Application Note on Power Point Tracking for Conext™ Core XC and XC-NA Series Inverters

AP-XC-007-EN
Revision D

⚠ DANGER

RISK OF ELECTRIC SHOCK, EXPLOSION, ARC FLASH, AND FIRE

This Application Note is in addition to, and incorporates by reference, the relevant product manuals for each product in the Schneider Electric Conext Core XC and XC-NA Series Grid-Tied Photovoltaic Inverters. Before reviewing this Application Note you must read the relevant product manuals. Unless specified, information on safety, specifications, installation, and operation is as shown in the primary documentation received with the product. Ensure you are familiar with that information before proceeding.

Failure to follow these instructions will result in death or serious injury.

Introduction

The Schneider Electric Conext Core XC and XC-NA Series inverters are designed to help optimize the drawing of power from photovoltaic (PV) arrays. The relationship between the inverter, PV array, and grid is shown in Figure 1.

The inverter firmware uses a series of algorithms with preset default values to monitor the power production of the PV array and determine when to connect to the PV array, when to begin maximum power point tracking (MPPT), and when to disconnect from the PV array.

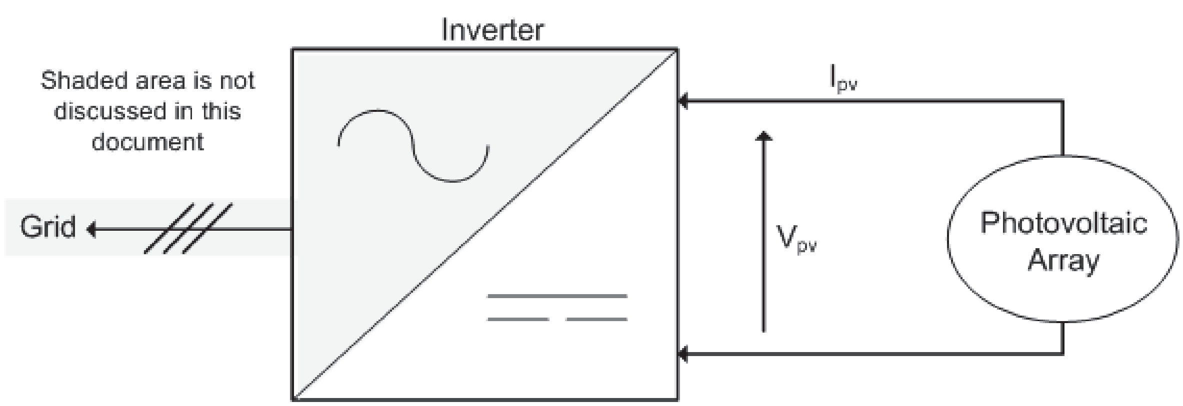

Figure 1 Inverter relationship to PV array and grid

The default parameter values that are set in the factory will work for any photovoltaic panel, but they are not always optimal for a particular PV array. In these cases, the default parameters can be changed to meet the custom requirements of the inverter-PV configuration.

This document describes and illustrates how an inverter transitions between its online and offline states and how it tracks power points to establish the optimal PV voltage at which to transfer power. Tips are provided about changing the default parameters.

Operating Modes

The Conext Core XC and XC-NA Series inverter monitors the PV array and goes online (connects to the PV array and grid) when the PV array generates a voltage level that is higher than the “PV OC Start Voltage” parameter. This normally occurs soon after sunrise. The inverter operates throughout the day in the following modes, as illustrated in Figure 2:

- At the beginning of the day, PV power levels are low and the inverter harvests energy in a low power (passive MPPT) mode.
- When the power level exceeds the preset “Low Power Threshold” parameter, the inverter leaves low power mode and enters active MPPT mode.
- As evening approaches, the PV power level drops below the “Low Power Threshold” parameter value and the inverter returns to low power mode.
- When the power level drops below the preset “PV noP Disconnect Threshold” parameter, the inverter goes offline (disconnects from the PV array and grid).

The following sections discuss the parameters that define each mode and the transitions between the modes.

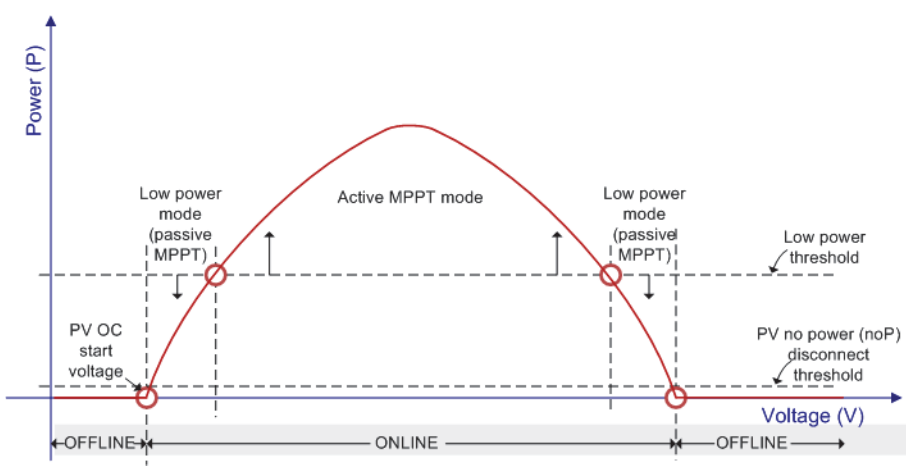

Figure 2 Inverter to PV array operating modes

Offline to Online Transition at Daybreak

The following parameters are used for the inverter transition from an offline state to an online state at daybreak, as illustrated in Figure 3 on page 4:

PV OC Start Voltage The PV voltage threshold at which the inverter, if offline, will prepare to go online (OC = open circuit). This voltage must be greater than or equal to the "LP PV Voltage Reference"—that is, the voltage must always drop when the inverter goes online.

The "PV OC Start Voltage" parameter has the following constraints:

PV OC Start Voltage ≥ LP PV Voltage Reference

Min Tracking Volt ≤ PV OC Start Voltage ≤ Max OC Voltage (1000 V)

The "PV OC Start Voltage" parameter has the following default value:

PV OC Start Voltage = LP PV Voltage Reference = Dynamic minimum tracking voltage

For information about setting the "PV OC Start Voltage" parameter to achieve the best MPPT performance, see "Optimizing MPPT Performance" on page 11.

PV Reconn Delay The length of time, in seconds, that the inverter waits before going online. This wait is to confirm that PV voltage is continuously above the "PV OC Start Voltage" threshold.

Default Values for Offline to Online Transition

The following settings are the factory default values for the offline to online transition, as illustrated in Figure 4 on page 5:

Table 1 Default values for the offline to online transition

Parameter	Default Value
PV OC Start Voltage	400 VDC
LP PV Voltage Reference	400 VDC
PV Reconn Delay	1200 s
LP Threshold	5% of $P_{nominal}$
LP Transition Delay	300 s

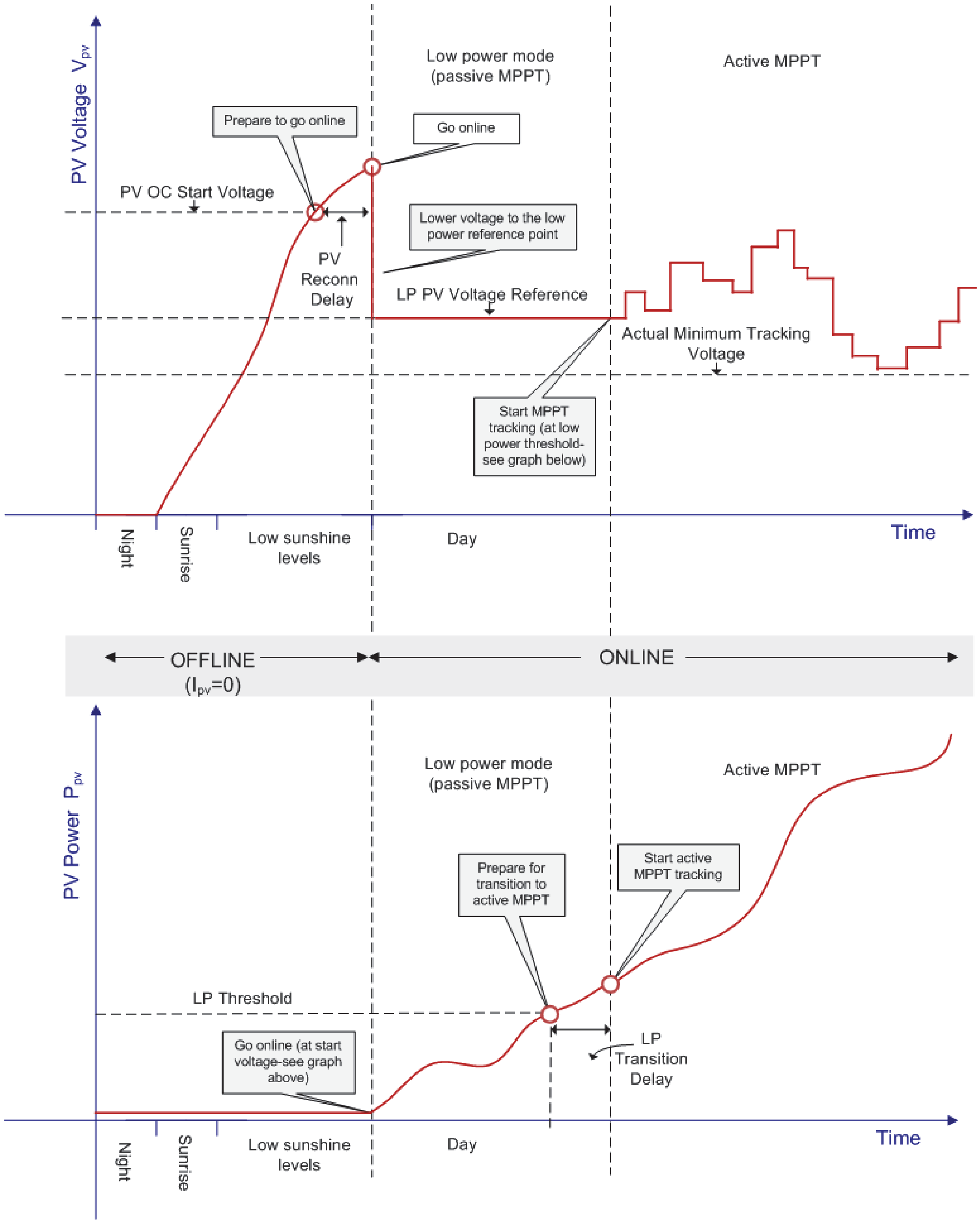

Figure 3 Inverter offline to online transition

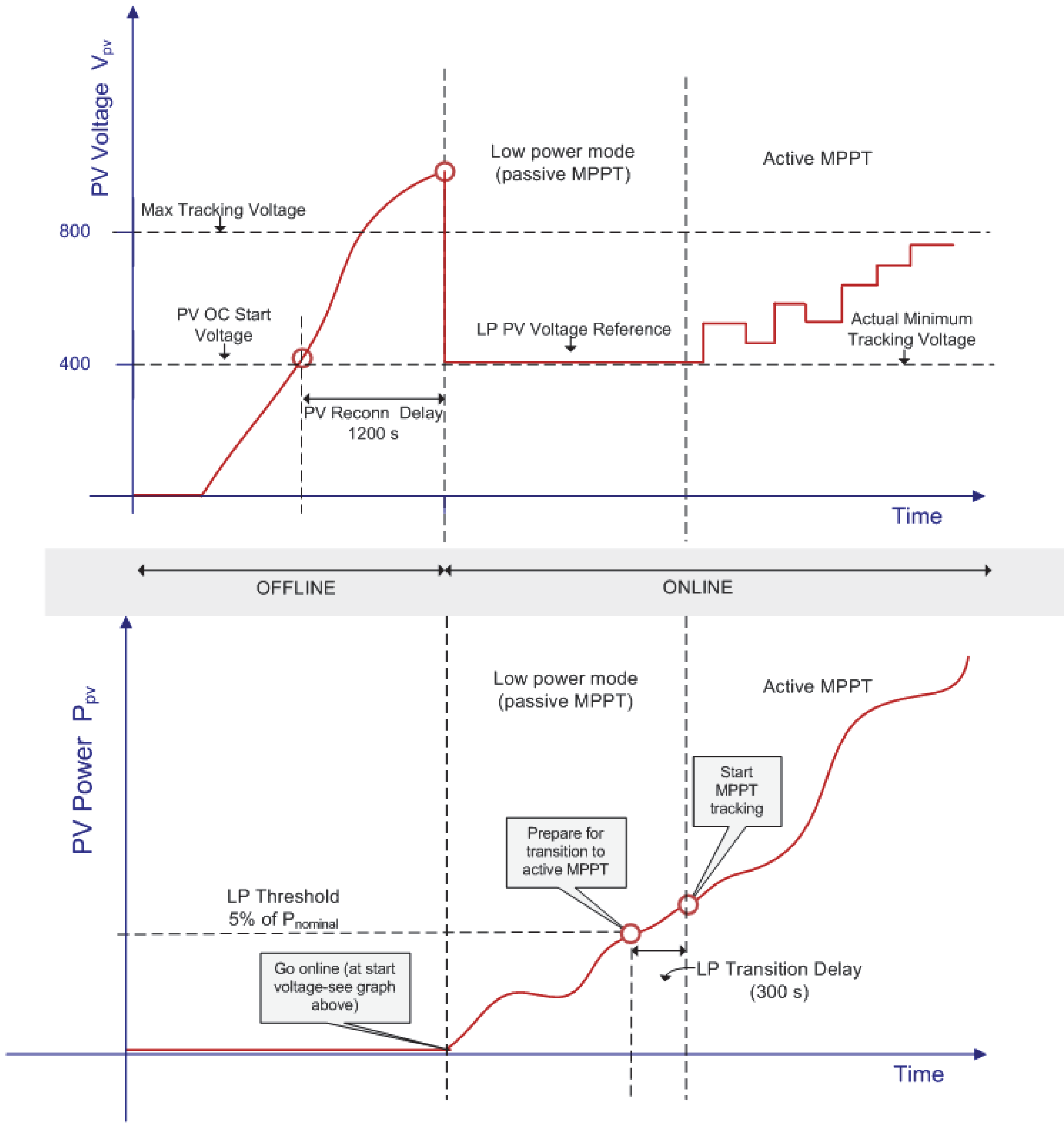

Figure 4 Default offline to online settings

Power Point Tracking

Power point tracking is a technique to obtain maximum power from the PV array as the environmental conditions change. The two MPPT regimes are low power MPPT (also known as passive MPPT) and active MPPT.

Low Power (Passive MPPT) Mode

When output power is low—that is, less than “LP Threshold”—the system is considered to be in low power (LP) mode. This mode is a passive MPPT regime where PV voltage is maintained at a fixed level (“LP PV Voltage Reference”).

The following parameters are used for low power mode:

LP PV Voltage Reference The PV voltage level which the inverter maintains while in low power (LP) mode. This voltage is always equal to or less than the “PV OC Start Voltage”.

The “LP PV Voltage Reference” parameter has the following constraints:

LP PV Voltage Reference ≤ PV OC Start Voltage

Min Tracking Volt < LP PV Voltage Reference < Max Tracking Volt (800 V)

For information about setting the “LP PV Voltage Reference” parameter to achieve the best MPPT performance, see “Optimizing MPPT Performance” on page 11.

LP Threshold The level of PV power above which the inverter operates in active MPPT mode and below which the inverter operates in low power (passive MPPT) mode.

LP Transition Delay The length of time, in seconds, that the inverter waits before changing between low power (passive MPPT) mode and active MPPT mode. This delay confirms that the PV power is above (or equal to) “LP Threshold.”

These settings are illustrated in Figure 3 on page 4 (offline to online transition) and Figure 9 on page 13 (online to offline transition).

Active MPPT Mode

When output power is above “LP Threshold”, the system is considered to be in active MPPT mode. Maximum power point tracking begins, using a Perturb and Observe method designed to improve tracking performance in the presence of dynamic insolation conditions. The procedure is cyclic, and the period of each cycle is called the “perturb interval.”

The following parameters are used for active tracking of maximum power point using perturb steps, as illustrated in Figure 5 on page 8:

MPPT Type The method used for trend prediction (how external factors affect dynamic power). Type 1 is the default method.

Type 0 = No trend prediction
Type 1 = 1st order (linear) trend prediction
Type 2 = 2nd order (quadratic) trend prediction

Min Tracking Volt The minimum PV voltage that can be maintained during power point tracking. This setting defines the tracking range and cannot be at a level below the system-calculated minimum tracking voltage. For details, see ““Min Tracking Volt” Limitation” on page 9.

Max Tracking Volt The maximum PV voltage of the tracking range.

Perturb Voltage Step The PV voltage delta in each perturbation. Perturb steps determine the granularity of the power point search algorithm. Smaller steps result in a more accurate search result, while larger steps allow for a more robust and reliable search process.

MPPT Sampling Interval The length of time, in ms, between two samplings of PV power.

MPPT Occurrence Factor The number of “MPPT Sampling Intervals” between two PV voltage perturbations.

MPPT Offset Factor A relative comparator hysteresis. This hysteretic element is used to determine the perturbation direction. A smaller offset factor results in more accurate tracking and a larger offset factor results in more robust tracking.

MPPT Offset Maximum The maximum offset voltage allowed.

MPPT Offset Minimum The minimum offset voltage allowed.

MPPT Reset Factor The factor used to equalize the initial conditions of the MPPT algorithm during extended power point shifting regimes. A higher reset factor results in faster equalization and a lower reset factor results in slower equalization.

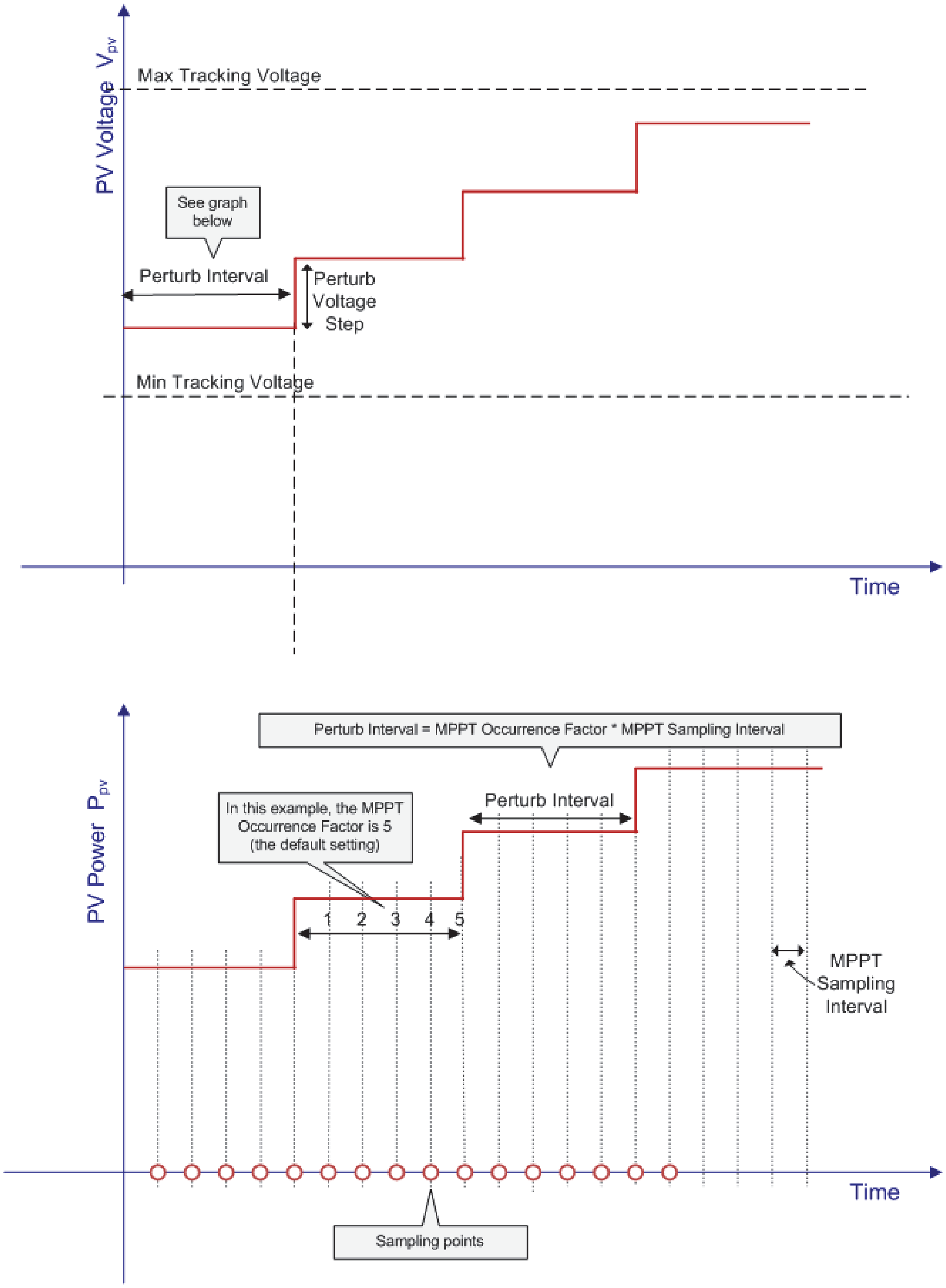

Figure 5 MPPT perturbations

“Min Tracking Volt” Limitation

“Min Tracking Volt” is a key parameter that defines the tracking range. This parameter sets the minimum PV voltage that can be maintained and is limited by the grid voltage amplitude, as shown in Figure 6.

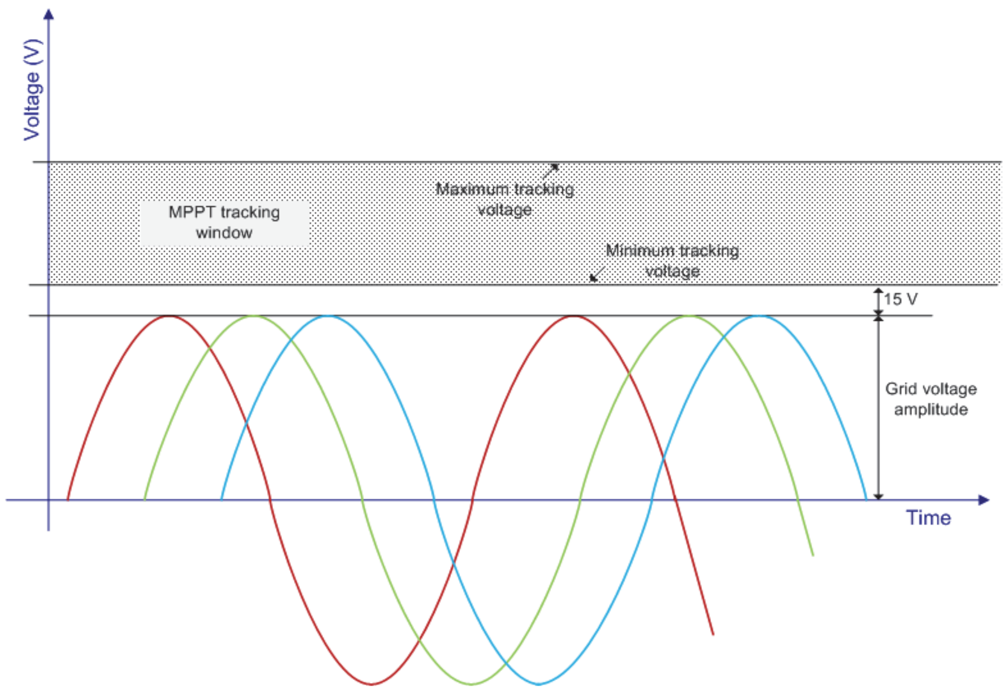

Figure 6 Minimum tracking voltage in relation to grid voltage

The “Min Tracking Volt” parameter is represented as $V_{trackmin}$. When reactive power is zero ($Q = 0$), $V_{trackmin}$ is defined as:

$V_{trackmin}$ = 15 V + grid voltage amplitude

Grid voltage amplitude = $\sqrt{2} \cdot V_{rms}$

Example:

If V_{grid} = 300 V_{rms}, then grid voltage amplitude = $\sqrt{2} \cdot 300\ V_{rms} = 424\ V$

With reactive power at zero ($Q = 0$), then:

$V_{trackmin} = 15 + 424 = 439\ V$

For information about calculating $V_{trackmin}$ when the reactive power is not zero (>0 or <0), see the next section.

Dynamic Minimum Tracking Voltage (System-Calculated)

The system-calculated minimum tracking voltage is also called “dynamic minimum tracking voltage”. The dynamic minimum tracking voltage is represented as $V^*_{trackmin}$, as shown in the following equations:

Capacitive mode (Q > 0)

$$V^*_{track\ min} = 15\,V + \sqrt{2\,V_{grid}^2 + 3.0 \cdot f_{grid} \cdot Q} \quad (1)$$

Inductive mode (Q < 0)

$$V^*_{track\ min} = 15\,V + \sqrt{2\,V_{grid}^2 + 1.0 \cdot f_{grid} \cdot Q} \quad (2)$$

f = grid frequency in Hz
Q = reactive power level in kVAr

Actual Minimum Tracking Voltage

The actual minimum tracking voltage is whichever value is greater: the user-set voltage $V_{trackminuser}$ or the system-calculated voltage $V^*_{track\ min}$, as shown in the following equation:

$$\text{Actual } V_{track\ min} = \max\{V^*_{trackmin}, V_{trackminuser}\} \quad (3)$$

The inverter constantly monitors V_{grid} and updates the $V^*_{track\ min}$ parameter. If a user sets the minimum tracking voltage below the system-calculated level (per equations 1 and 2), the inverter overrides the user setting. An example of this scenario is shown in Figure 7 on page 11.

The inverter does not allow the PV voltage to drop below the dynamic minimum tracking voltage.

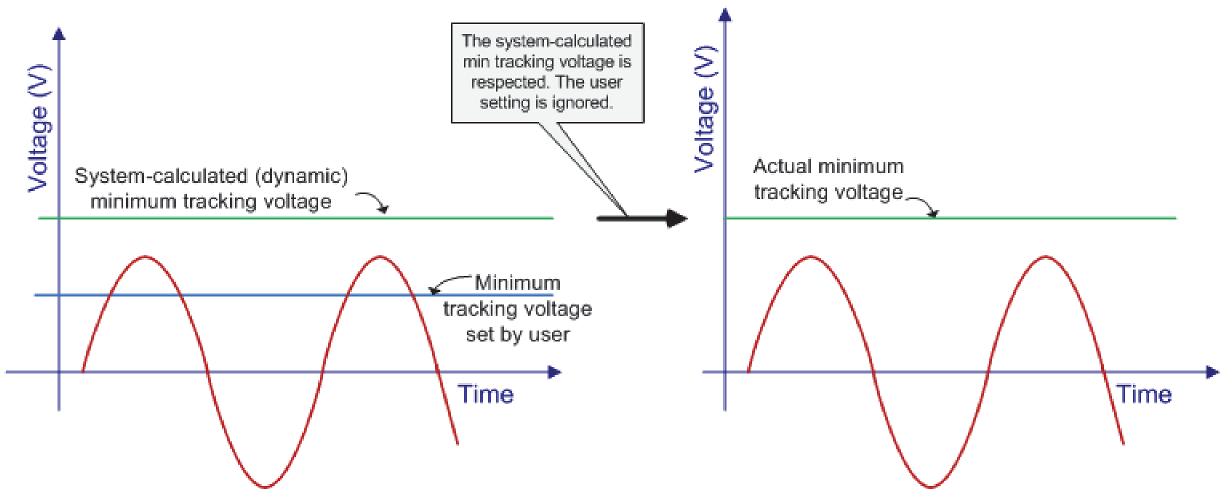

Figure 7 Calculating the actual min tracking voltage

Optimizing MPPT Performance

When power point tracking is optimized, the energy harvest in low power (passive MPPT) mode is optimized, as shown in Figure 8.

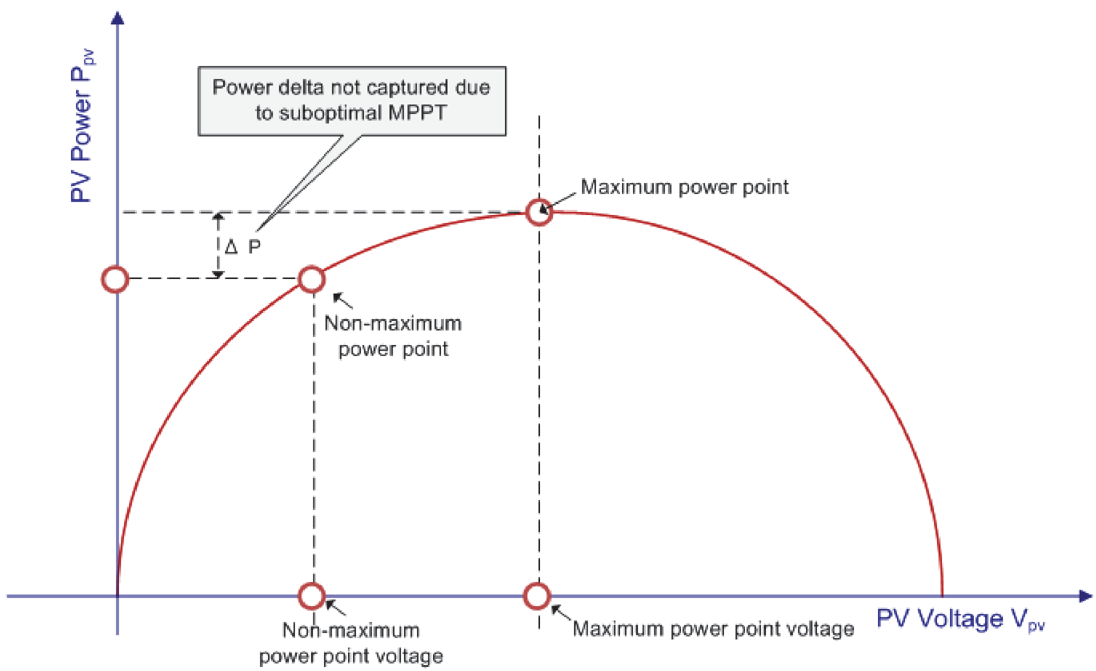

Figure 8 Unused energy when power point tracking is not optimized

In order to get the best MPPT performance from the Conext Core XC and XC-NA Series inverter, we recommend that the “PV OC Start Voltage” and “LP PV Voltage Reference parameters be adjusted as described in the following procedure.

To optimize MPPT:

1. Determine the maximum power point voltage of the PV strings at standard test condition (STC).
2. Using the front panel user interface on the inverter, adjust the “PV OC Start Voltage” and “LP PV Voltage Reference” settings according to the following table:

Maximum Power Point of PV Strings at Standard Test Condition (STC)	Parameter Value
PV OC Start Voltage (defined on page 3)	
≤ 650 VDC	400 VDC (default)
> 650 VDC	650 VDC
LP PV Voltage Reference (defined on page 6)	
≤ 650 VDC	400 VDC (default)
> 650 VDC	650 VDC

Note: The maximum power point of the PV strings must not exceed 800 VDC,

Online to Offline Transition at Nightfall

The following parameters are used for the inverter transition from an online state to an offline state, as illustrated in Figure 9 on page 13:

PV noP Disconnect Threshold The power level at which the PV array is considered to be generating no power and the inverter prepares to go offline.

PV noP Disconnect Delay The length of time that the inverter waits before going offline, to confirm that the PV power is constantly below the “PV noP Disconn Threshold.”

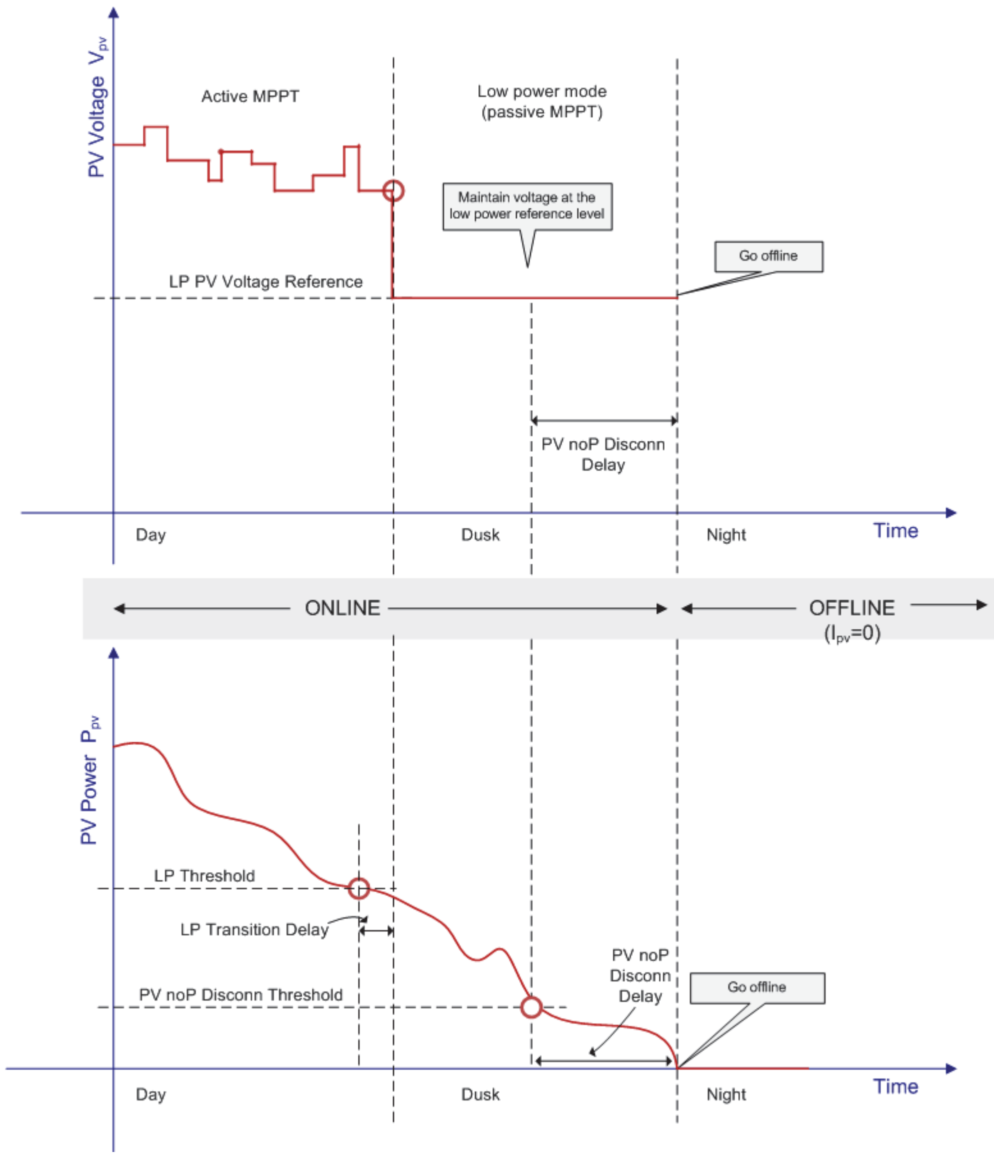

Figure 9 Inverter online to offline transition

Default Values for Online to Offline Transition

The following settings are the factory default values for the online to offline transition:

Table 2 Default values for the online to offline transition

Parameter	Default Value
LP Threshold	5% of $P_{nominal}$
LP Transition Delay	300 s
LP PV Voltage Reference	400 VDC
PV noP Disconn Threshold	1% of $P_{nominal}$
PV noP Disconn Delay	3000 s

The following relationship is also a factory default:

LP PV Voltage Reference = Dynamic minimum tracking voltage

For information about dynamic minimum tracking voltage, see “Dynamic Minimum Tracking Voltage (System-Calculated)” on page 10.

Diagnostic Parameters

The configurable parameters described in this section are used for diagnostic purposes.

Sweep

The Fast Sweep™ technology is used to help identify the global maximum power point in a system. The following parameters are used for performing a user-initiated sweep, as illustrated in Figure 10 on page 15:

Sweep Enable Enable periodic sweeping. When sweeping is enabled, power point tracking is interrupted periodically and PV power is swept.

Sweep Occurrence The length of time, in seconds, between each sweep.

Sweep Duration The length of time, in seconds, that the sweep event lasts.

Sweep Start Voltage The PV voltage at which sweeping starts.

Sweep Stop Voltage The PV voltage at which sweeping stops.

Sweep Range Voltage A voltage range between which sweeping occurs. The range occurs around a preset voltage reference in the system (not configurable). When “Sweep Range Voltage” = 0, the sweep starts at “Sweep Start Voltage” and stops at “Sweep Stop Voltage.”

MPPT Sweep Trigger Initiates a single sweep event.

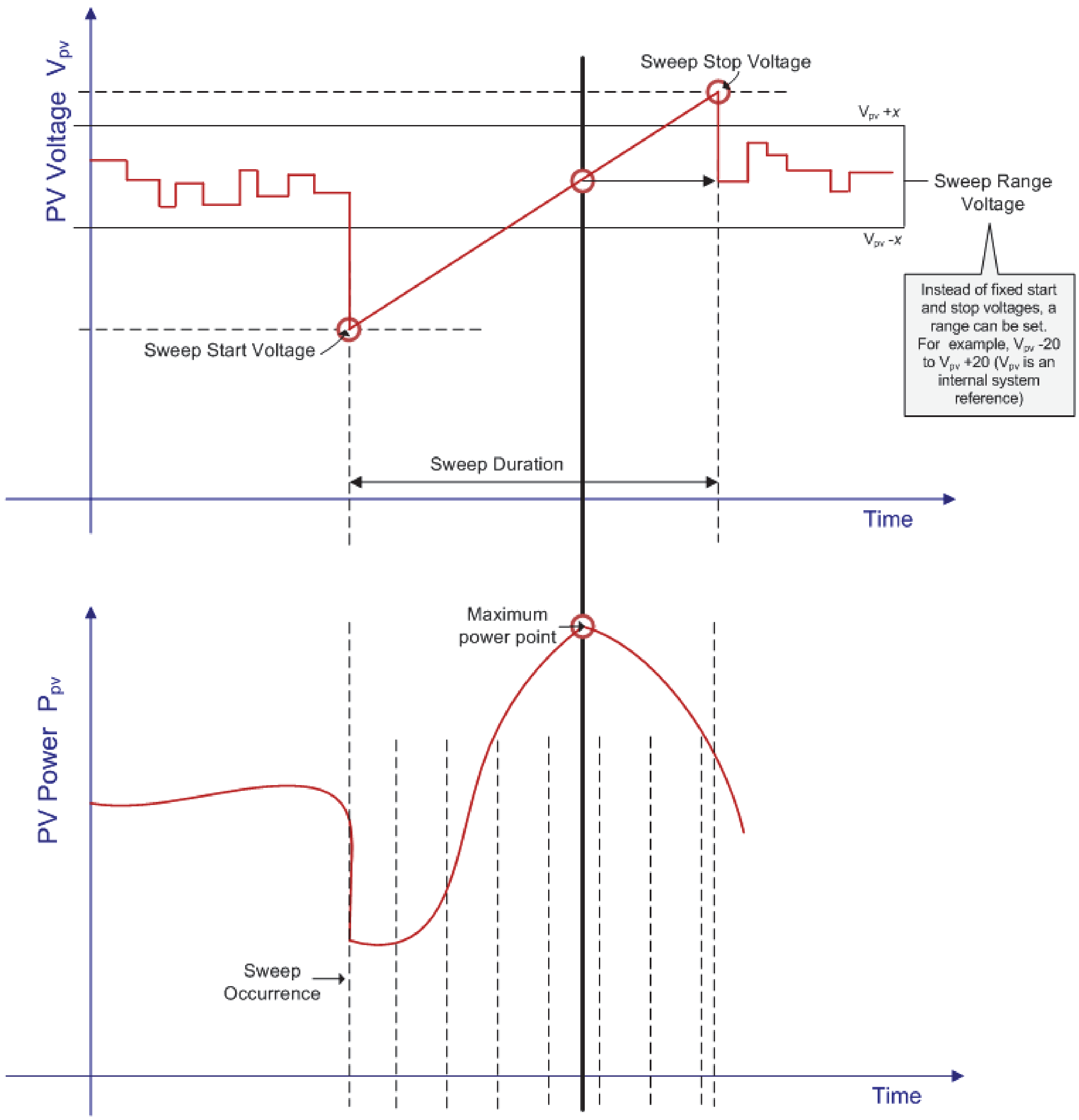

Figure 10 Sweep settings

User PV Voltage Reference

The "User PV Voltage Ref" parameter enables a user to set their own PV voltage reference to override the active MPPT settings.

User PV Voltage Ref The user's desired PV voltage reference. When this reference is set to zero, the inverter is in active MPPT mode.

The default "User PV Voltage Ref" is 0.

Negative Current

If current flows in the opposite direction and into the PV generator for any reason, the following parameters will trigger an error and prevent potential damage to the PV strings:

PV Neg Disconn Threshold The threshold value of PV negative current before an error is triggered.

PV Neg Disconn Delay The length of time that the inverter waits before triggering an error due to "PV Neg Disconn Threshold."

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