

# Network & Protection Studies

**Marketing Material** 

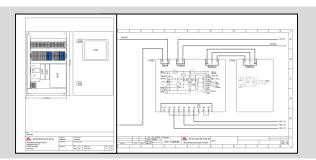


### From Product to System up to Solution



- Network Study
- Remote Access Capability
- Link to superior systems (SCADA) via bus / Ethernet
- Implementation into existing installation / customization
- Commissioning
- etc.
- Gen.-Set Control & Protection Panel
- Common Control & Protection Panel
- Protection Boards









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



Gen.-Set
 Common
 Protection

### **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



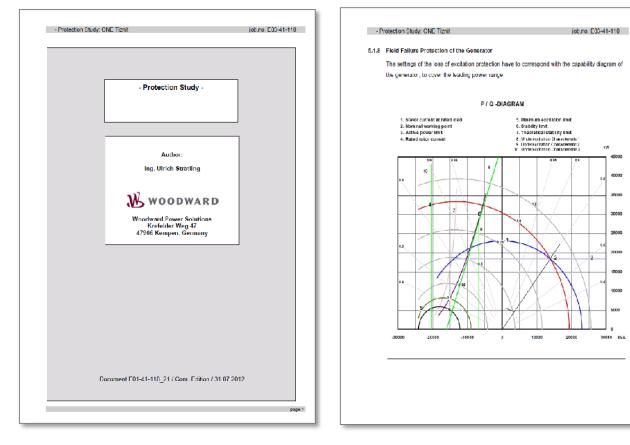
### **Network Study - Purpose**

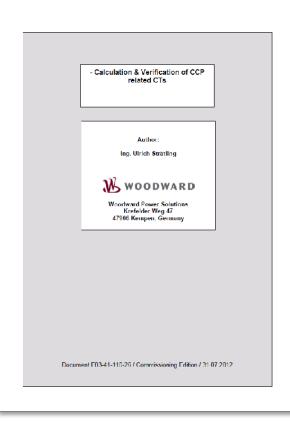
- Protection of Network Elements, e.g.
  - Network Elements
    - Generators
    - Power Transformers
    - Motors & Feeders
    - Power Cables
  - Dimensioning Parameters
    - Min. Short-Circuit Current
    - Operation Current



### **Network Study - Content**

#### Content of a Network Study

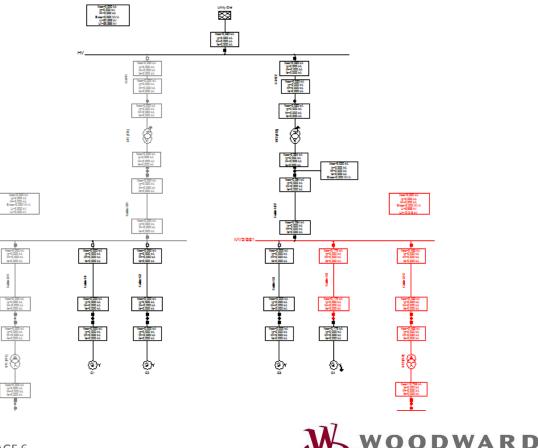






### **Network Study - Data Input**

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



Always Innovating for a Better Future

# **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

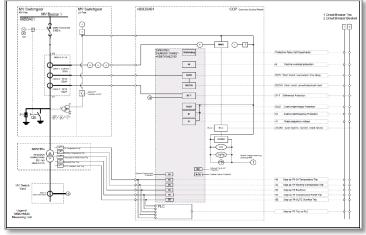


### **Network Study - Protection Functions**

#### **Generator Protection**

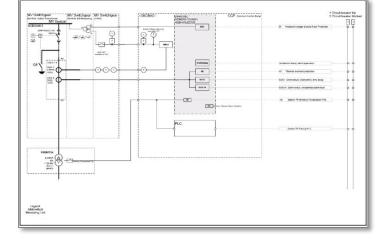
UV Skindhgear MV Buildear UVSer USer	C.CDAC	20 editer with development water     30 editer with net-otherwater expend     30 editer     30 editer expend     30 editer     30 editer expend     30
		Simpland      Construction
		31     Nagefinishes inspirate invested       52     MMI 0207       62     Ossumers (see hits)
		B         Overage average         Overage average           B         Overage average         Overage average           B         Overage average         Overage average           B         Overage average         Overage           B         Overage average         Overage           B         Overage         Overage           D         Over
	COST     COST	Orin Reside La Analazi     Orio Contractore     Orin Reside La Analazi     Orin Reside La Analazi     Orinada Insuestaria     Orinada Insuestaria     Orinada Insuestaria
		Bi Strandala položa PARB → Braza U Prata P D Las destanto (17) (2)
Sector Se	CDP 2014 downline1     CDP 00.46 color/faul     PT2777     PT2777     PT277     PT277     PT277     PT27     PT277     PT277     PT27     PT27     PT27     PT27     PT27      PT2      PT27      PT27	233 Standardstream     37 Control for the form (Frinder)     37 Control for the form (Frinder)
		Bene abley parentialized on the land many Cline. Microsoftware Triny Jos able - arthrop

#### **Step-up Transformer Protection**

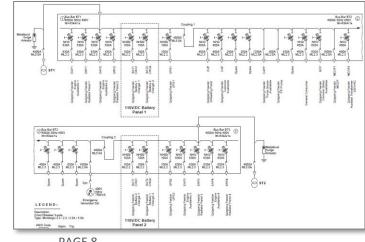


#### PROPRIETARY INFORMATION - © 2016 WOODWARD, INC.

#### **Station Transformer Protection**



#### **Main-LV Protection**





# **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**

	MRD-Setting Calculation	MRI-Setting Calculation WOODWARD
MPU-Setting Calculation		SEG Job-No.: A01-64-13G
	SEG Job-No.: A01-64-13G	Project Name: Power Station
EG Job-No.: A01-64-13G	Project Name: Power Station	Date: 03.01.2013
roject Name: Power Station	Date: 03.01.2013	
ate: 03.01.2013		
		Determination of the overcurrent tripping current I <sub>super</sub> of the generator :
	Determination of the differential current I det (Is = 0 - Is) at no-load condition referring to	To protect the generator against overcurrents (see generator data sheets) the following has to be fulfilled:
	Calculation of the current losses at no-load condition :	- Overcurrents of 1.1 x In Gen. should lead to a trip after 1h lately (once in 12h); acc. to IEC
etermination of the undervoltage $U_c$ and $U_{ec}$ of the generator :	I <sub>0</sub> = P <sub>0.0</sub> /S <sub>N.0</sub> = 0,007	- Overcurrents of 1.5 x in Gen. should lead to a trip after 220 s lately, acc. to generator manufacturer (after 120s acc. to IEC)
protect the generator against undervoltages (see generator data sheets) the follow	- Calculation of the setting value I <sub>am</sub> (I <sub>a</sub> = 0 · I <sub>N</sub> ) at no-load condition :	- Overourrents of 3.0 x In Gen. should lead to a trip after 9 s lately, acc. to generator manufacturer.
Undervoltages of 0,92 · U <sub>N,0</sub> can be withstand for continuous operation acc	no-load current losses lo = 0.007	<ul> <li>Overlaments of solv in contractions and a large and a solvery, accurately accurate manual content.</li> <li>To make sure that the operator is adequate protected, the EINV current characteristic is selected.</li> </ul>
Undervoltages of 0,90 Undervoltages of 0,90 Undervoltages of 0,90		
o make sure that the generator is adequate protected, the following pick-up voltage:	+ safety margin (10%) = 0,100	with ti> = 0,66s and i> = 1 · in,ct (nearest adjustable value)
$=> U_{c} = 0.92 \cdot U_{N,0} \cdot U_{N,VT,sec} / U_{N,VT,sec}$	-> I <sub>dm</sub> (I <sub>0</sub> = 0 - I <sub>N</sub> ) = 0,107	which leads to a trip at the following overcurrents (acc. to IEC 255-4):
=> U, = 101.2 V	-> I <sub>att</sub> (I <sub>5</sub> = 0 · I <sub>N</sub> ) = 0,11 · I <sub>N,CT</sub> = 0,12 · I <sub>N,G</sub> =	t <sub>(1.1 ⋅ N,G)</sub> = 3187 s ≪ 3600 s q.e.d.
		t <sub>n.5-INGI</sub> = 59,3 s < 220 s q.e.d.
=> t <sub>ox</sub> = 10,0 s	Determination of the differential current $I_{aut}$ ( $I_s = 2 \cdot I_u$ ) caused by the power loss at dou	t <sub>000-ING</sub> = 8,0 s < 9 s q.e.d.
=> U <sub>ee</sub> = 0,90 · U <sub>N,0</sub> · U <sub>N,VT,ano</sub> / U <sub>N,VT,prim</sub>	referring to the nominal generator current :	
=> U_{**} = 99 V		Determination of the overcurrent tripping current I <sub>separt</sub> of the generator :
=> t <sub>uee</sub> = 1,0 s	Calculation of the current losses at double load condition :	
1,0 B	I <sub>1/2</sub> = 4 · P <sub>K,0</sub> /S <sub>N,0</sub> = 0,041	The independent short-circuit stage of the overcurrent relay is also used as back-up protection in case of
	<ul> <li>Calculation of the setting value I<sub>dm</sub> (I<sub>s</sub> = 2 · I<sub>N</sub>) at double load condition :</li> </ul>	failures within the generator stator winding.
etermination of the overvoltage U, and U,, of the generator :	double load current losses I <sub>k2</sub> = 0,041	For getting a staggering to the differential protection relay the following setting was selected :
protect the generator against overvoltages (see generator data sheets) the followi	no-load current losses I <sub>0</sub> = 0,007	=> I_**,0MT = 4.6 · I_NCT = 5.04 · I_NG = 2308 A (nearest adjustable value)
Overvoltages of 1,08 U <sub>N,0</sub> can be withstand for continuous operation acc	+ safety margin (2x10%) = 0,200	=> t <sub>ss,0MT</sub> = 0,6 s 0,6 s
Overvoltages of 1.10 U <sub>N.0</sub> can be withstand for short-term operation and	+ CT tolerances 2x (2x1,2%) = 0,048	
o make sure that the generator is adequate protected, the following pick-up voltage:	-> l <sub>dff</sub> (l <sub>5</sub> = 2 · l <sub>N</sub> ) = 0,296	Furthermore the following inequation has to be checked :
=> U <sub>2</sub> = 1,08 · U <sub>N,0</sub> · U <sub>N,VT,sec</sub> / U <sub>N,VT,prim</sub>	-> I <sub>aff</sub> (I <sub>5</sub> = 2 · I <sub>N</sub> ) = 0,32 · I <sub>N,CT</sub> = 0,34 · I <sub>N,G</sub> =	- optimized in the second seco
=> U, = 118,8 V		458,3A < 500A < 1833A < 2308A < 2787A
=> t <sub>0</sub> , = 10,0 s	Determination of the differential current lat (Is = 10 · Is) caused by the power loss at ter	458 500 1833 2308 2787
=> U <sub>**</sub> = 1,10 · U <sub>N/G</sub> · U <sub>N/VT,sec</sub> / U <sub>N/VT,prim</sub>	referring to the nominal generator current :	
=> U <sub>10</sub> = 121 V	- Calculation of the current losses at ten-fold load condition :	
	I <sub>kt0</sub> = 100 · P <sub>K0</sub> /S <sub>N,0</sub> = 1,022	
=> t <sub>ue</sub> = 1,0 s	<ul> <li>Calculation of the setting value lat (Is = 10 - In) at double load condition :</li> </ul>	
termination of the underfrequency fc and fc of the generator :	ten-fold load current losses Ikto = 1,022	
protect the generator against underfrequency (see generator data sheets) the follo	no-load current losses I <sub>0</sub> = 0,007	
Underfrequencies of 0,97 · f <sub>NG</sub> can be withstand for continuous operation acc.	+ safety margin (10x10%) - 1,000	
	+ CT tolerances 10x (2x2,9%) = 0,579	
Underfrequencies of 0,98 f <sub>N,0</sub> can be withstand for short-term operation and s	-> $l_{diff}(l_p = 2 \cdot l_N) = 2,608$	
o make sure that the generator is adequate protected, the following pick-up frequen	-> Ider (Is = 2 · IN) = 2,70 · INCT = 2,85 · ING =	
$=> f_{e} = 0.97 \cdot f_{N,0}$		
=> f, = 58.2 Hz	a design of the second s	
=>t, = 10.0 s	Determination of the maximum permitted differential current $\mathbf{I}_{\mathrm{off}} >>$ (high set) of the block	
=> f <sub>ee</sub> = 0.98 · f <sub>NO</sub>	By using the following inequation the setting value of the maximum differential current Idiff $\gg$	
	I <sub>op,max,G</sub> < I <sub>N,MRD</sub> < I <sub>ddfini</sub> < I <sup>*</sup> <sub>K,2pmin</sub>	
=> f <sub>ex</sub> = 57,6 Hz	458,3A < 50DA < 1834A < 2787A	
=> t <sub>ex</sub> = 1,0 s	458 500 1834 2787	
	-> latt-> 3,7 · In.ct = 4,0 · In.c	
termination of the overfrequency f, and f, of the generator :	varies	
	Defensive of the effect of characteristic same from sinks here.	
o protect the generator against overfrequencies (see generator data sheets) the foll	Determination of the offset of characteristic curve from static basic characteristic curv	
Overfrequencies of 1,03 f <sub>N,0</sub> can be withstand for continuous operation acc.	This factor raises the characteristic curve in case of harmonics. Harmonics can be caused fr	
Overfrequencies of 1,04 f <sub>N,G</sub> can be withstand for short-term operation and s	station transformers or from 1 side CT saturation in case of a heavy through fault current cau	
o make sure that the generator is adequate protected, the following pick-up voltages	In practice a setting of d(I <sub>d</sub> ) = 2,1 · I <sub>N,CT</sub> = 2,2 · I <sub>N,Q</sub> =	
=> f, = 1,03 · f <sub>NG</sub>		
=> f. = 61.8 Hz	Summary of the results	
	lamin-box = 0,11 · Incr = 0,12 · Incr	
=> t <sub>r</sub> , = 10,0 s		
=> f <sub>ss</sub> = 62,4 Hz		
=> t <sub>ex</sub> = 1,0 s		
17 18 B	d(l <sub>d</sub> ) = 2,1 · l <sub>N,CT</sub> = 2,2 · l <sub>N,G</sub> =	
$=> f_{yy} = 1.04 \cdot f_{N,0}$ $=> f_{yy} = 62.4 \text{ Hz}$	langu=boo 0,3 · ln,cr 0,3 · ln,cr langu=boo 2,7 · ln,cr 2,9 · ln,c langu=boo 3,7 · ln,cr 4,0 · ln,c	Power Train - Protection Calculations and Settings_Example.xisx MRI-Setting Calculation 28.01.2013 page 5/31
	Down Train Distantion Calculations and Softings, Example view	
	Power Train - Protection Calculations and Settings_Example.xisx	in a county convention between page dot
ver Train - Protection Calculations and Settings_Example.vlsx	Power Train - Protection Calculations and Settings_Example.xisx MRD-Setting Calculation 28.01.2013	mini wexeng werkeneni bere i
ver Train - Protection Calculations and Settings_Example.vlsx J-Setting Calculation 28.01.2013	Power Train - Protection Calculations and Settings_Example.xisx MRD-Setting Calculation	intra occurry ouronation and a secondation page dut
ver Train - Protection Calculations and Settings_Example.xlsx J-Setting Calculation 28.01.2013	Power Train - Protection Calculations and Settings_Example.xisx MRD-Setting Calculation 28.01.2013	in o componential in the componentin the componential in the componential in the compo
ver Train - Protection Calculations and Settings_Example.xlsx J-Setting Calculation 28.01.2013	Power Train - Protection Calculations and Settings_Example.xisx MRC-Getting Calculation 28.01.2013	

**WOODWARD** Always Innovating for a Better Future

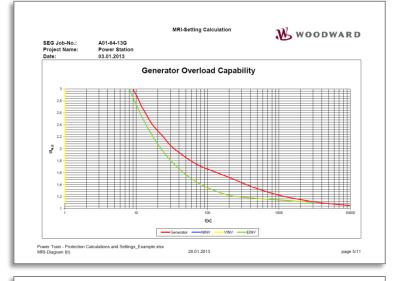
### **Network Study - Protection Setting List**

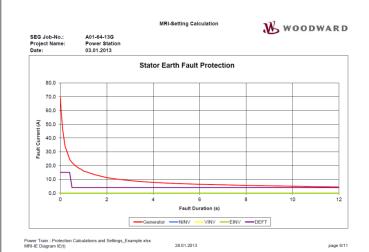
Setting Lis	t MRI3		K	wood	WARD
Project Name:	Power Station			Project Job No.	A01-64-13G
Function Group:	=3.GanB	Location:	+3Sx.TL	Relay Code:	-F9
Relay Function:	Overcurrent, Short-Circo	uit and Restricted	Earth Fault Protection	ANSI Code:	51/50/67N
Password:	++++			Date:	03.01.2013
x = 1-12, a = A-T, n = 1-2 <b>1. System P</b> a					

Function	Relay Type: MRI3- IER	Default Settings	Actual Settings
I <sub>primär</sub> (phase) Indication as kA	X	500	
I <sub>primär</sub> (earth) Indication as kA	X	50	
Uprim/Usek (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-	Default	Actual
	IER	Settings	Settings
2 parameter sets	×	set 1	
I> (=xxt*IN)	X	1,00	
CHAR I>	X	EINV	
t <sub>⊳</sub> (V) / t <sub>⊳</sub> (R)	X	0,66	
0s / 60s (phase)	X	60	
<pre>&gt;&gt; (=xx*IN)</pre>	X	4,6	
t <sub>p&gt;</sub> (V) / t <sub>p&gt;</sub> (R)	X	0,6	
RCA			
U <sub>E&gt;</sub>	X	11	
I <sub>E&gt;</sub> (=xx*IN)	X	0,080	
trip / warn	X	Trip	
CHAR I <sub>E</sub>			
t <sub>ie&gt;</sub> (V) / t <sub>ie&gt;</sub> (R)	×	20,00 12,00	
0s / 60s (phase)			
exx*IN)	X	0,30	
t <sub>iE≫</sub> (V) / t <sub>iE≫</sub> (R)	X	2,0 0,4	
SIN / COS	X	COS	
SOLI / RESI			
Block/trip – time	X	EXIT	
CEFP	X	EXIT	
RS485 / Slave	X	1	
Baud-Rate (only Modbus Protocol)	x	9600	
Parity-Check (only Modbus Protocol)	×	Even	

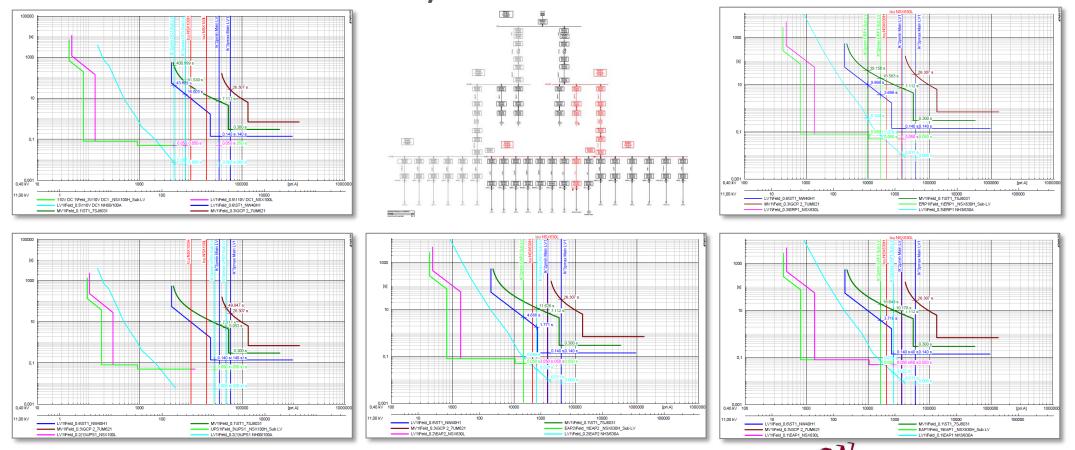






### **Network Study - Verification of Coordination**

Verification of Selectivity



WOODWARD

Always Innovating for a Better Future

### **Network Study - Verification of Current Transformer**

#### - Calculation & Verification of GCP related CTs

- 2. Generator Current Transformers Rating Calcul
- 2.1. Objective

All current transformer protection cores shall be oprotection relays are guaranteed. Therefore the f

- 2.2. Calculation of Generator CTs
- 2.2.1. Calculation of Generator CTs Requirement 1 For the verification of the CTs requirements it ha actual and rated burden has no impact on satura

$$\begin{split} I_{pu} < I_{bn,CT,suc,N} = I_{F,dh} \cdot \frac{I_{CT,suc,N}}{I_{CT,prim,N}} \end{split}$$
 with 
$$\begin{split} k_{oolf} = k_{nalf} \cdot \frac{S_{CT,suc,N}}{S_{CT,suc,M}} = k_{nalf} \cdot \frac{S_{ch}}{S_{CT,suc,M}} \\ S_{oobk} \approx 2 \cdot R_L \cdot I_{CT,suc,N}^2 = \frac{2 \cdot L}{\chi \cdot A} \cdot I_{CT,suc,N}^2 \\ S_{nalow} = Z_{nalow} \cdot I_{CT,suc,N}^2 \end{split}$$

 $S_{CT,I} \approx R_{CT,I} \cdot I_{CT,IMCN}^2$ 

pick-up value of the pro rated short-time therma

calculated max\_primar

actual secondary curre

rated secondary current

rated secondary curre

rated primary current of

actual overcurrent factor rated overcurrent factor actual load of the CT's

rated load of the CT's

rated power of the CT's power consumption of

loop resistance of the C cable length

cable conductivity

cable cross - section

power consumption of the

internal power consump resistance of the CT's s

whereby Ipu

IE th

l"<sub>K,max,3pol</sub>

kn C T sec eff

kn C T, sec N

C T prim N

Sc.T.,sec,eff,load

SC.T., sec, N

2 R<sub>L</sub> :

1.1

γ:

A٠

S<sub>relays</sub> : Sc.t., :

R<sub>CTI</sub>:

- Calculation & Verification of GCP related CTs

2.2.2. Calculation of Generator CTs - Requirement 2: Sat For the verification of the CTs requirements is has to b actual and rated knee point voltage has no impact on s detection.

 $U_{kn,C,T,N} \ge U_{kn,C,T}(I^{"}_{K,\max,3pol}) = 2 \cdot I^{"}_{K,\max,3pol}$ 

$$\begin{array}{ll} \text{with} \qquad Z_{coble} \approx 2 \cdot R_L = \frac{2 \cdot L}{\chi \cdot A} \\ \\ Z_{relays} = \sum \frac{S_{relay}}{I_{C.T.N}{}^2} \end{array}$$

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

Zrelavs

whereby	Ukn,C.T.,N :	rated knee point voltage
	Ukn,C.T.(I"K,max,3pol) :	actual knee point voltag
	I <sub>F,th</sub> :	rated short-time therma
	I"K,max,3pol	calculated max. primary
	IC.T.,sec,N	rated secondary current
	IC.T.,prim,N :	rated primary current of
	kn.C.T.N	secondary exciting curre
	Z <sub>C.T.J</sub> :	impedance of the CT's :
	R <sub>c.T.J</sub> :	resistance of the CT's s
	Z <sub>cable</sub> :	cable impedances
	2 R <sub>L</sub> :	loop resistance of the C
	L:	cable length
	χ:	cable conductivity
	A:	cable cross - section
	2 R <sub>L</sub> : L: χ:	loop resistance of th cable length cable conductivity

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.

$$I_{pu} < I_{in,C.T.,\mathsf{sec},N} = I_{F, \#} \cdot \frac{I_{C.T.,\mathsf{sec},N}}{I_{C.T.,prim,N}} < I_{in,C.T.,\mathsf{sec},\#} = I_{C.T.,\mathsf{sec},N} \cdot k_{oolf}$$

3.1.1.1. Generator Star Point Phase Current Transformer

3.1.1.2. Generator MV Switchgear Phase Current Transformer

$$\Rightarrow I_{\mu\nu} = 3.51A < 67.5k4 \cdot \frac{14}{1350A} = 50.4 < 1A \cdot 52.9 = 52.9A \qquad \checkmark \quad q.e.d.$$
with
$$k_{odf} = k_{mdf} \cdot \frac{S_{CT, ue, N, hood}}{S_{CT, ue, N, hood}} = k_{mdf} \cdot \frac{S_{CT, ue, N} + S_{CT, J}}{S_{colu} + S_{relays} + S_{CT, J}}$$

$$\Rightarrow k_{odf} = 20 \cdot \frac{15V4 + 7.373VA}{1.030VA + 0.05VA + 7.373VA} = 20 \cdot 2.647 = 52.9$$

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

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

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

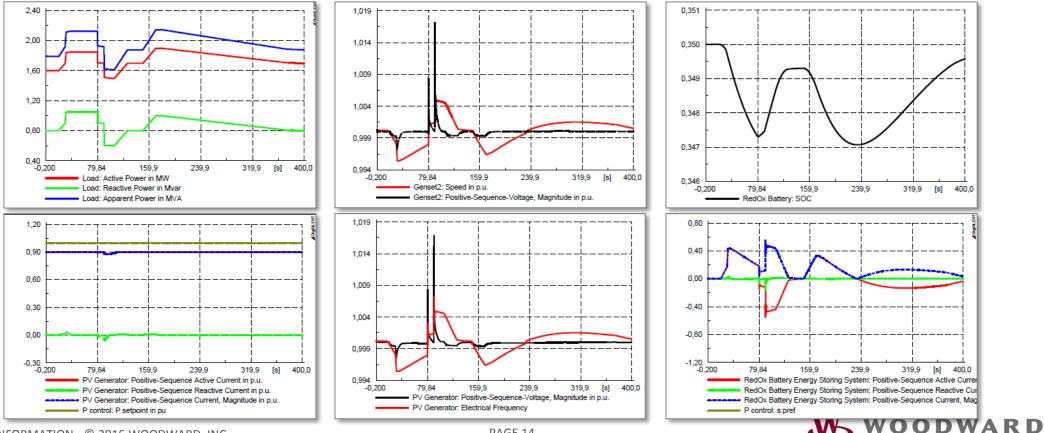
$$page 10$$

**WOODWARD** Always Innovating for a Better Future

PROPRIETARY INFORMATION - © 2016 WOODWARD, INC.

# **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)



PROPRIETARY INFORMATION - © 2016 WOODWARD, INC.

Always Innovating for a Better Future

### **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 O† Protection Settings with secondary Injection Tests on-site.

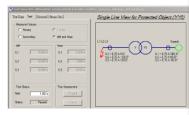


Figure 46: Test Module Diff Configuration – Test results external fault

4.5.2 Differential Operating Characteristic L1-L2-L3 - 870

#### Internal fault:

 The diff operating and trip time characteristic is base based on Inom as shown in the Diff Operating Chara 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 currer
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 diag Ibias ). With using the button "add" the test point is listed.

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

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

Pla Edt Vevs Text Parameters Vierdes H					
INN N DE 2 DRA	l olol eletet	81 <b>7</b> 14	ei		
Test Charts Net Departure Anto-	_	_			
🛋 🕶 1211 🔊 🔊 UU 🖻 🖀	12 22				
- C South Australia	Generator Differentia		Annual on March		
D (7) 73/452	Stat Mana	0	Description	Value	Unit
E C Relay Farandar Sector E C Addawal Information		harman	Rumber of Vindings		
2 - Of Additional Procession			The reference winders	Printan	
8. of Tereside Centreller			Protected Object	Generate	
B-0710			Plaintys current tolerance	2.16	
in 🗇 Device	Tel. 1aba.	TOL 485	Absolute current tolenance	0,60	
<ul> <li>Germatic Differential</li> <li>Window</li> </ul>	Tel. trel.	TTOL FEL	Molative time tolerance	1,60	
- CT Windry2	<ul> <li>Tel. tabe.</li> </ul>	1105, 485	Absolute time tolerance	0,81	0
G CT OF Bas	Time ret	1927	Time reference of fault inception	Fast	
H-CT Generator Officenzal Stat Curve	34 Theset	1927	Meest delay time of device	78,25	
8 - D Incelance	a Mantaet time	TMAK	Planimal territime	0,50	
8 😅 Urdepotation	Pet.current	1127	Noming currents is current of prot. obj	Paz. skjez	
R-CE Dut of Sep	Use proved CT		Use ground current measurements inp-		
<ul> <li>Stage Reserved Overcurent Paiks</li> <li>Cli Certilization</li> </ul>	No barrat, mode		Transformer model deactivated		
K - Cardy and an	<ul> <li>Delts compeno</li> </ul>		Activate compensation for delta connel		
E of Themal Starbert Men.	No Combined	NO_COMB	The device does not require the combi-		

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 compare deviation is within the tolerances, the testing will be passed.

ket Points				WE IN L	
of 0.5h 0.5h 0.8h 0.8h 0.8h 1.9h 1.9h 2.9h 2.3h 2.3h	0.40 m 0.40 m 1.30 m 1.30 m 5.50 m 5.50 m 5.50 m 5.50 m 5.50 m	1942 5.7 0.014 x 0.1755 5.7 0.1255 8.7 0.1255 8.7 0.1255 8.7 0.1255 8.7 0.1255	2005 507 012s 025+ 507 012s 507 012s 507 012s 507 012s 507 012s 012s 012s 012s	2,75 2,80 2,25 2,00 1,75 1,80 1,25	Ţ
# 230 h	6.00 h		Report	100 0.75 0.50 0.25 0.00	ê 7

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 Dely = 10s

#### 5.9 Group Underexcitation Protection; Group Characteristics

No.	Settings	Value	Group
3002	Susceptance Intersect Characteristic 1	0,41	A
3003	Indination Angle of Characteristic 1	72*	A
3004	Characteristic 1 Time Delay	10,00 sec	Α
3005	Susceptance Intersect Characteristic 2	0,37	A
3006	Indination Angle of Characteristic 2	90 °	A
3007	Characteristic 2 Time Delay	10,00 вес	A
3008	Susceptance Intersect Characteristic 3	1,05	A
3009	Indination Angle of Characteristic 3	84*	A
3010	Characteristic 3 Time Delay	0,50 sec	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.

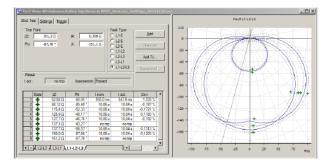


Figure 57: Test Module Distance - Test results Underexcitation trip times



39

