Battery Charging in AC Coupled Grid Connected Battery Systems

Introduction

The advent of Grid Connected Battery (GCB) systems in Australia has led to increased interest in coupling GCB systems with existing or new solar PV system to increase energy self-sufficiency. GCB systems can be connected to a PV system as a DC coupled system, where the PV array is connected through a charge controller directly to batteries, or as an AC coupled system, where the battery and the PV system are interconnected via their respective inverters. The latter configuration is especially popular to be retrofitted, because AC coupled systems require minimal reconfiguration of the pre-existing PV array and grid-connect inverter.

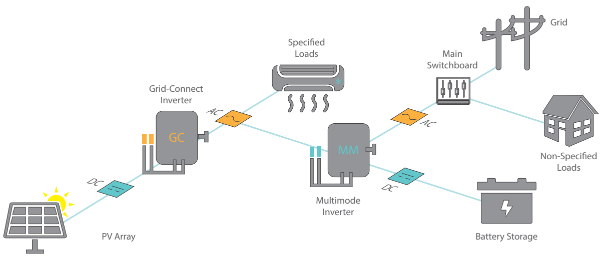

Figure 1 - An example of an AC coupled GCB system (GSES Configuration 5)

GCB systems need to be designed carefully to ensure that the battery bank is charged safely and reliably under all circumstances, as overcharging the battery bank can produce devastating consequences.

One issue identified is the possibility of the grid-connected PV system overcharging the battery bank in grid outage conditions when the GCB system and PV system are configured in a particular way. In this configuration, the PV generation is first delivered from the grid-connect (GC) inverter to the specified loads, and thereafter to the multimode inverter to charge the battery bank, with any excess power exported to the grid. GSES refers to this configuration as GSES Configuration 5 in its publications and course material.

More information on DC and AC coupled system and the possible configurations are available in GSES' article, Configuring Battery Storage Products - Comparing Apples and Oranges?

Potential to overcharge battery during grid outage

In AC coupled GCB systems, the GC inverter is designed to deliver the maximum power from the PV array. Under normal circumstances, this power is used to supply the specified load, charge the battery bank, or be exported to the grid, in order of priority.

When there is a grid outage, typically the GC inverter would turn off as a result of its anti-islanding settings. However, in this configuration, the GC inverter will continue to work due to the voltage and frequency reference signal provided by the multimode inverter. This means that, if the sun is shining, the GC inverter will continue to try and deliver maximum power from the PV array.

The power input from the GC inverter would not be an issue if the specified loads are drawing power, or if the battery is low on charge. However, when there is no demand, and when the excess power cannot be exported to the grid due to the grid outage, the power from the GC inverter has the potential to be fed through the multimode inverter and to overcharge the battery bank.

There needs to be a way to control the GC inverter to prevent overcharging the battery bank in this scenario. This article explores the various mechanisms that can be adopted to safely charge the battery bank in an AC coupled system.

Strategies for safe battery charging on AC coupled systems

In all GCB systems, there are requirements for safe and reliable operation while charging the battery bank from any source, as overcharging the battery bank can lead to potential fires and catastrophic failures resulting in damage to both the equipment as well as to personnel.

Various strategies exist to mitigate the risks of overcharging the battery bank during a grid outage condition as presented in an AC coupled GCB system. Some of these strategies are described below:

- **Communications between inverters:** This method of controlling the GC inverter relies on the ability of the multimode inverter to send a communications signal to the GC inverter and to request it to ramp up or down depending on the state of charge of the battery bank.

  The communications can be based on either CAN bus, MOD bus or any other protocol. However, this type of control mechanism relies on the ability of the GC inverter and multimode inverter to communicate with each other. This means that this control method may not be an option for a retrofit system if the pre-existing GC inverter does not have this function.

  This method of control is usually referred as managed or controlled AC coupling setup.

- **Using a voltage controlled relay:** Some manufacturers recommend the use of a voltage controlled relay to shut down the GC inverter when the battery bank reaches a voltage set point of charging. This technique prevents the excess solar PV energy from being fed into the battery bank.

  Retrofitting of existing GC systems with the combination of multimode mode inverter and battery storage can be achieved using this technique. This methodology will work regardless of whether the GC inverter and the multimode inverter communicate with each other.

- **Using diversion loads or dump loads:** Diversion loads or dump loads can be used to divert the excess PV energy during a grid outage. Examples of some of these dump loads are pool pump and water heating/cooling systems.

  Care must be taken to ensure enough redundant diversion or dump loads are always present to ensure that the battery bank is not overcharged under any circumstances.

- **Frequency shifting technique:** Some models of GC inverter have the ability to linearly reduce its output power based on the frequency signal set by the multimode inverter. This feature of the GC inverter is known as frequency shift power control.

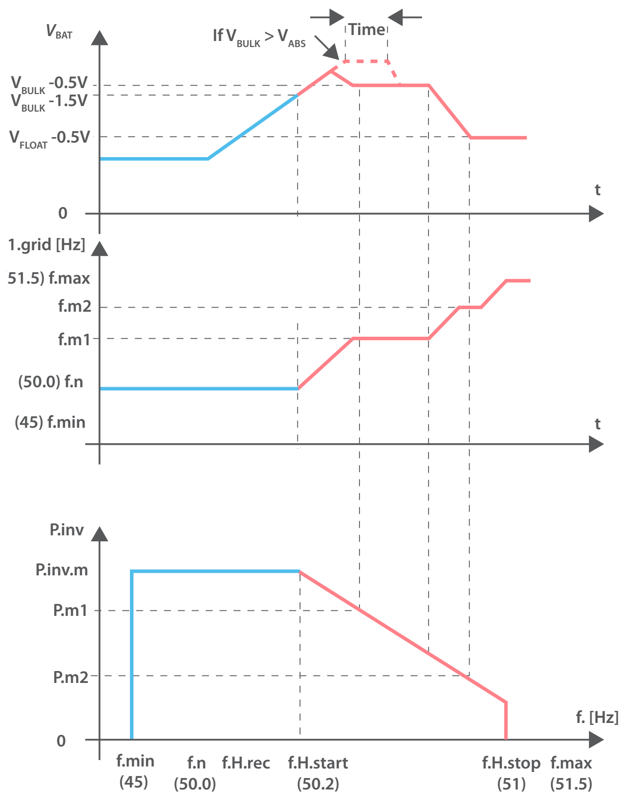

Figure 2 - Power reduction vs frequency graph

In an AC coupled system installed with a GC inverter and having the frequency shift function, the multimode inverter monitors the battery voltage and current. During the charging of the battery bank when the voltage or current approaches the desired set point for the bulk, absorption or float stages of battery charging, the multimode inverter will start to increase the frequency and thereby command the GC inverter to reduce it power output (Fig. 2).

If the battery bank is fully charged, the multimode inverter will set the frequency such that the GC inverter trips on high frequency condition and does not overcharge the battery bank.

Conclusion

The danger of overcharging battery banks is very real and cannot be overlooked. A control method must be in place to ensure safe and reliable charging of the battery bank. Some manufacturers of multimode inverters have offered ways to address the risk of overcharging batteries. System designers should always refer to the manufacturer's instructions in relation to safety and product warranties before implementing any of the above techniques.

The different GCB system configurations and respective protection requirements are covered in detail in the GSES Grid Connected PV System with Battery Storage course.

GSES welcomes feedback on technical papers and other resources available on www.gses.com.au, please contact GSES by email at info@gses.com.au or by telephone on 1300 265 525.