APPENDIX 5C

Interconnection Data Sheet for the System Impact Study

CALIFORNIA ISO

Generator Interconnection Application Form

The following form is to be filled out for generators that intend to interconnect to the ISO grid. **Three copies** of the completed Application should be sent to:

Gary Brown
New Resource Interconnection
California ISO
P.O. Box 639014
Folsom, CA 95763-9014

copied
T.A.
~Arz

Overnight address: 151 Blue Ravine Road, Folsom, CA 95630

It is important that the data provided via this form is accurate. Additional transmission system facility costs, associated with changes in facility requirements, that are due to differences between model data provided by the generation developer and the actual generator test data, may be the responsibility of the generation developer.

1. General Project Information

A. Project Name: **Humboldt Energy Facility**

B. Project Location:
Street Address: **B & Ocean Streets**
City, State: **Eureka, California**
Zip Code: **95501**

Revised
5/2/05

C. Proposed Testing date: **July 1, 2008**
Proposed Commercial Operation date: **August 1, 2008**
Proposed Term of Service: **20-yr PPA**

D. Type of Project
Cogeneration: ____ Reciprocating Engine : X
Biomass: ____ Steam Turbine: ____
Gas Turbine: ______ Wind: ____
Hydro: ____ Photovoltaic: ____
Combined Cycle: ____
Other (please describe): ______________

E: Total Generator rated output (kW): **166,050 *****
Individual generator rated output (kW for each unit): **16,638 *****
Generator auxiliary load (kW): **4,050**
Project net capacity (kW): **162,000**
Standby load when generator is off-line (kW): **200**
*** For ISO conditions at site elevation

F. The interconnection point(s) and the location of interconnection:
60 kV Bus inside of the existing PG&E Humboldt Power Plant Substation

G. Project Developer **Ramco Generating Two**
Name: **Kent Fickett**
Street Address: **61 Avenida De Orinda, Suite 35**
City, State: **Orinda**
Zip Code: **California 94563**
Phone Number: **(925)258-9829**
Fax Number: **(925)258-9802**
Email Address: **k.fickett@comcast.net**

H. Site Owner **Same as Above**
Name: ____________
Street Address: ____________
City, State: ____________
Zip Code: ____________
Phone Number: ____________
Fax Number: ____________
Email Address: ____________

I. Person Responsible for completing this Application
Name: **Alex Takahashi**
Title: **Principal Engineer**
Company Name: **WestPower, Inc.**
Street Address: **3055 Alvarado St, Suite 122**
City, State: **San Leandro**
Zip Code: **California 94577**
Phone Number: **(510)904-1000**
Fax Number: **(510)351-6655**
Email Address: **alex@westpower.com**

Signature: **(Original Signed)** Date: **10/15/04**

2. Two original prints and one reproducible copy (no larger than 36" x 24") of the following:

A. Site drawing to scale, showing generator location and point of interconnection with the ISO Grid.

(See Attachment "A")

B. Single-line diagram showing applicable equipment such as generating units, step-up transformers, auxiliary transformers, switches/disconnects of the proposed interconnection, including the required protection devices and circuit breakers. For wind generator farms, the one line diagram should include the distribution lines connecting the various groups of generating units, the generator capacitor banks, the step up transformers, the distribution lines, and the substation transformers and capacitor banks at the point of interconnection with the utility.

(See Attachment "A")

3. Generator Information

(See Attachment "B")

A) Number of Generators: **10**
(Please repeat the following items for each generator)
B) Manufacturer: **ABB Industry Oy/Machines, or equal**
C) Year Manufactured: **TBD**
D) Nominal Terminal Voltage: **13,800 V**
E) Rated Power Factor (%): **0.80**
F) Type (Induction, Synchronous, D.C. with Inverter): **Synchronous**
H) Phase (3phase or single phase): **3-Phase**
I) Connection (Delta, Grounded WYE, Ungrounded WYE, impedance grounded): **STAR WITH HRG**
K) J) Generator Voltage Regulation Range: **13.8 kv +/- 5%**
L) For combined cycle plants, specify the plant output for an outage of the steam turbine or an outage of a single combustion turbine: **N/A**

____

4. Synchronous Generator – General Information:

(See also Attachment "B")

A. Rated Generator speed (rpm): **514**
B. Rated MVA: **20.797**
C. Rated Generator Power Factor: **0.80**
D. Generator Efficiency at Rated Load (%): **97.52**
E. Moment of Inertia (including prime mover): **12,550 kgm^2**
F. Inertia Time Constant (on machine base) H: **1.16** sec or MJ/MVA
G. SCR (Short-Circuit Ratio - the ratio of the field current required for rated open-circuit voltage to the field current required for rated short-circuit current): **0.73**

J. Please attach generator reactive capability curves. (See Attachment "B")
K. Rated Hydrogen Cooling Pressure in psig (Steam Units only): N/A
L. Please attach a plot of generator terminal voltage versus field current that shows the air gap line, the open-circuit saturation curve, and the saturation curve at full load and rated power factor. (See Attachment "B")

6. Excitation System Information

(See also Attachment "C")

A. Indicate the Manufacturer: Basler Electric. and Type 4 of excitation system used for the generator. For exciter type, please choose from 1 to 8 below or describe the specific excitation system.

1) Rotating DC commutator exciter with continuously acting regulator. The regulator power source is independent of the generator terminal voltage and current.

2) Rotating DC commentator exciter with continuously acting regulator. The regulator power source is bus fed from the generator terminal voltage.

3) Rotating DC commutator exciter with non-continuously acting regulator (i.e., regulator adjustments are made in discrete increments).

4) Rotating AC Alternator Exciter with non-controlled (diode) rectifiers. The regulator power source is independent of the generator terminal voltage and current (not bus-fed).

5) Rotating AC Alternator Exciter with controlled (thyristor) rectifiers. The regulator power source is fed from the exciter output voltage.

6) Rotating AC Alternator Exciter with controlled (thyristor) rectifiers.

7) Static Exciter with controlled (thyristor) rectifiers. The regulator power source is bus-fed from the generator terminal voltage.

8) Static Exciter with controlled (thyristor) rectifiers. The regulator power source is bus-fed from a combination of generator terminal voltage and current (compound-source controlled rectifiers system.

B. Attach a copy of the block diagram of the excitation system from its instruction manual. The diagram should show the input, output, and all feedback loops of the excitation system.

C. Excitation system response ratio (ASA): ____________
D. Full load rated exciter output voltage: ____________

E. Maximum exciter output voltage (ceiling voltage): ____________

F. Other comments regarding the excitation system?

____
____
____

7. Power System Stabilizer Information.

(See also Attachment "D")

A. Manufacturer: Basler Electric PSS-100

B. Is the PSS digital or analog? Digital

C. Note the input signal source for the PSS?

X Bus frequency ______ Shaft speed _____ Bus Voltage
____________________ Other (specify source)

D. Please attach a copy of a block diagram of the PSS from the PSS Instruction Manual and the correspondence between dial settings and the time constants or PSS gain. (See Attachment "E")

E: Other comments regarding the PSS?

____
____
____

8. Turbine-Governor Information

(Please repeat the following for each generator)

Please complete Part A for steam, gas or combined-cycle turbines, Part B for hydro turbines, and Part C for both.

A. Steam, gas or combined-cycle turbines:

1.) List type of unit (Steam, Gas , or Combined-cycle): Gas Engines

2.) If steam or combined-cycle, does the turbine system have a reheat process (i.e., both high- and low-pressure turbines)? _______

3.) If steam with reheat process, or if combined-cycle, indicate in the space provided, the percent of full load power produced by each turbine:

Low pressure turbine or gas turbine: ______%
High pressure turbine or steam turbine: ______%

B. Hydro turbines:

1.) Turbine efficiency at rated load:_______%

2.) Length of penstock: ______ft

3.) Average cross-sectional area of the penstock: _______ft2

4.) Typical maximum head (vertical distance from the bottom of the penstock, at the gate, to the water level): ______ft

5.) Is the water supply run-of-the-river or reservoir:___________

6.) Water flow rate at the typical maximum head:_________ ft3/sec
7.) Average energy rate:_________ kW-hrs/acre-ft
8.) Estimated yearly energy production: ________kW-hrs

C. Complete this section for each machine, independent of the turbine type.

1.) Turbine manufacturer: ____________________
2.) Maximum turbine power output: ____________________
3.) Minimum turbine power output (while on line): ______MW
4.) Governor information:
a: Droop setting (speed regulation): ______
b: Is the governor mechanical-hydraulic or electro-hydraulic (Electro-hydraulic governors have an electronic speed sensor and transducer.)?
All Electrical
c: Other comments regarding the turbine governor system?
____

____

9. Synchronous Generator and Associated Equipment – Dynamic Models:

(See Attachment E)

For each Generator, governor, exciter and power system stabilizer, select the appropriate dynamic model from the General Electric PSLF Program Manual and provide the required input data. The manual is available on the GE website at:

https://quickplace01.geextranet.com/QuickPlace/psec_ge_pslf/PageLibrary85256A2A00654741.nsf/h_Index/5F812CDC8192571285256A3B00693C43/?OpenDocument.

The models are listed alphabetically in Table 3.2 and by model type in Table 3.3. These tables are in Section 3.10.3 of the manual. Links to these tables are provided in the Program Manual's Table of Contents. There are links in the tables to a detailed description of the specific model, a definition of each parameter, a list of the output channels, explanatory notes, and a control system block diagram. The block diagrams are also available on the Ca-ISO website.

If you require assistance in developing the models, we suggest you contact General Electric (John Burns 518-385-8150). Accurate models are important to obtain accurate study results. Costs associated with any changes in facility requirements that are due to differences between model data provided by the generation developer and the actual generator test data, will normally be the responsibility of the generation developer.

10. Induction Generator Data:

A. Rated Generator Power Factor at rated load:____________
B. Moment of Inertia (including prime mover): ____________

C. Do you wish reclose blocking? Yes ___, No ___
Note: Sufficient capacitance may be on the line now, or in the future, and the generator may self-excite unexpectedly.

11. Generator Short Circuit Data

For each generator, provide the following reactances expressed in p.u. on the generator base:

- X"1 – positive sequence subtransient reactance: ______
- X"2 – negative sequence subtransient reactance: ______
- X"0 – zero sequence subtransient reactance: ______

Generator Grounding:

A. _X_ Solidly grounded
B. ___ Grounded through an impedance

Impedance value in p.u on generator base: R:____________p.u.
X:____________p.u.

C. ______Ungrounded

12. Step-Up Transformer Data

For each step-up transformer, fill out the data form provided in Table 1.

13. Line Data

*** TBD – Pending confirmation of the site**

There is no need to provide data for new lines that are to be planned by the Participating Transmission Owner. However, for transmission lines that are to be planned by the generation developer, please provide the following information:

Nominal Voltage: **60 kV**
Line Length (miles): ___*___
Line termination Points: ___*___
Conductor Type;___*___ Size: ___*___
If bundled : Number per phase:___*___, Bundle spacing ___*___ in.
Phase Configuration: Vertical ___*___, Horizontal: ___*___
Phase Spacing (ft): A-B ___*___, B-C___*___, C-A: ___*___
Distance of lowest conductor to Ground:___*___ ft
Ground Wire Type:___*___ Size:___*___ Distance to Ground:___*___ft
Attach Tower Configuration Diagram
Summer line ratings in amperes (normal and emergency) ___*___

Resistance (R): ____*____________p.u.**
Reactance: (X): ____*____________p.u**
Line Charging (B/2): *____________p.u**
** On 100-MVA and nominal line voltage (kV) Base

14. Will the Participating Transmission Owner be responsible for conducting the System Impact Study and Facility Study or will the project proponent be utilizing another party to complete these studies?

PTO (PG&E) will perform SIS and FS

TABLE 1

TRANSFORMER DATA

UNIT: T-1 & T-2 (60 KV TRANSFORMERS)

NUMBER OF TRANSFORMERS 2 PHASE 3

RATED KVA	H Winding	X Winding	Y Winding
Connection (Delta, Wye, Gnd.)	WYE	DELTA	N/A
55 C Rise	75/100/125	75/100/125	N/A
65 C Rise	140	140	N/A
RATED VOLTAGE	60 KV	13.8 KV	N/A
BIL	350 KV	110 KV	N/A
AVAILABLE TAPS (planned or existing)	+/- 2 x 2.5%	N/A	N/A
LOAD TAP CHANGER?	NO	NO	N/A
TAP SETTINGS	N/A	N/A	N/A

COOLING TYPE : OA______ OA/FA______ OA/FA/FA X OA/FOA______

IMPEDANCE	H-X	H-Y	X-Y
Percent	9%	N/A	N/A
MVA Base	75	N/A	N/A
Tested Taps	3	N/A	N/A
WINDING RESISTANCE			Y
Ohms	0.16	0.013	N/A

CURRENT TRANSFORMER RATIOS

H (3) 1200:5, C-800 X N/A Y N/A N (1) 800:5, C-400

PERCENT EXCITING CURRENT 100 % Voltage; 0.434 110% Voltage 1.2

Supply copy of nameplate and manufacture's test report when available YES

Attachment E

Humboldt Energy Facility

Dynamic Models
for
Synchronous Generators
and
Associated Equipment

WÄRTSILÄ

Power system modelling for

WÄRTSILÄ 18V50DF

10. November 2004

Table of contents:

Generator model parameters, gensal 2
Excitation model parameters, exac8b 3
Power system stabilizer model parameters, pss2a 4
Governor model parameters, ggov1 5

Appendixes:

Appendix 1	Generator technical specification
Appendix 2	Questionnaire for the Calculation of PSS settings
Appendix 3	Functional Specification UN 1000 PSS (PSS is integrated in ABB Unitrol 1000 AVR)

WÄRTSILÄ

Generator model parameters for Wärtsilä 18V50DF

Model Name: gensal

Description: Salient pole generator represented by equal mutual inductance rotor modelling

Prerequisites: Generator present in load flow working case

Inputs: Network boundary variables, Field Voltage, Turbine Power

Invocation: gensal [<n>] {<name> <kv>} <id> :

Parameters:

EPCL Variable	*18V50DF data*	*Description*
Tpdo	6.348	D-axis transient rotor time constant
Tppdo	0.04201	D-axis sub-transient rotor time constant
Tppqo	0.1512	Q-axis sub-transient rotor time constant
H	1.53	Inertia constant, sec
D	*)	Damping factor, pu
Ld	1.572	D-axis synchronous reactance
Lq	0.86	Q-axis synchronous reactance
Lpd	0.337	D-axis transient reactance
Lppd	0.187	D-axis transient reactance
Ll	0.161	Stator leakage reactance, pu
S1	**)	Saturation factor at 1 pu flux
S12	**)	Saturation factor at 1.2 pu flux
Ra	0.00350	Stator resistance, pu
Rcomp	***)	Compounding resistance for voltage control, pu
Xcomp	***)	pounding reactance for voltage control, pu
General data		
S (kVA)	20797	Generator power
PF	0.8	Power Factor
U (kV)	13.8	Voltage
f (Hz)	60	Frequency
Speed	514	Nominal speed

*) Pls. refer to Complex Synchronizing Coefficient curve (Generator technical specification)
**) Pls. refer to no load voltage curve (Generator technical specification)
***) Unknown parameter

WÄRTSILÄ

Excitation model parameters for Wärtsilä 18V50DF

Model Name:	exac8b
Description	Brushless exciter with PID voltage regulator
Prerequisites:	Generator model ahead of this model in dynamic models table
Inputs:	Compounded generator terminal voltage, generator field current, generator speed

Parameters:

EPCL Variable	*18V50DF Data*	*Description*
Tr	0.02	Voltage transducer time constant, sec.
Kvp	7.02	Voltage Regulator Proportional Gain
Kvi	9.12	Voltage Regulator Integral Gain
Kvd	1.47	Voltage Regulator Derivative Gain
Tvd	0.03	Voltage Regulator Derivative Time Constant, sec.
Vimax	0.545	Voltage Regulator Input Limit, p.u.
Ta	0	Voltage Regulator time constant, sec.
Vrmax	5.07	Maximum controller output, p.u.
Vrmin	0	Minimum controller output, p.u.
Ke	1.0	Exciter field proportional constant
Te	0.12	Exciter field time constant, sec.
Kc	0	Rectifier regulation factor, p.u.
Kd	0	Exciter regulation factor, p.u.
E1	3.95	Exciter flux at knee of curve, p.u.
S(E1)	0.953	Saturation factor at knee
E2	5.27	Maximum exciter, p.u.
S(E2)	0.996	Saturation factor at max flux
Rcomp	0.0	Regulator compensating resistance, p.u.
Xcomp	0,0	Regulator compensating reactance, p.u.

WÄRTSILÄ

Power system stabilizer model parameters for Wärtsilä 18V50DF

Model Name:	PSS2A
Description	Dual input Power system stabilizer (IEEE type PSS2A)
Prerequisites:	Generator model ahead of this model in dynamic models table
Inputs:	Generator shaft speed Frequency of generator terminal or system bus voltage Generator electric power or accelerating power Voltage amplitude of generator terminal bus or system bus Current amplitude specified branch

Parameters:

EPCL Variable	18V50DF Data	Description
J1	1	Input signal #1 code
K1	0	Input signal #1 remote bus number
J2	3	Input signal #2 code
K2	0	Input signal #2 remote bus number
Tw1	10	First washout on signal #1, sec.
Tw2	10	Second washout on signal #1, sec.
Tw3	10	First washout on signal #2, sec.
Tw4	10	Second washout on signal #2, sec.
T6	0.10	Time constant on signal #1, sec.
T7	0	Time constant on signal #2, sec.
Ks2	7.75	Gain on signal #2
Ks3	1	Gain on signal #2
Ks4	1	Gain on signal #2
T8	0.30	Lead of ramp tracking filter
T9	0.15	Lag of ramp tracking filter
n	1	Order of ramp tracking filter
m	5	Order of ramp tracking filter
Ks1	20	Stabilizer gain
T1	0.16	Lead/lag time constant, sec.
T2	0.02	Lead/lag time constant, sec.
T3	0.16	Lead/lag time constant, sec.
T4	0.02	Lead/lag time constant, sec.
Vstmax	0.2	Stabilizer output max limit, p.u.
Vstmin	0.07	Stabilizer output min limit, p.u.
a	1	Lead/lag num. Gain. (not in IEEE model)
Ta	0	Lead/lag time constant, sec. (not in IEEE model)
Tb	0	Lead/lag time constant, sec. (not in IEEE model)

To calculate more accurate default parameters, please fill in items 1.2 and 1.3 on appendix 2, "for the Calculation of PSS settings".

WÄRTSILÄ

Governor model parameters for Wärtsilä 18V50DF

Model Name: ggov1

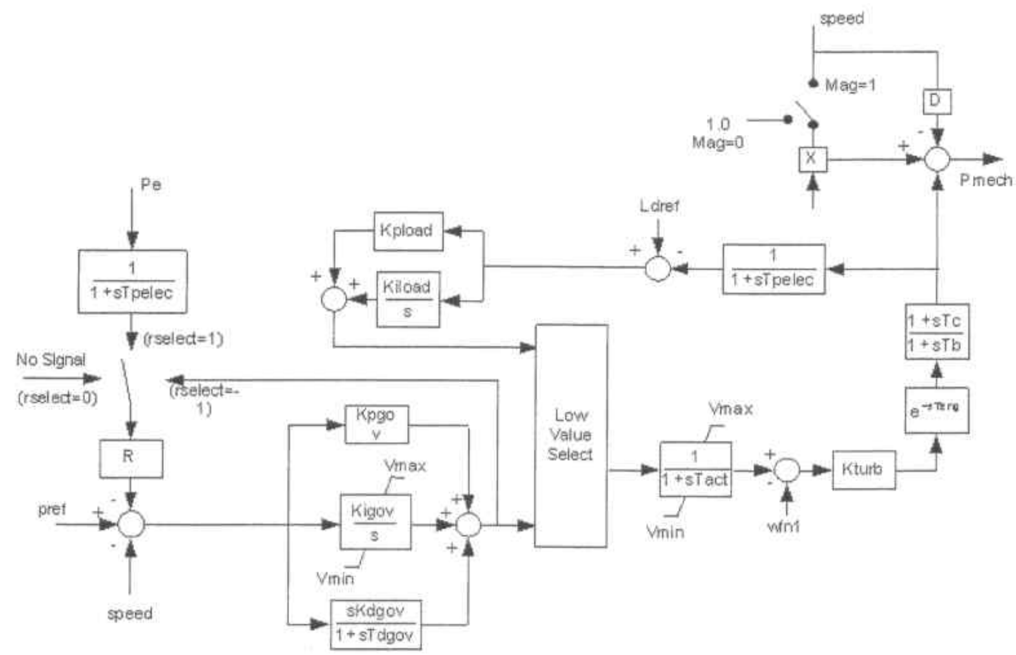
Description: General governor model

Prerequisites: Generator model ahead of this model in the dynamic models table

Parameters:

Name	Description	Value
R	Permanent droop, p.u	0.04
Rselect	Selction for feedback signal for droop = 1 selected elcetrical power = 0 isochronous governor = -1 selected governor output	1.0
tpelec	Electrical power transducer time constant, sec.	0.16
maxerr	Maximum value for speed error signal	10.0
miner	Minimum value for speed error signal	-10.0
kpgov	Governor proportional gain	5.96
kigov	Governor integral gain	5.96
kdgov	Governor derivative gain	0.000993
tdgov	Governor derivative controller time constant	0.01
vmax	Maximum valve position limit	1.1
vmin	Minimum valve position limit	0.0
tact	Actuator time constant	0.01
kturb	Valve-to-power gain	1.0
wfnl	No load fuel flow, p.u.	0.071
tb	Power development lag time constant	0.5*t0
tc	Power development lead time constant	-0.5*t0
flag	Switch for turbine output 0 for power proportional to fuel flow 1 for torque proportional to fuel flow	1.0
teng	Transport lag time constant for diesel engine	0.03
tfload	Load Limiter time constant	1.0
kpload	Load limiter proportional gain for PI controller	1.0
kiload	Load limiter integral gain for PI controller	1.0
ldref	Load limiter reference value pu	10.0
dm	Mechanical damping coefficient, pu	0.0

WÄRTSILÄ



Picture 1. Governor model for Wärtsilä 18V50DF (based on ggov1)

TECHNICAL SPECIFICATION

Project name:	**ISO California**
Our reference number:	4366JK101
Customer's reference number:	
Customer:	Wärtsilä Finland, Power Plants
Final customer:	
Application:	Diesel/Gas engine
Type designation:	AMG 1600SS14 DSE

NOTES

CONTENTS

SECTION:

1 PERFORMANCE DATA (Calculated values) *2*

2 CONFIGURATION AND SCOPE OF SUPPLY *4*

3 ACCESSORIES *6*

1 PERFORMANCE DATA (Calculated values)

TYPE

Type designation: AMG 1600SS14 DSE

RATINGS

Output:	20797	kVA	Direction of rotation		
Duty:	S1		(Facing drive end):	CCW	
Voltage:	13800	V	Stored energy constant		
Current:	870	A	(Rotative energy divided		
Power factor:	0,80		by rated effect):	0,87	s
Frequency:	60	Hz	Weight:	57900	kg
Speed:	514	rpm	Inertia:	12550	kgm^2
Overspeed:	617	rpm	Protection by enclosure:	IP23	
			Cooling method:	IC0A1	
			Mounting arrangement:	IM7303	

STANDARDS

Applicable standard:	IEC
Marine classification:	None
Hazardous area classification:	None
Temperature rise stator / rotor:	F/F
Insulation class:	F

ENVIRONMENTAL CONDITIONS

Ambient temperature:	50	°C	Altitude:	1000	masl
Coolant temperature:		°C	Location:		

ASSUMED DATA

Driving equipment:	Wärtsilä 18V50DF	
Appr. mec. power:	17020	kW

EFFICIENCY in %

load:		110 %	100 %	75 %	50 %	25 %
Efficiency @ power factor	0,80	97,73	97,75	97,70	97,31	95,64
Efficiency @ power factor	1,00	98,37	98,38	98,31	97,98	96,62

REACTANCES IN %

XD (U):	157,2	XD' (S):	33,7	XQ'' (S):	21,0	X0 (U):	9,9
XQ (U):	86,0	XD'' (S):	18,7	X2 (S):	19,8	XP (S):	27,8
X1 (U):	16,1						

(S) = Saturated value, (U) = Unsaturated value

TIME CONSTANTS (SEC.) AT 75 °C

TD0':	6,348	TD':	1,495	TQ0'':	0,1512	TA:	0,136
TD0'':	0,04201	TD'':	0,02381	TQ'':	0,0406		

RESISTANCES AT 20 °C

Stator winding:	0,0320 Ω	Field winding:	0,1440 Ω
Excitation winding:	8,6 Ω		

SHORT CIRCUIT

Short circuit ratio:	0,72	
Sustained short circuit current:	1,7	p.u. (rated excitation)
	> 2.5	p.u. (voltage regulator)
Sudden short circuit current:	4650	A (symmetric RMS)
	11850	A (peak value)

VOLTAGE VARIATION

Maximum allowed amount of starting load:

Maximum voltage drop	Power factor	Load	
15 %	0.1	9150	kVA
15 %	0.4	9800	kVA
15 %	0.8	13500	kVA
20 %	0.1	12600	kVA
20 %	0.4	13500	kVA

Voltage drop at sudden increase of rated load:	22	%
Voltage rise at sudden drop of rated load:	29	%

REACTIVE LOADING

Steady state reactive loading at rated excitation:	17050	kVAR
Steady state reactive loading at zero excitation:	10200	kVAR

TORQUE

Rated load torque (Calculated of rated output in kVA): 386200 Nm

The peak values of sudden short circuit air gap torques:

2-phase short circuit: 675 % 3-phase short circuit: 490 %

BEARINGS

D-end bearing oil flow: 12,4 liter / min N.D-end bearing oil flow: 11,6 liter / min

TERMINAL CONNECTIONS

Direction of main connection:	Right down
Direction of zero connection:	Left down

EXCITATION

	Exciter field			
No load:	4,1	A	45,0	V
Rated load:	9,9	A	107,8	V

2 CONFIGURATION AND SCOPE OF SUPPLY

GENERAL

The generator is designed to operate together with a diesel or gas engine.

CONSTRUCTION

The stator frame is a rigid welded steel structure construction. The stator core is built of thin electric sheet steel laminations which are insulated on both sides with heat-resistant inorganic resin. The radial cooling ducts in the stator core insure uniform and effective cooling of the stator.

The rotor consists of a shaft, a hub and poles fixed on the hub. The shaft is machined of steel forging. The poles are manufactured of 2 mm sheet steel and bolted to the hub. The pole laminations are pressed together with steel bars which are welded to the end plates.

All windings are completely vacuum pressure impregnated with high quality epoxy resin. The windings are provided with very strong bracing which withstands all expected mechanical and electrical shocks and vibrations as well as chemicals. For more information ask for brochure "MICADUR-Compact Industry Insulation System".

The stator frame and endshields are made of fabricated steel and welded together. The stator frame is closed with steel panels that guide the ventilation air and provide the degree of protection required.

According to IM7201 the machine has two pedestal bearings. The feet are at the bottom of the machine. Cylindrical shaft end.

FOUNDATION

The machine can be mounted using shimming, machined blocks, chock fast or on grouted sole plates or bed plate. Before using other mountings, contact us.

COOLING

The machine has two shaft mounted fans inside. The surrounding air is used for cooling. The cooling air is drawn in through air filters (self charging electrostatic panels) and blown out to the surrounding environment.

CONTROL SYSTEMS

Brushless excitation. The excitation system includes following components: Current transformers for booster excitation and actual value measurement. 2-core voltage transformer for measurement and excitation power supply.

TESTING

Testing is according to Wärtsilä Generator testing instruction 4V64L0037, IEC and ABB internal requirements. The test may be observed by the customer without extra charges. The test procedures is described below. Additional information in the following PIF -files: PIF 3a-315, PIF 3a-316 are available upon request. Other tests to be agreed separately.

ROUTINE TESTS

1. Visual inspection *
2. Air gap measurement and bearing clearance *
3. Insulation resistance measurement *
4. Resistance measurement of windings and elements *
5. Direction of rotation
6. First running: checking of bearings *
7. No-load curve, U1= f(Im), n = nN
8. Short-circuit curve, I1= f(Im), n = nN
9. Tests with voltage regulator
   - adjusting of basic settings
   - initial voltage build-up and voltage regulation speed at no-load
   - testing of voltage setting range
   - setting of under frequency limit and function testing
   - measuring of sustained short-circuit current
   - measuring of remanence voltage
10. Overspeed test, t = 2 min, n = 1.2 * nN
11. Vibration measurement at no-load, U1 = U1N, n = nN
12. High voltage test:
    stator winding
    rotor winding
    field winding
    space heaters
    Pt-100 (stator)
    Pt-100 (others)
13. Insulation resistance measurement
    - polarization index 10/1 min for stator windings

* Tests to be completed before witness tests
(Performing order of the tests may differ from the listed above.)

SURFACE TREATMENT

Colour: RAL 5019 Grade: C1 - Special color

The surface treatment of the machines is based on epoxy paint system, which includes solvent free topcoat. This paint system is suitable especially for urban and industrial atmospheres with moderate corrosive attack (ISO 12944-2, C2 and C3 without direct UV-radiation). Total film thickness is 180 um.

DOCUMENTATION

User's Manual in electronic format. Documentation language is English.

3 ACCESSORIES

No pc/pcs	Item
3	Anticondensation heater - RER 1-800W/235V - 9871213 Voltage (1-ph.) 220-250 V, power 3 x 700-900 W Voltage (3-ph) 380-430 V, total power 2100-2700 W
1	1PT - Voltage transformer for exc.power & actual value meas. - KSG 3PU180/63/E - 70006553 Un/165/110 V Secondary 1: 165 V 3200VA for excitation Secondary 2: 110 V 300VA for actual value measurement
3	3CT - Current transformer for short circuit exc.power - KSG IFJ-3-PNT3 - 9874921 XXX/X.X A, 10P2.5/3, 50/60 Hz (Exact values to be specified later)
1	2CT - Current transformer for actual value measurement - KSG 1000T2 - 9872231 1000/1A, 5 VA, CL 0.5, 50/60 Hz
3	4CT - Current transformer for differential protection - ARTECHE 6b ACFR-17 1000/5/5 - 9877355 ACFR-17 1000/5/5 A, 50/60 Hz Core 1: 20VA5P10 Core 2: 20VA5P10
6	PT100 for stator winding - PYR PT100LG7/3 - 60042012
2	PT100 for sleeve bearings (radial bearing surface)
1	Automatic Voltage Regulator with plate - Unitrol 1000 with plate (Wärtsilä) Unitrol 1000
2	Multidiameter cable entry seals (Rox System) for main cables - NLR...
1	Mounting of machined coupling half The machined coupling half must be delivered latest 1 week before the delivery date of the generator to our factory.
1	Mounting on common base frame
1	Cable ladder for phase cables and conduit for neutral cable
1	Top mounted direct air cooling unit incl. air filter Air filters in air inlet
1	Drive-end sleeve bearing - ZLL SCZCK36-340CCY - 9871359 Foot mounted sleeve bearing Normal end float +/- 2.5 mm or +/- 1/8 inch. inch Max. axial force 21 kN. D-end

1 Non-drive-end sleeve bearing - ZLL SCZCQ36-340EPCY - 9871112
Foot mounted sleeve bearing
Insulation between bearing and pedestal.

ABB Oy			Machines
Handled by: JUKE			18.10.2004

Type: AMG 1600SS14 DSE

Sn:	20797 kVA	cos:	0.80		Tn:	386160	Nm
Un:	13800 V	n:	514	rpm	In:	870.10	A
f:	60 Hz						

P / Q -DIAGRAM

1. Stator current at rated load
2. Nominal working point
3. Active power limit
4. Rated rotor current
5. Minimum excitation limit
6. Stability limit
7. Theoretical stability limit

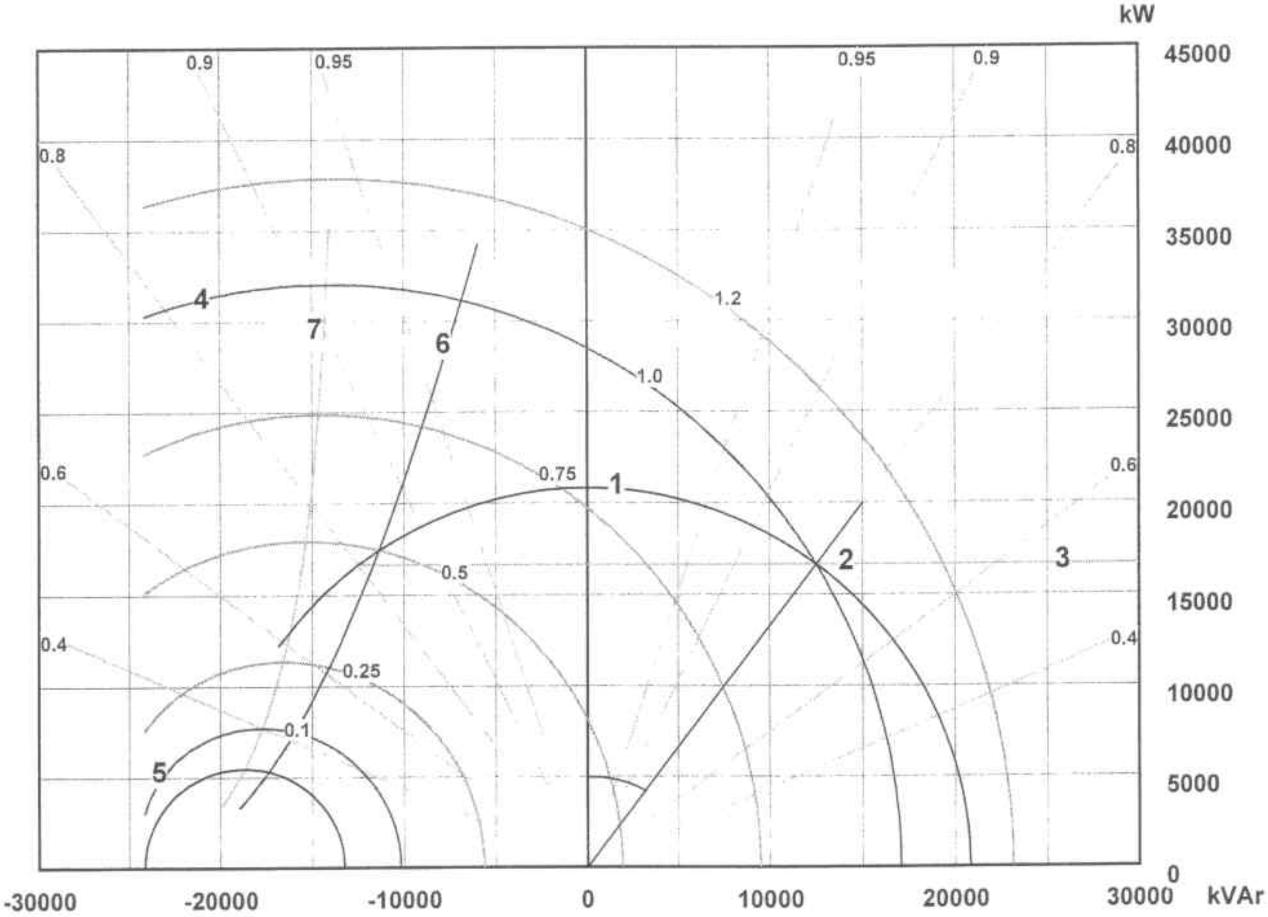
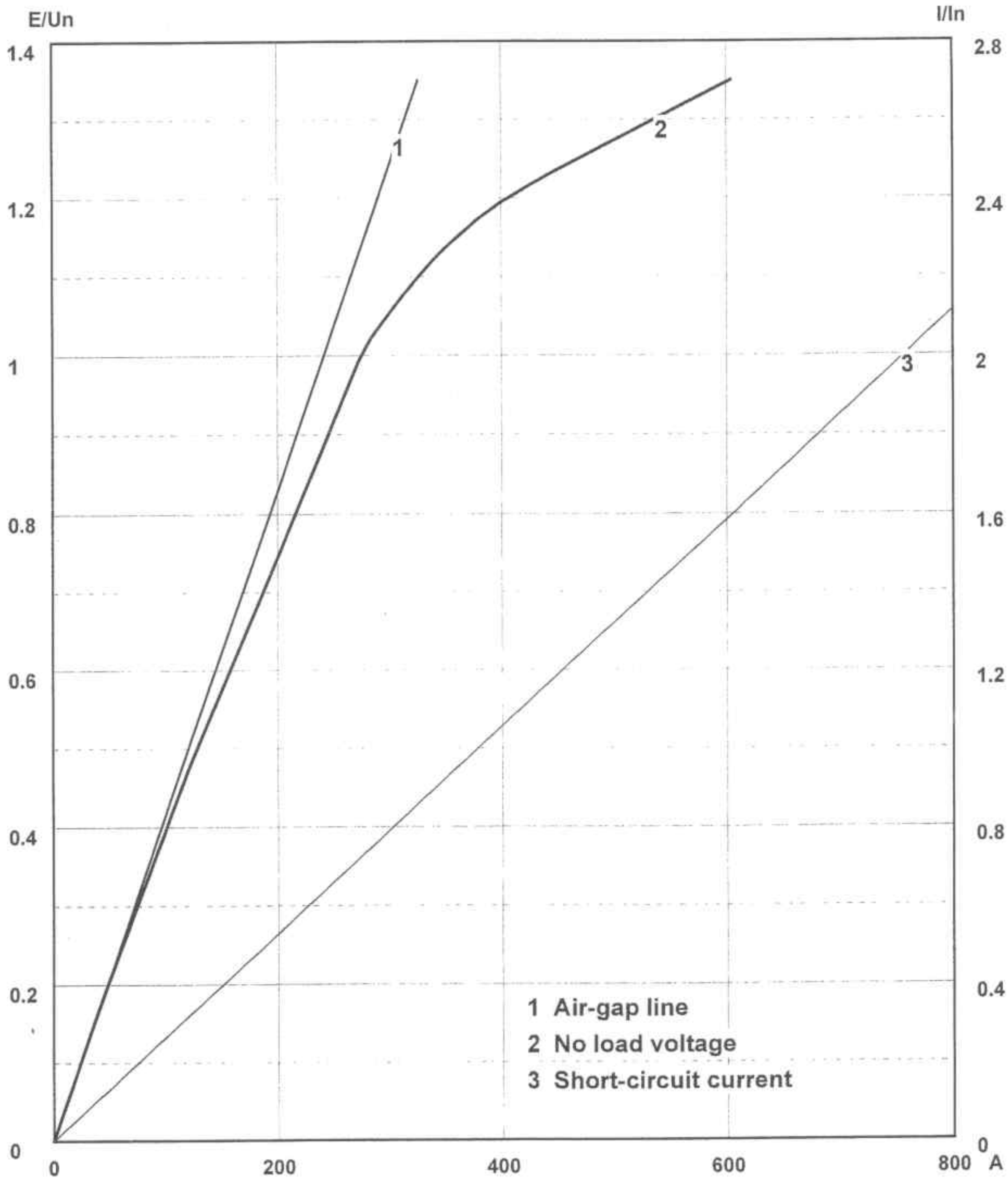
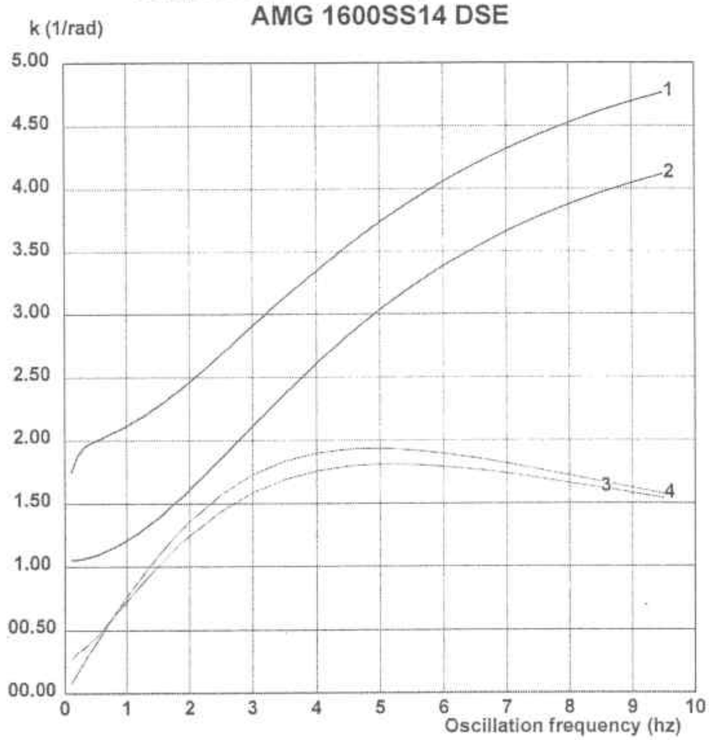


ABB Oy								Machines
Handled by: JUKE								09.11.2004
Type: AMG 1600SS14 DSE								
Sn:	20797	kVA	cos:	0.80		Tn:	386160	Nm
Un:	13800	V	n:	514	rpm	In:	870.10	A
f:	60	Hz						

Excitation current (A)



Complex synchronizing coefficient
AMG 1600SS14 DSE



1 = Synch. factor at rated load
2 = Synch. factor at no load
3 = Damping factor at rated load
4 = Damping factor at no load

REFERENCE: Dieter Rumpel: Das Drehmomentverhalten von Drehstromgeneratoren bei sinusf¯rmigen Pendelungen, MTZ, 26.Jahrgang Heft 2 1965 s. 35-42

$\Delta M / M = k * d$ (9)

$k = \Delta M / M / d * (\cos(e) + j \sin(e))$ (10)

k = complex synchronizing coefficient,
  the real part is synchronizing (or elastic) factor,
  the imaginary part is damping factor
  d = the oscillating part of rotor angle in electrial radians
  d = p * dm, where
    p = the number of polepairs and
    dm = the angle in mechanical radian
M = the base torque of generator 386160 Nm
e = the phase difference angle between the oscillating
  rotor angle and the corresponding torque

Data required for the calculation the PSS parameters.

1.1 Synchronous machine and exciter data

Generator rated apparent power (Sn):	.... [MVA]
Non-saturated direct axis synchronous reactance (Xd):	.... [p.u.] *1)*
Stator leakage reactance (Xas):	.... [p.u.] *1)*
Non-saturated direct axis open circuit transient time constant (Tdo'):	.... [s]
Non-saturated direct axis trasient time constant (Td'):	.... [s]
Nominal machine frequency (fn):	.... [Hz]
Exciter time constant (Te):	.... [s]
Inertia constant for whole shaft (H):	.... [MW * s / MVA]
Type of driving system (Turbo/Gas or Hydro) :	

1.2 Unit transformer and grid data

Unit transformer reactance (XT):	.... [p.u.] *1)*
Maximum grid reactance (XE) or:	.... [p.u.] *1)*
Lowest grid short circuit power:	.... [MVA] *2)*

1.3 Oscillation frequencies

Lowest possible osc. frequency:	.... [Hz]
Inter-area osc. frequency :	.... [Hz]
Local area osc. frequency:	.... [Hz]
Highest possible osc. frequency:	.... [Hz]

Notes:

1) All p.u. values based on machine rated apparent power. Attention! In case that the machine and the unit transformer have different capabilities, use the p.u. base system refereed to the machine and not to the transformer !

2) At H.V. side of step up transformer

Functional Specification

UN 1000 PSS

Author: H. Eschbach ATPT2	04-02-18	Functional Specification UN1000 PSS				Pages 7
File Name. F-Spec UN1000 PSS						
Resp.: ATPT2						
ABB Switzerland Ltd		Document Number Part 3BHS 130 963 E41	Language E	Revision A		Page 1

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1 GENERAL INFORMATION

This document describes the PSS functionality on UN1000. Figure 1 presents the PSS and related functions.

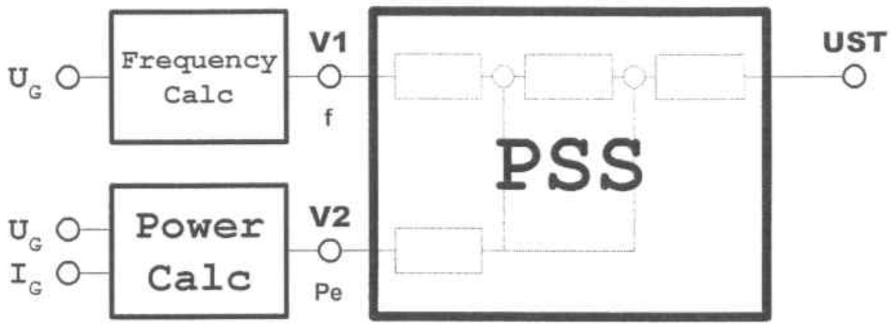

Fig. 1 UN1000 PSS function overview

2 INPUT MEASUREMENT

The input measurement as described here is already implemented in UN1000. The topic is presented here to provide information regarding the achievable accuracy of the IEEE PSS 2B in UN1000.

2.1 Input measurement of the machine frequency (V1)

The machine frequency is calculated out of the machine voltages (1 or 3 phases measurement) The ADC samples are filtered with a FIR filter and the result is stored in a circular buffer with 128 entries, which is multiplied with Hanning window. Hanning window is of the form:

$$\begin{aligned} w_H &= \frac{1}{2}\left[1-\cos\frac{2\pi\cdot n}{M}\right] \\ &= \sin^2\frac{\pi\cdot n}{M}, \end{aligned}$$
$$where\ n = 0,1,2,\ldots,M$$

Afterwards a FFT is calculated. The Frequency is now calculated from the highest and two adjacent peaks on both sides of the square of the FFT result.

The time constant for this measurement is **64ms.**
The resolution of the frequency is **10mHz**
The accuracy of the frequency is **12mHz at 50Hz and 10mHz at 60Hz**

2.2 Input measurement of the electrical power (V2)

The electrical power is calculated from the measured and filtered generator voltage (1 or 3 phases) and the measured and filtered generator current (1 phase).

The time constant for this measurement is **64ms.**
The resolution of the power is **0.01%**
The accuracy of the power is **0.05% at 50Hz and 0.1% at 60Hz**

3 POWER SYSTEM STABILIZER

3.1 Principle of the IEEE PSS 2B

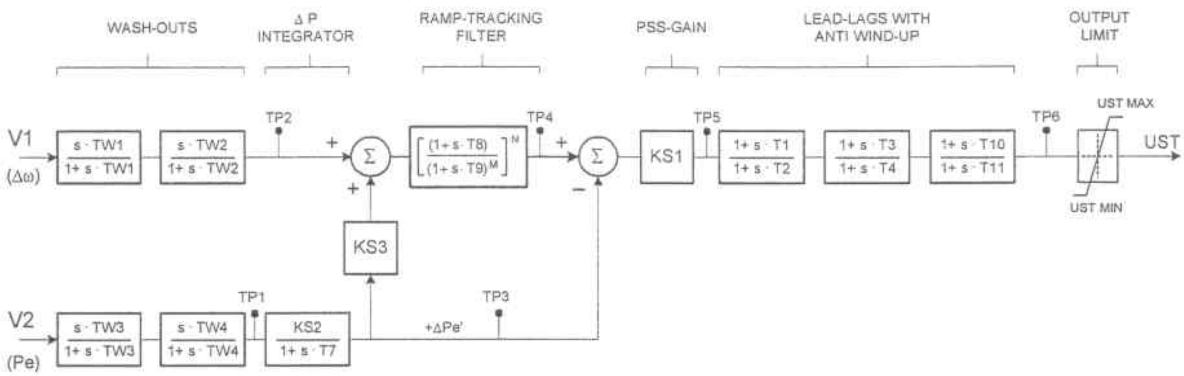

Fig. 2 Computer representation of PSS 2B according to IEEE Std. 421.5

3.2 Short Model Description

(ref. to fig. 1)

The model consists of the following sub models:

- Calculation of driving power
- Filtering of torsional oscillations and noise components
- Calculation of acceleration power
- Phase and gain conditioning for stabilizing signal

The required signals for the generation of stabilizing signals are V1 and V2.

The input signal V1 normally corresponds to the filtered value of rotor angular frequency deviation Δω. In UN1000 PSS the machine frequency is used (see chapter 2.1). V2 corresponds to the filtered value of the electric power PT at machine terminals (see chapter 2.2).

The signals V1 and V2 are submitted to two washout stages, which are provided for the elimination of steady state signal component.

An approach for the integral of the electric power is obtained by applying the output of the second washout filter of the V2 channel to a first order transfer function. The value T7 shall correspond to the washout time constants TW1, TW2, TW3 and TW4 (normally 0) that are selected to allow the operation of the PSS in the frequency range of interest (e.g. >0.1 Hz). The constant Ks2 shall be equal to T7/(2H) [H = inertia time constant] in order to obtain a proper signal relationship between V1 and V2.

Ks3 is provided for the fine scaling between the signals coming from channels V1 and V2. Normally Ks3 is equal to 1.

The integral of the driving power is obtained from the summation of the conditioned V1 signal and the calculated integral of electric power variation.

A selective low pass filter so called "ramp tracking filter" is provided for the suppression of high frequency components (e.g. shaft torsional oscillations).

The integral of the acceleration power is calculated from the difference between the integral of driving power and the integral of electric power.

The conditioning network consisting of the gain Ks1 and three lead-lag stages (the third one normally used in indirect excitation systems) is provided in order to achieve the required phase and gain compensation for the stabilizing signal.

3.3 Control Logic / Activation Conditions

The PSS output (UST) is calculated if the PSS is selected (parameter PSS SELECT = ON). If the absolute value of the actual machine power is equal or greater than the PSS activation value (parameter P MACH min), the PSS output (UST) is an additional input for the AVR output signal.
If the actual power falls under this level for longer than 2s, the PSS output is disabled.
If the actual machine voltage falls under 80% (U MACH MIN) of nominal value, the PSS output is disabled.
If the actual machine voltage is higher than 120% (U MACH MAX) of nominal value, the PSS output is disabled.

3.4 Calculation Speed

Every **10ms** a new output value (UST) of the PSS is calculated.

3.5 Parameter List and setting Ranges

Parameter	Description	Unit	Range
TW1, TW2	Wash out time constants	s	0.0...30.0
TW3, TW4	Wash out time constants	s	0.0...30.0
KS1	PSS gain factor	p.u.	0.1...50.0
KS2	Compensation factor for calculation of integral of electric power	p.u.	0.01...5.00
KS3	Signal matching factor	p.u.	0.01...5.00
T1, T3, T10	Lead time constants of conditioning network	s	0.03...6.00
T2, T4, T11	Lag time constants of conditioning network	s	0.03...6.00
T7	Time constant for integral of electric power calculation	s	0.00...30.00
T8	Ramp tracking filter time constant	s	0.00...2.50
T9	Ramp tracking filter time constant	s	0.00...2.50
M	Ramp tracking filter degree	-	2...5
N	Ramp tracking filter degree	-	0...4
UST max	Upper limit of stabilizing signal	p.u.	0.00...0.25
UST min	Lower limit for stabilizing signal	p.u	0.00...-0.25
P MACH min	Activation level for PSS functionality	p.u.	0.00 0.50
PSS SELECT	General activation	-	OFF / ON

4 REVISION

Rev. ind.	Page (P) Chapt.(C)	Description	Date Dept./Init.
		Initial revision	04-02-18 ATPT2 / HE
A	P5 / C3.1 P6 / C3.3 P6 / C3.5	TP1 – TP6 added U MACH MIN and U MACH MAX added T10 and T11 changed, Low limit of T1,T2,T3,T4,T10 and T11 set to 30ms	04-04-22 ATPT2 / HE

Attachment E-1

Humboldt Energy Facility

Dynamic Models
for
Power System Stabilizer-Alternate
(Basler PSS-100)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED
A	Added torsional filter, limit logic, and 4th optional lead-lag block.	4/11/2002	AK, PR, KK
B	Fixed error in switching logic (SW3 and 4) in Figure 2	4/11/2002	AK, KK

ORIGINAL DATE OF DRAWING 28 Nov, 2000	**BASLER ELECTRIC COMPANY** HIGHLAND, ILLINOIS				
WRITTEN BY Kiyong Kim					
CHECKER	Mathematical Per-Unit Model of the PSS-100 Power System Stabilizer				
APPD					
APPD					
APPD	CODE IDENT NO. 97520	SIZE A	DRAWING NO. 9318600012		REV. B
APPD	SCALE	WT		SHEET 1 OF 9	

1.0 SCOPE

This document contains the mathematical model of the Basler PSS-100 Power System Stabilizer, which is a device that improves the damping of generator electromechanical oscillations. The Basler PSS-100 is a dual input power system stabilizer that uses combinations of power and speed to derive the stabilizing signal. It is based on the type PSS2A model available in the reference of IEEE 421.5.

2.0 DUAL INPUT POWER SYSTEM STABILIZER

The PSS-100 is designed to add damping to the generator rotor oscillations by controlling its excitation using supplemental stabilizing signal. To supplement the generator's natural damping, it produces a component of electrical torque that opposes changes in rotor speed and introduce a signal proportional to measured rotor speed deviation into the automatic voltage regulator (AVR) input.

As depicted in Figure 1, the PSS-100 monitors frequency and power to produce the integral of accelerating power, which is used for obtaining a derived speed signal (ω_{DEV}). Filtering of the derived speed signal provides a phase lead at the electro-mechanical frequency of interest. This phase lead compensates for the phase lag introduced by the closed loop voltage regulator. Prior to connecting the stabilizer output signal to the voltage regulator input, adjustable gain and limiting are applied as depicted in Figure 1.

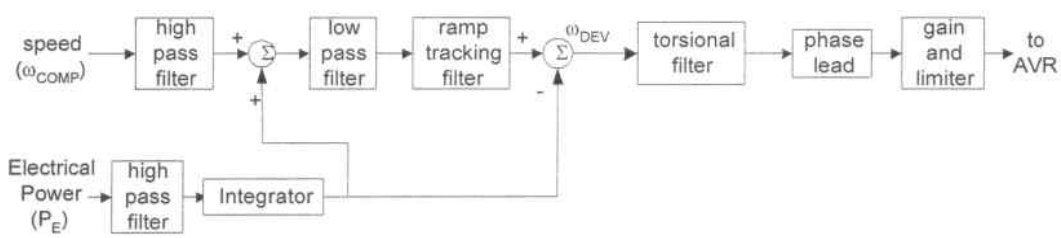

Figure 1 Functional Block Diagram of PSS-100

The PSS-100 performance is configured using filter time constants and software control switches. Figure 2 illustrates the detailed block diagram including the position of each software switch.

WRITTEN BY Kiyong Kim	DATE 28 Nov. 2000	TITLE Mathematical Model of the PSS-100 Power System Stabilizer	DWG. NO. 9318600012	REV. B
APPR. BY	DATE	DEPT. Power Systems Group		
LET. / REVISION		**BASLER ELECTRIC** HIGHLAND, ILLINOIS	SHEET 3 OF 6	

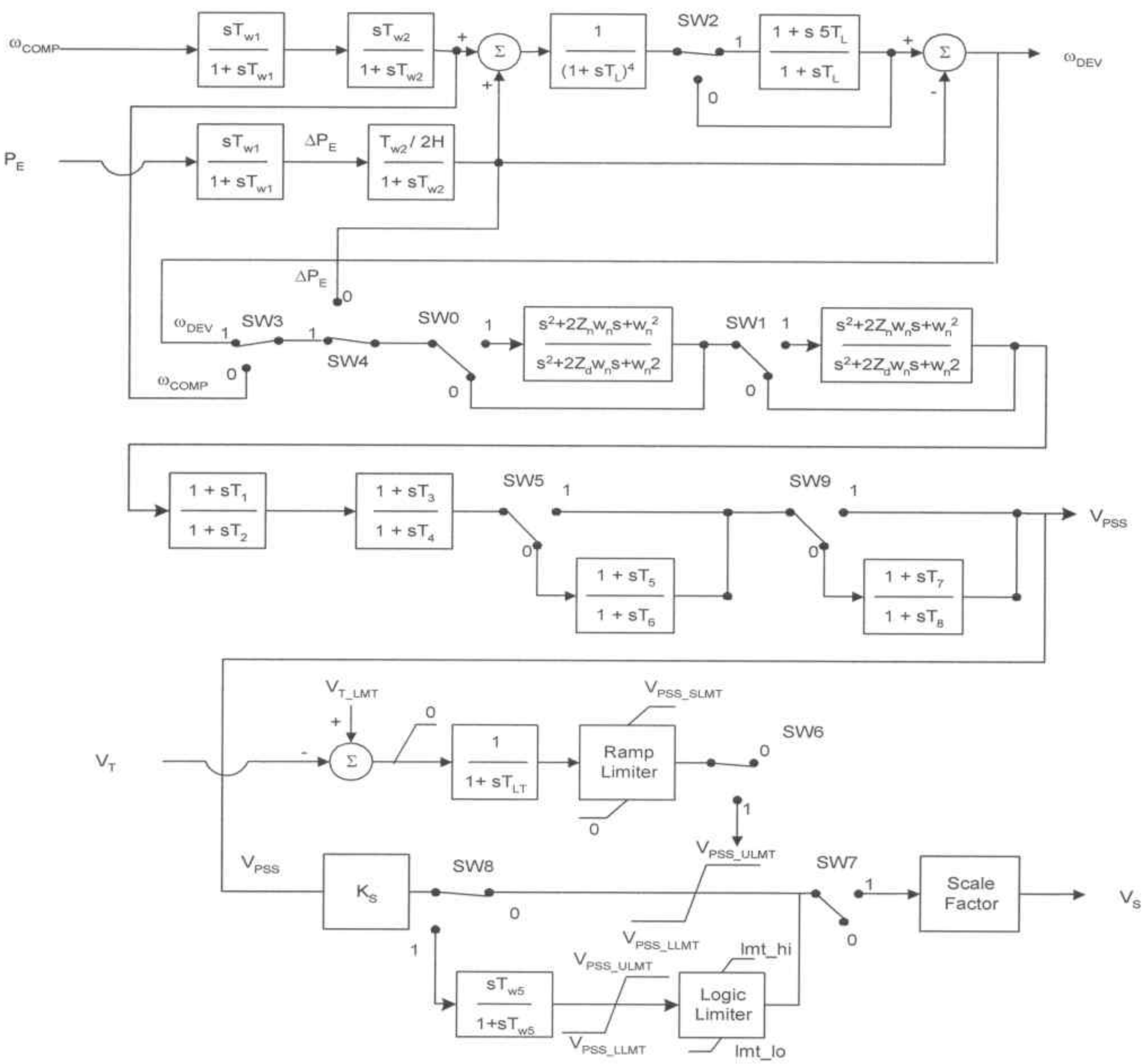

Figure 2 Detailed Block Diagram of PSS-100

High-Pass Filtering and Integration: High-pass filtering is used to remove low frequency components from electrical power and rotor speed (or compensated frequency) signals. This ensures that the stabilizer does not alter the steady-state reference to the voltage regulator. High-pass filtering is implemented using a time constant T_{w1}. Integration of the electrical power signal is accomplished using time constant T_{w2} and the rotor inertia constant H. Time constant T_{w2} is also used in another high-pass filter for the compensated frequency_signal. This allows the frequency signal to match the output of the integral of electric power deviation signal so they can be added together to obtain integral of mechanical power deviation. Time constants T_{w1} and T_{w2} are also called the washout time constants. Their adjustable range are

$0.01 \leq H \leq 25.0$ in MW-seconds / MVA
$1.0 \leq T_{W1} \leq 20.0$ in seconds
$1.0 \leq T_{W2} \leq 20.0$ in seconds

Low-Pass/Ramp Tracking Filter: A fourth order low pass filter processes the calculated mechanical power deviation signal. This filtering may be excessive for hydro-electric units with high rates of mechanical power change. An optional filter stage is provided to allow for ramp changes to the input mechanical power. The low-pass time constant (T_L) is adjustable from 0.05 to 0.2 seconds.

Torsional Filter: Torsional Filter provides desired gain reduction at the specified frequency. The filter is used to compensate the torsional frequency components present in the input signal. There are two stages of torsional filters that can be selected by SW0 and SW1. Each torsional filter is a bi-quadratic type filter where the torsional parameters are adjustable within the range:

$0.00 \leq z_n \leq 1.00$
$0.00 \leq z_d \leq 1.00$
$10.0 \leq w_n \leq 150.0$

Phase Compensation: Filtering of the derived speed signal provides a phase lead at the electro-mechanical frequency of interest. As depicted in Figure 2, the derived speed signal is modified before it is applied to the voltage regulator input. The signal is filtered to provide phase lead at the electromechanical frequencies of interest i.e., 0.1 Hz to 5.0 Hz. The phase lead requirement is site-specific, and is required to compensate for phase lag introduced by the closed-loop voltage regulator. With switches SW3 and SW4 in the closed position, the derived speed deviation is used as the stabilizing signal. These software switches allow the user to select an alternate configuration based upon the available input signals. The first two lead-lag blocks are normally adequate to match the phase compensation requirements of a unit, however two additional stages may be added by opening software switches SW5 and SW9. The transfer function for each stage of phase compensation is a simple pole-zero combination. Typical values of phase lead and lag time constant (T_1 to T_8) range from 0.001 to 6.0 in seconds.

Stabilizer Gain and Terminal Voltage Limiter: The phase compensated signal (V_{PSS}) is multiplied by the stability gain (K_S). To prevent an overvoltage condition, the upper limit of the stabilizer can be reduced to zero if the terminal voltage exceeds the setpoint. If the terminal voltage becomes greater than the setpoint, the upper limit (V_{PSS_ULMT}) on the stabilizer output will be steadily lowered to zero. If the overvoltage condition goes away, the upper limit will be steadily raised until it reaches the set upper limit setpoint (V_{PSS_SLMT}). To avoid errors, a low-pass filter is used in the path to measure the deviation of the terminal voltage. This level is normally selected such that the limiter will operate to eliminate any contribution from the PSS-100 before the generator's timed overvoltage or V/Hz protection operates. The limiter will reduce the stabilizer's upper limit (V_{PSS_ULMT}) at a fixed rate until zero is reached, or the overvoltage is no longer present. The limiter does not reduce the AVR reference below its normal level; it will not interfere with system voltage control during disturbance conditions. The error signal (terminal voltage minus limit setpoint) is processed through a conventional low-pass filter to reduce the effect of measurement noise.

Typical values of the limit setpoint are as follow:

$0.0 \le K_S \le 50.0$	in per unit E_T / per unit $\Delta\omega$
$0.0 \le V_{PSS\_SLMT} \le 0.5$	in per unit
$0.0 \le V_{PSS\_LLMT} \le 0.5$	in per unit
$0.0 \le T_{LT} \le 5.0$	in seconds

With SW8 a logic limiter can be selected. The logic limiter consists of a washout filter and a logic timer. The washout filter has two time constants : normal time constant and limit time constant (lesser than normal time constant).

The logic limiter compares the signal with the upper and lower limit value. If the signal is outside the limit then it starts a counter. If the counter reaches delay time set in the limiter, the time constant for the washout filter is changed to the limit time constant from normal time constant.

At any time if the signal is within the specified limit the counter is reset and the time constant is changed back to normal time constant in washout filter.

The time constants are adjustable within the range:

$5.0\text{ s} \leq T_{w5}\text{ (normal)} \leq 30.0\text{ s}$
$0.00\text{ s} \leq T_{w5}\text{ (limit)} \leq 1.00\text{ s}$

The parameters for the logic limiter are adjustable within the range:

0.010 ≤ lmt_hi ≤ 0.040
-0.040 ≤ lmt_lo ≤ -0.010
0.00 s ≤ lmt_dly ≤ 5.00 s

Output Scaling: When configuring the PSS-100, the output should be matched to the voltage regulator being used. Stabilizer output scaling allows the output signal to match the voltage regulator gain. With a scale setting of 8.0, a 0.5 per unit output before the output scaling stage will produce a 4.0 Vdc signal at the analog output.