IEEE T&D

FACTS Panel Session – Part II (08TD0140)

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Improving Power System Dynamic Performance in Laredo, TX

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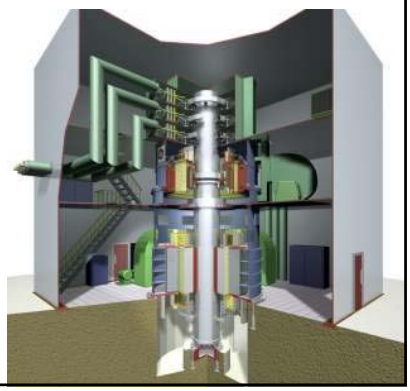
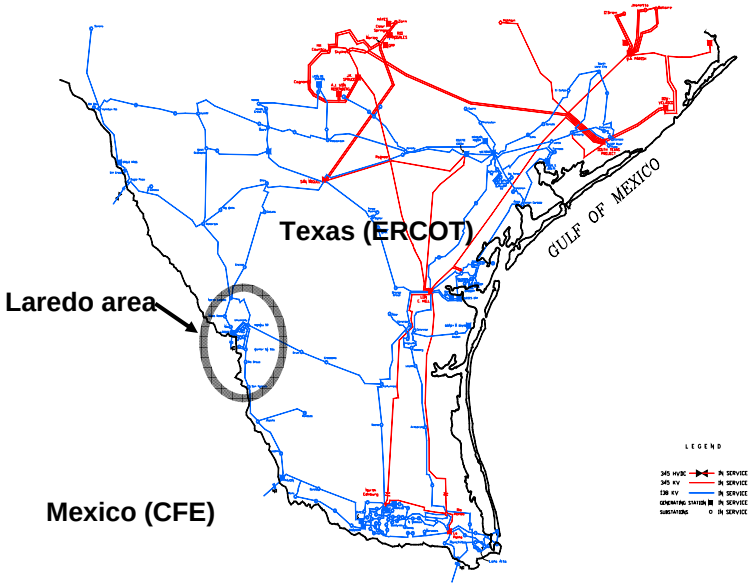


Laredo, Texas and surrounding area

- Roughly 450 MW load peak in 2006
- Served by four long 138 kV lines
- High load growth, up to 5% annually
- Requires local generation at 350 MW
- Non-economic local generation (under RMR) up to 179 MW

South Texas Transmission System



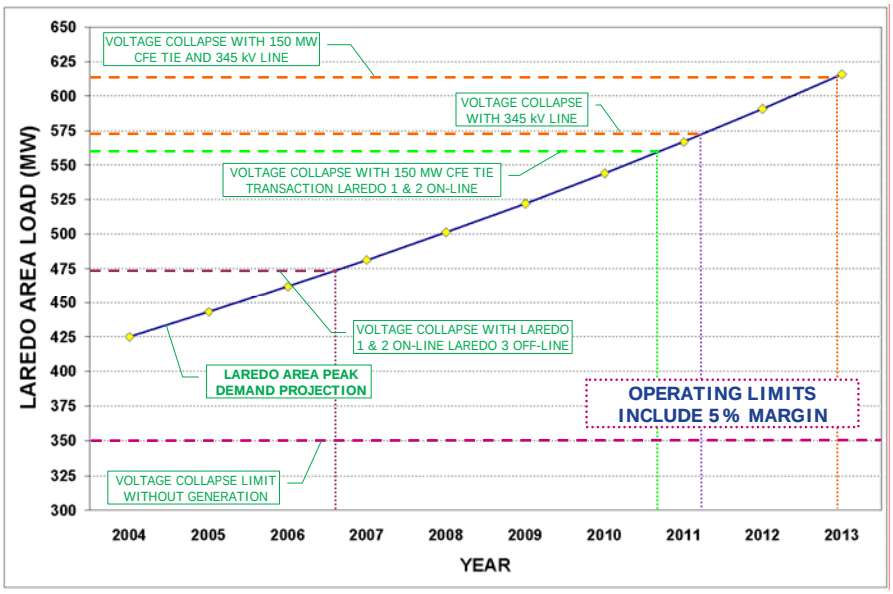
Prepared for NATD June 2006 - Montreal

Justification for the Laredo VFT

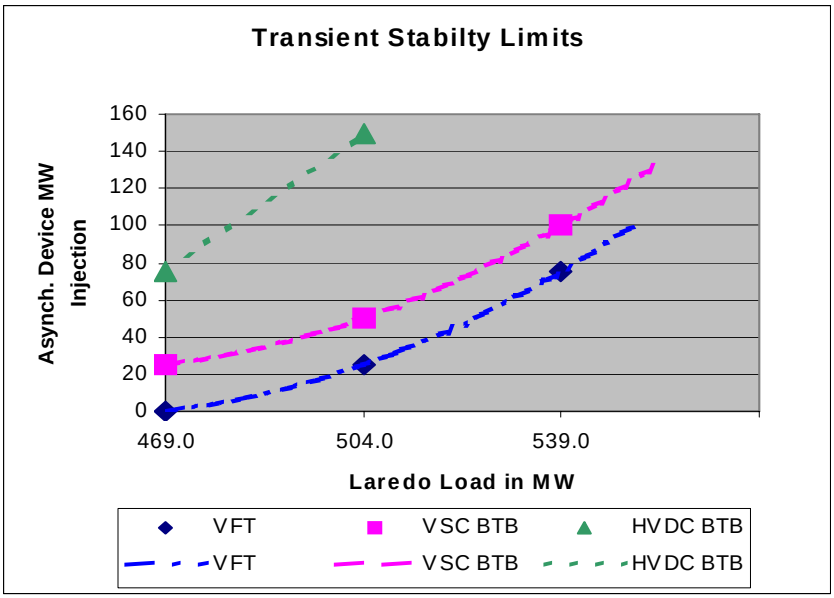
- Laredo Plant units contracted for RMR service due to voltage collapse potential at load level of 350 MW.
- In 2007, with the largest generating unit unavailable and remaining units (70 MW) operating, voltage collapse is probable at a load level of 450 MW.
- By 2010, a new 345 kV line will be completed in order to remove the need for RMR generation.
- Variable Frequency Transformer (VFT) asynchronous tie was found to maintain stability in 2007 through 2010 and augment capacity of the new 345 kV line, deferring the need for the next line.

Prepared for IEEE T&D 2008 - Chicago

Application of ERCOT Planning Criteria



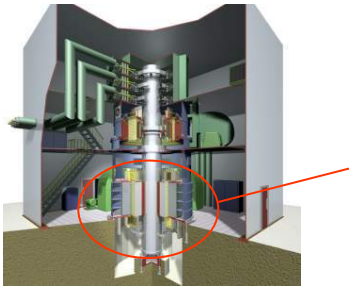
Imports Required to Sustain Transient Stability

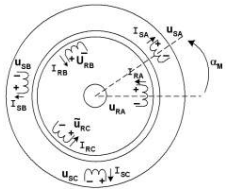


What is a VFT?

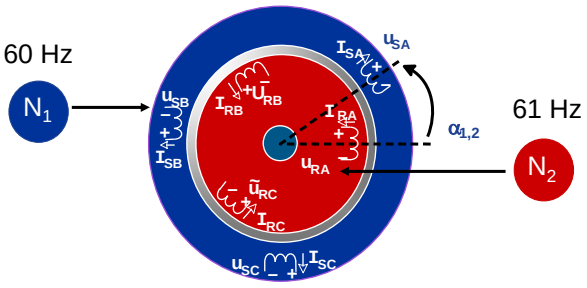
The Variable Frequency Transformer (VFT) is a bi-directional transmission device that can transfer power between asynchronous or synchronous networks.

The VFT is a rotating phase-angle regulator with continuous controllability enabling power transfer from one grid to another from 0 to 100 MW.





VFT Asynchronous Operation



Any frequency difference is accommodated by rotation of the rotor

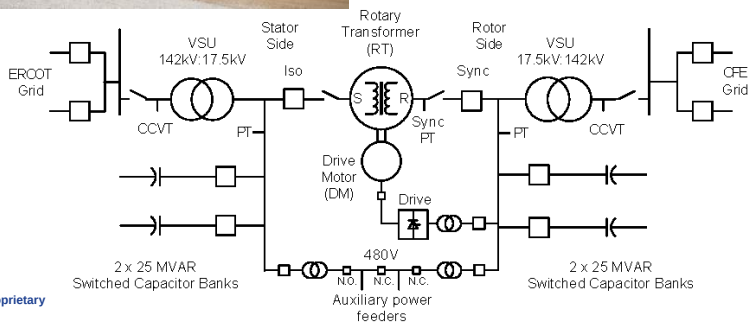
4 pole machine => 1Hz = 30 rpm

Up to 3 Hz difference

Laredo VFT Installation

100 MW tie connecting the U.S. and Mexico

- Formal AEP bid processes – April '04
- Laredo project awarded to GE – March '05
- GE breaks ground at Laredo site – Nov '05
- Rotating machine installation – 2H06
- Commence commissioning\testing – 1Q07
- Commercial Operation – May 18, 2007



Laredo Application of VFT

Voltage depression resulting from a fault on any of the four 138 kV lines supporting Laredo increases slip on induction load such as air conditioning, causing reactive power consumption to escalate.

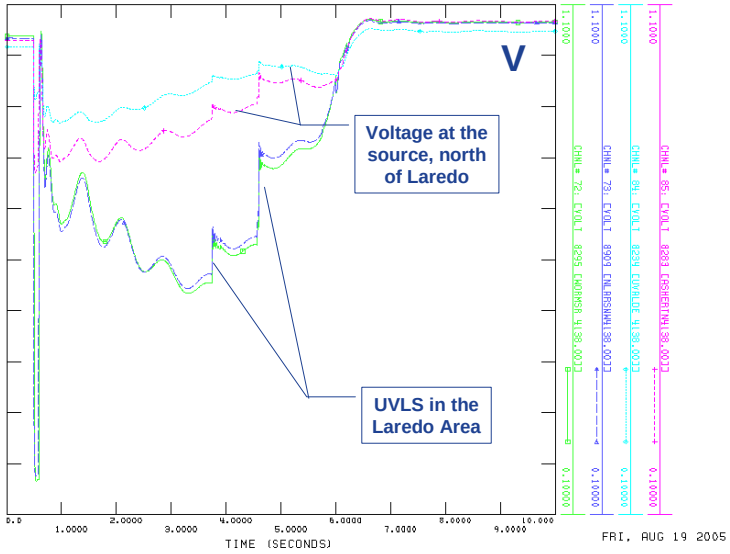
Without relief from reactive power demand, under voltage load shed (UVLS) is necessary for recovery.

VFT provides:

- Injection of real power, offsetting power flow on heavily loaded 138 kV lines that consume reactive power
- Injection of reactive power providing voltage support in Laredo

This transient response, which is passive, offsets the need for active power imports and reduces the need to operate RMR generation.

Voltage Response to Disturbance in Laredo



Real and Reactive Power Response of VFT to Disturbance

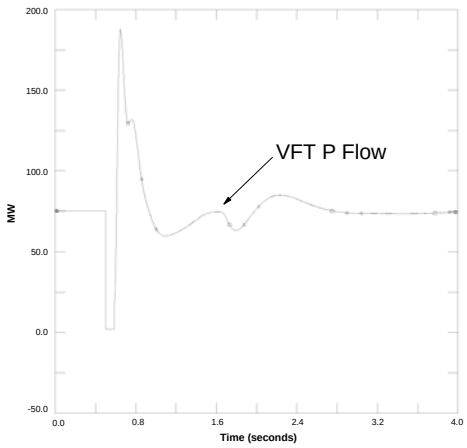


Fig. 1. Injection of Real Power through VFT during and immediately after a fault.

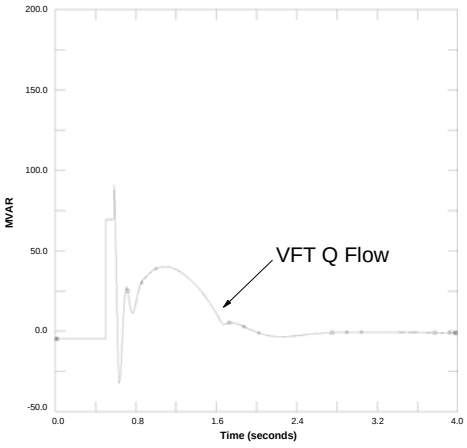
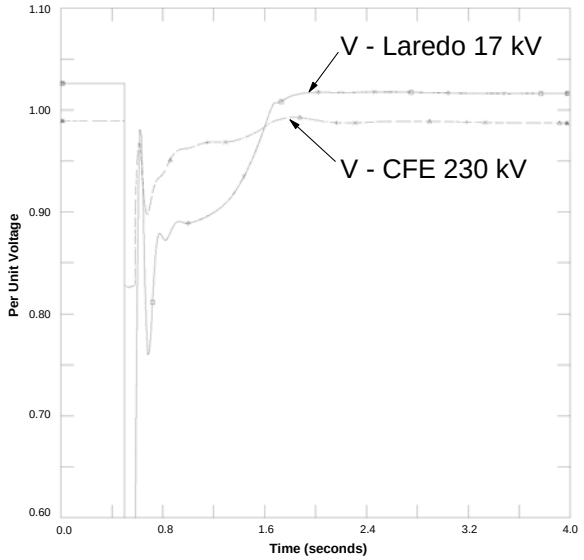
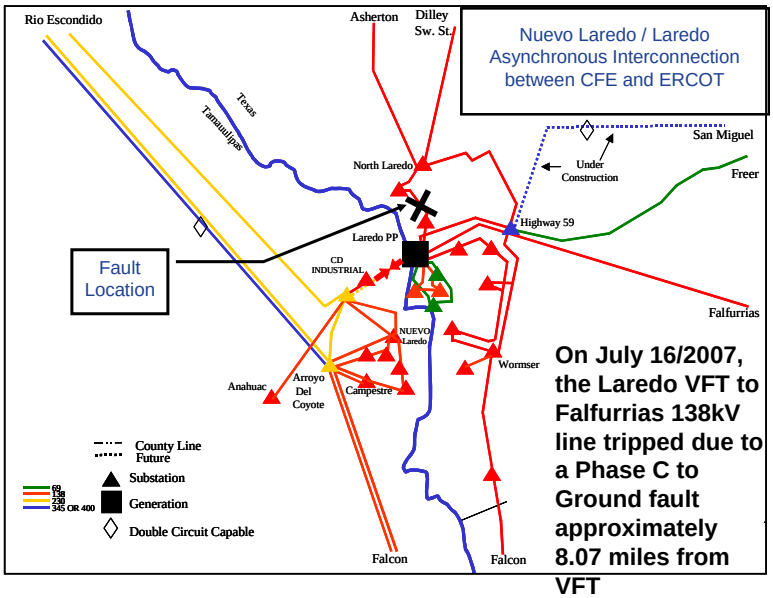


Fig. 2. Injection of Reactive Power through VFT during and immediately after a fault.

Voltage at VFT Terminals through Disturbance



Nuevo Laredo / Laredo



On July 16/2007, the Laredo VFT to Falfurrias 138kV line tripped due to a Phase C to Ground fault approximately 8.07 miles from VFT

Actual VFT fault response

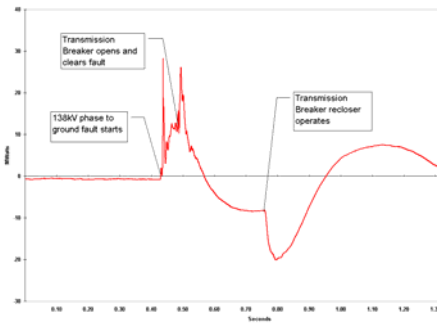


Fig. 3. Real power through the VFT during an actual 138kV transmission line fault.

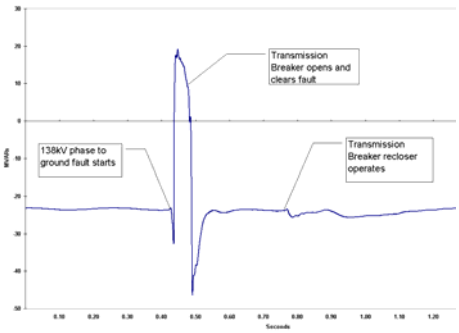


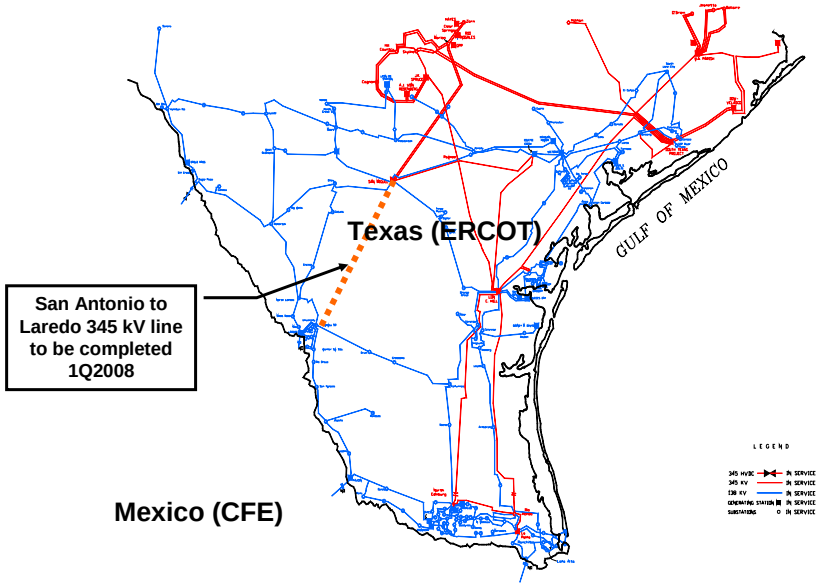
Fig. 4. Reactive power through the VFT during an actual 138kV transmission line fault.

On July 16, 2007, two months after the VFT entered commercial operation, a fault occurred on one of the ERCOT 138kV transmission lines terminating at the VFT. The event was a temporary phase to ground fault 8 miles away from the VFT. The fault was cleared in 4 cycles by the breakers protecting the faulted line and the line was successfully reclosed in about 18 cycles. The demonstrated performance of the VFT matches earlier simulations.

VFT is a Comprehensive Solution

- Passive response to post-fault disturbance can produce a 200% real power injection
- Supplies reactive power during and after faults
- Provides complementary support to RMR Generation, existing STATCOM and 345 kV line

South Texas Transmission System



VFT compatibility with future enhancements

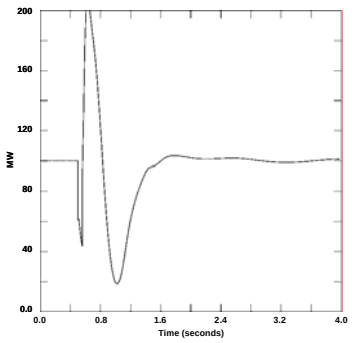


Fig. 5. Real power through the VFT with loss of 345kV line and future load levels.

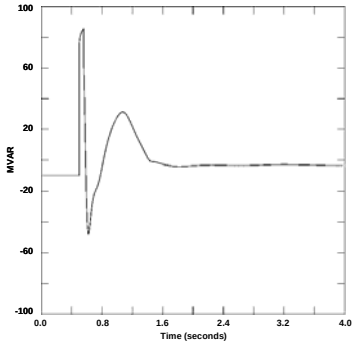


Fig. 6. Reactive power through the VFT with loss of 345kV line and future load levels.

While the benefits provided by the addition of this line are substantial, an unfortunate side affect is that with this improvement alone to the Laredo area system, the 345 kV lines become the greatest liability for dynamic stability. Because the majority of power flowing into Laredo is diverted to the 345 kV line, the event of its outage becomes the worst contingency for that area. Real and reactive power injection across the VFT offsets the interrupted flows of the 345 kV line.

Conclusions

- The VFT has a natural beneficial stabilizing characteristic.
- The VFT's passive response in the transient time frame plays an important role in maintaining acceptable post-fault dynamic performance in the Laredo area.
- Actual experience has confirmed predictions of the simulation model.