IQ System Controller 2 and 3G – Electronic hardware interlock between the generator and the utility grid

Contents

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Introduction

The IQ System Controller is a smart switch connecting the grid and other distributed energy resources (DER). The IQ System Controller 2 and 3G allow a standby generator to be connected at the generator port. The correct method for using backup generators in parallel with batteries and solar is covered in the Generator integration with the Enphase Energy System technical brief.
The IQ System Controller ensures that the generator and utility grid are not connected simultaneously. The IQ System Controller creates an electronic hardware interlock between the generator and the grid. This functionality is achieved by having two relays, one connected on the grid side (MID) and the other on the generator side (GID).

A microgrid interconnect device (MID) automatically detects and seamlessly transitions the home energy system from grid power to backup power in the event of a grid failure.

MID comprises a 200 A latching relay with two states:

- Open: open when a microgrid is formed.
- Close: close is for grid-tied operation.

The generator interconnect device (GID) comprises an 80 A latching relay, which is used to isolate the generator power from the grid and load on the detection of grid power.

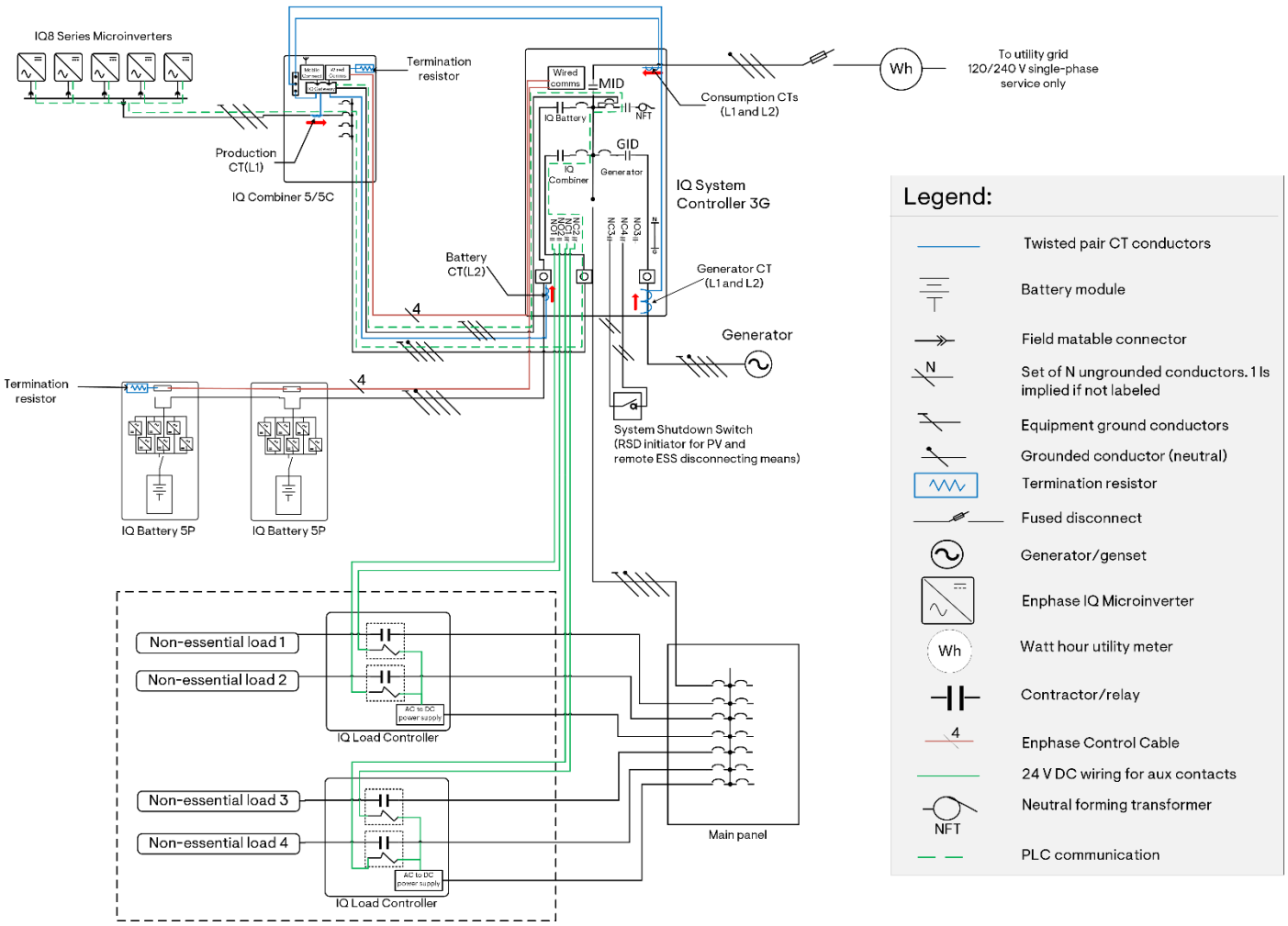

Figure 1: *Whole home backup configuration with IQ Battery 5P, IQ System Controller, and generator*

Logical circuit for interlock

The states of MID and GID are enforced in hardware to work mutually exclusively; that is, closing the MID forces the GID to open, and opening the MID permits the GID to close. Relay drivers drive the states for MID and GID relays to ensure the system performs as expected.

Both relays are continuously sensed to know the actual state. System behavior is not compromised, even in the event of a fault with any relay.

The logical circuit for interlock in Figure 2 shows:

- The MID relay opens when either Disengage _mains or Engage_generator is true.
- The MID relay closes only when Engage_mains is true.
- The GID relay opens when either Engage_mains or Disengage_generator is true.
- The GID relay closes only when Engage_generator is true.

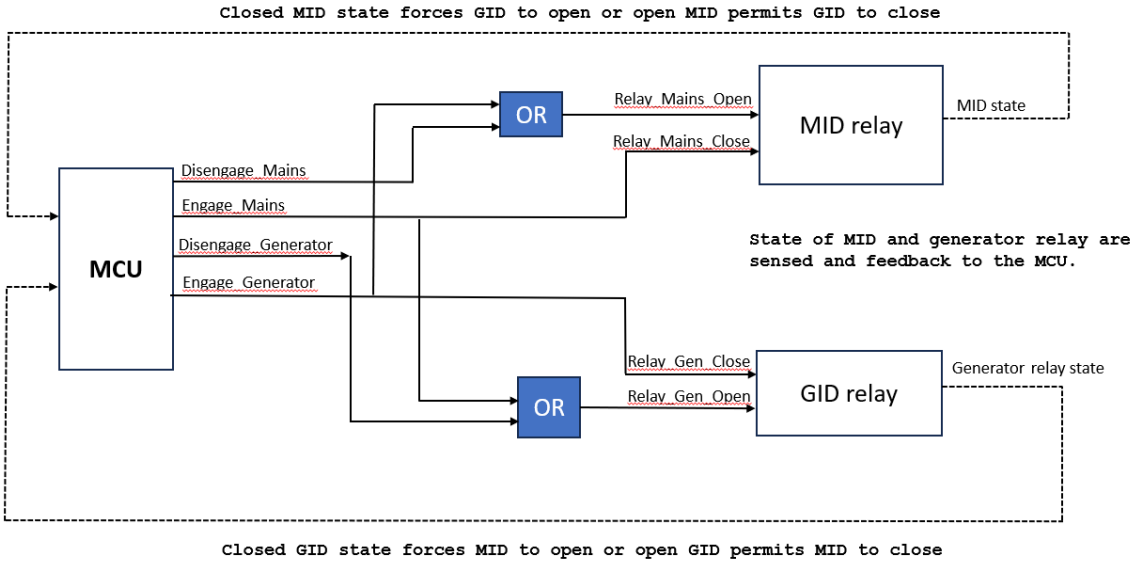

Figure 2: *Logical implementation of MID and GID relay interlocking*

Normal operation

The transition between the grid-tied state and the off-grid state of the system depends upon the MID and GID states. Table 1 specifies the MID and GID driver input to drive the MID and GID relay.

- Grid-tied state: When the system is tied to the grid, Relay_Mains_Close is true, driving Relay_Gen_Open also to be true. It is resulting in MID to close while GID opens up.

- Off-grid state: Microgrid sources are functional without grid power but with a generator. Relay_Mains_Open is true, driving Relay_Gen_Close to be true. It is resulting in MID to be open while GID closes.

To summarize, MID and GID are electronically interlocked to ensure that both relays cannot close simultaneously during the transition from off-grid to on-grid or vice versa.

Table 1: *Logical truth table for generator and mains relay during normal operation*

States	MCU output	Relay_Mains_Close	Relay_Mains_Open	Relay_Gen_Close	Relay_Gen_Open	Output
Grid-tied state	Engage_Mains	Y	N	N	Y	MID close GID open
Off-grid state	Engage_gen	N	Y	Y	N	GID close MID open

Failure mode handling

- MID is stuck in an open state: MID is faulty and stuck in an open state; that is, the transition to the grid is non-functional. GID remains open and is not permitted to be closed.

- MID is stuck in a close state: MID is faulty and stuck at a closed state that is tied with the grid; hardware interlocking does not allow the GID to close.

- GID is stuck in an open state: GID is faulty and stuck in an open state; MID is not permitted to be closed.

- GID is stuck in a close state: When GID is faulty and stuck at a closed state, that is, the generator is operational, and hardware interlocking does not allow the MID to close.

Table 2: *Failure mode handling*

States	Relay_Mains_Close	Relay_Mains_Open	Relay_Gen_Close	Relay_Gen_Open	Output
MID in a stuck open state	N	Y	N	N	MID opens
MID in a stuck close state	Y	N	N	Y	MID closes with GID open
GID in a stuck open state	Y	N	N	Y	GID open with MID close
GID in a stuck close state	N	N	Y	N	GID closed with MID open MID remains open
MCU fault	Y	N	Y	N	No change in MID and GID states from the last state
MCU fault	N	Y	N	Y	No change in MID and GID states from the last state

Conclusion

Based on the logical circuit for transition between grid-tied to off-grid state, MID and GID never close at the same instance. Apart from normal operation, the IQ System Controller is well-equipped to handle faults with MID, GID, and MCU. All the listed failure cases are handled within the system controller to ensure MID and GID do not close simultaneously.

Revision history

Revision	Date	Description
TEB-00081-1.0	September 2023	Initial release