UPS Behavior Under Grid Disturbances: Technical Implementation of FRT Functions in the Galaxy V Series

Flemming Johansen
Senior Principal Architect,
Schneider Electric

Schneider Electric

Executive summary

The rise of new grid-stability requirements from global TSOs now demands that large electrical loads—especially data centers— maintain connection and recover rapidly during voltage and frequency disturbances, shifting expectations for UPS behavior.

Schneider Electric is updating the Galaxy V series with enhanced Fault-Ride-Through capabilities including expanded voltage and frequency ride-through ranges, rapid post-fault active power recovery, and support for ROCOF tolerances to meet emerging standards. While regulations are still evolving, these firmware enhancements position the Galaxy V series to align with the most advanced proposed grid-code requirements and ensure grid-friendly operation across diverse regions.

Background

To ensure system wide stability of the grid, there is a need for large loads to behave in a “grid friendly” manner in the face of typical transmission and distribution disturbances. While disturbances are not frequent, the impact of even short duration voltage and frequency disturbances can cause grid stability if the pre and post disturbance power flow on the network is dramatically different. Because data centers can represent a large percentage of loads on a grid, it has become important to require load profile behavior of data centers in the presence of these grid disturbances.

Historically it was acceptable for a data centers to disconnect from the grid and power its local loads from UPS and/or Generator starting with the onset of a disturbance and not restoring to the grid for seconds or minutes post event. The behavior can be problematic if several large load data centers are concentrated and leaves the grid prone to stability concerns even for small duration faults causing pre and post fault power to be vastly different for seconds or minutes.

Transmission System Operators (TSOs) around the world has released proposals of expected fault-ride-through behavior for large electrical loads, including data centers. As the main part of the load in a data center is protected by UPS, these requirements are passed on to the UPS. These proposals are quite new, and the current version of the Galaxy V products will have to be updated to meet the requirements. The description in this document explains the functionality that will be added in upcoming firmware releases for the products.

Galaxy V series behavior

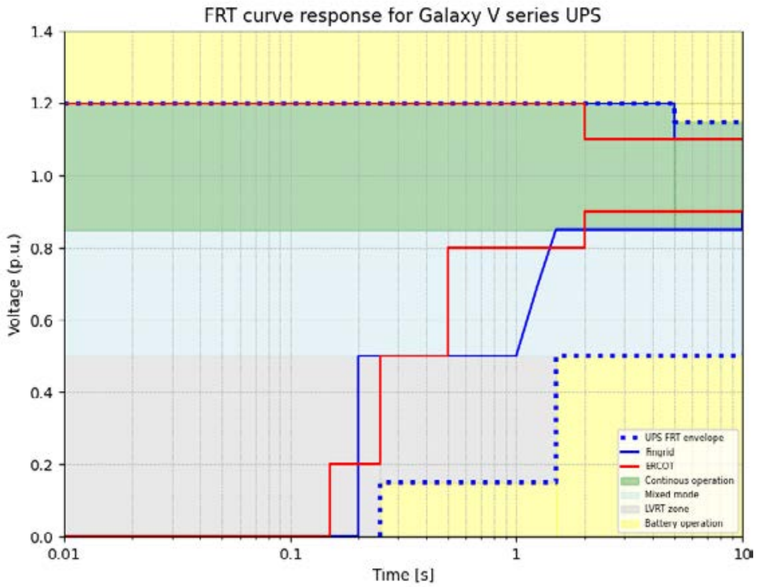
The voltage ride-through behavior is limited in the UPS by different factors, where LVRT primarily is limited by functionality in the controls, like synchronization to grid, the HVRT is primarily limited by the hardware of the product, like the ratings on IGBT’s and DC capacitors. The Galaxy V series UPSs family consist of different models, developed at different times, and do not have the same hardware, so there will be variations on performance between products to the description below.

The Galaxy V series UPS can operate in different modes, but in order to meet the FRT requirements, the UPS must operate in normal operation, (dual conversion mode). In eConversion mode, the UPS will transfer fully to battery operation mode when the voltage falls outside the +/- 10% tolerance window, and transfer back to grid (dual conversion mode) using the default ramp in time, when the grid is within tolerance again. These limits and the behavior are not following the FRT requirements.

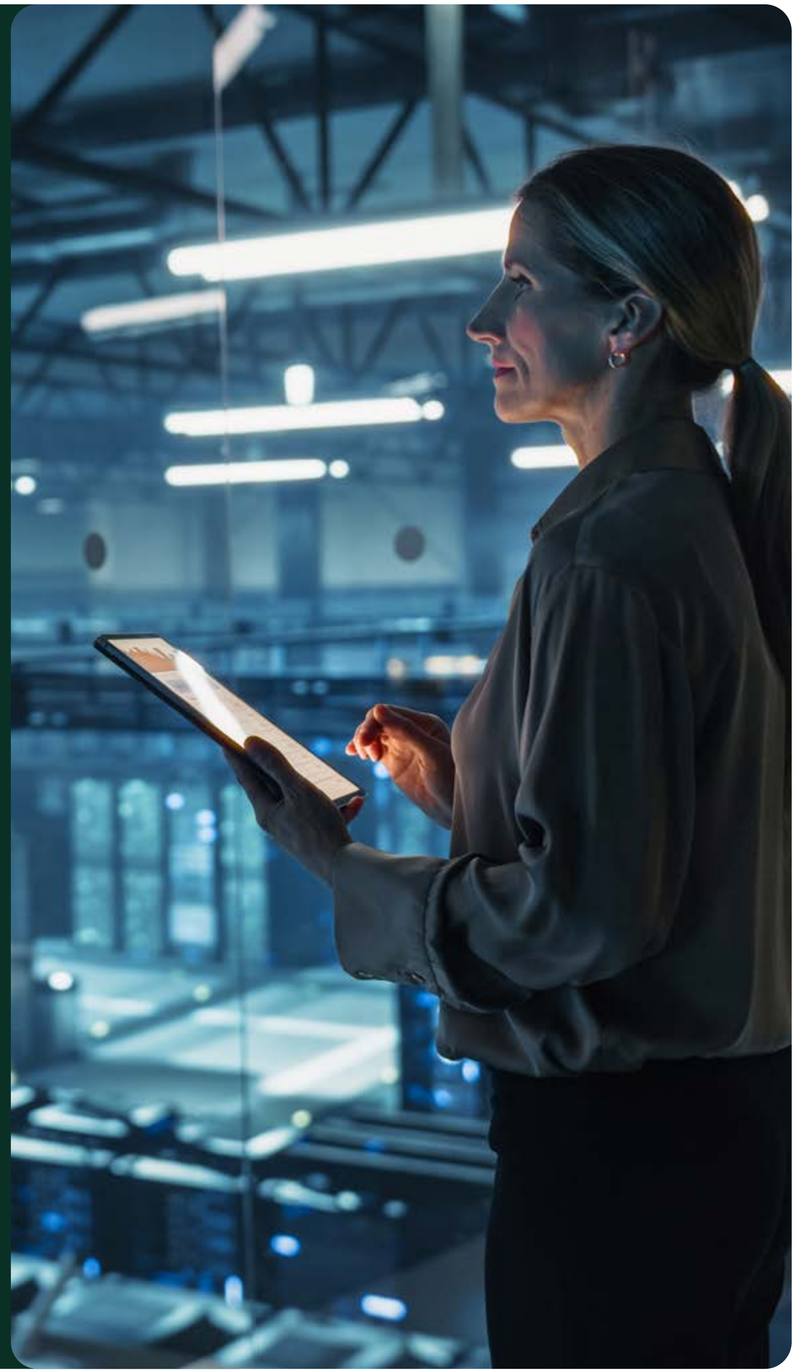
FRT requirements

The FRT proposals from TSOs are covering both voltage ride-through and frequency ridethrough behavior requirements. In the following the 5 main requirements are explained.

For voltage-ride-through the capabilities are shown in figure 1.



Area	Voltage limits	Behavior
Green area Continuous operation	1.15pu < V < 1.20pu	UPS operates in normal operation for minimum 5 seconds, taking all power from grid Note: GVX will support 1.25pu up to 60s.
	0.85pu < V < 1.15pu	UPS operates in normal operation continuously, taking all power from grid
Light blue area Mixed mode	0.5pu < V < 0.85	UPS operates in a mixed mode where power is taken from both grid and battery. This mode is time limited to minimum 60 seconds.
Grey area LVRT zone	0.15pu < V < 0.5pu	UPS operates in battery mode, taking all power from battery, but it does not switch the UPS mode to battery operation but will show normal operation, and will recover fast if the voltage exits this area within 1.5s
	0pu < V < 0.15pu	In this range the time limit is decreased to 250ms
Yellow area Battery operation		In this area the UPS transfers fully to battery operation and awaits a stable grid for 1 second, before transitioning back to grid operation, using the standard ramp-in function. (10 seconds as default). This is the same behavior as the current implementation.



HVRT: High Voltage Ride through

HVRT is considering voltage swells. The Galaxy V series can withstand 1.2pu for at least 5 seconds, without transferring to battery operation. Some products can perform better, like the GVX as example, has a wider range and can do 1.25pu for 60 seconds. The GVXL series will have an upper limitation of 1.15pu, if configured for 415V nominal voltage.

LVRT: Low Voltage Ride Through

The large electrical loads are not allowed to disconnect due to short disturbances on the grid, like short voltage sags. It is acceptable for the load to be temporarily reduced and limit the input current, to avoid tripping up-stream overcurrent detection, but the UPS must return to normal operation if voltage is restored again (to the green region) with a certain timeframe, e.g. 150ms if voltage was below 0.5 pu, as stated by ERCOT
as shown on the graph.

PFAPR: Post Fault Active Power Recovery

The large electrical loads must reconnect fast again after a short grid disruption. This is historically not how UPSs have been designed to operate. Most UPSs operate under the principle of, once disconnected, they remain on battery until a stable grid has returned, before it slowly ramps in again. The requirement is now to reconnect to grid, resume normal operation and reestablish pre-fault conditions.

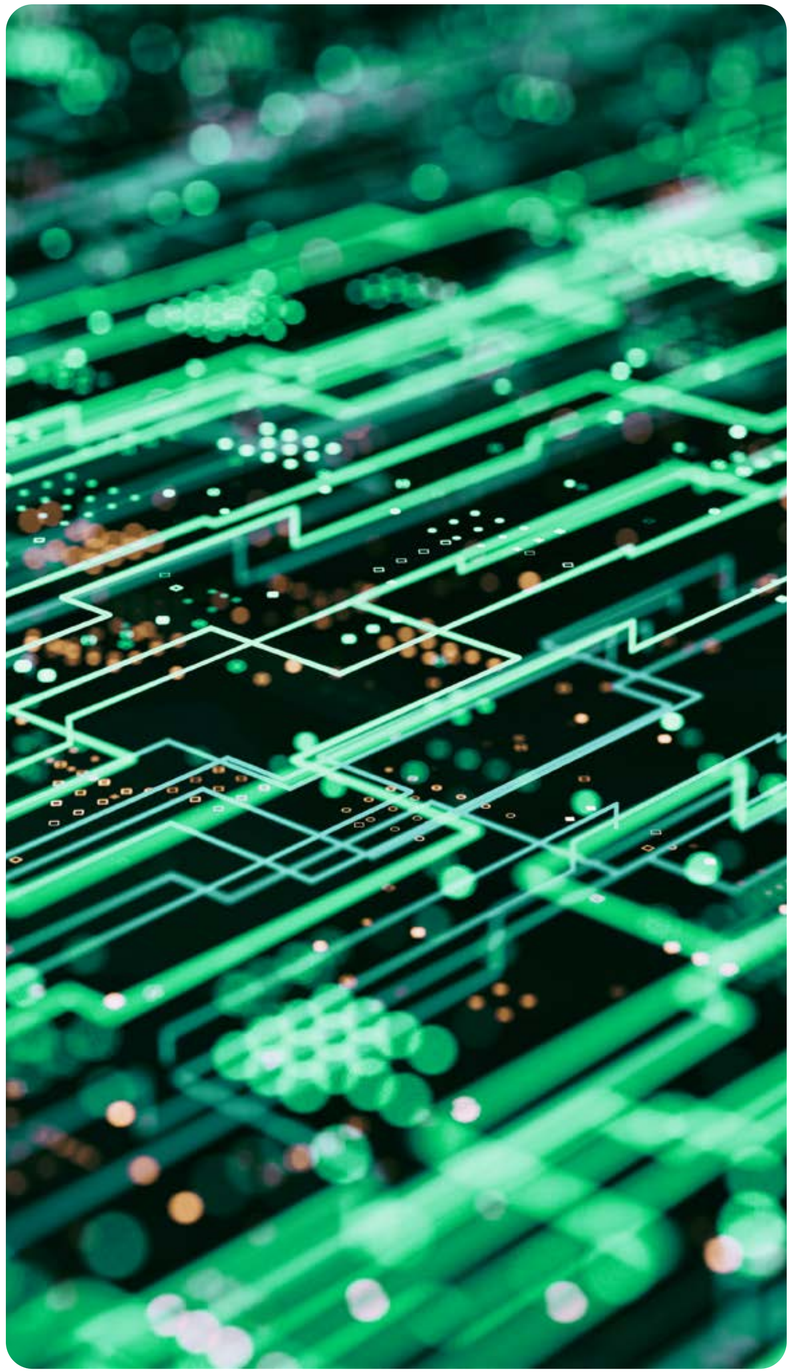
The definition of this is when the voltage reaches 0.9pu, the power from grid must resume 90% within a certain time limit, spanning from 0.3 seconds to 5 seconds depending on TSO. The Galaxy V series UPS can resume power within the 0.3 seconds and to meet all known TSO requirements at this stage.

Frequency window

The frequency window where UPS can operate is wider than the grid requirements, as the UPS is designed to work on generators which in nature has lager frequency window, and faster ROCOF. Galaxy V series has a window on 40Hz-70Hz which covers all known TSO specifications.

ROCOF

The rate of change of frequency is specified from different TSOs, historically 1Hz/s, but now ranging from 2Hz/s to 5Hz/s, which is within the capabilities of the Galaxy V series UPS.



Summary

As the requirements for fault-ride-through are quite new to the demand side grid codes, the current version of the Galaxy V series cannot meet the requirements. They will be updated to include the functionality descried in this document, which will meet the requirements from TSOs like ERCOT in US and the proposed requirements from Fingrid and Eirgrid in Europe. The description is a general behavior description of the Galaxy V series, and there can be variations between different product families.

The regulatory is evolving and not harmonized as this point, and many TSOs have proposals out on their perspective of behavior for large electrical loads. Waiting till all are settled and becoming regulatory before acting is not a suitable approach, and it must be addressed now. With the updates described in this document, the Galaxy V series is taking a great step in the right direction. The modifications do not meet all known proposed requirements at this stage, but they are covering what is believed to becoming industry standard. Schneider Electric will keep following the changes to the different proposals closely and adapt accordingly to the TSO specific requirement curves when they solidify and become a standard.

Schneider Electric

Author

Flemming Johansen
Senior Principal Architect
Schneider Electric