

Voltage Control and VAR Control

Renewables Rendezvous 2010



Agenda

- Various methods of Voltage/VAR control
- Other considerations
- Switched Capacitor Control Example



Methods of Voltage/VAR Control

- Wind Turbines
- Substation DSTATCOM/DVAR
- Substation fixed compensation
- Combination of the above



Wind Turbine Voltage/VAR Control

- Asynchronous generator
 - switched capacitor banks on each turbine
 - Requires additional VAR compensation at the substation level
- Doubly fed induction generator (DFIG)
 - Voltage injected into rotor for continuously variable VAR output typically with power factor of +/- 0.9
 - Often no substation VAR control needed for power factor and voltage regulation
- Full conversion AC-DC-AC generator
 - Best performance for VAR, Voltage control

Substation Voltage/VAR Control

- DSTATCOM/DVAR
 - Power electronics used to source or sink VARs
 - Continuous/smooth PF or Voltage control
 - Controlled by manufacturer proprietary system
- Fixed compensation
 - Typically switched capacitors
 - May include fixed reactors depending POI
 - Typically custom designed controller
- DSTATCOM / DVAR can be complimented by switched capacitors or reactors

Substation Voltage/VAR Comparison

- DSTATCOM / DVAR
 - Roughly \$1M to \$3M per 100MW for asynchronous generator site
 - Provides “high resolution” set points
- Fixed compensation
 - Roughly \$500k per 100MW for asynchronous generator site
 - Delta V is typically in the 1% to 2% range
 - Multiple stages in the 5-20 MVAR range each

Other Considerations

- Harmonics
 - Can tune up with capacitor banks in certain configurations
 - Can be predicted with study
- Low voltage ride-through
 - Enhanced by the ability to instantly inject VARs into the system
- Future regulatory changes
 - Windows of voltage and/or PF at the POI can change

What solution is right for a specific site?

- Technical analysis
 - Interconnect requirements
 - Grid strength / load flow
 - Wind turbine type used
 - Control capabilities
- Economic analysis
 - Capital
 - Penalties
 - Losses / efficiencies

Capacitor Bank Control Example

- Programmable control with HMI Interface for multi-stage capacitor banks
- Maintains PF or voltage at either Local Bus or POI
- “Averages” operation of individual capacitor stages
- Provides email-able alarms for problematic system conditions or failed switching devices
- Control set points and system limits are user definable – on the fly



POWER ENGINEERS WIND FARM AUTOMATIC CAP BANK CONTROL SETTINGS

ALARMS

SINGLE LINE

GENERAL SETTINGS		
AUTO ENABLE TIME	0	MINUTES
CHECK DELAY TIME	3	MINUTES
MAX LOCAL BUS VOLTAGE	107 %	= 36.9 kV
MIN LOCAL BUS VOLTAGE	93 %	= 32.1 kV
MINIMUM MW OUTPUT	100	MW
NOTE: MINIMUM MW OUTPUT APPLIES ONLY TO PF MODES		

PF WINDOW SETTINGS		
MINIMUM PF LAGGING	1	LAGGING
MINIMUM PF LEADING	0.998	LEADING

PF TARGET SETTINGS	
TARGET PF	1
ENTER POSITIVE VALUE FOR LAGGING (EXPORT VARs) ENTER NEGATIVE FOR LEADING (IMPORT VARs)	

VOLTAGE SETTINGS		
BANDCENTER	102 %	= 164.2 kV
BANDWIDTH	1.8 %	= 161.3 kV to 167.1 kV

REMOTE METERING		LOCAL METERING	
Mw	-1.5	Mw	-1.4
MVAR	5.6	MVAR	5.8
PF	0.202 LEAD	PF	0.237 LEAD
kV	165.1	kV	34.9

CAP BANK CONTROLS AND STATUS									
MANUAL CONTROL	ENABLE OR DISABLE	BANK ENABLED	NEXT TO CLOSE	NEXT TO OPEN	LOCAL / REMOTE	RELAY TRIP	BANK FAILED	OP COUNT	DISCHARGE TIMER
CAP 1	DISABLE	●	●	●	REMOTE	●	●	22	READY
CAP 2	DISABLE	●	●	●	REMOTE	●	●	19	READY
CAP 3	DISABLE	●	●	●	REMOTE	●	●	19	56 SEC
CAP 4	DISABLE	●	●	●	REMOTE	●	●	18	READY
CAP 5	DISABLE	●	●	●	REMOTE	●	●	18	READY
VESTAS CAPS	DISABLE	●	●	●	● REQUESTING CONTROL	● REQUESTING ADD CAPS	● REQUESTING REMOVE CAPS		

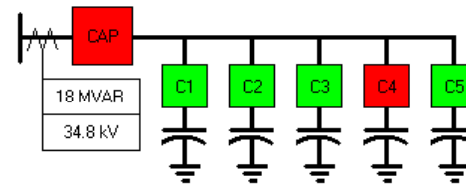
TIME TO ENABLE: 0 MIN TIME TO CHECK: 2 MIN	CONTROL MODE ● PF WINDOW ● PF TARGET ● VOLTAGE ● MANUAL	AUTOMATIC CONTROL MODE PF WINDOW CONTROL ● PF TARGET CONTROL ● VOLTAGE CONTROL ● MANUAL CONTROL ●	MANUAL CONTROLS CLOSE NEXT BANK ● OPEN NEXT BANK ●
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METER SOURCE
CHANGE SOURCE

● LOCAL
● REMOTE

RAPID CAP INSERTION
ENABLE/DISABLE

● ENABLED
● ACTIVE



ALARMS

- SYSTEM OK
- PF LAGGING
- PF LEADING
- VOLTAGE LOW
- VOLTAGE HIGH
- BLOCK CLOSE
- RI OCK OPFN

Multi-technology voltage control

- Fast
 - Most Wind Turbine VAR controls
 - DSTATCOM / DVAR
- Intermediate
 - Transformer Load Tap Changer (Local Bus)
- Slow
 - Fixed compensation switching
 - Dispatch
- Work together, must be coordinated

Questions and Discussion

