VESTAS W.T. & VOLTAGE DIPS

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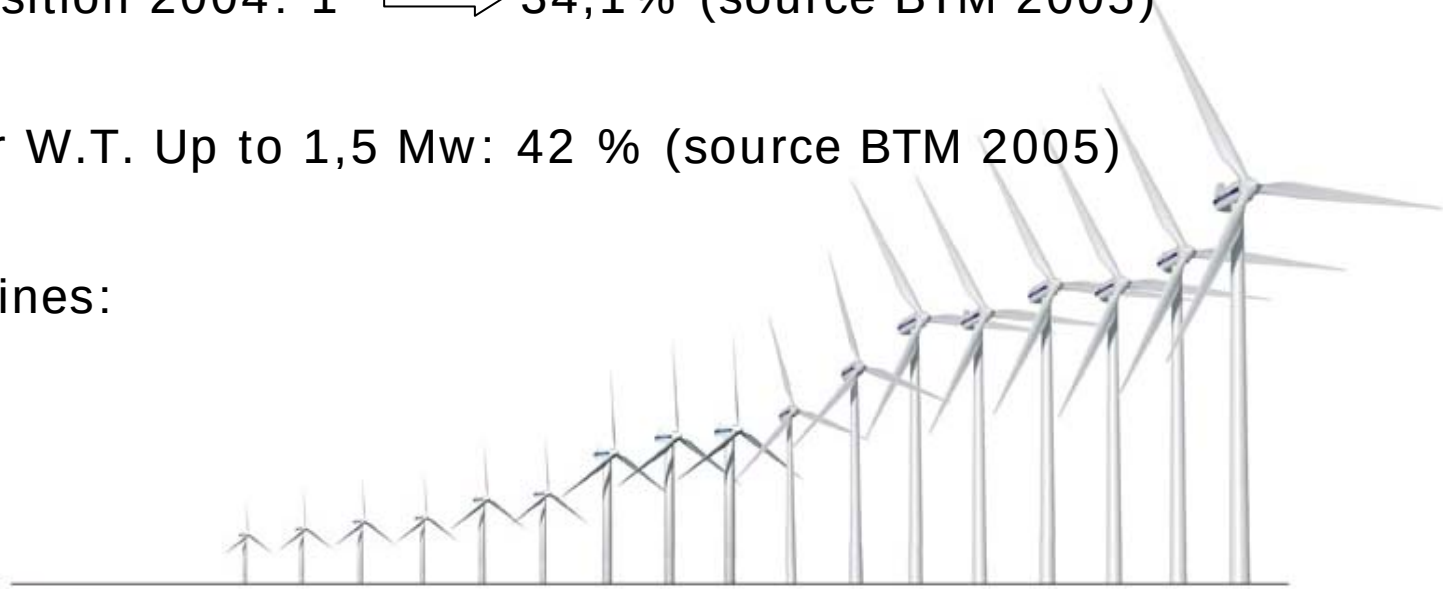
- Information contained in the following expresses general views and shall not be construed as an expression of the policies or views of Vestas.
- Information contained in the following shall not be construed as detailed description of the properties or functioning of wind turbines manufactured by Vestas.
- Information contained in the following should merely be viewed as a contribution to the debate on the development of grid code requirements and the utilization of the potential of wind turbines in securing grid stability.

Contents

- Vestas information
- Situation
- Vestas Wind turbines
- DFIG (8 slides)
- ASG (5 slides)

Vestas information

- Global installed capacity in 2004: 8,154 MW (source BTM 2005)
- Global accumulated installed capacity 2004: 47,912 MW (source BTM 2005)
- Market position 2004: 1º ⟹ 34,1% (source BTM 2005)
- Market for W.T. Up to 1,5 Mw: 42 % (source BTM 2005)
- Wind turbines:



Product/ Rotor diameter (m)	V15	V17	V19	V20	V25	V27	V39	V44	V47	V52	V66	V80	V82	V90	V90	V100	V120
Year of installation	1981	1984	1986	1987	1988	1989	1991	1995	1997	2000	1999	2001	2003	2004	2002	(2006)	(2009)
Capacity (kW)	55	75	90	100	200	225	500	600	660	850	1,750	1,800 2,000	1,650	1,800 2,000	3,000	2,750	4,500
MWh/year	217	265	301	346	481	647	1,304	1,581	1,947	2,530	4,705	6,320 6,668	6,414	7,498 7,295	9,154	-	-

Situation

- Electrical grids with a high number of wind turbines
- Weak grids

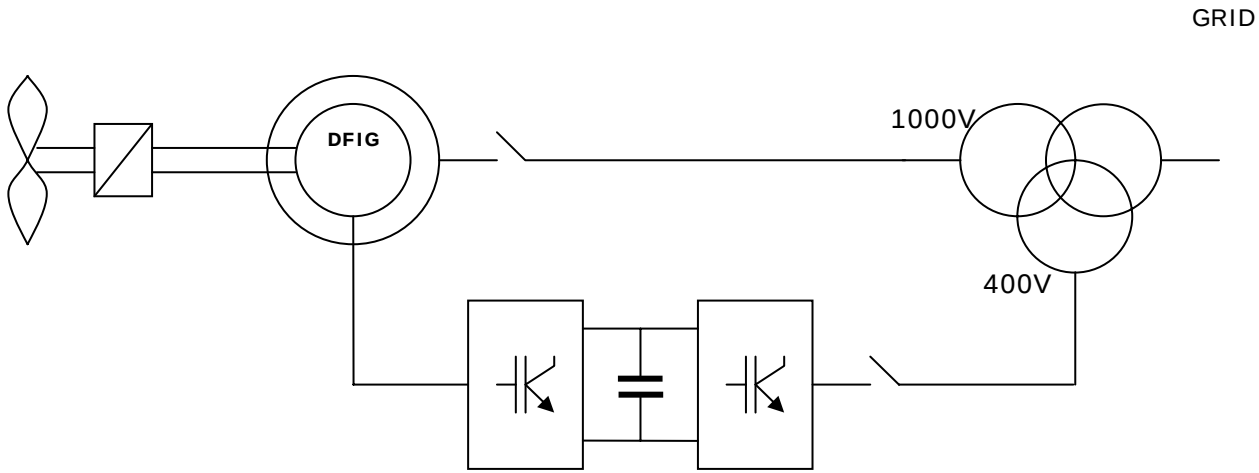
Solutions:

It is necessary to create wind turbines with the same behaviour as traditional generators (big synchronous)

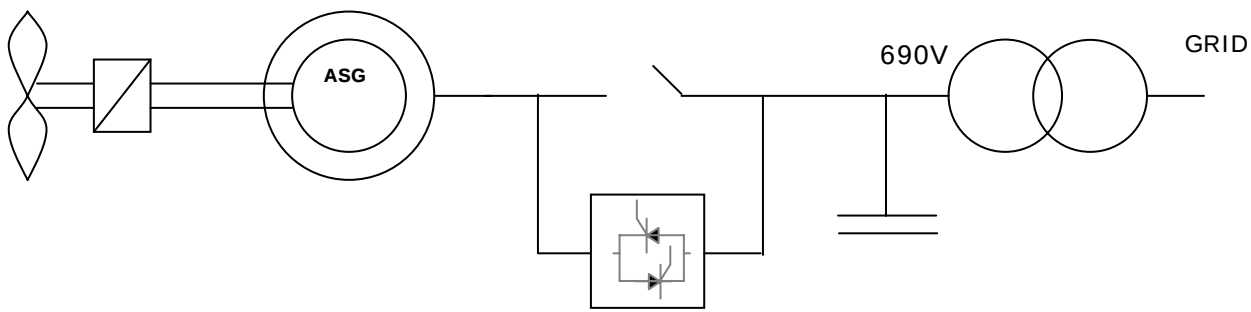
- Improve the response of the WT during faults in the grid (no disconnection and injection of reactive current).
- Systems Prediction of the energy that the wind turbines will produce.
- Possibilty to use, if the grid operator demands it, frequency and voltage controls.

Vestas wind turbines

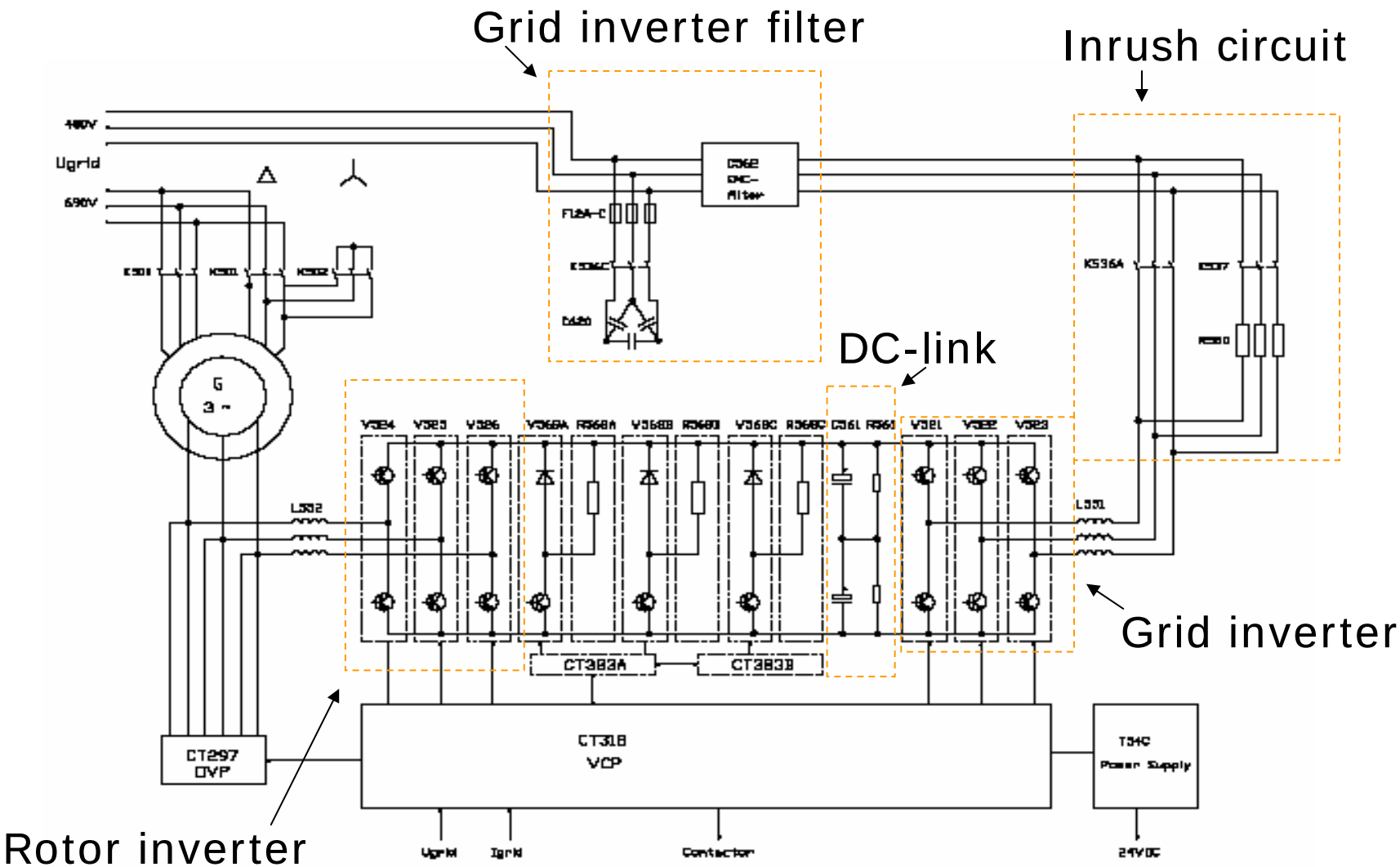
- Double feed induction generator (DFIG):
  - **Pitch control**
  - **variable speed**



- Asynchronous generator (ASG):
  - **Active stall**
  - **Fixed speed**

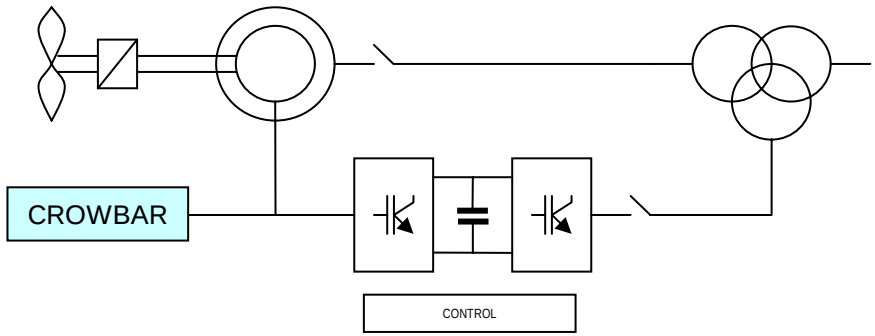


DFIG


Grid inverter filter
Inrush circuit
DC-link
Grid inverter
Rotor inverter
Ugrid
690V
G
3 ~
CT297
OVP
CT318
VCP
T34C
Power Supply
Ugrid
Igrid
Contactor
24VDC
CT3833A
CT3833B

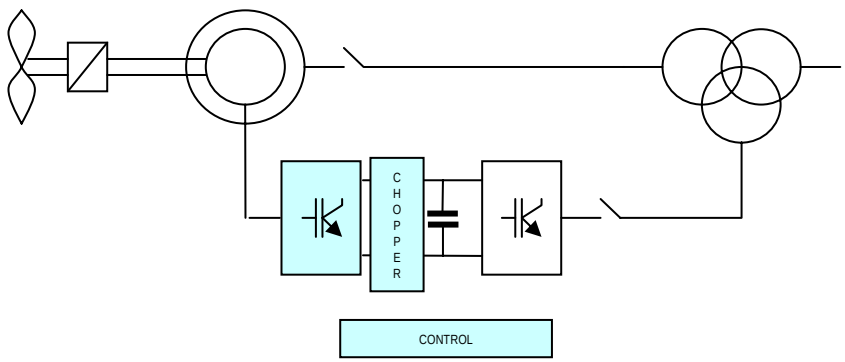
DFIG

- IN THE PAST: INSTANTANEOUS DISCONNECTION OF THE DFIG TO PROTECT ELECTRONIC DEVICES



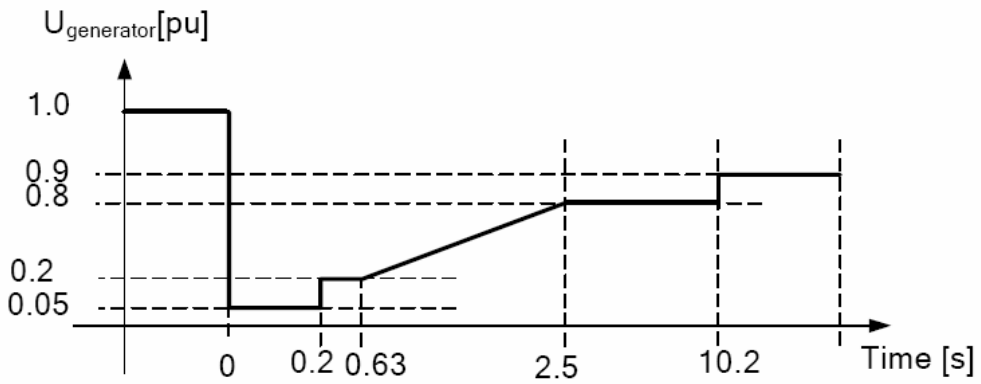
- NOWDAYS:

GRID SUPPORT ⇒ { NO DISCONNECTION ; REACTIVE CURRENT SUPPORT } ⇒ A.G.O. solution (advanced grid option)

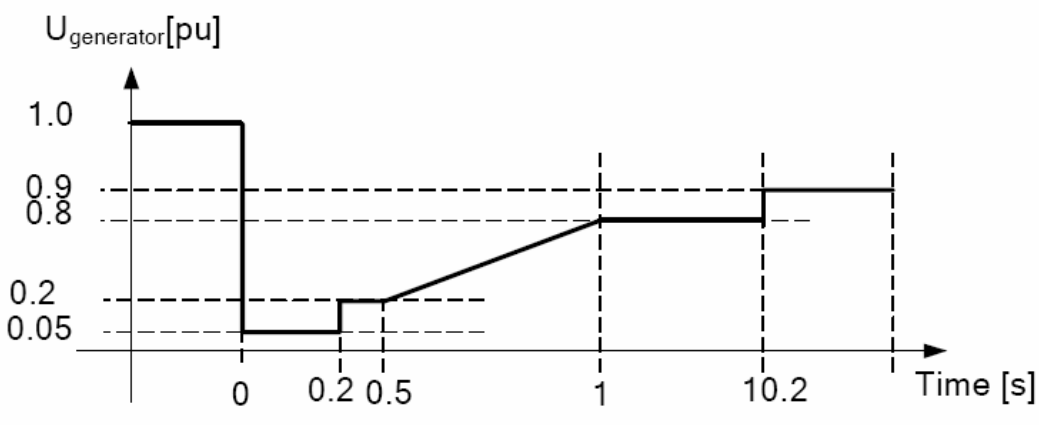


DFIG

- VOLTAGE TOLERANCE FOR SYMMETRYCAL FAULTS (LOW VOLTAGE SIDE)



- VOLTAGE TOLERANCE FOR ASYMMETRYCAL FAULTS (LOW VOLTAGE SIDE)



DFIG

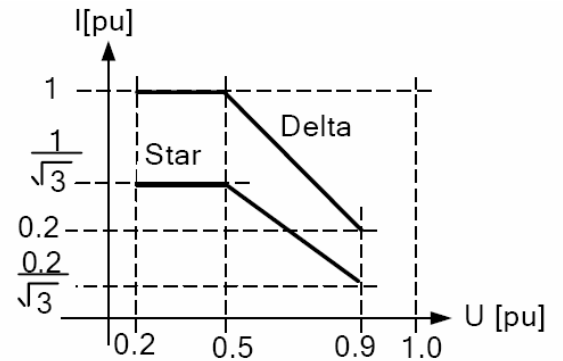
- Pitch system: The system control pitch has been improved in order to have good response during the faults in the grid.

- U.P.S: A back-up power system has been installed in order to supply the energy required to the control systems and necessary devices during the grid faults, at most during 30 seconds.

DFIG

- Converter:

  The rotor converter has been reinforced in order to support the greater currents during the faults. Because of this, the control of the converter will not be lost during the fault.



Current contribution for symmetrical faults

- Chopper:

  The Chopper is the system for dissipating the excess energy in the D.C. Bus that could be created during the faults.

DFIG

- Velocity sensor:

  A velocity sensor is used to control the position during the fault.

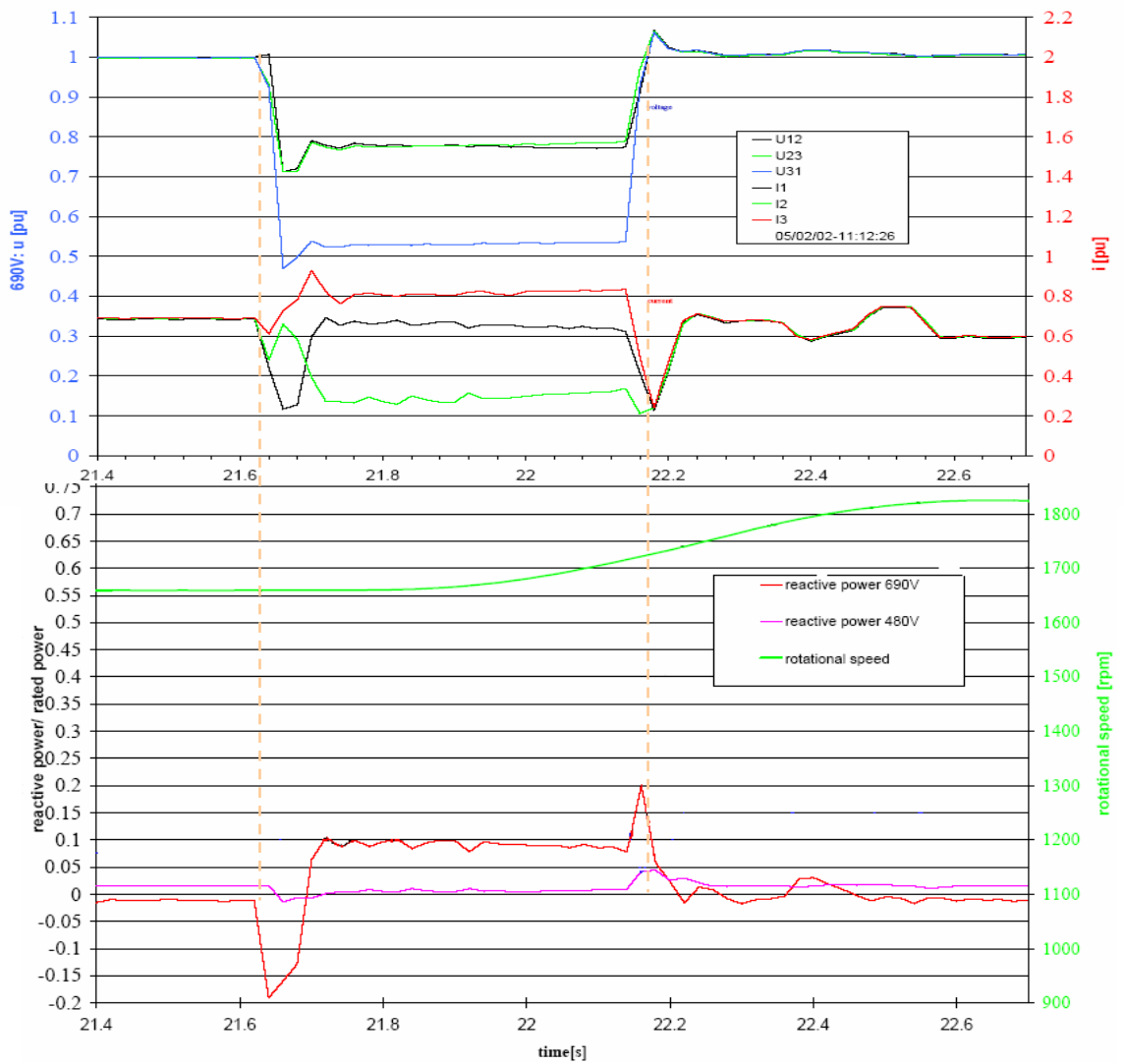
- Control:

  The system control of the wind turbine has been improved, in order to gain a better dynamic response.(storage of cynetic energy, damping oscillations, etc)

DFIG

- TEST BENCH RESULTS (2MW WIND TURBINE):

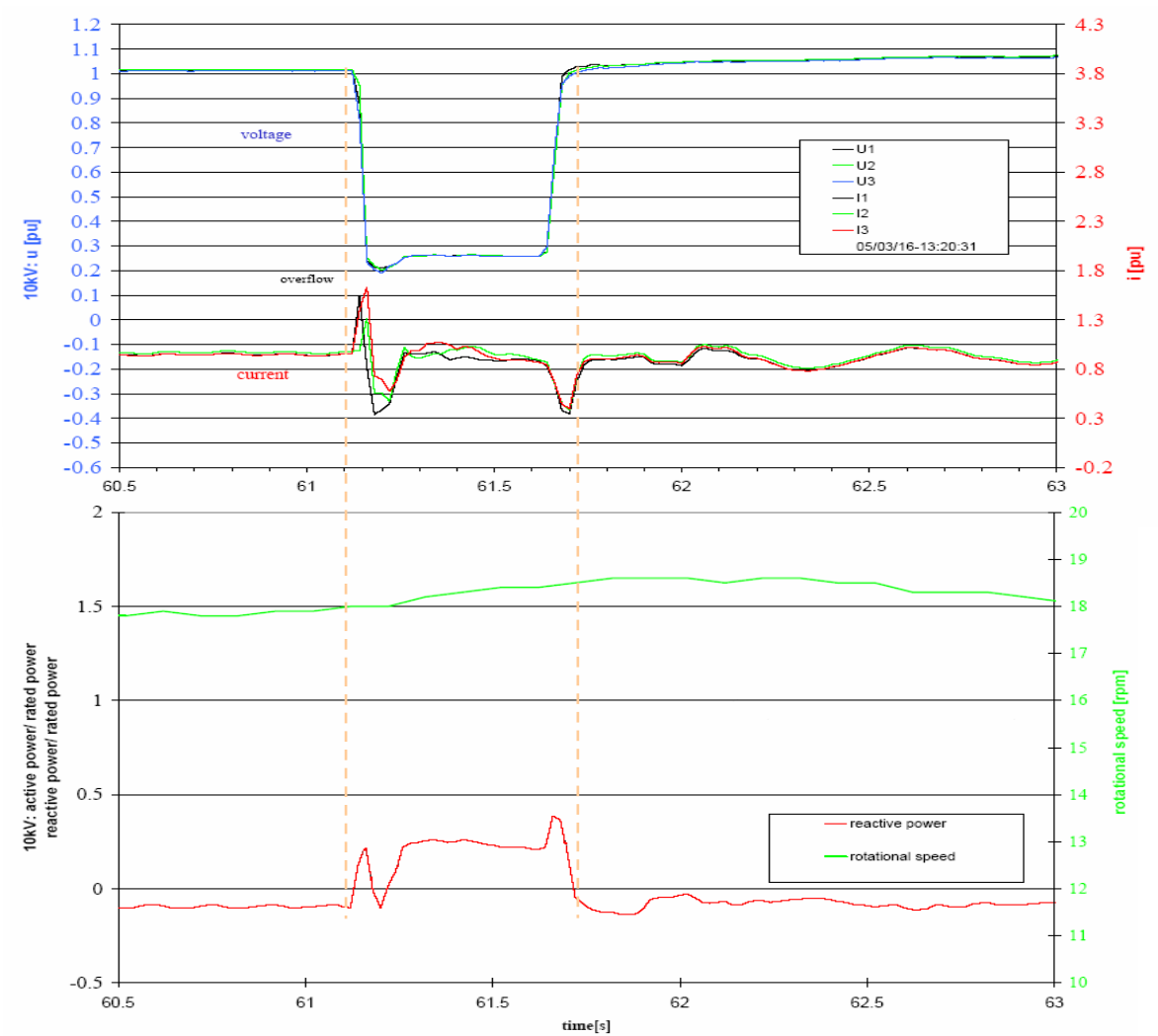
  ASYMMETRYCAL FAULTS (500ms- 75% OF RATED POWER)



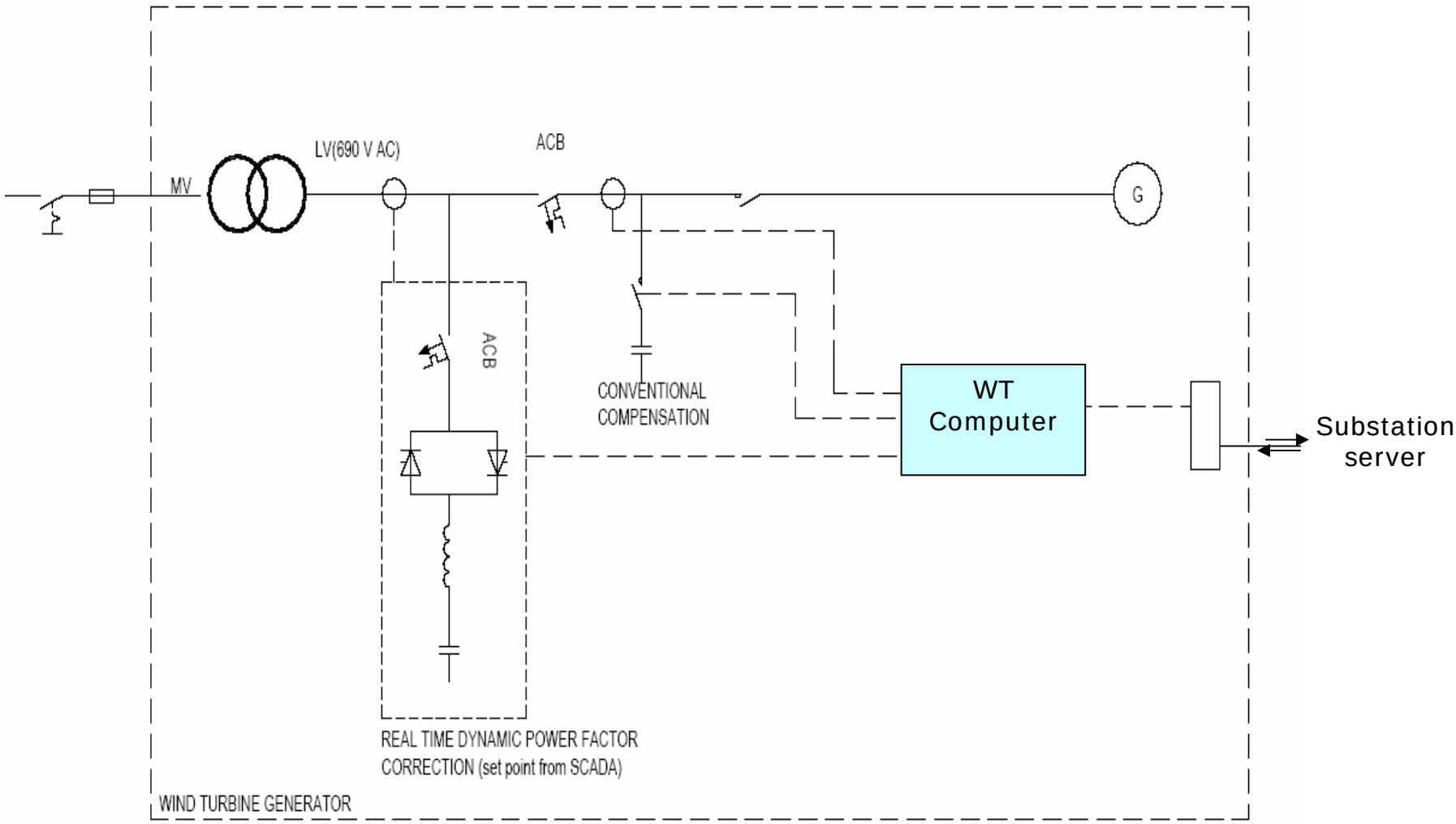
DFIG

- HVDC TEST RESULTS (2MW WIND TURBINE):

  SYMMETRYCAL FAULTS (500ms – U*0,2 - 100% RATED POWER)



ASG

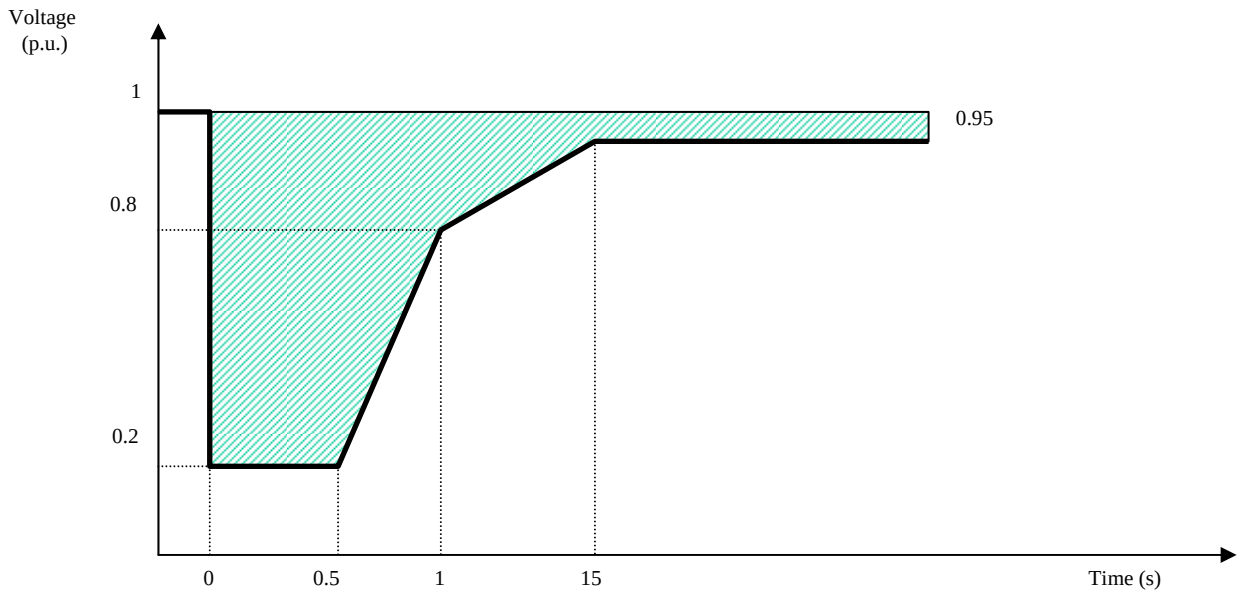

MV
LV(690 V AC)
ACB
G
ACB
CONVENTIONAL
COMPENSATION
WT
Computer
Substation
server
REAL TIME DYNAMIC POWER FACTOR
CORRECTION (set point from SCADA)
WIND TURBINE GENERATOR

ASG

- Pitch system: Design modifications to pitching system
- Design changes and modifications to protection philosophy, controller algorithms and settings
- U.P.S supply on all auxiliary systems
- Dynamic power factor correction with 20ms response time

ASG

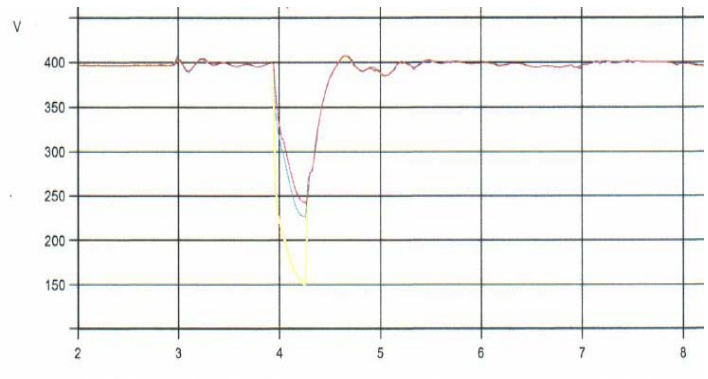
- VOLTAGE TOLERANCE FOR SYMMETRYCAL AND ASYMMETRYCAL FAULTS FOR SPANISH MARKET (LOW VOLTAGE SIDE)

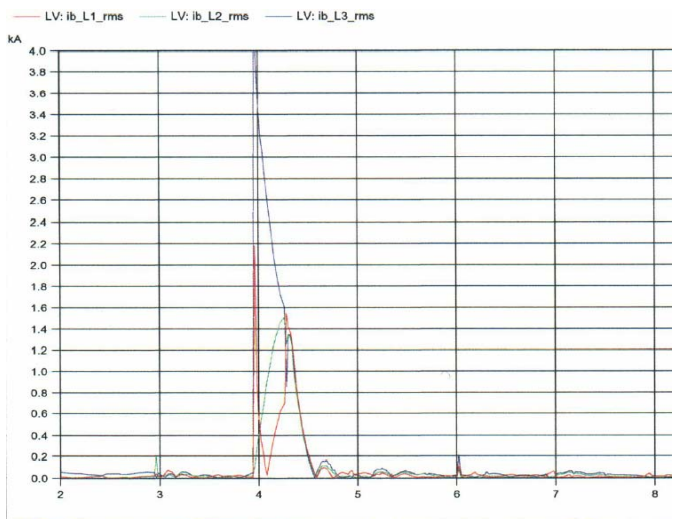


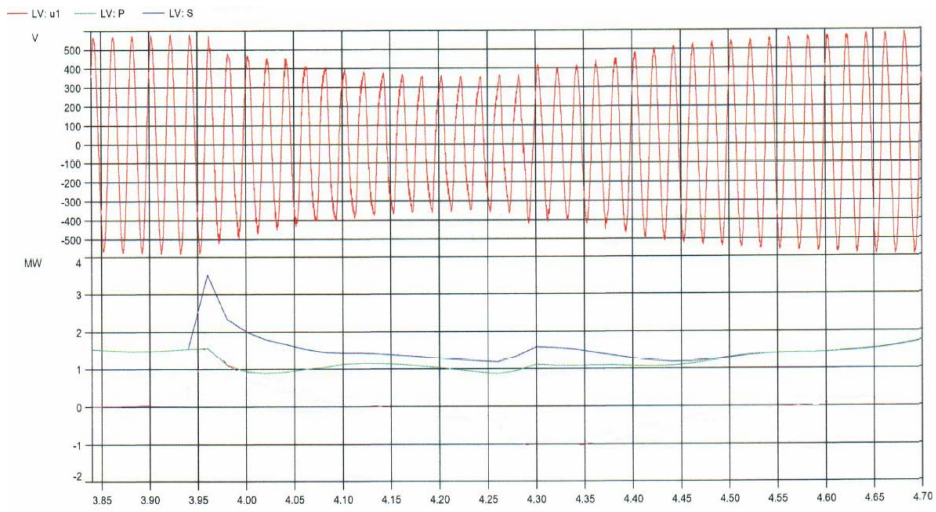
ASG

- FIELD TEST RESULTS (1,65MW WIND TURBINE):

  ASYMMETRYCAL FAULTS (400ms - U*0,5 - 100% OF RATED POWER)



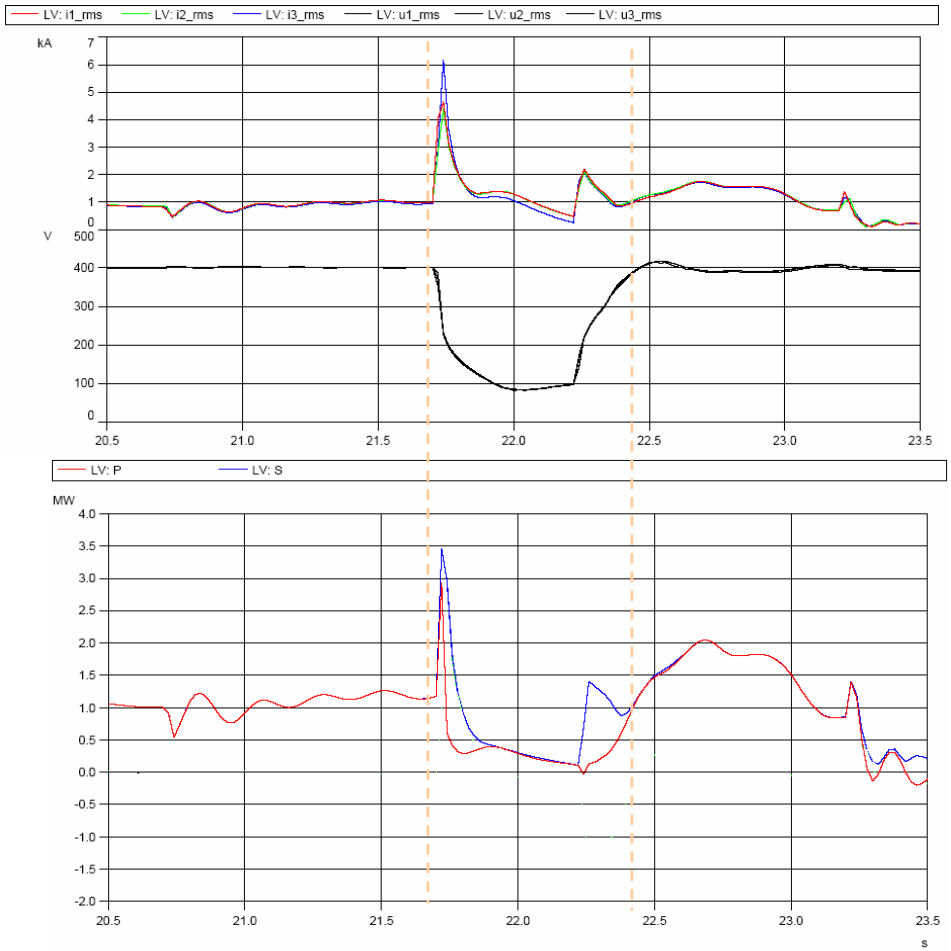




ASG

- FIELD TEST RESULTS (1,65MW WIND TURBINE):

  SYMMETRYCAL FAULTS (500ms - U*0,2 - 67% OF RATED POWER)

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