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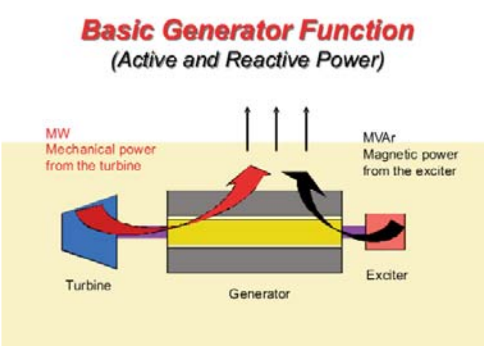
Generation Power Management

By: Arthur J. Smith, P.E.

Generation control allows operation of two or more generators in parallel by sharing both running and transient load changes. Dissimilar power producers can increase control complexity with complex generation control systems typically referred to as "Power Management Systems" (PMS). This article starts with the high level basics of generation power control and progresses through a recent complex PMS system design controlling many different types of power producers including variable frequency drives with Active Front Ends (AFE) that have the capability of operating as synchronous generators, an industry first.

The Basics

Generators provide both real power (kW or MW) and reactive power (KVAR or MVAR) based on connected load requirements. Real power is required for mechanical work such as turning pumps. Reactive power required for electrical system operation is energy that "sloshes" back and forth between the load and the generators but provides no real work similar to water sloshing back and forth in a bowl.



Layout of a Typical Generator Room

Generator Operation

Governors control the prime mover portion of the generator (e.g. engines or turbines) and voltage regulators control the generated voltage by controlling exciter output. When real power requirements increase, the governor must also increase prime mover fuel or machine speed will reduce, affecting generated frequency. Reactive power fluctuations require similar changes in generation excitation or system voltage will fluctuate.

A single generator can easily be controlled with its voltage regulator set to maintain a constant voltage and its governor set to maintain a constant frequency/speed regardless of changes in system load.

Constant Speed or Voltage Operation

Unfortunately, this simple control system which is more than adequate for single generators does not work with multiple generators operated in parallel. The problem is that each generator governor constant frequency/speed setting and voltage regulator constant voltage setting will not exactly match other governor speed settings or voltage regulator voltage settings. When generators are paralleled the frequency and voltage of each machine must exactly match since the generators are electrically connected once paralleled. Any mismatch in governor setting no matter how small will force one machine governor to maximum fuel while shutting fuel off on the other machine. For example, let's say the pre-paralleled frequency of the first generator is 60Hz and the pre-paralleled frequency of the second generator is 60.1Hz. Once the generators are paralleled, the resultant frequency will be between 60Hz and 60.1Hz. The first

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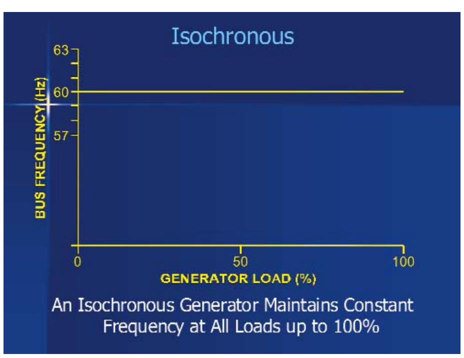
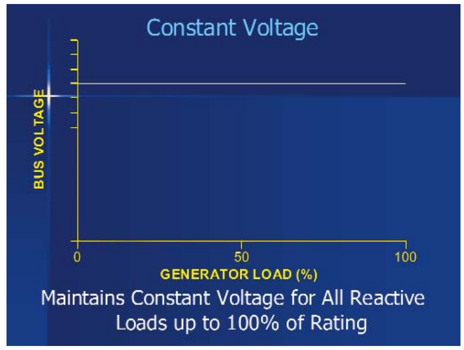
generator with a governor setting of 60Hz will see the higher frequency (e.g. 60.05Hz) as an overspeed and start reducing fuel to the prime mover in an attempt to reduce the 60.05Hz overspeed and try to maintain its 60Hz setting. At the same time the second generator with a governor setting of 60.1Hz will see the 60.05Hz frequency as an underspeed and start increasing fuel in an attempt to increase what it interprets as an under frequency (e.g. 60.05Hz) and maintain its 60.1Hz setting. Very quickly the generator governor with a



Isochronous (Constant Speed) Control

60.1Hz setting will go to a full throttle setting while the generator governor with a 60Hz setting will shut off fuel as each tries to maintain their constant frequency settings. Constant voltage control reacts in a similar manner with one machine's voltage regulator producing maximum excitation as it tries to match its higher voltage setting while the other machine produces minimum excitation trying to match its lower voltage setting.

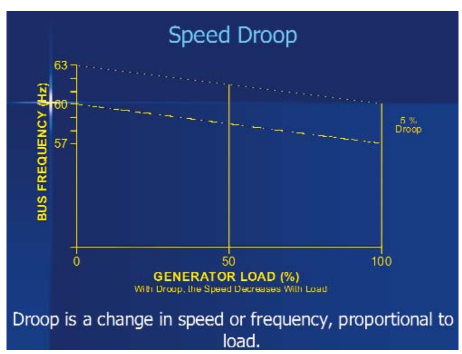
The most basic method to allow generators to share load is to provide "speed



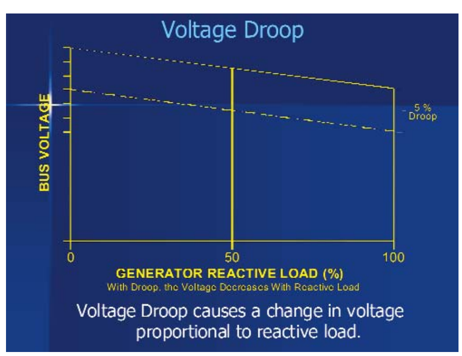
Constant Voltage Control

droop" to each governor and "voltage droop" to each voltage regulator. As generator MW load increases the governor speed setpoint decreases proportionately to load. Therefore a governor with a 5% droop running at 60Hz no load would run at 57Hz under full load conditions unless manually adjusted as the load changes. This method allows multiple generators to be operated in parallel and share loads as indicated below.

The disadvantage with speed or voltage droop operation is that system frequency and voltage vary with changes in system



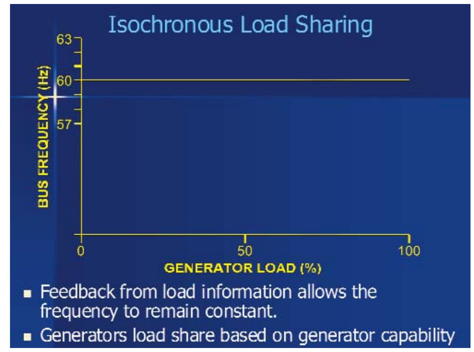
Speed Droop



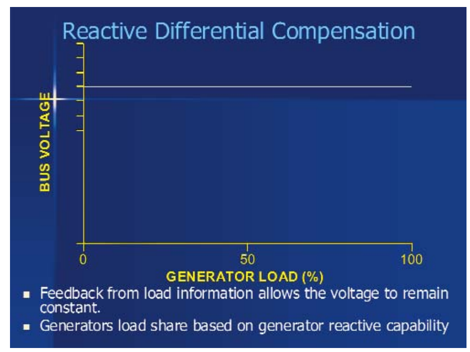
Voltage Droop

load according to the speed or voltage droop settings. Maintaining system frequency and voltage therefore requires manual intervention as loads change or accepting slight variations in frequency and voltage.

Isochronous (constant) speed operation has the advantage of system operation at a constant frequency/speed regardless of system load. Unfortunately this system will not work with simple constant speed



Isochronous Load Sharing



Reactive Differential Compensation

(isochronous) governors and voltage regulators as described under the single generator operation above. Fortunately, voltage regulators and governors can be equipped with current transformers (CTs) and potential transformers (PTs) allowing each device to measure generation power flow. These measurements can then be compared and communicated with each governor or voltage regulator allowing internal adjustments similar to the manual intervention described under droop control to maintain constant speed and constant voltage operation without operator input and regardless of system load.

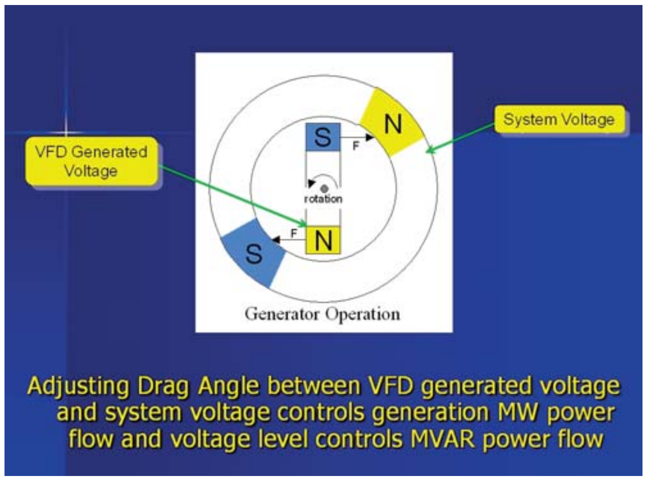
Complex Generation System Operation

As system generation sources differ, so does the complexity of the power management system. Steady state operation is typically not a problem, but different response times of steam generators, gas generators, and diesel or gas engines increase the complexity of the power management design which will be required to compensate for various response rates in the design to equally share load transients.

A recent power management system first was a design that controlled not only large steam turbines, a gas turbine and ties to another facility but also variable frequency drives. Each VFD was provided with an active front end (AFE) that was capable of supplying real power or reactive power to the plant grid. Whenever excess turbine power was available the VFDs could supply real power with reactive power supplied anytime the VFDs were online.

Real power to the motor/generator was controlled by adjusting the VFD output current phase angle with respect to motor/generator voltage. This controlled the direction of motor/generator torque and therefore MW power flow to or from the motor/generator. In a similar manner the active front end controlled power flow from the grid by retarding the current angle relative to system voltage to draw power out of the plant distribution system, or advanced this angle to push power into the plant power distribution system. Reactive power was also controlled by the AFE by adjusting voltage to control the export of reactive power to the plant grid. Since VFDs isolate the motor/generator from the plant grid by converting plant power from AC to DC and then to a variable AC, power flows between the plant grid and the motor/generator are independent of motor/generator shaft speed.

These drives tie synchronous machines which are part of large compression strings to the plant electrical distribution system. Each compression string consists of a large gas turbine, synchronous motor and gas compressors. The synchronous motor not only provides purge and starting torque for the gas turbine and compression string but also adds torque in a helper motor mode when the gas turbine is power limited. However, when excess turbine power is available the VFDs allow the synchronous machine to operate as a synchronous generator supplying both real and reactive power. Excess turbine torque is dependant on both ambient temperature and compression load. This change in turbine power availability required that we accommodate load swings from helper motor conditions to proportionate generation load sharing based on constantly varying gas turbine power availability.



Since the VFDs isolate the motor/generator from the plant grid by converting plant power AC to DC and then to a variable AC supplying the compression string motor/generator, power flows between the plant grid and the motor/generator independent of turbine driven motor/generator shaft speed. This was critical since the process required compression string speed variations.

Both real and reactive power produced by the compression string VFDs was controlled by a power management system (PMS) designed to respond to load changes and share power with all electrical power producers within the facility. One unique feature of the power management system was its ability to scale the “size” of the VFD generation power available based on compression string excess torque as calculated by the turbine controls. This unique feature allowed proportionate load sharing between the compression string VFDs in generation mode with other power generation throughout the facility.

VFD generation testing under PMS system control validated the VFDs not only functioned as “typical” synchronous generators but that they also shared load with the remaining electrical power producers within the facility. This was accomplished by successful operation of the VFDs supplying real and reactive power in a plant environment and confirming that they respond to compression and/or plant load fluctuations while supporting facility electrical power generation and proportional load sharing with other power producers.

Community Activities Keep Employees Involved

New Orleans Corporate Cup Run - 2010

Above l to r; Jack Neelis, Thi Dao, Derrick Millet, John Joseph and Bobby Baker

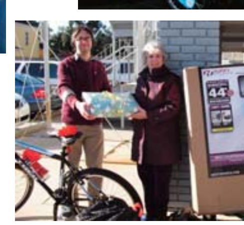
Right, l to r: Patricia Griffin, Robert Griffin and Ken Schlag

Rebuilding New Orleans

Back, l to r; O.L. Haas, Rick Trzaska, Bill Landry, Zach and Steve Reed. Front, l to r; Tad Duhe, Anthony Beard, Steve Prados, Ginger Dodge, Pauline Prados and Steve Clavin.

Salvation Army Angel Tree and Volunteers of America Gift Giving Programs

Above; Felicia Abu-Fannoun and Slater Bass.



Left; Karen Martin and VOA Marketing Coordinator, Dan Darbandi.

Waldemar S. Nelson and Company 2010 Employee Recognition Dinner

On Wednesday, November 3rd, a celebration was held at Ralph's on the Park to honor NELSON employees who have had twenty or more continuous years of service with the company. The year's honorees were: Rene Delaune, Ernie Orgeron, Mike Daussin, Barry Valence, Dwayne McElroy, Buddy Grinder, Randy Chatagnier, Ed Merchan, Tony Hoffman and Bob Chandler, all celebrating twenty years with the firm.

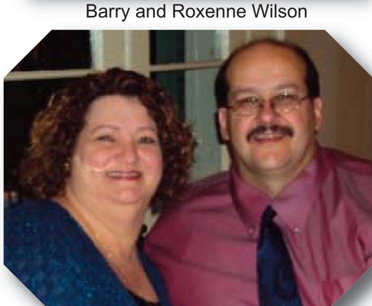
For twenty-five years' service, Mary Dauzat and Robby Denman were honored. In recognition of thirty years' service, David Stewart, Lonnie Robin, Tony Catalanotto, Barry Wilson, Steve Johns and Carl Cappel received heartfelt congratulations and thanks from our Chairman.

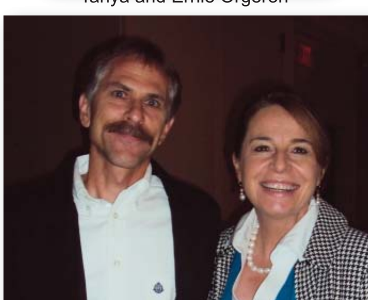
The ongoing loyal support of these individuals is what continues to keep our company strong and make possible the services we provide to our clients. We salute this group and look forward to our continued relationships.

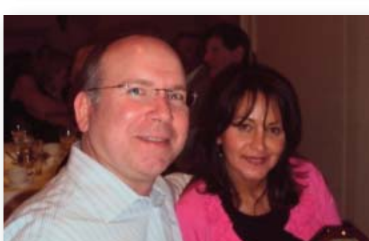

Dave and Susan Stewart


Tony Catalanotto, Ginger Dodge, Randy Chatagnier


Barry and Roxenne Wilson


Tanya and Ernie Orgeron


Tony and Debra Hoffman


Mike Daussin and Maggie Desai


Debbie and Lonnie Robin


Bob Chandler


Rene and Rosalie Delaune


Rob Denman and Mary Dauzat


Buddy and Sheila Grinder


l to r:; R Delaune, E. Orgeron, M. Daussin, Dwayne McElroy, B. Grinder, R. Chatagnier, B.Chandler, T. Hoffman. Not pictured Barry Valence and Ed Merchan


l to r; T. Catalanotto, D. Stewart, Steve Johns, B. Wilson, L. Robin
Not Pictured Carl Cappel

New Orleans and Houston Employees Enjoyed Festive Christmas Celebrations


Tara and Francisco Merchan


Amy and Steve Simon


Jane and Rich Cabiro, Cindy Larsen


Patricia Cazaux and Bob Badeaux

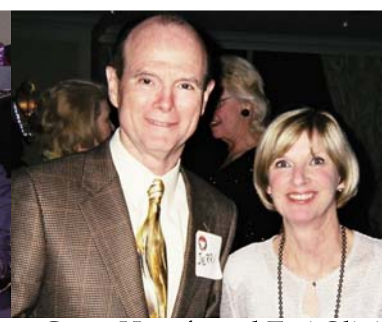

Shane Pizani and Pat Pizani


Kate Simister


Wayne and Janet Talley


Peg and Sid Walker


Laura and Jim Lane


Gerry Hanafy and Teri Olivier


Mike and Caimy Harbison, Keith Mathenia


Charmaine and Ron Villere


l to r; Felicia Abu-Fannoun, Angel Carmichael, Jennifer Buchholz and Amy Simon


Karin Levesque and Ken Nelson

NELSON By The Numbers

A few interesting recent statistics on the company . . . . . .

In a 2011 New Orleans City Business survey, NELSON was noted to have among its engineers, 100 holding professional registrations.

As of 2010, we have been in business for 65 years.

For the year 2009, in the Engineering News Record listings, NELSON ranked number 144 in the Top 200 International Design Firms and number 176 in the Top 500 U.S. Design Firms.

For the year 2009, in the Houston Business Journal Book Of Lists, NELSON ranked 20th among Houston's Top Energy Engineering Firms.

We have over 8,000 books listed in our technical library.

We are pleased to announce our RECENT WEBSITE UPDATE !
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