Technical Note – Seamless Switching to Backup Mode

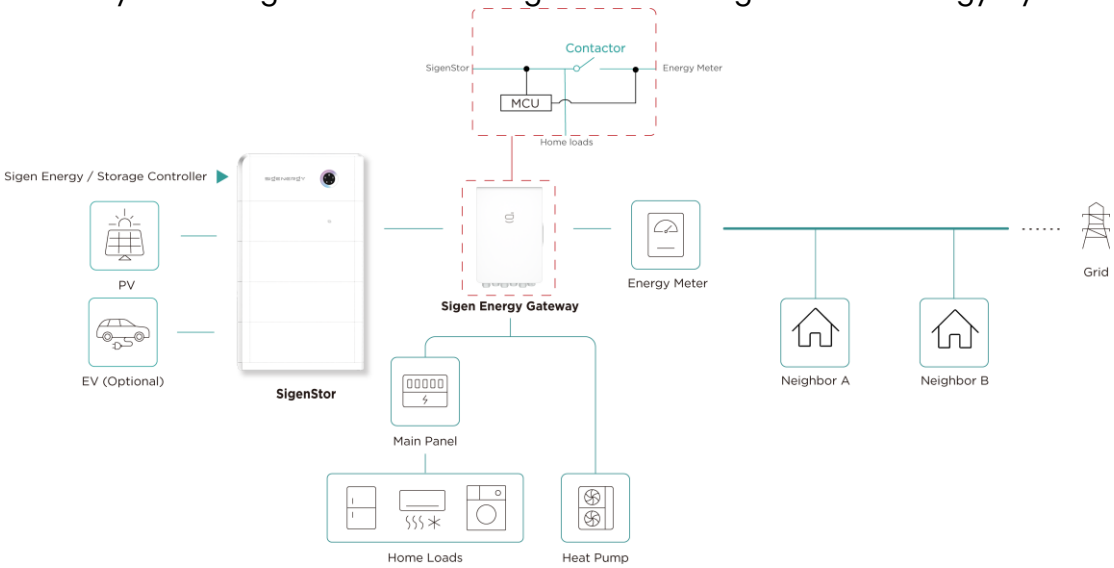
Revision History

Version 1.0, June 2024 – Initial release

Introduction

Backup mode is a mode of operation for the Sigenergy home energy system that uses a battery or batteries to provide backup energy in the event of grid failure. Sigen Energy Gateway can detect the off-grid state through grid voltage and frequency abnormalities, switch to backup energy, and disconnect the grid-side contactor with a conversion time of 0 ms (open circuit), which is at an industry-leading level in this sector.

This feature is only available when using both the SigenStor and Sigen Energy Gateway. Following is a network diagram of the Sigen Home Energy System:



As shown inside of Sigen Energy Gateway (red dashed box), sampling points (represented by black dots) on the power cables (represented by blues lines) which are connected to SigenStor and Energy Meter, detect line voltage and frequency information, which is transmitted to the MCU. MCU determines whether the circuit is normal and whether the contactor disconnects from the grid or not.

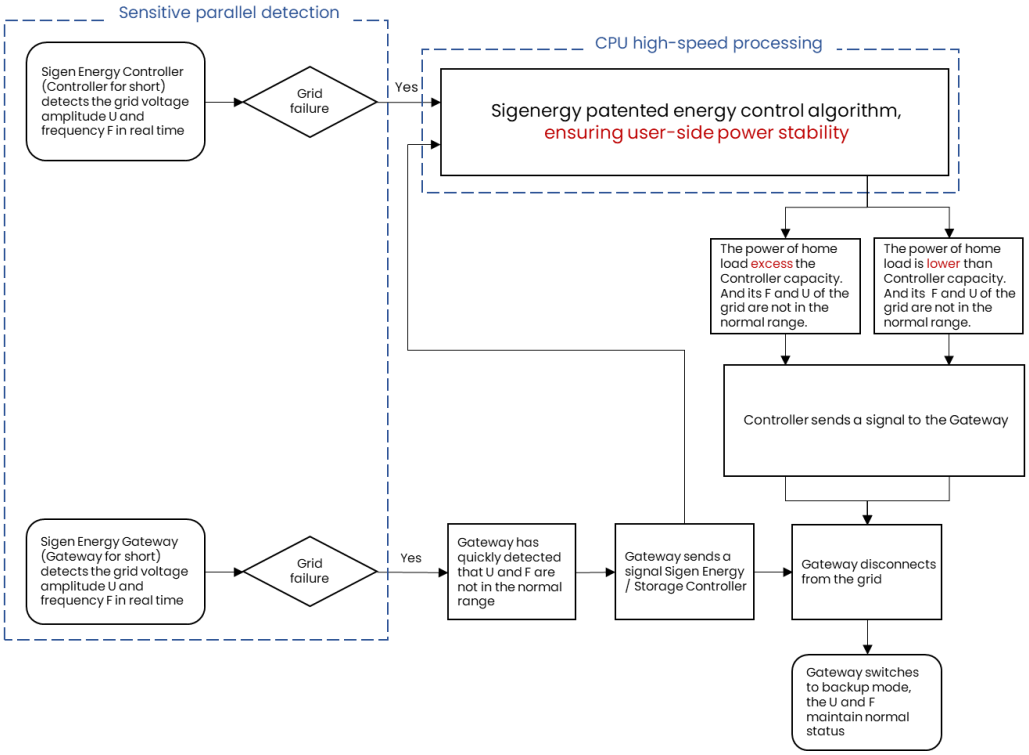
The contactor controls the grid-side energy input. If a power outage happens,

the contactor will be disconnected. As a result, the energy from the battery and PV side will be prevented from flowing into neighbors' energy systems or feeding into the grid which triggers the Islanding effect.

This document explains how the Sigenergy home energy system realizes quick switching to backup mode.

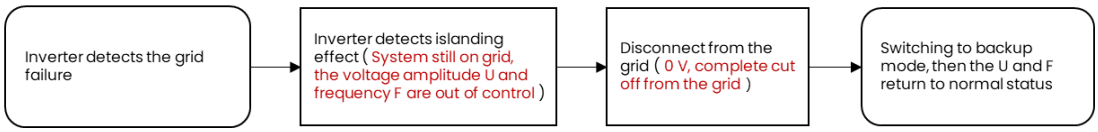
Technical Description

Sigenergy fast & accurate switching method



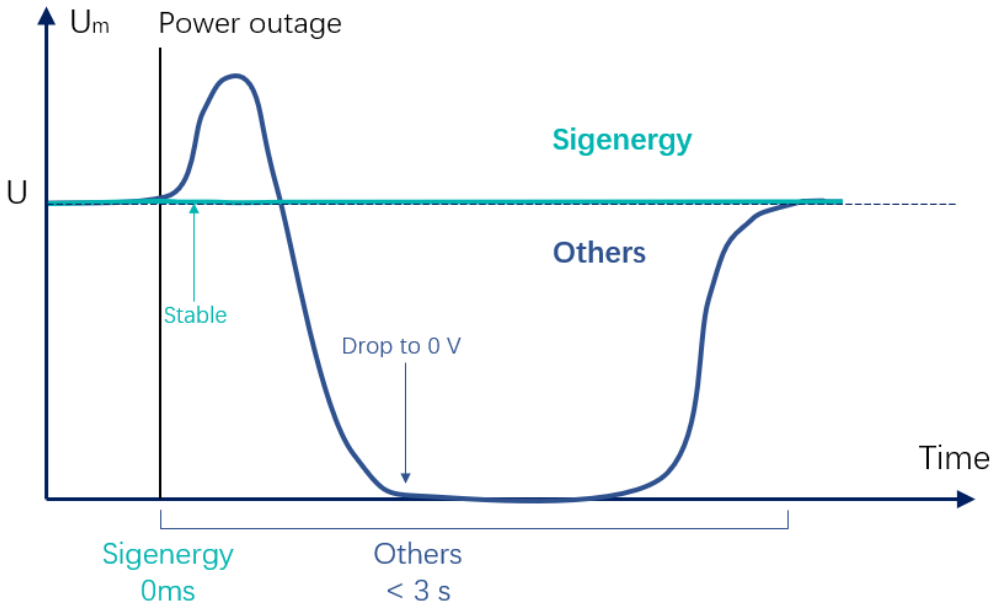
As Sigenergy new switching method shows above, Sigen Energy / Storage Controller can ensure user-side power stability when facing a power outage because of the excellent algorithm. At the same time, Sigen Energy Gateway can quickly switch to backup mode and disconnect the grid-side contactor. According to our laboratory testing, it takes close to 0ms to return to normal status, and the voltage has slight fluctuations, which means that home loads will not experience a power outage.

Others switching method

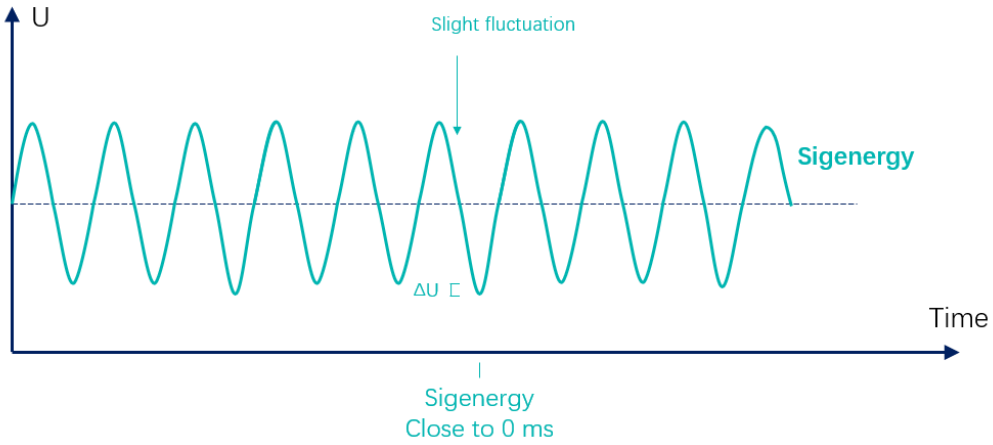


For other switching methods, when the inverter detects a grid failure, the system disconnects completely from the grid at first and then switches to backup mode, not involving the process of power stabilization. As a result, large voltage fluctuation brings the energy system shut down. It is claimed by other vendors that the switchover time is less than 3 seconds, which means that the homeowners will have to restart their home loads.

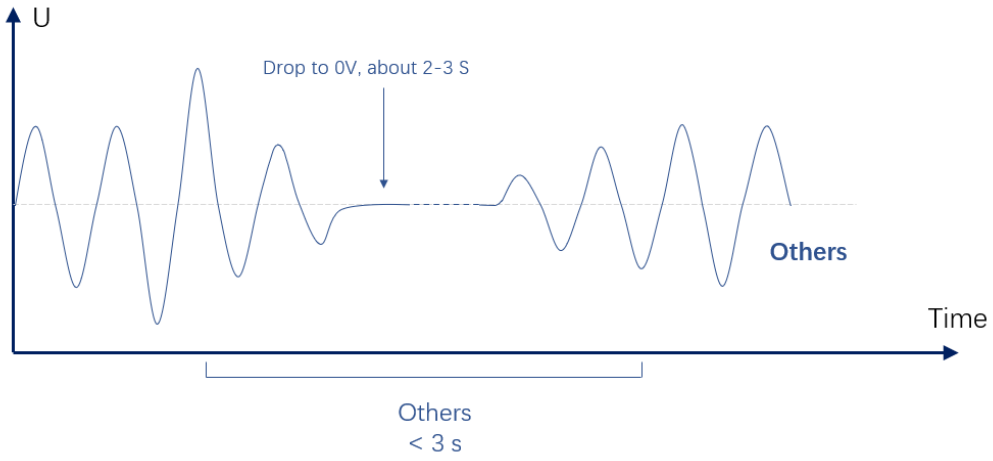
These diagrams show the different performance between Sigenergy and other home energy solutions when you suffer a power outage:



This axis shows a comparison of the peak voltage Um between Sigenergy and others' home energy solutions in the event of a power outage; Sigenergy peak voltage fluctuates slightly, close to 0ms. While others' peak voltage fluctuates greatly as the entire system shuts down and restarts, taking about 3 seconds.
The figure below shows a more detailed comparison of the AC waveform graphs. The voltage U and frequency F of the Sigenergy have a slight fluctuation and are almost hard to detect.



While the AC waveform graph of others shows very huge fluctuations in both voltage U and frequency F. The voltage plunges to 0V and the system completely shuts down for 2-3 Seconds before restarting and returning to normal.



Power Terminology

Backup
A mode of operation for the solar inverter that uses a battery or batteries to provide backup energy in the event of grid failure.

Off-grid
A type of solar PV system that runs independently from the utility grid. Off-grid systems feature enough solar panels and battery storage to generate sufficient energy onsite, without access to utility-generated electricity.

Islanding Effect
Islanding is a critical and unsafe condition in which a distributed generator, such as a solar system, continues to supply power to the grid while the electric utility is down. Islanding causes many problems, like safety concerns, damage to customers' appliances, and inverter damage.

Islanding detection time
As per the IEEE 1547 distributed generation interconnection standards, the islanding will be identified in 2 seconds and the distributed generation must be turned off.

Sigen Energy/ Storage Controller
The first part of SigenStor, the built-in PCS, inverter, and EMS can realize energy management of the solar + energy storage system / AC-coupled energy storage system.

Active Power (P)

It represents useful power consumed by loads to perform real work, that is, to convert electric energy to other forms of energy. Real work performed by an incandescent light bulb is to convert electric energy into light and heat. Active power is the rate at which energy is consumed, dissipated, or consumed by the load, and is measured in units of watts (W). P can be computed by averaging the product of the instantaneous voltage and current, that is,

$$P = \frac{1}{T}\int_0^T v(t)i(t)dt.$$

Reactive power (Q)

The power consumed in an AC circuit does not perform any useful work but has a big effect on the phase shift between the voltage and current waveforms. Reactive power is linked to the reactance produced by inductors and capacitors and counteracts the effects of real power. Reactive power does not exist in DC circuits.

Reactive Power $Q = I^2X = V*I*\sin(\Phi)$ volt-amperes reactive, (VAr's)

MCU

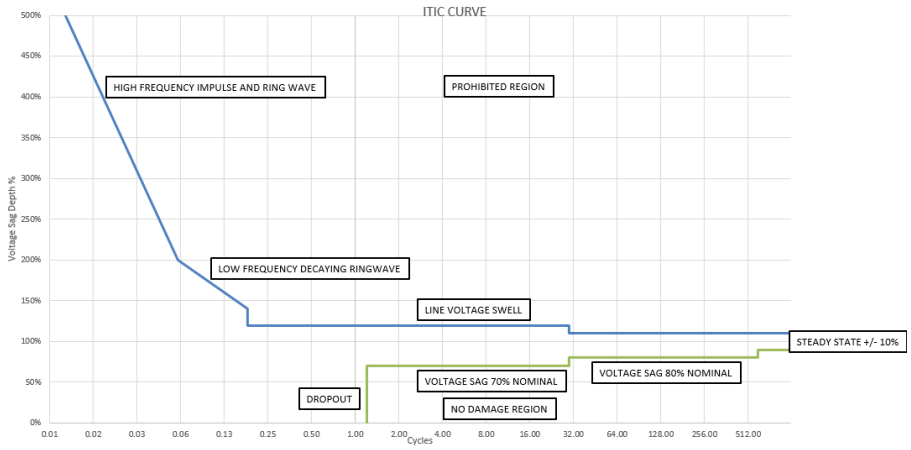
An MCU (Microcontroller Unit) is an intelligent semiconductor IC that consists of a processor unit, memory modules, communication interfaces, and peripherals. The MCU in Sigen Energy Gateway can process the data detected by the sensor on the circuit to determine whether the circuit is operating normally.

Comprehensive evaluation

When the voltage falls below a particular threshold for a certain period, the device will stop running.

1. Computer

The computer is the most common sensitive load. The computer power fault tolerance level is 20ms. When the power outage time is less than 20ms, the computer components can still keep operating (data from the ITIC curve).

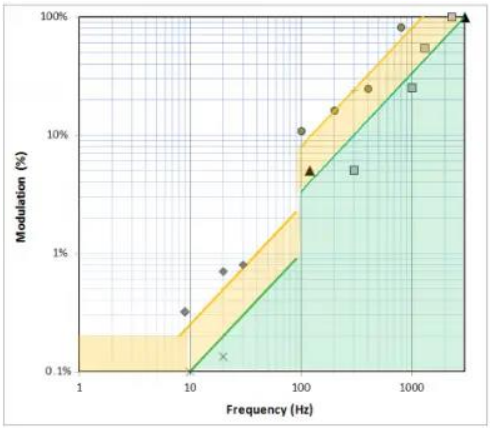


ITIC curve is published by Information Technology Industry Council (ITIC) formerly known as Computer & Business Equipment Manufacturer's Association (CBEMA). This curve provides an AC voltage boundary that most information technology equipment (ITE) can tolerate or ride through without experiencing unexpected shutdowns or malfunctions.

Voltage dropout includes both severe RMS voltage sags and complete interruptions of the applied voltage, followed by immediate re-application of the nominal voltage. Interruption may last up to 20 ms (1.2 cycles). This transient could occur during a temporary fault in the power system followed by a clearing of the fault.

2. Lamp

For nominal LED lamps, according to *IEEE1789-2015 Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to viewers*, when the flicker frequency is higher than 100hz, the human eye cannot observe the change of light and dark, which means that when the power outage time is less than 10ms, the user cannot notice the change of LED lamp.



Incandescent lamp is also a common light source. The current passing the tungsten wire causes high temperatures above 2000 degrees Celsius heat and

luminescence. The tungsten wire's temperature and heat will scarcely fluctuate in a short period like 5 ms, therefore the effect of flicker frequency on the light is so minor that can be neglected. The light and intensity are relatively stable, and almost will not change.

3. *IEC 61000-4-11/GB/T17626.11* defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations:

Voltage dips and interruptions	**IEC 61000-4-11:2004 (≤16A)** **IEC 61000-4-34:2005 and IEC 61000-4-34:2005/AMD1:2000 (>16A)**	**40% residual voltage** **70% residual voltage** **0% residual voltage** **0% residual voltage**	**for 10/12 cycles at 50/60 Hz** **for 25/35 cycles at 50/60 Hz** **for 1 cycle at 50/60 Hz**	**B[e)]** **B[e)]** **B[e)]** **C**

Taking B[e)] as an example, when voltage drops to 0%, the maximum withstand time of the device is 1 cycle at 50/60 Hz, that is, about 20ms. Once this time is exceeded, the device stops running.

0ms backup switching time is much shorter than the duration time of sensitive loads. When the grid outage happens, Sigen Energy Gateway will atomically switch to backup power in a flash. You will even not notice the home loads power outage, which is worry-free energy usage.