle of Characteristic 2	90°	A
3007	Characteristic 2 Time Delay	10.00 ms	A
3009	Susceptance Inverted Characteristic 3	1.00	A
3009	Inclination Angle of Characteristic 3	84°	A
3010	Characteristic 3 Time Delay	0.50 ms	A

After testing nominal value (Nom.) and actual value (Act.) are compared and assessed. If the deviation is within the tolerances, the testing will be passed.

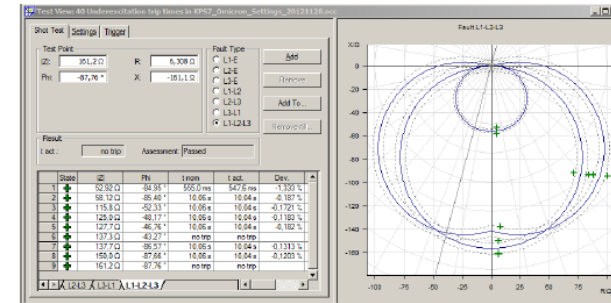


Figure 57: Test Module Distance – Test results Underexcitation trip times

