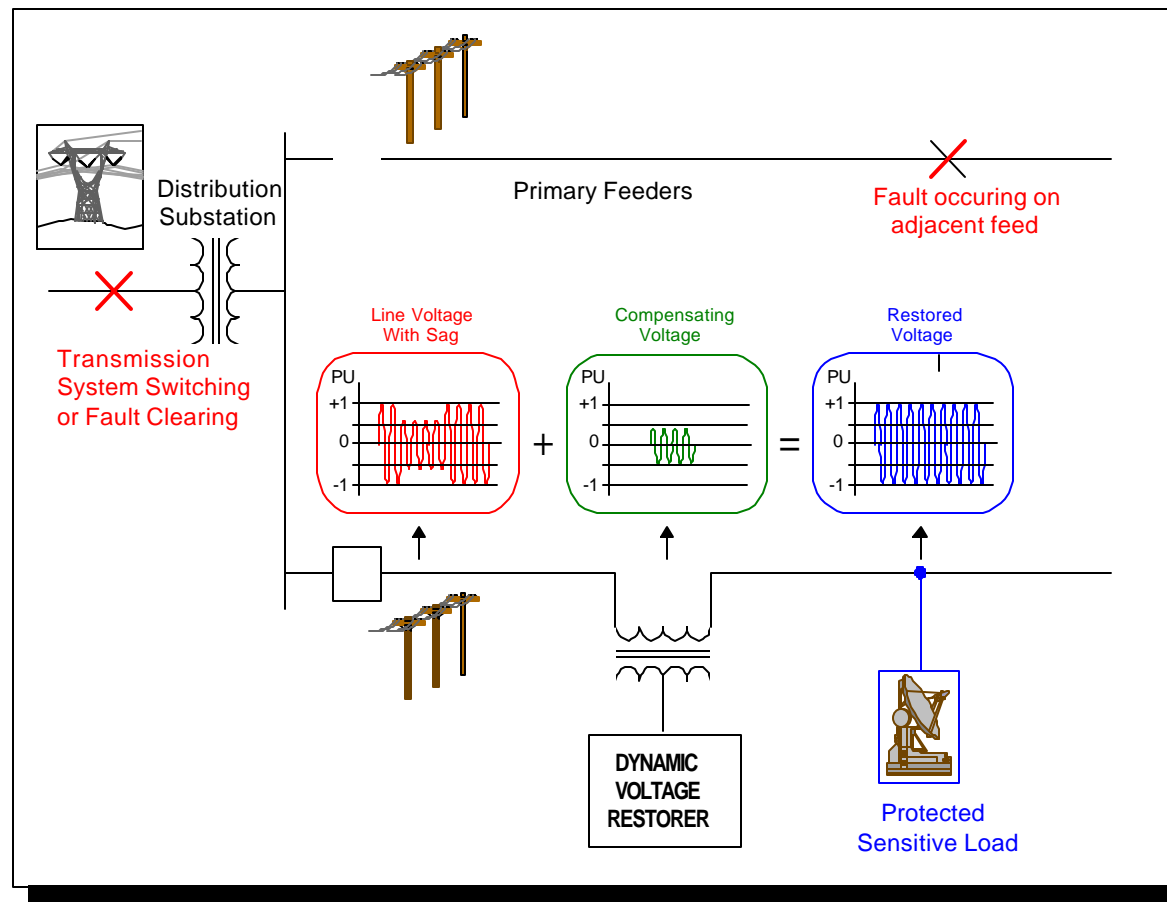


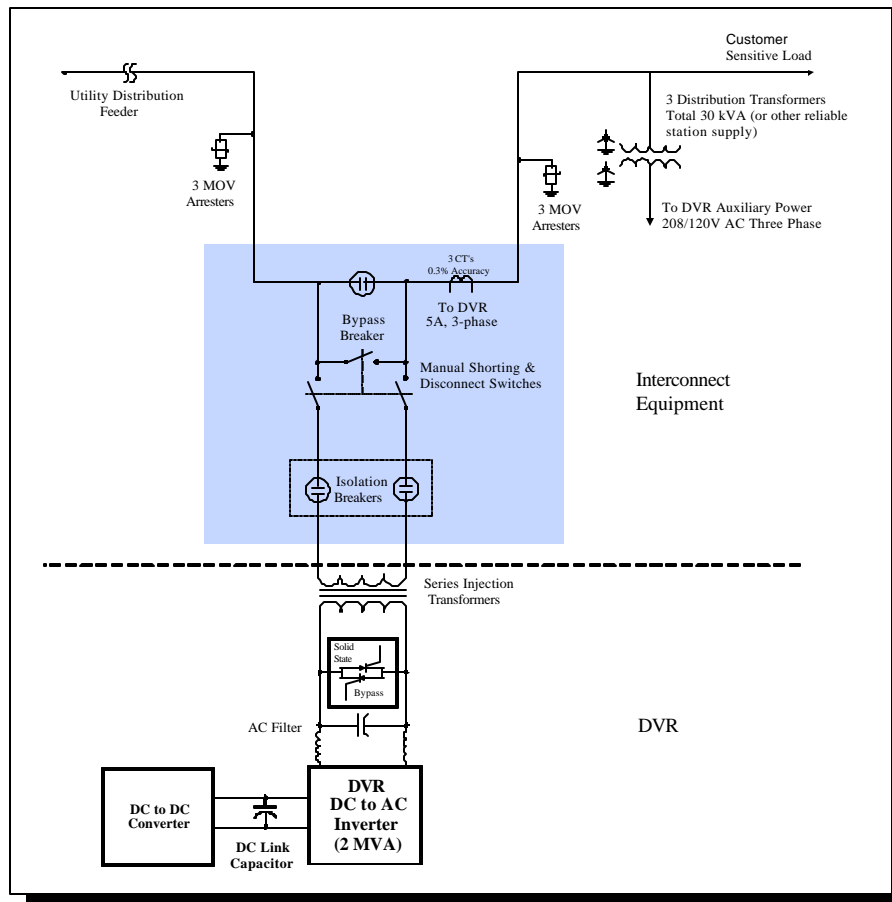
# **Field Experience With Dynamic Voltage Restorer (DVR<sup>TM</sup> MV) Systems**

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# Dynamic Voltage Restorer (DVR™ MV)



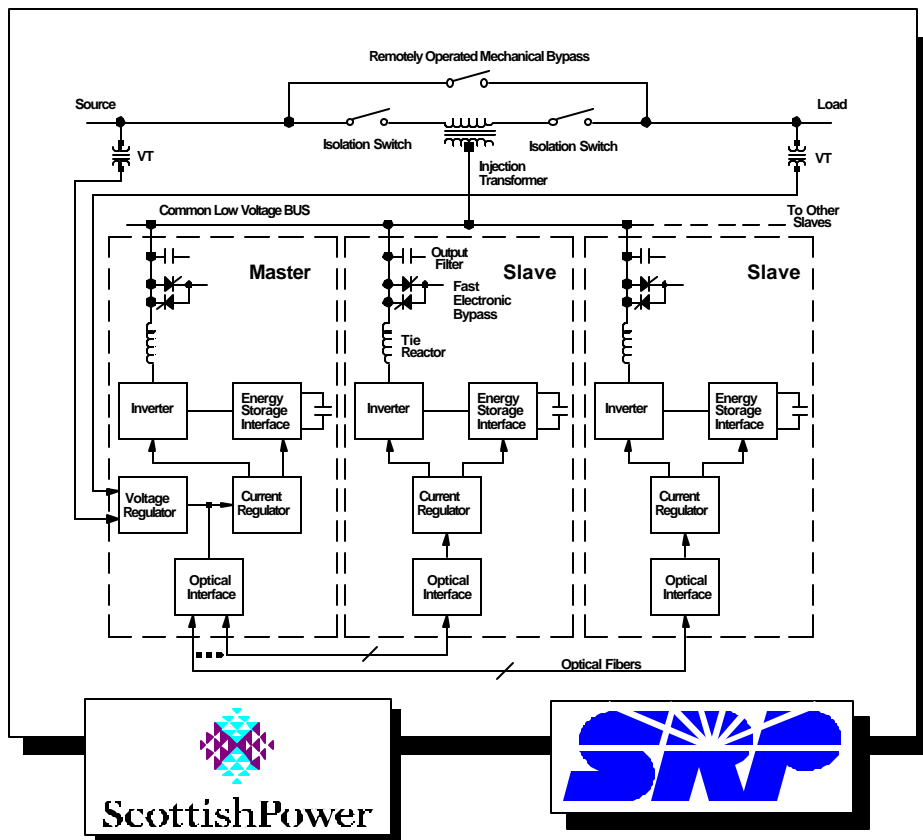
## Dynamic Voltage Restorer (DVR™ MV)



## Interconnection Equipment

- Bypass switch protects DVR™ MV
- Shorting switch protects power electronics
- Isolation breakers remove DVR™ MV from system
- Auxiliary power from load side

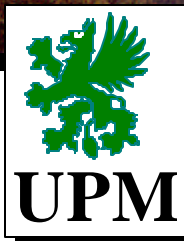
## Dynamic Voltage Restorer (DVR™ MV)



## 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<sup>TM</sup> MV)



### Caledonian Paper plc DVR<sup>TM</sup> 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<sup>TM</sup> MV interconnection equipment

## **Dynamic Voltage Restorer (DVR™ MV)**

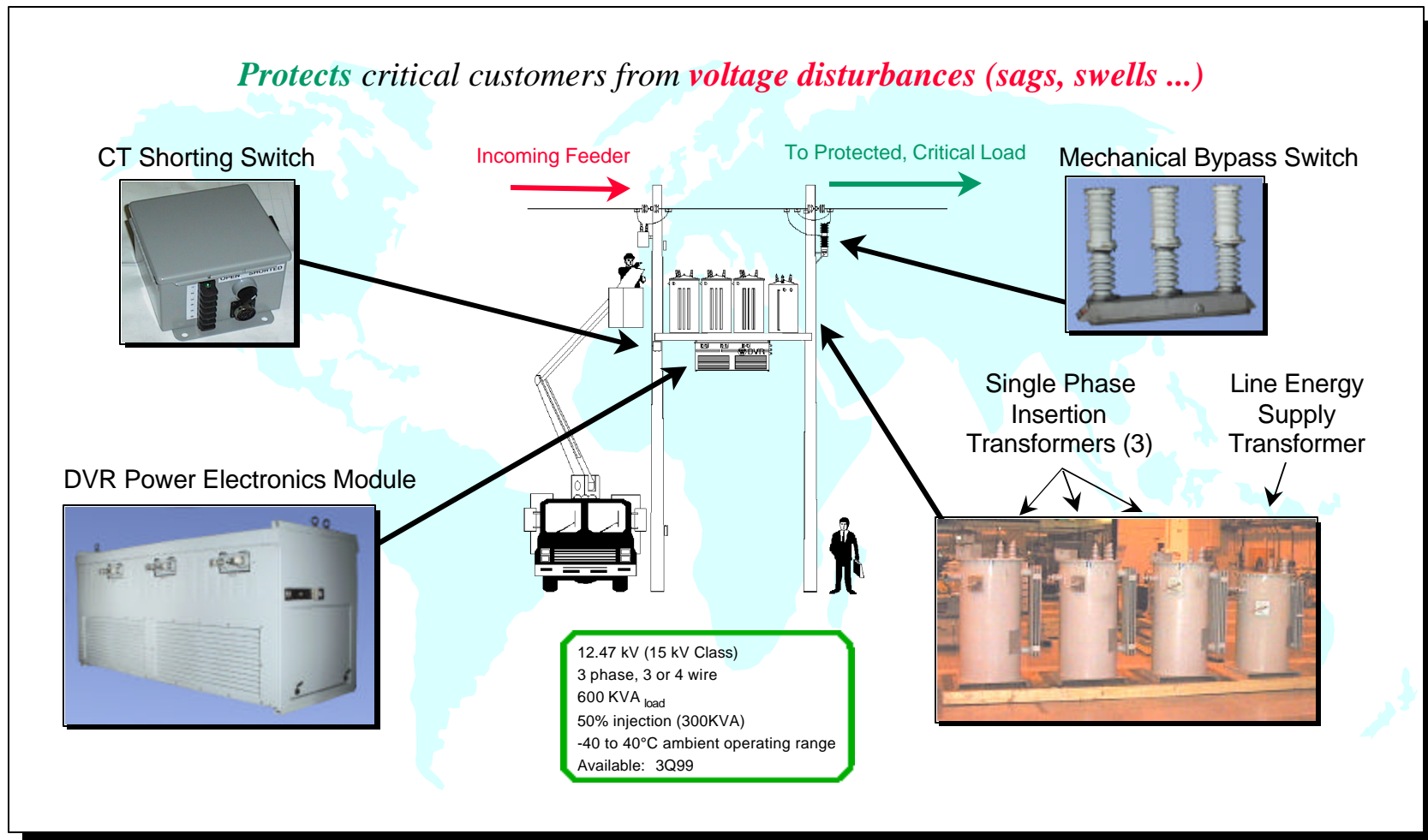
### **Twin Multi-Module DVR™ MV Systems**



- Protects state-of-the-art microprocessor fabrication plant
- 69/12.5kV substation fed by three 69kV overhead lines
- 12.5kV<sub>L-L</sub> (7.2kV<sub>L-G</sub>) 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

## Platform-Mounted DVR (DVR™ PM)

*Protects critical customers from voltage disturbances (sags, swells ...)*



## **Platform-Mounted DVR (DVR™ PM)**

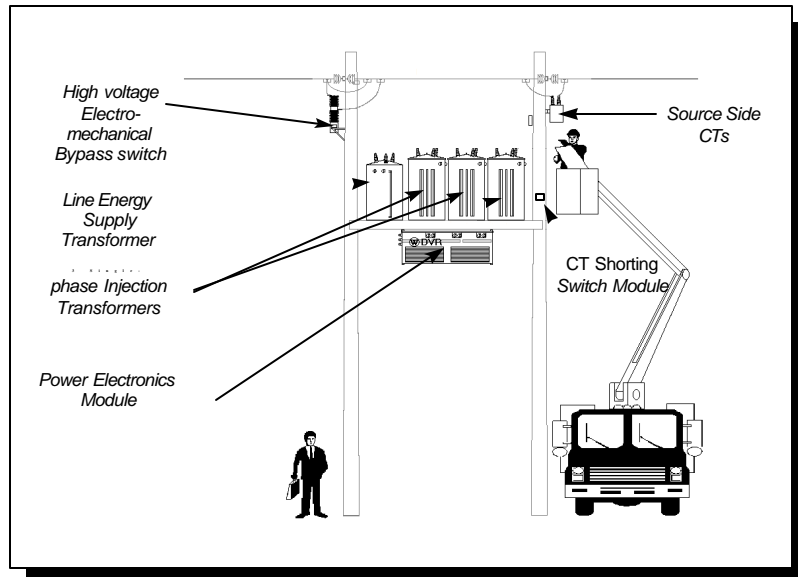
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### **Prototype Installation**

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

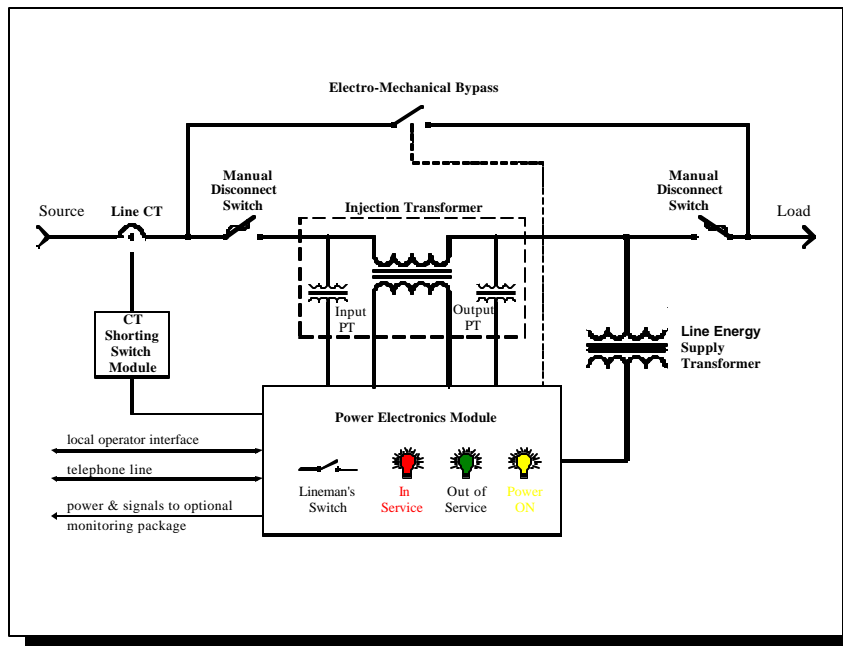
## **Platform-Mounted DVR (DVR™ PM)**



## **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)

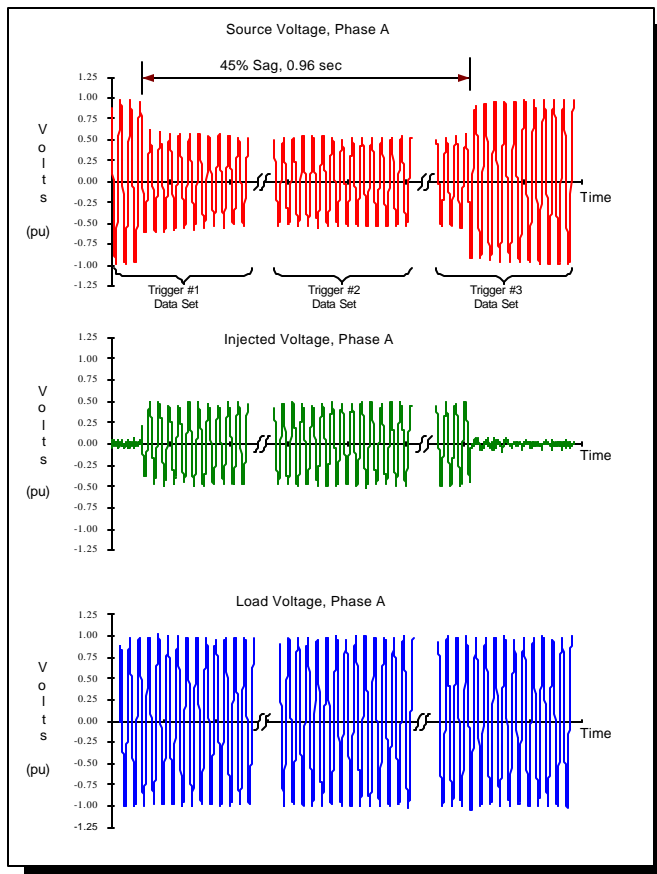


## Distribution System Interconnection

- 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

## DVR™ PM - Field Demonstration

### Phase A



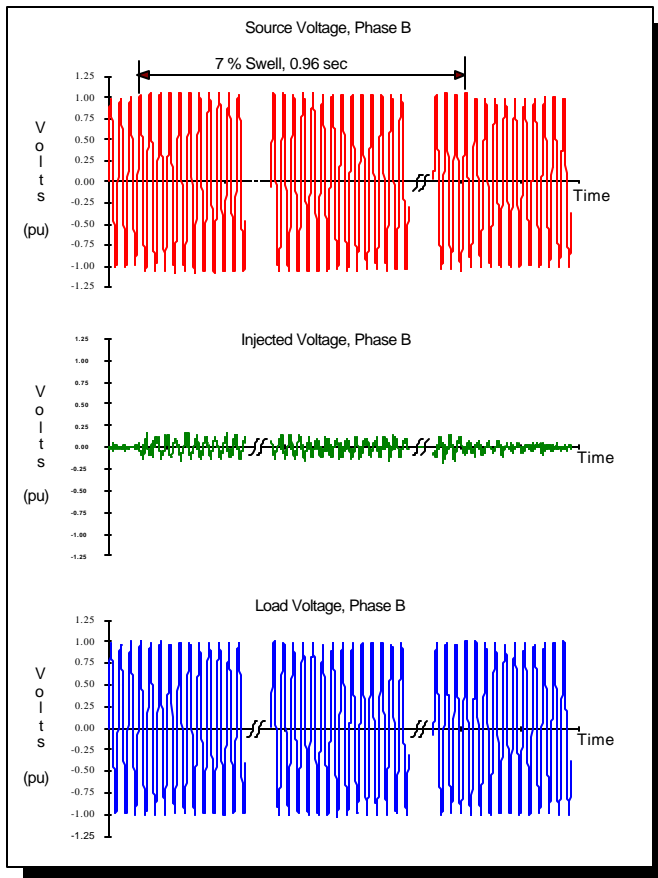
### “First Save” by DVR™ PM

- 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



#### Phase C

