Conext CL-60 Inverter
Active and Reactive Power Control and LVRT

976-0381-01-01/B
March 2017
Application Note

Objective

The goal of this application note is to describe the CL-60 Inverter's active/reactive power control and Low Voltage Ride Through (LVRT) methods, input parameters, and range.

⚠ DANGER

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

This Application Note is in addition to, and incorporates by reference, the relevant product manuals for each product in the Conext CL-60 Inverter. 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.

CL-60 Active and Reactive Power Controls and LVRT Settings

Standards: BDEW, VDE-AR-N-4105

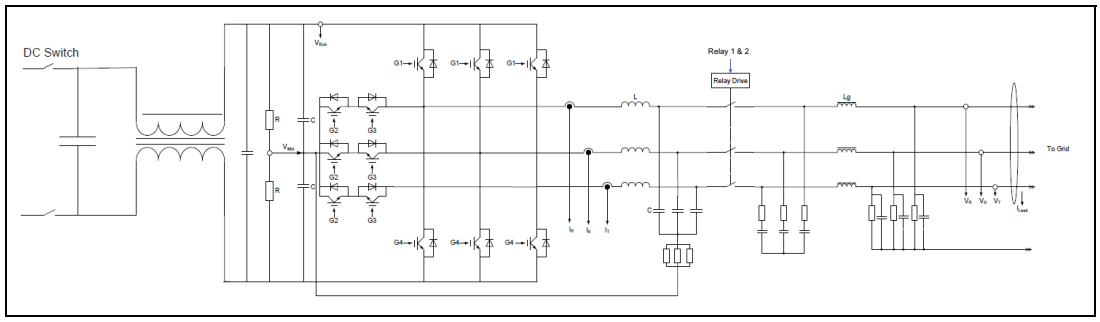

Figure 1 Block diagram of CL-60 PV Inverter

The control of inverter power can be implemented manually through the LCD display or remotely using the Conext CL Easy Config Tool.

Author: Keyur Javiya. For local customer technical support go to: http://solar.schneider-electric.com/tech-support.

Active Power Control

The actual active power that the inverter delivers is a function of the available power in the PV array, but users can set the active power limit using these methods.

- Method 1 is useful when a set limit of active power is required for a specific application. See *"Method 1: Nominal power limit (P-W): [scale in %]" on page 2*.
- Method 2 is useful for applications such as zero export or to improve the overall system stability. See *"Method 2: Maximum Nominal Active power limit function of the frequency P(f): Derating" on page 4*.

The active power output limit could be set using the Modbus communication signals from an external controller, the Conext CL Easy Config Tool, or through the LCD display interface on the inverter.

The inverter responds to the command within 1-2 seconds, but because the communication method also includes some time delay, the overall response time for the event depends on the method used to deliver the command.

Method 1: Nominal power limit (P-W): [scale in %]

Figure 2 P-Q parameter settings menu tree

Table 1 CL-60: Active Power parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
P-W Limit	%	0%	110% (66000)	110% (66000)	1%	The nominal power can be limited in %
Rate Limit	-	-	OFF	-	OFF/ON	Set the active power change rate. When it is ON, the user can set the rate to rise or decline.
Power rise, Gradient	%/min	8%/min	100%/min	100%/min	1%	When Rate limit is ON, this parameter can be set.
Power Decline, Gradient	%/min	8%/min	6000%/min	6000%/min	0.1%	When Rate limit is ON, this parameter can be set.

CL-60: Active power ramping

When the inverter returns to the online state after a grid event, the active power may be ramped up gradually from 0% to 110% over a specified period using the “Fault slow up” parameter.

For example, if the user sets the “Fault slow up” to ON with a slow-up rate of 10%/min, then the power will rise at 10% per minute. When 100%/min slow-up rate is selected, the inverter will supply full active power from the available PV power into the grid.

Table 2 CL-60: Active power ramping parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Fault slow up	-	-	ON	-	ON/OFF	Set the state of the power rise rate change when a fault is cleared. When this is ON, the active power rise rate can be set by the user.
Slow up rate	%/min	8%/min	100%/min	100%/min	1%	Set the active power rise rate after clearance of a fault event
Save P-W settings	-	-	OFF	-	OFF/ON	Selection of the above settings to be saved or not

CL-60: Time parameter change

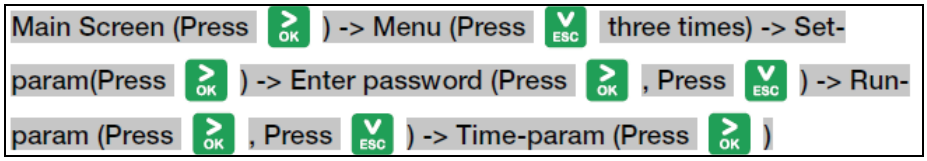

Figure 3 Time parameter settings menu tree

Table 3 CL-60: Time parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Standby Time	Sec	20 Sec	20 Sec	255 Sec	1 Sec	Time from inverter standby to start up
Recover Time	Sec	0 Sec	300 Sec	900 Sec	1 Sec	Time from inverter fault clearing to standby

Method 2: Maximum Nominal Active power limit function of the frequency P(f): Derating

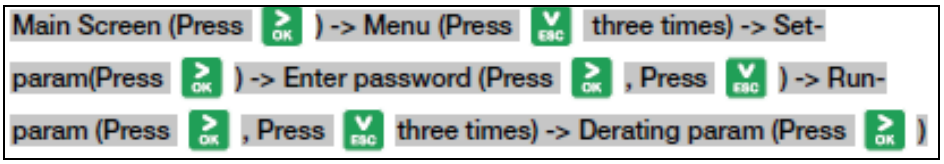

Figure 4 Derating parameter settings menu tree

Frequency-based active power de-rating allows users to control the inverter's active power output with respect to change in frequency. This control method follows a defined slope based on three power and frequency values. The inverter LCD screen will display these values and allow users to change them for defining the curve. When defining the values, ensure that P1>P2>P3.

Table 4 CL-60 Active Power P(f) Derating parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Fre-Derating	-	-	OFF	-	ON/OFF	Set the Derating parameter to OFF/ON. When ON is selected, the inverter will operate in active power derating mode when the grid frequency exceeds the set value.
F1 F2 F3	Hz	-	-	100%	0.1 Hz	These three values of frequency and power define the curve for frequency derating. Users will decide the slope of the derating and enter the calculated values P1>P2>P3
P1 P2 P3	%	0%	-	100%	1%	

Reactive Power Control

CL-60 Inverters are designed with spare capacity to generate on-demand reactive power while keeping the 60kW active power rating intact. The CL-60E and CL-60A inverters can generate 28.7 kVAR and 27.6 kVAR respectively without any nameplate (60 kW) de-rating. If the PV plant is designed to operate on unity PF only, these inverters can generate an additional 10% (CL-60E) and 6% (CL-60A) active power. So, if the PV system is to be designed for unity power factor, 66kW (IEC) or 63.4 kW (UL) rating should be used for total nameplate rating capacity of your PV plant. The Power Factor limit is -0.8 (Ind) to +0.8 (Cap). The Highest Reactive kVARs from the inverter is +/-39.6 (CL-60E) and +/-38.0 (CL-60A).

The inverter has a Q-Var switch that enables the option to generate Reactive Vars to the Off or On position.

There are four methods to control Reactive VARs generated by CL-60 Inverters:

- Configurable fixed PF - cos-Φ. See *"Method 1: Pf-Configurable Constant Power Factor, cosΦ = cosΦ" on page 6*
- Configurable Constant Q - % Var Limit. See *"Method 2: Qt-Configurable Constant Reactive Power Q" on page 8*.
- Configurable PF (cos-Φ) as a function of Active power P. See *"Method 3: Q(P) - Configurable Power Factor Function of the Active Power, cosΦ(P)" on page 8*.
- Configurable Reactive Power Q as a function of Grid voltage U. See *"Method 4: Q(U) - Configurable Reactive Power Function of the Grid Voltage, Q(U_{grid})" on page 9*.

NOTE: When one method is selected, the other methods are disabled.

Figure 5 P-Q parameter settings menu tree

Table 5 CL-60 Reactive Power parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Save Q-Var Settings	-	-	ON	-	Options: Pf/ Qt/Off/Q(P)/ Q(U)	Select ON or OFF to apply the selected Q-Var control method and settings

Table 5 CL-60 Reactive Power parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Q-Var switch	-	-	OFF	-	OFF/ON	This option is to turn the selected reactive power regulation function ON or OFF.
PF	-	-0.8 (ind)	1.0	+0.8 (cap)	0.1	Power Factor of Inverter output AC power
Q-Var limits	%	-100%	0.0%	+100%	1%	Limits of Inverter output reactive power

Method 1: Pf-Configurable Constant Power Factor, cosΦ = cosΦ

The following graph for CL-60E and CL-60A represents the default structure implementation. It limits the selectable value for Q as a function of active power P.

$$\cos\varphi = \frac{P}{\sqrt{P^2 + Q^2}} \qquad |Q| = \sqrt{S^2 + P^2}$$

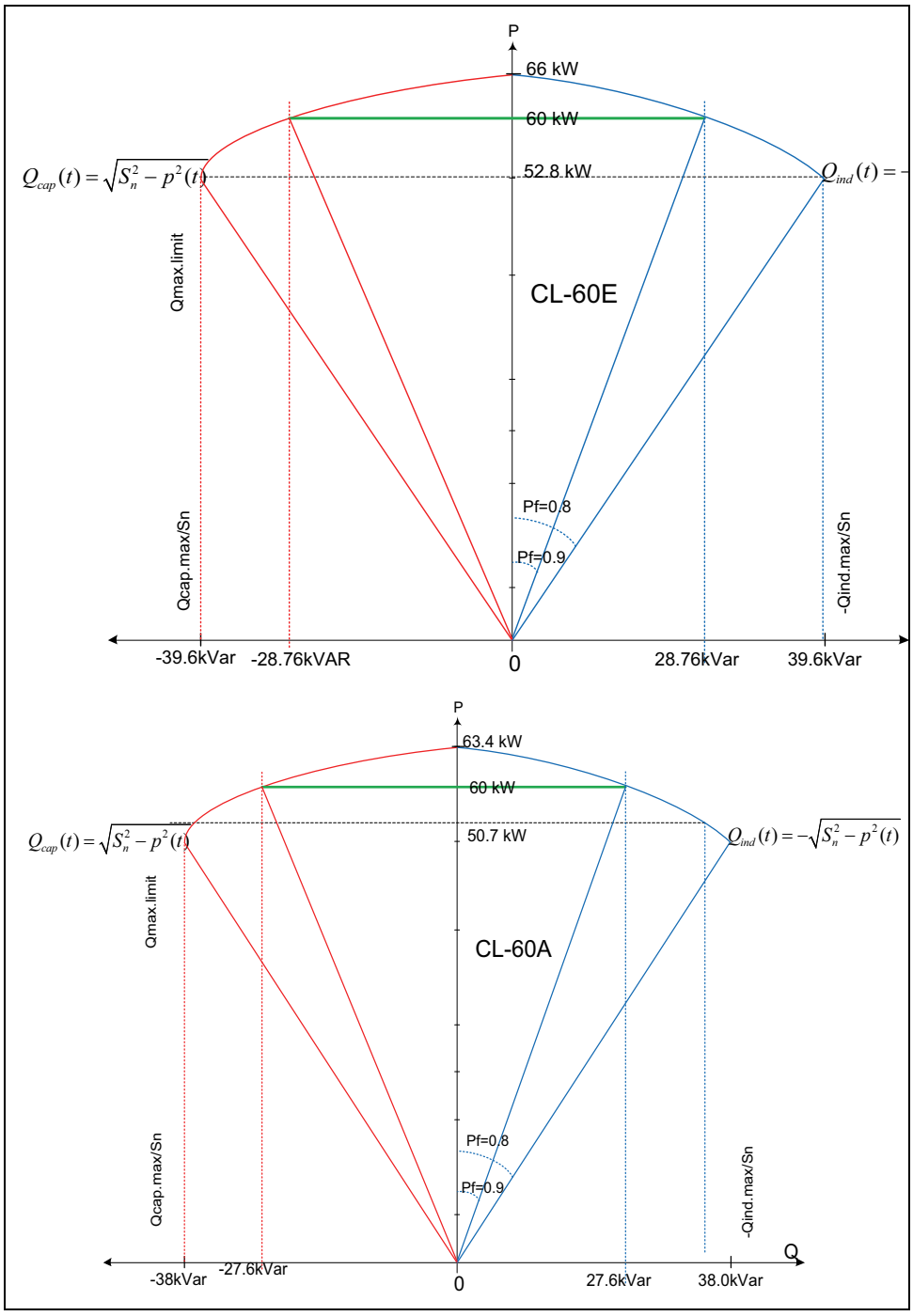

Figure 6 P-Q Curves for CL-60

Table 6 PF parameters settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
PF	-	-0.8 (ind)	1.0	+0.8 (cap)	0.1	Power Factor of inverter output AC power

$$\text{When } p >= 80\%\ P_n \qquad Q_{cap}(t) = \sqrt{S_n^{\,2} - p^2(t)} \qquad Q_{ind}(t) = \sqrt{S_n^{\,2} - p^2(t)}$$

Method 2: Qt-Configurable Constant Reactive Power Q

The inverter delivers configured value (%) of constant reactive power Q when this method is selected. The corresponding value of Q of the selected % value would be based on Figure 6 on page 7.

Table 7 Q-Var limits parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Q-Var limits	%	-100%	0.0%	+100%	1%	Limits of inverter output reactive power

Method 3: Q(P) - Configurable Power Factor Function of the Active Power, cosΦ(P)

The following graph represents the default structure implementation. There is no requirement for $Q < 10\%S_n$ – implement Q=0 for $Q<5\%S_n$.

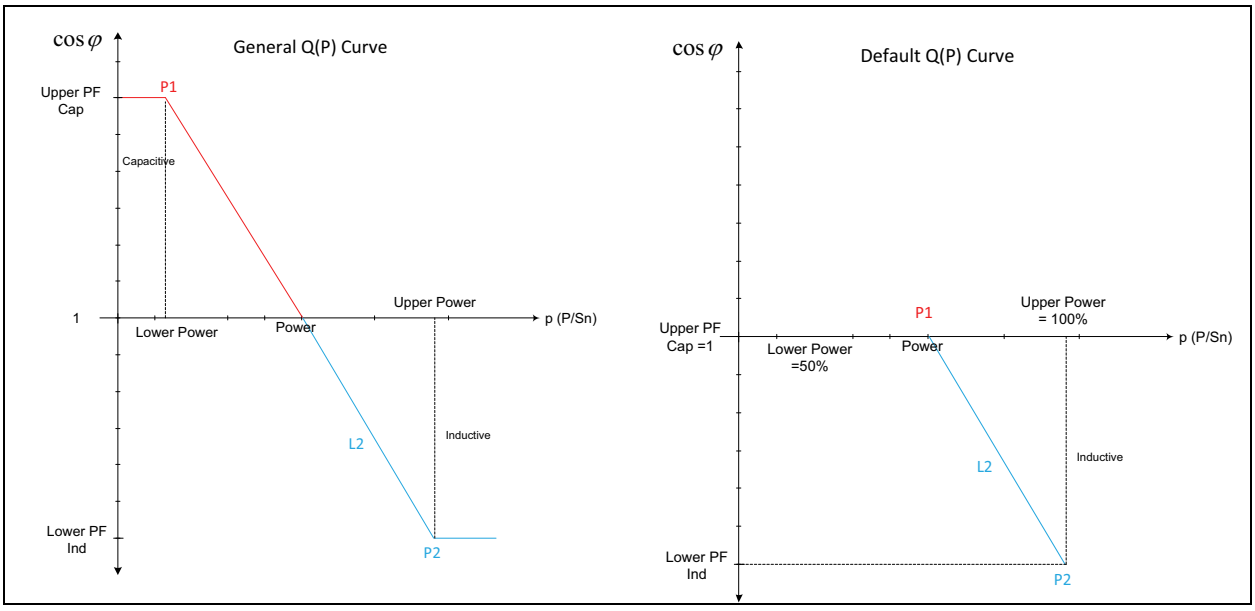

Figure 7 General and Default Q(P) curve for CL-60

Table 8 Q(P) method parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Upper PF Cap	-	0.9	1	1	0.01	Power Factor of point P1 in the Q(P) mode curve
Lower Power	%	0	50%	50	1%	Output power of point P1 in the Q(P) mode curve
Lower PF Ind	-	0.9	0.9	1	0.01	Power Factor of point P2 in the Q(P) mode curve
Upper Power	%	50	100%	100%	1%	Output power of point P2 in the Q(P) mode curve

Method 4: Q(U) - Configurable Reactive Power Function of the Grid Voltage, $Q(U_{grid})$

This method offers the change in ratio Q/Sn with respect to grid voltage.

Table 9 Q(U) method parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
Lower Q/Sn Ind.	%	0%	25%	50%	1%	Inductive Q/Sn value of point P4 in the Q(U) mode curve
Upper Q/Sn Cap.	%	0%	25%	50%	1%	Capacitive Q/Sn value of point P1 in the Q(U) mode curve
Lower U limit	%	80%	80%	90%	1%	Grid voltage limit of point P1 in Q(u) mode curve (in %)
Upper U limit	%	110%	115%	115%	1%	Grid voltage limit of point P4 in Q*u) mode curve (in %)
U1 limit[a]	%	95%	95%	100%	1%	Grid voltage limit of point P2 in Q(u) mode curve (in %)
U2 limit[a]	%	100%	105%	105%	1%	Grid voltage limit of point P3 in Q(u) mode curve (in %)
Hysteresis	%	0%	3%	5%	1%	Hysteresis voltage width (in %)

a.U1 limit + Hysteresis < U2 limit - Hysteresis

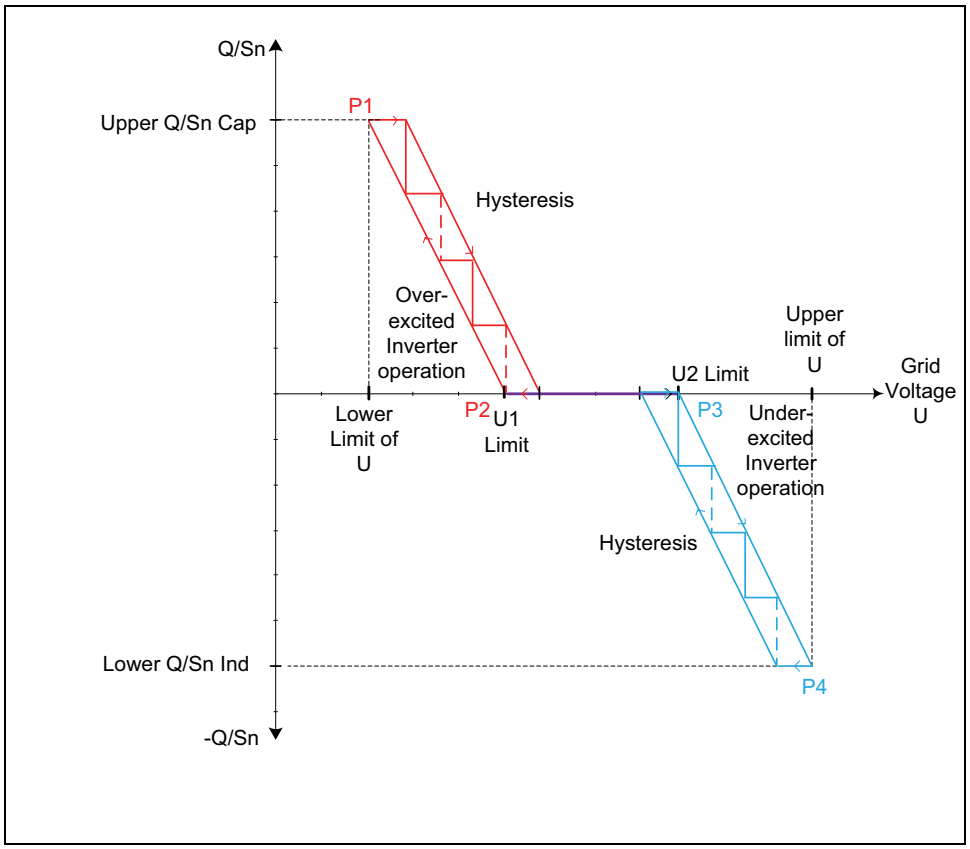

Figure 8 Q(U) settings curve for CL-60

Convention:

1. Reactive Capacitive Power injected to grid: positive value set
2. Reactive Inductive Power injected to grid: negative value set

Low Voltage Ride Through (LVRT)

Main Screen (Press OK) -> Menu (Press ESC three times) -> Set-param(Press OK) -> Enter password (Press OK , Press ESC) -> Run-param (Press OK , Press ESC twice) -> LVRT param (Press OK)

Figure 9 LVRT parameter settings menu tree

During the Fault Ride Through, the inverter continues to operate under a defined duration of low grid voltage. Voltage ride through (VRT) is the capability of the inverter to maintain output current and remain online when the voltage in the grid is temporarily outside the nominal dead band. When the grid voltage drops below the preset low voltage (LV) threshold, the event is called low voltage ride through (LVRT).

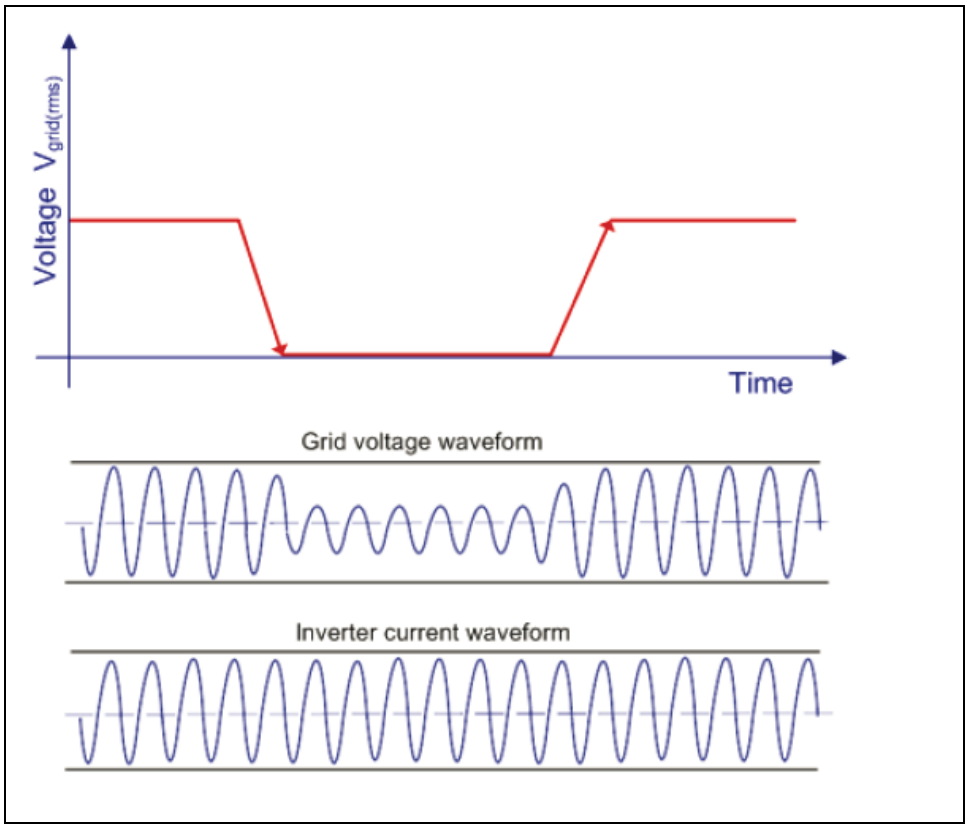

Figure 10 LVRT

After the voltage dip, the reactive current reference would be changed according to the country specific requirements as shown in Figure 11.

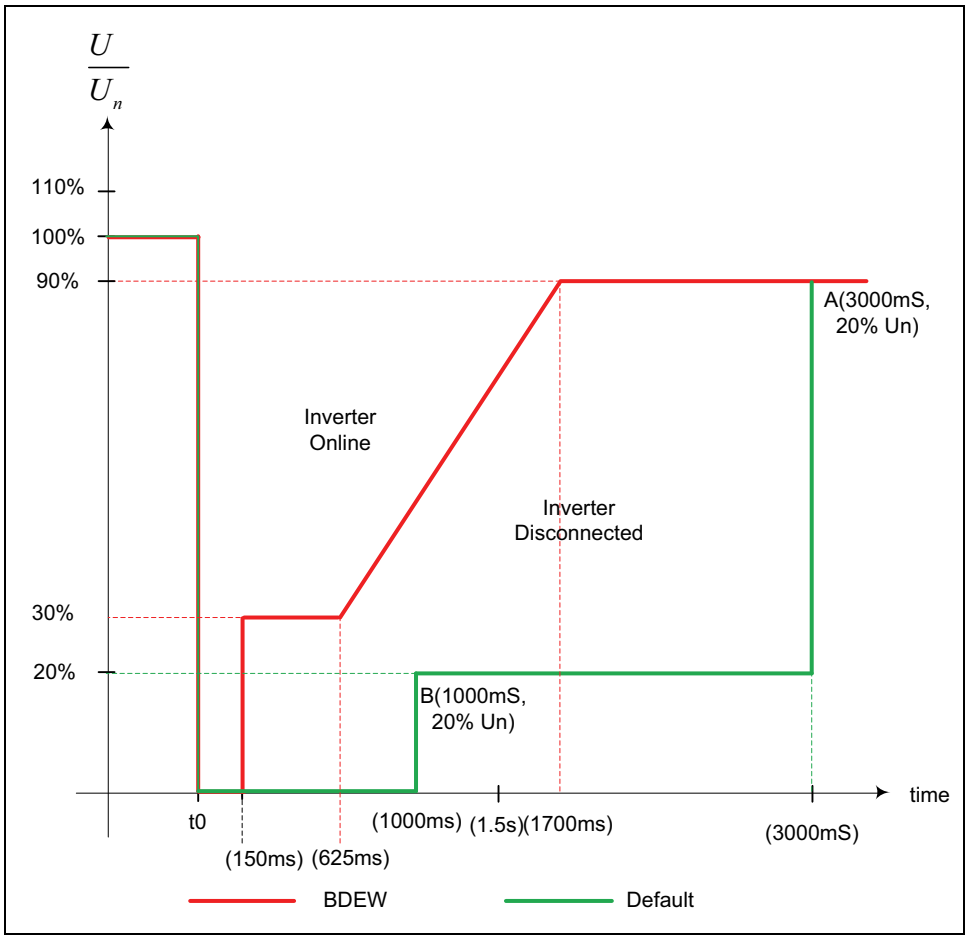

Figure 11 Low voltage ride through curve for CL-60

Table 10 Low voltage ride through parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
LVRT	-	-	OFF	-	OFF/ON	This option sets the LVRT capability to OFF or ON state. When LVRT is ON, the inverter will remain grid connected during fault conditions and provide reactive power.
LVRT normal Volt V1	V	0	85%	100	1%	User set parameter
LVRT tolera Volt V2	V	0	15%	100	1%	User set parameter
LVRT T1	S	10 ms	620	10 s	10 ms	User set parameter

Table 10 Low voltage ride through parameter settings

Parameter	Unit	Min	Default	Max	Resolution	Parameter Value Information
LVRT T2	S	10 ms	3s	10s	10ms	User set parameter
LVRT kf	-	0	2	4	1	User set parameter