Power Augmentation Control (PAC©)

GT-APS

Description

Under-frequency operation impacts efficient operation to the degree that nominally controlled turbine outputs which described by manufacturer, GE, can be exceeded in order to meet the specification defined Primary Frequency Control requirement by the National Grid Company (NGC).

As speed decreases, the compressor airflow decreases, reducing turbine output. If this normal output fall-off with speed results in loads less than the defined base load, power augmentation must be applied in order to eliminate inefficient operation and combined cycle output losses.

Turbine Peak Fire is the most obvious power augmentation option but other means such as utilizing gas turbine water systems, e-sprint, aux. inlet cooling etc. have some potential as an augmentation action.

Why PAC©?

Generator drive turbines operating in a power system grid are sometimes required to meet operational requirements that are aimed at maintaining grid stability under conditions of sudden load or capacity changes regarding grid frequency. Most codes require turbines to remain on line in the event of a frequency disturbance.

For under-frequency operation, the turbine output decrease that will normally occur with a speed decrease is allowed and the net impact on the gas turbine as measured is minimal. In some grid systems, there are more stringent codes, such as primary frequency control regulation, that require remaining on line while maintaining load on a defined schedule of load versus grid frequency. One example of a more stringent requirement is defined by the National Grid Company (NGC). In the NGC code, conditions under which frequency excursions must be tolerated and/or controlled are defined as shown in Figure-1.

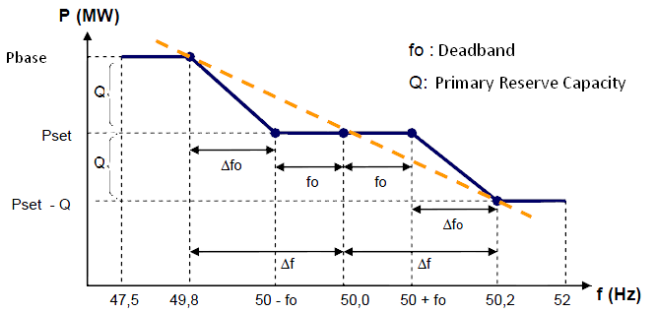

Figure-1. The NGC requirement for output versus frequency disturbance.

Gas turbines are aerodynamically designed for optimal performance at base load levels. If the gas turbine is not operated at this load level, the flow triangles in the compressor and turbine expander stages will differ from design assumptions, and more energy will be dissipated.

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Aero-derivative LM series, GE, gas turbines are designed to operate over a 96,5 % to 105% for speed and 6% to 9% (ALARM and SDTI) T48 temperature range.

However, operation at other than rated XNSD speed (3625rpm) and temperature T48 (1600°F), T3 (1008°F) has big impact on gas turbine efficiency as specific fuel consumption and output during NGC primary frequency requirements. Depending on the NGC code requirements, the specifics of the turbine design and the turbine control philosophy employed, operating conditions can result that will accelerate fuel consumption as well as the life of hot section and fuel system components such as HPTR, stg1 and stg2 nozzle assemblies, combustor, fuel control valves etc. Where this is true, the EFFICIENCY LOSS factor, associated with primary frequency control operation must be understood and these speed and temperature events analyzed so as to include in the efficiency loss for aero-derivative gas turbine based power plants.

With specification in Figure-1, the unit will respond to a frequency change with a load change according to the configured droop. Existing GT-APS PFC™ software for primary frequency control was developed to enable the unit to support the net frequency and limit the load change within predefined limits as required by National Grid Company. GT-APS PFC™ is active if selected on HMI and the unit is running in frequency control at preselect load rather than base load.

With Power Augmentation, The NEW software named as Primary Frequency Regulation, PFR©, controls the unit still running on speed control, required by NGC, that equal to BASE LOAD (Pbase) conditions (T48-T3-PS3 controls), with increased settings when needed, continuously and is still capable and able to increase the load accordingly if the net frequency drops below 50Hz.

The Primary Frequency Regulation, PFR©, software allows the unit operating in base load with eliminated 2% primary frequency control reserve load, if Power Augmentation (PAC©) is activated from HMI.

How It Works?

The Power Augmentation logic is created to enable the unit to support the net frequency and limit the load change Preserve within predefined limits as required by National Grid Company while running on BASE LOAD.

The logic is active if PFR© is running on control and PAC© (Power Augmentation Control) enabled, by doing so the unit is in speed/load control. If the unit is in base load by Power Augmentation, the unit will run to a calculated value by Peak Fire if frequency drops below 50Hz to support the net frequency. The power augmentation will be achieved by Peak Fire through core software to enable the customer within the area that is

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defined by NGC as shown in Figure-2 and Figure-3.

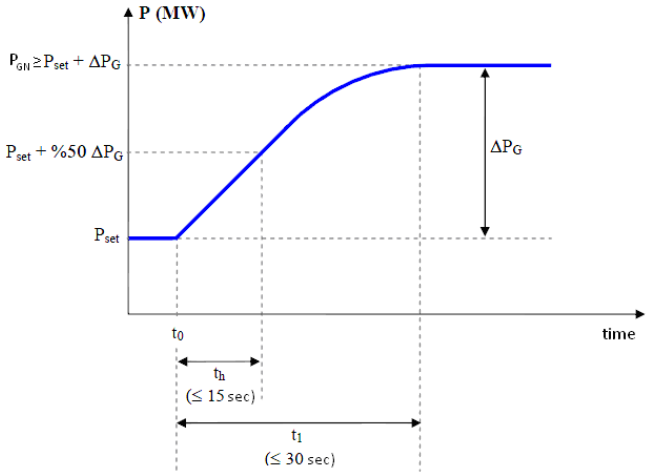

Figure-2. The NGC requirement for unit output during under-frequency conditions with Power Augmentation Control (PAC) "OFF".

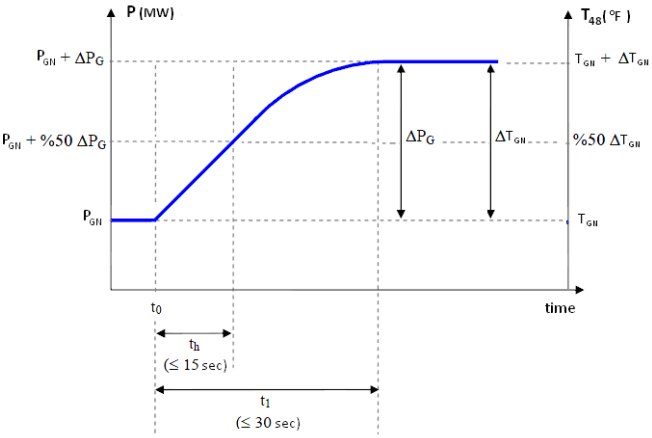

Figure-3. The unit output during under-frequency conditions with Power Augmentation Control (PAC) "ON"

With Power Augmentation, Pset = PGN (Nominal unit output) and ΔPG will be covered by Peak Fire if the frequency drops below 50Hz as shown in Figure-4.

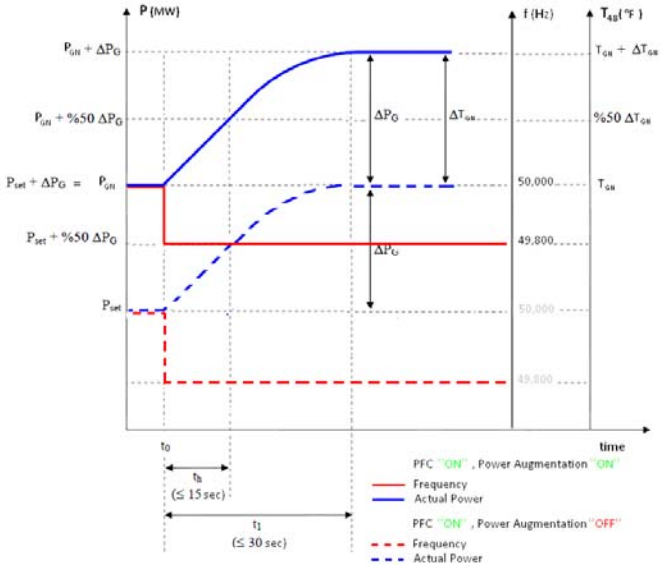

Figure-4. The unit output with PEAK FIRE Power Augmentation Control (PAC) "OFF" and "ON".

By Peak Fire, LM series machines response faster from any other power augmentations in order to meet and maintain the specification defined Primary Frequency Control requirement by the National Grid Company. If the frequency disturbance remains longer than 15sec's than secondary power augmentations take over due to impact of the life of hot section parts. This results Peak Fire settings return back to the original values while Primary Frequency

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Regulation, PFR©, software is still active and maintaining load on a defined schedule of load versus grid frequency. At the end of 15th second water injection, sprint flow, air inlet chillers etc. become effective to compensate remaining time for reserve capacity as shown in Figure-5.

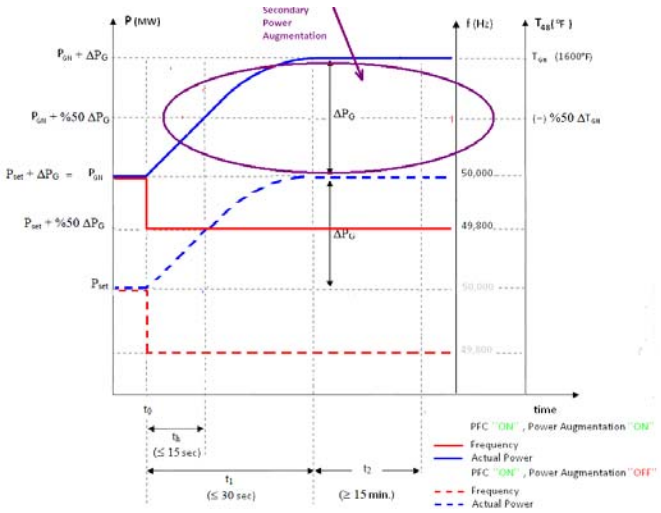


Figure-5. The unit output with Secondary Power Augmentation Control "ON".

PAC© Benefits

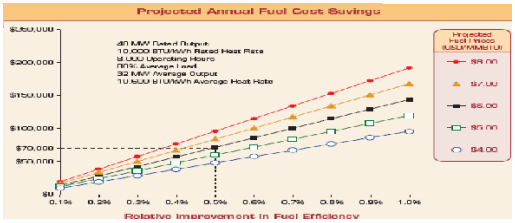
With Power Augmentation Control (PAC©), by the function of Primary Frequency Regulation, PFR©, software the power plant Owner's/ O&M companies are allowed operating their units in base load without losses which causes by primary frequency control reserve load.

The most obvious loss for power producers is efficiency of gas turbine that mostly named as specific fuel consumption (SFC). The fuel consumption criteria are calculated fuel usage per kWh power production.

However, latest control system equipped LM series gas turbine packages have better fuel consumption besides older designed GTG packages. Therefore SFC becomes as an important loss on partial loads for any reason in LM series GE gas turbines.

Primary Frequency Regulation, PFR©, software with Power Augmentation Control (PAC©)has the following;

1. Fuel consumption recovery, minimum 1,88-3% or 0,006-0,008m3/kWh(SC).



2. Recovery of gas turbine production loss that caused by 2% primary frequency control reserve,
3. Recovery of CC production losses,
4. HR recovery, caused by NGC,