Field Experience With Dynamic Voltage Restorer (DVR™ MV) Systems

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Dynamic Voltage Restorer (DVR™ MV)

Fault occurring on adjacent feed

Line Voltage With Sag

Compensating Voltage

Restored Voltage

Protected Sensitive Load
Dynamic Voltage Restorer (DVR™ MV)

Interconnection Equipment

- Bypass switch protects DVR™ MV
- Shorting switch protects power electronics
- Isolation breakers remove DVR™ MV from system
- Auxiliary power from load side
Dynamic Voltage Restorer (DVR™ MV)

Multi-Module DVR™ MV Large System

- 2MVA inverter rating per module
- single series injection transformer couples combined inverter to output
- single set of interconnection switchgear
- each module has own SCR crowbar shorting switch for protection
- tie reactors provide impedance for sharing output current
- master/slaves communications via fiber optical links
Dynamic Voltage Restorer (DVR™ MV)

Caledonian Paper plc
Irvine, Scotland

- 325 t/yr coated paper
- 47MVA total plant load
- 11kV (50 Hz) plant system fed from Scottish Power 132kV transmission
- Deepest sag 0.34 pu retained volts
- 37 sags per year
- Plant “hardened” to 0.74 pu
Dynamic Voltage Restorer (DVR™ MV)

Caledonian Paper plc
DVR™ MV Installation

- 4 MVA, .8MJ DVR; 40% injection; 200 msec (10 cycles)
- 11 kv cable-connected
- 2 - 2MVA power electronic modules
- 2 - 0.4MJ capacitor energy storage modules
- Underground pad-mounted DVR™ MV interconnection equipment
Dynamic Voltage Restorer (DVR™ MV)

Twin Multi-Module DVR™ MV Systems

- Protects state-of-the-art microprocessor fabrication plant
- 69/12.5kV substation fed by three 69kV overhead lines
- $12.5kV_{L-L}$ (7.2$kV_{L-G}$) dedicated feeds
- 3x2MVA power electronic modules per DVR system (master + 2 slave)
- 1.8MJ capacitor energy storage per system
- Inserted voltage: 23, 26, 30, 35% on 26, 23, 20, or 17 MVA taps
Protects critical customers from voltage disturbances (sags, swells ...)

CT Shorting Switch
Incoming Feeder
To Protected, Critical Load
Mechanical Bypass Switch

DVR Power Electronics Module

12.47 kV (15 kV Class)
3 phase, 3 or 4 wire
600 kVA load
50% injection (300kVA)
-40 to 40°C ambient operating range
Available: 3Q99
Prototype Installation

- Demonstration project on BC Hydro system at Dawson Creek, BC
- Protects Northern Lights Community College sensitive load (computers, etc.)
- Ambient temperature range extended to -40°C site conditions
- In service February, 1999. (Photo shows installation in progress.)
Prototype System

- Compact power electronics module includes control and injected voltage waveform synthesis
- Three independent single-phase injection capability
- Hybrid solid-state & mechanical bypass system for overcurrent protection
Platform-Mounted DVR (DVR™ PM)

Distribution System Interconnection

- Uses proven DVR technology
- Compact mechanical design to apply on overhead systems
- Ratings suited to individual commercial & small industrial critical customer loads
- Low maintenance, high reliability
“First Save” by DVR™ PM

- Actual results from prototype PMDVR field demonstration project

- Cause: Lightning arrester failure on adjacent distribution feeder at 0230 hrs on Wednesday, March 3, 1999

- Substation feeder breaker on affected feeder cleared the fault

- Two phases sag; third swells (7%)

- Event duration: 0.96 sec

- Critical downstream load unaffected
DVR™ PM - Field Demonstration

“First Save” by DVR™ PM

**Phase B**

- **Source Voltage, Phase B**
- **Injected Voltage, Phase B**
- **Load Voltage, Phase B**

**Phase C**

- **Source Voltage, Phase C**
- **Injected Voltage, Phase C**
- **Load Voltage, Phase C**