

# Maximizing generator set performance via gains tuning

## White Paper

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Cummins Power Generation aims to be a world leader in a host of industrial global power generation markets, including consumer, commercial, and military. These markets have diverse needs and applications ranging from landfill (low BTU) gas to RV diesel power generation.

Any of the markets mentioned can, in simple terms, require a generator set to operate in one of three basic operation modes:

- Standalone: generator set with load only
- Paralleling: load share (island mode)
- Paralleling: load govern (utility parallel)

In any of these operating modes (within any of these marketplaces), a Cummins Power Generation product can be expected to perform in accordance with highly specific exacting performance requirements, which in the context of industrial power generation are the following performance parameters:

- Steady-state load frequency stability
- Steady-state load voltage stability
- Frequency recovery following load acceptance or rejection
- Voltage recovery following load acceptance or rejection
- Control power factor

The exact performance requirements in question can be satisfied via the gains tuning process in any of the operation modes listed above. This process involves making appropriate modifications to certain algorithmic parameters to produce a desired level of performance.

The gains tuning process is loosely common to all control systems, and should be applied to each of the following algorithms (contained within the relevant device), according to the following sequence:

1. Prime mover: This is the first entity that must be tuned regardless of the operation mode. The prime mover is responsible for providing the mechanical energy (in Hz or RPMs) that is fundamental to the output of the generator set.

2. Generator set AVR: These parameters are always relevant to maintaining stable voltage output from the generator set (specifically the alternator). The AVR must be tuned regardless of the operation mode. In the load govern environment, it must be tuned at least once. Due to the complexities associated with load govern applications, the AVR gains may need to be retuned on an application and site-specific basis.

3. Paralleling parameters: Paralleling parameters can be broken down into two categories.

- Load share: These parameters are only applicable in load share applications and are to be adjusted to suit an appropriate customer order.
- Load govern: These parameters are only applicable in load govern applications and are to be adjusted to suit an appropriate customer order. In addition, some amount of re-adjusting of the generator set AVR gains are required to accommodate customer requirements adequately during standalone and load govern operation.

The default gains parameters present in every controller shouldn't be regarded as a one-size-fits-all set of numbers. Rather, they should be treated as a set of adjustable performance parameters that when used properly can cause a generator set to demonstrate maximum performance per the factors listed above.

The gains tuning process involves appropriately and progressively setting specific parameters including proportional, integral, derivative, damping, and volts per hertz roll-off terms within the appropriate controller subject to the sequence above, in order to achieve a desired level of performance from the generating set.

Of course to perform gains tuning for every single generator set may be impractical, even though it may be worth considering on any of the following bases, subject to a strong enough business case:

- A case-by-case application basis
- A case-by-case customer basis
- A case-by-case paralleling project basis
- Any mixture of the above

Customers need not know that gains tuning has been performed, though some will have clearly defined performance requirements.

Therefore, it is essential to demonstrate a quality offering through the following:

- Demonstrating the technical expertise needed to show that products can outperform rival offerings in both standalone and parallel marketplaces
- Bidding for standalone and paralleling projects on the basis of being able to advertise industry-leading performance for these applications

## Viridor

In 2007, Viridor Ltd., a waste management company based out of the United Kingdom, reported generator set performance issues related to overvoltage trips and kVAr swapping. The problems were reported for both of the HHP QSV gas generator sets at a site in near Exeter, UK.

The application in question is a utility parallel load govern application whereby the customer was getting paid for delivering power to a local utility company. This issue was raised as an ESB PIR, and given high priority by virtue of the severity of the reported issues, which were repeating, as opposed to simple one-off Viridor are certainly a very important customer to Cummins Power Generation.

The customer reported repeated occurrences of overvoltage trips and kVAr swapping. In response, we initiated an ESB PIR meeting to review the issue. The team formulated a theory as to the cause of the reported serious overvoltage tripping and kVAr instability: It seemed gains tuning (in stand-alone and parallel operation mode) had not been undertaken.

The customer presented a wealth of reliable data, obtained via SCADA equipment, demonstrating the extent of the overvoltage generator set circuit breaker tripping and kVAr swapping. The team subsequently travelled to the Viridor site to test the hypothesis that gains tuning had not been performed, and that this was causing the overvoltage trips and kVAr swapping.

We observed kVAr swapping and reviewed the customer's SCADA evidence for the overvoltage breaker trips. Our observations reinforced the hypothesis. The author and site team corrected the issue described in accordance with the process described generally in this paper.



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## About the author

Ian Skeels graduated from London South Bank University with a Bachelor of Engineering Degree in 2002. He has worked for Cummins Power Generation for more than four years in

commercial generator set controls product support for the Cummins Power Generation, Manston, Ramsgate, Kent aftermarket, distributors, and end-users.

## Aggreko

In 2007, Aggreko, based out of Glasgow, Scotland, reported problems similar to those experienced by Viridor at its Dar-es-Salaam, Tanzania site. This utility parallel site has multiple QSK60 HHP gas generator sets. The customer presented quantitative evidence indicating similar kVA<sub>r</sub> swapping and overvoltage trips. As was the case with Viridor, there was compelling evidence that gains tuning hadn't been performed to an adequate level of voltage stability.

We travelled to the customer site in question and subsequently re-tuned the entire site (including 44 generator sets) to permit both steady-state load frequency stability and steady-state load voltage stability.

## Cummins UK

In May of 2009, Cummins UK visited Cummins Power Generation, in Manston, Ramsgate, Kent regarding a hospital application in Northern Ireland. The hospital was interested in purchasing multiple diesel QSK60 generator sets and associated value-added equipment, for a prime power application. The requirements stated voltage and frequency recovery time subject to specific load acceptance/rejection conditions.

In this case, Cummins Power Generation was able to use prior experience with Aggreko and Viridor to take a proactive approach to meeting the customer's needs. The team determined that gains tuning could assist in achieving the voltage and recovery times to both the prime mover and the AVR. The team undertook the project to prove that Cummins Power Generation is capable of industry-leading performance against exacting customer requirements that exceed ISO8528 specifications.

The team was able to garner maximum performance from the QSK60 generator set and was able to demonstrate that the product could meet the hospital's needs. As a result, the hospital chose Cummins Power Generation's solution.

## Conclusions

- Gains tuning results in maximized generator set performance.
- The gains tuning process is expected to become more and more relevant to the implementation of premium paralleling solutions.
- Cummins Power Generation has made a commitment to refining and mastering processes for the following areas:
  - Voltage dip/overshoot and recovery during load acceptance/rejection.
  - Implementation of gains tuning in specific standalone and paralleling applications in order to provide additional in-depth analysis and world-class end products.
  - Informing and educating our distribution network to identify applications that would benefit from this capability, enabling them to provide power solutions which satisfy the requirements of applications with the most stringent load acceptance/rejection criteria.

For additional technical support, please contact your local Cummins Power Generation distributor. To locate your distributor, visit [www.cumminspower.com](http://www.cumminspower.com).



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