PV Curtailment White Paper

FRANKLINWH

Background

PV Curtailment and Frequency-Droop Control in the FranklinWH System

When operating off-grid, **PV curtailment** is necessary to match the battery's charging capacity and prevent overcharging from excess PV power. Previously, the FranklinWH system controlled the PV output using a relay-based on/off logic. While this provided a simplified way to manage excess PV, it sometimes resulted in the PV system going offline during peak production periods.

To address this, the FranklinWH system now leverages **inverter frequency-droop technology (Freq/Watt control)** to enhance PV utilization during outages in addition to the relay based logic. This approach aligns with the **IEEE 1547-2018** standard, specifically the requirements for **mandatory frequency tripping** and **frequency-droop (frequency-power) characteristics**.

In accordance with Clause 5.4.3 of IEEE Std 1547-2018, distributed energy resources (DERs) must support frequency-droop control, where the inverter reduces power output as voltage source frequency increases. This helps maintain the balance between power generation and load during off-grid operation.

Compliance with this functionality is verified through **UL 1741 SB**, which outlines the test procedures to ensure safe and effective system performance during outages. The FranklinWH system is certified to UL 1741 SA, SB, PCS and other necessary certifications which can be found our product datasheets here.

Frequency / Watt Control

Previously, the FranklinWH system primarily used relay-based logic for PV curtailment. In off-grid or outage scenarios, when PV generation exceeded the capacity of the connected batteries and home loads, there was no path to absorb the excess energy. To prevent overproduction and protect the system, the PV relay would open, disconnecting the PV array from the system—resulting in potential energy loss during that time period.

With the introduction of the **aPower 2**, we have transitioned to a **hybrid control mode** that combines traditional relay-based control with more advanced **Frequency-Watt (Freq/Watt)** regulation. This method dynamically adjusts PV output based on grid frequency, allowing for more efficient and flexible management of solar production during outages. It offers improved system reliability and enhances overall performance in backup mode.

For optimal performance, we recommend connecting up to **12 kW of AC-coupled PV** per aPower 2, and up to **7.6 kW of AC-coupled PV** per aPower X. These general guidelines are designed to ensure stable operation, especially during outages. However, larger PV systems can also be integrated using the FranklinWH platform.

If you're working with a larger PV system or need design support, feel free to contact us at engineering@franklinwh.com — FranklinWH is happy to help.

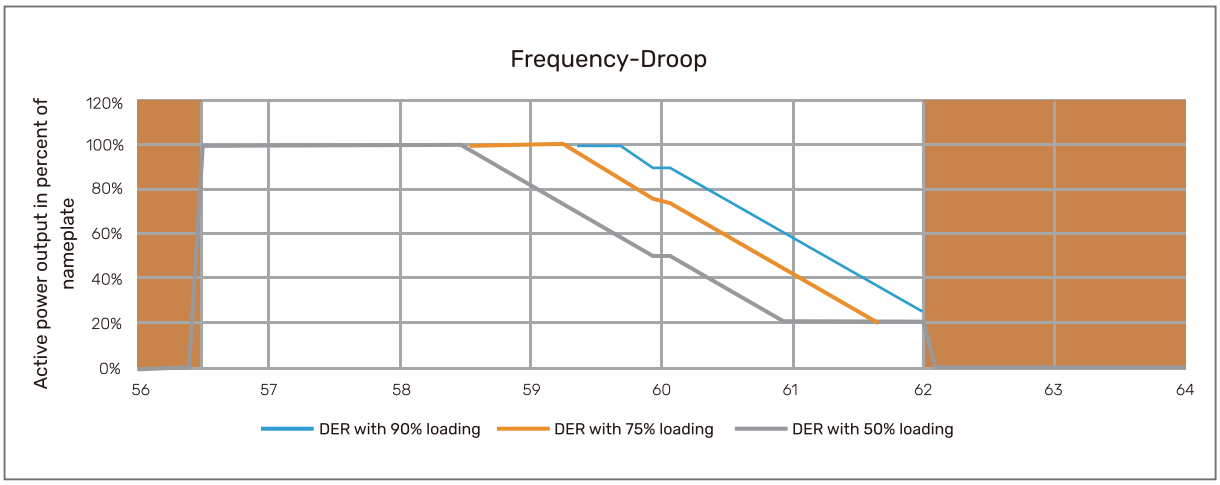
PV Generation Droop Control

PV generation can be curtailed through frequency-based controls which follow standard over-frequency trip settings:

1. Over-Frequency Trip 1 (OF1)
If the system frequency exceeds 61.2 Hz (default setting) for more than 300 seconds, PV generation will be immediately shut off.

Shall trip function	Default settings[a]		Ranges of allowable settings[b]	
	Frequency[c] (Hz)	Clearing time (s)	Frequency (Hz)	Clearing time (s)
OF2	62.0	0.16	61.8–66.0	0.16–1000.0
OF1	61.2	300.0	61.0–66.0	180.0–1000.0
UF1	58.5	300.0[c]	50.0–59.0	180.0–1000
UF2	56.5	0.16	50.0–57.0	0.16–1000

2. Over-Frequency Trip 2 (OF2)
If the frequency exceeds 62 Hz (default setting) for 0.16 seconds, PV generation will be immediately shut off.



PV Output Limiting via Frequency Droop

When the system frequency rises above 60 Hz + dbOF (default dbOF = 0.036 Hz, resulting in 60.036 Hz), the PV output is capped at the target power level. From this point, the output is dynamically adjusted up or down using a droop rate (kOF, default 0.05), which corresponds to approximately 33.33% of rated power per Hz.

The FranklinWH System further refines this control by applying a ramp rate of 0.2 Hz/second, equivalent to around 6.67% per second of rated PV power, to manage PV generation in line with battery charging capacity.

Full Battery Handling

When the aPower battery reaches full charge, the system frequency is increased to 62.2 Hz to completely curtail PV output. PV generation resumes once the battery's state of charge (SOC) drops below 97%.

aPower Charging Capacity

The FranklinWH system intelligently regulates PV power to align with the battery's charging capacity under normal conditions. Additionally, its peak charging feature allows the system to temporarily absorb sudden surges in PV power—such as those caused by significant load shedding—before the Freq/Watt control ramps the PV output down to a stable level, as shown in Table 1.

aPower Type	Charge Capacity	Recommended PV: ESS sizing	Peak Charge Capacity
aPower 2	8.0 kW	12 kW PV AC	13 kW (30 seconds)
aPower X	5.0 kW	7.6 kW PV AC	7.6 kW (30 minutes)

Table 1. aPower charge capacity list

FAQ

Q1: Do all PV inverters support Freq/Watt control?

A: No. Only PV inverters that are compliant with IEEE Std 1547-2018 can respond to Freq/Watt control logic. Please check your PV inverter datasheet for the list of certifications.

Q2: How much PV capacity (kW) can be connected to a single aPower 2?

A: From a PV-to-ESS sizing perspective, we recommend connecting up to 12 kW of AC-coupled PV to a single aPower 2, and up to 7.6 kW of AC-coupled PV to a single aPower X for optimal system performance especially during an outage. Additional PV can always be integrated into the FranklinWH system, as long as certain design considerations are properly addressed. Please consult our team at engineering@franklinwh.com.

Q3: Can PV be connected directly to the aGate without a PV relay or aPbox?

A: We do not recommend landing PV directly on the backup lugs of the aGate that does not utilize the PV breaker on the aGate or the aPbox. Please note PV can always be landed on non-backup lugs with split CTs however that PV will not be available during an outage. Connecting PV directly to the aGate without a relay may result in a 30-second power-off in your home under the following conditions:

a. During a grid outage with high PV output while the battery is at 100% SOC

b. In off-grid mode, when PV production exceeds charging capacity at low battery temperatures (e.g., in winter)

Q4: Can Freq/Watt control manage multiple PV inverters on the system?

A: Yes. As long as the inverters are compliant with IEEE Std 1547-2018, the FranklinWH System can control multiple PV inverters using Freq/Watt logic.

Q5: What happens if my PV inverter is not a smart inverter?

A: If the PV inverter is not a smart inverter, it won't respond to frequency droop control during off-grid operation. In such cases, the system will revert to relay-based control, toggling the PV connection on or off as needed.

Q6: Will Freq/Watt control affect my home's electrical loads during an outage?

A: No. The Freq/Watt feature does not impact thehousehold loads. Most appliances tolerate frequency variations up to 62.2 Hz without issue. However, some frequency-sensitive devices may behave abnormally in rare cases.

Q7: Does FranklinWH still use relay-based logic?

A: Yes. While Freq/Watt control is now integrated, relay-based logic remains active. The PV relay will still be triggered if PV output exceeds the aPower's charging capacity, regardless of frequency droop control.

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