24.10.2023 rev.9.5

INVERTER APPROVAL FOR INSTALLATION IN ISRAEL

STANDARDS APPLIED FOR SAFETY EVALUATION OF INVERTERS:

AS/NZS 3100
Approval and test specification – General requirements for electrical equipment

SI 4777 Part 2 / AS/NZS 4777.2: 2005
Grid connection of energy system via inverters – Part 2: Inverter requirements

SI 4777 Part 3 / AS/NZS 4777.3: 2005
Grid connection of energy system via inverters – Part 3: Grid protection requirements

IEC 62109-1: 2010 / EN 62109-1: 2010
Safety of power converters for use in photovoltaic power systems – Part1: General requirements

IEC/EN 62109-2: 2011 / VDE 0126-14-2:2012
Safety of power converters for use in photovoltaic power systems – Part2: Particular requirements for inverters

EN 50178
Electronic equipment for use in power installations

UL1741
Inverters, Converters, Controllers and Interconnection System equipment for Use with Distributed Energy Resources

42 Chaim Levanon St, Tel Aviv 6997701 Israel. www.sii.org.il

OPTION 1

The SII Test Report and the certificate issued based on review of provided test reports and basic safety tests

Required documentation:

1. Full test reports* according to **any one** of the applied standards / set of standards (see the list below) issued by an accredited laboratory and the laboratory accreditations according to ISO/IEC 17025: 2017 including the scope covering the applicable standards.
   Note: provided test reports shall include the list of critical components.
   * CB Scheme test reports are given preference.

Applicable Standards
AS / SI 4777 Parts 2, 3: 2005 + AS 3100
EN 50178
UL 1741
VDE 0126-14-2: 2012 + IEC 62109-1: 2010
IEC 62109-2 + IEC 62109-1: 2010

2. A sample of the inverter for testing.
3. User / Installation Manual.
4. Manufacturer declaration* stating whether the **specific** inverter **models** employ or do not employ an for protection of the **DC** line in case of excessive residual currents and excessive sudden changes of the residual current. Protection means shall include an **automatic disconnection function**.
   Please note, that having an integrated RCD/RCM is not a condition for getting the inverter approved by the SII, however, providing exact and unambiguous information regarding it is essential for installation of the inverter into the grid and is one of the requirements of the Israeli Electrical Company.
5. Manufacturer declaration* of compliance with "Guidelines document: Technical requirements for photovoltaic inverters", update 6.2022 (see Appendix 2, pages 5-16 of this document).

* For detailed explanation regarding the declaration, see Appendix 1 on page 4.

6. Cost NIS 8,600

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OPTION 2

The SII certificate issued based on the review of provided test reports

Required documentation:

1. Full test reports* according to **any one** of the applied standards / set of standards (see the list below) issued by an accredited laboratory that has signed a mutual agreement with the SII (see the table below) and laboratory accreditations according to ISO/IEC 17025: 2017 including the scope covering the applicable standards.
   Note: provided test reports shall include the list of critical components.
   * CB Scheme test reports are given preference.

SII Approved Testing Labs*	Applicable Standards
Bureau Veritas, Germany UL TÜV Rheinland TÜV SUD INTERTEK SGS Spain, Madrid	AS / SI 4777 Parts 2, 3: 2005 + AS 3100 EN 50178 UL 1741 VDE 0126-14-2: 2012 + IEC 62109-1: 2010 IEC 62109-2 + IEC 62109-1: 2010

   * Only the branches that have a mutual agreement with the SII for acceptance of test reports.

2. Manufacturer declaration* stating whether the **specific** inverter **models** employ or do not employ an **integrated** residual leakage current device/monitor (RCD/RCM) for protection of the **DC** line in case of excessive residual currents and excessive sudden changes of the residual current. Protection means shall include an **automatic disconnection function**.
   Please note, that having an integrated RCD/RCM is not a condition for getting the inverter approved by the SII, however, providing exact and unambiguous information regarding it is essential for installation of the inverter into the grid and is one of the requirements of the Israeli Electrical Company.

3. Manufacturer declaration* of compliance with "Guidelines document: Technical requirements for photovoltaic inverters", update 6.2022 (see Appendix 2, pages 5-16 of this document).

* For detailed explanation regarding the declaration, see Appendix 1 on page 4.

4. No sample is required.

5. Cost NIS 2,500

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APPENDIX 1

Manufacturer Declaration

A proper declaration shall contain the following wording:

We, _____ (name and address of the inverter manufacturer), hereby declare that the inverter models listed below*

1. Can be adjusted according to "Guidelines document: Technical requirements for photovoltaic inverters", update 6.2022 (attached);
2. Are suitable for connection to the **HV** / **LV** / **HV+LV** (choose one) grid;
3. Employ / Do not employ (choose one) an **integrated** residual leakage current device/monitor (RCD/RCM) (choose one) for protection of the **DC** line in case of excessive residual currents and excessive sudden changes of the residual current.

*Note: the model names should be specified and listed in full exactly as they appear in the test report. Naming a series of models will not be accepted.

The declaration should be duly **dated** and **signed** by an authorized person, specifying his/her full name and a position in the company. It should be **sealed** with a company official stamp.

The declaration should bear an official **company logo** and the **company details** (its full name, address and contact details).

The original Guidelines document shall be attached to the declaration.

Only the declarations made up as specified above will be accepted.

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APPENDIX 2

Guidelines document: Technical requirements for photovoltaic inverters
Part A: Technical requirements for photovoltaic inverters connected to low voltage

(11 pages attached)

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חברת החשמל
Israel Electric

נגה
ניהול
מערכת
החשמל

Guidelines document: Technical requirements for photovoltaic inverters

Update: 6/2022

Part A: Technical requirements for photovoltaic inverters connected to low voltage

1. Voltage withstand capability:

a. Continuous operation - the inverter will operate continuously when the voltages are within the normal operation range (Un ± 10%).
b. Abnormal conditions - the inverter will continue to operate during and after a grid fault, which causes a voltage disturbance, according to the LVRT/HVRT (Low/High Voltage Ride Through) curves shown below:

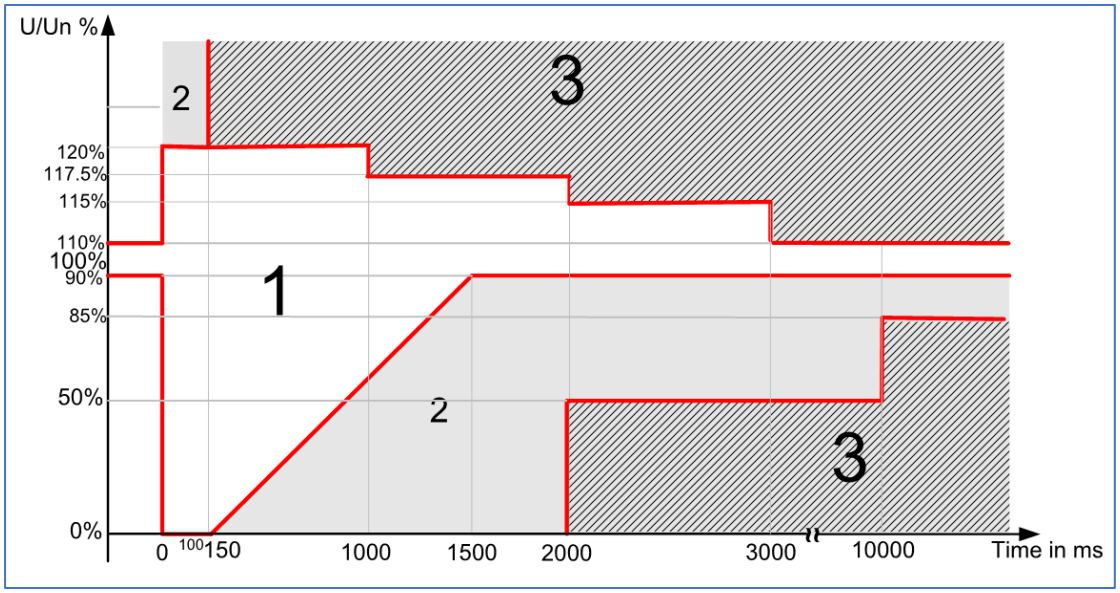

Diagram 1: LVRT/HVRT curves for low voltage installations

where:

Zone 1 (*): The inverter will not disconnect from the grid and will continue to supply energy to the grid.

Zone 2 (*): The inverter may stop supplying energy to the grid.

Zone 3 (*): The inverter must stop supplying energy to the grid.

(*) After the failure is over, the active current value that the inverter supplied before the fault should return to its pre-fault value. The response time $T_{Response90\%}$ for a step-type disturbance, defined as the time required to reach 90% of the set-point value, will not exceed one second.

2. Frequency withstand capability:

2.1 Continuous operation: the inverter will operate continuously in the frequency range of 47 Hz to 52 Hz (47 Hz < f < 52 Hz).

2.2 Minimum value of frequency: at a frequency equal to or lower than 47 Hz ($f \leq 47$ Hz), the inverter will reduce the output active power to 0 MW after a delay of 1 second.

2.3 Maximum value of frequency: at a frequency equal to or higher than 52 Hz ($f \geq 52$ Hz) the inverter will reduce the output active power to 0 MW in about 0.2 second.

2.4 The increase in output active power and reconnection of the inverter after disconnection from the power grid due to operational action or automatic protection will be possible when the grid voltage is within the normal operation voltage limits, and the grid frequency is between 47.0 Hz and 50.1 Hz (47 Hz < f < 50.1 Hz). After disconnecting the inverter from the grid, the inverter will be connected to the system with a delay of 5 minutes (or another period of time to be determined by IECo) as long as the voltage and frequency conditions specified in this section are met.

The active power increase rate after connecting the inverter will be adjustable between 5% and 40% of the rated power per minute. Default value is 20% of the rated power per minute.

2.5 Rate of Change of Frequency (ROCOF): the inverter will operate normally for Rate of Change of Frequency that is less than or equal to 3 Hz/s.

2.6 Frequency Response:

a. The inverter will have active power frequency response, according to a measurement accuracy of -/+ 0.01 Hz or less. For this purpose, the inverter will be equipped with a frequency-power regulator or a similar regulator that allows a response to the frequency change.
b. Inverters regulation:

1. In the frequency range of [(50 - DB_{UF}) < f < (50 + DB_{OF})] the inverter will produce maximum available active power ($P_{available}$) up to the nameplate active power rating of the inverter.

2. When the frequency increases above 50 Hz, the inverter will reduce the active power output.

3. When the frequency decreases below 50 Hz, the inverter will increase the active power output (subject to the available power).

4. The inverter will decrease / increase the active power output according to the following formula:

when the frequency is higher than 50Hz + DB_{OF}:

$$\Delta P = -\frac{P_{ref}}{R_{OF}} \cdot \frac{f - (50 + DB_{OF})}{50}$$

when the frequency is lower than 50Hz - DB_{UF} and the available power is higher than P_{ref}:

$$\Delta P = -\frac{P_{ref}}{R_{UF}} \cdot \frac{f - (50 - DB_{UF})}{50}$$

provided that the frequency is between the limits of 47 Hz < f < 52 Hz.

Where:

ΔP - is the active power output change in response to the frequency change.

f - is the actual system frequency (Hz)

$P_{available}$ – is the available active power depending on the solar radiation and the state of the inverter.

P_{ref} - active power output of the inverter when exceeding the deadband (DB) range.

R_{OF}, R_{UP} - regulation constants for Over-Frequency (OF) and Under-Frequency (UF) (frequency droop).

5. The default deadband (DB_{OF}, DB_{UF}) settings are DB_{UF} = 0.2 Hz DB_{OF} = 0.1 Hz, or another value between 0 and 0.5 Hz to be determined by the System Operator.

6. The default frequency droop setting is 3% ($R_{OF}, R_{UF} = 0.03\ p.u$) , or another value between 2% and 5% to be determined by the System Operator.

7. Droop and deadband setting values will be adjustable.

8. The frequency control of the inverter is required to operate continuously and immediately.

9. The $T_{Response90\%}$ response time to a step-type disturbance, defined as the time required to reach 90% of the set-point value including the frequency measurement time, will not exceed 2 seconds for Over-Frequency (OF), and will not exceed 10 seconds for Under-Frequency (UF).

3. The inverter will have the ability to synchronize with the grid under the following conditions:

a. System frequency in the range of 47 Hz < f < 52 Hz.
b. Voltage at the point of connection to the grid is within the normal operation range.

4. The inverter will provide voltage control capability with following operating modes:

a. Constant power factor
b. Power factor as a function of the active power
c. Reactive power as a function of the voltage
d. Active power as a function of the voltage

5. The inverter will provide capability to operate in the following power factor range at the point of connection to the grid:

From overexcited 0.9 to underexcited 0.9.

($\tan\phi = \pm 0.484$ of the active power of the inverter).

6. The inverter should disconnect from the grid upon detection of an electrical islanding conditions (Anti-Islanding Detection) and in addition according to the conditions below:

Table 1: Passive anti-islanding voltage limits

Function	Default setting	Delay time	Maximum time to disconnect
Under-Voltage 2 (U<<)	30% Un	2s	3s
Under-Voltage 1 (U<)	85% Un	10s	11s
Over-Voltage 1 (U>)	115% Un	3s	4s
Over-Voltage 2 (U>>)	120% Un	-	0.2s

Table 2: Passive anti-islanding frequency limits

Function	Default setting	Delay time	Maximum time to disconnect
Under-Frequency (*f*<)	47 Hz	2s	3s
Over-Frequency (*f*>)	52 Hz	0.2s	0.4s

After the failure is over, the inverter should operate in accordance with the instructions listed in section 2.4.

7. Compliance of the inverters with the standards

The inverter will meet the requirements for harmonics according to Israeli standard50160, for flicker according to IEC 61000-3-7 standard and the requirements defined for PV installations.

Part B: Technical requirements for photovoltaic inverters connected to medium voltage

Any photovoltaic inverter that will be connected to a medium voltage grid will meet the following requirements:

Note: An inverter that will be connected to the high/extra high voltage system will comply with the requirements and instructions set by the System Operator.

1. Voltage withstand capability:

a. Continuous operation - the inverter will operate continuously when the voltages are within the normal operation range (Un ± 10%).
b. Abnormal conditions - the inverter will continue to operate stably during and after a grid fault, which causes a voltage disturbance, according to the LVRT/HVRT (Low/High Voltage Ride Through) curves shown below:

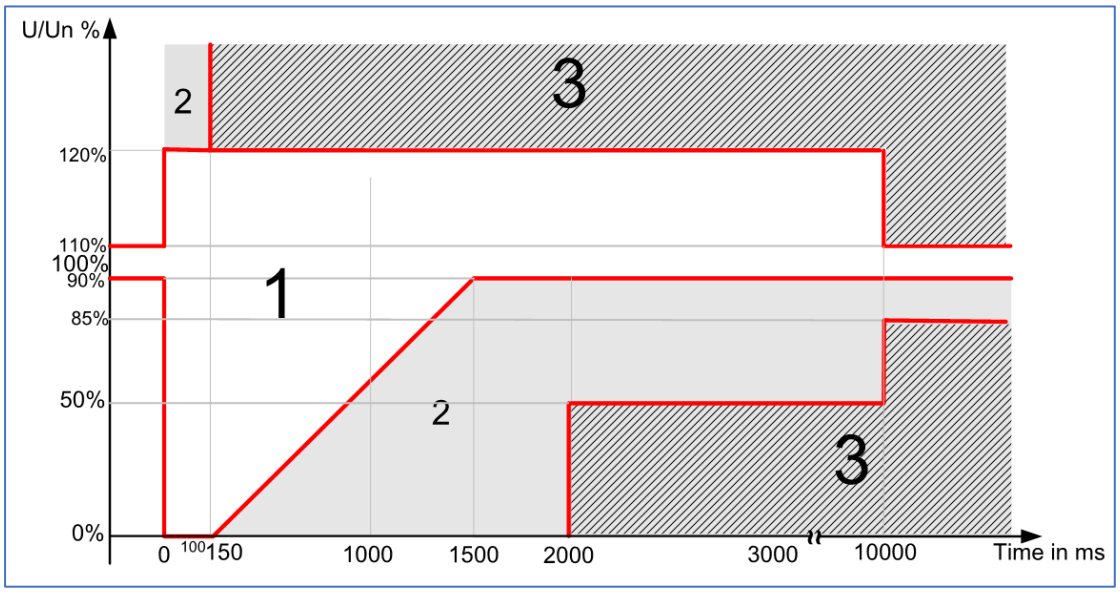

Diagram 2: HVRT/LVRT curves for medium voltage installations

where:

Zone 1 (*): The inverter will not disconnect from the grid and will continue to supply energy.

Zone 2 (*): The inverter may stop supplying energy to the grid.

Zone 3 (*): The inverter must stop supplying energy to the grid.

(*) After the failure is over, the active current value that the inverter supplied before the fault should return to its pre-fault value. The response time $T_{Response90\%}$ for a step-type disturbance, defined as the time required to reach 90% of the set-point value, will not exceed one second.

2. Dynamic response of the inverter in abnormal conditions, outside normal operation range, i.e. U<Un-Δ, U>Un+Δ:

a. The inverter is required to have the ability to dynamically support the power grid by reactive current injection during disturbance, and according to the Diagram 3:

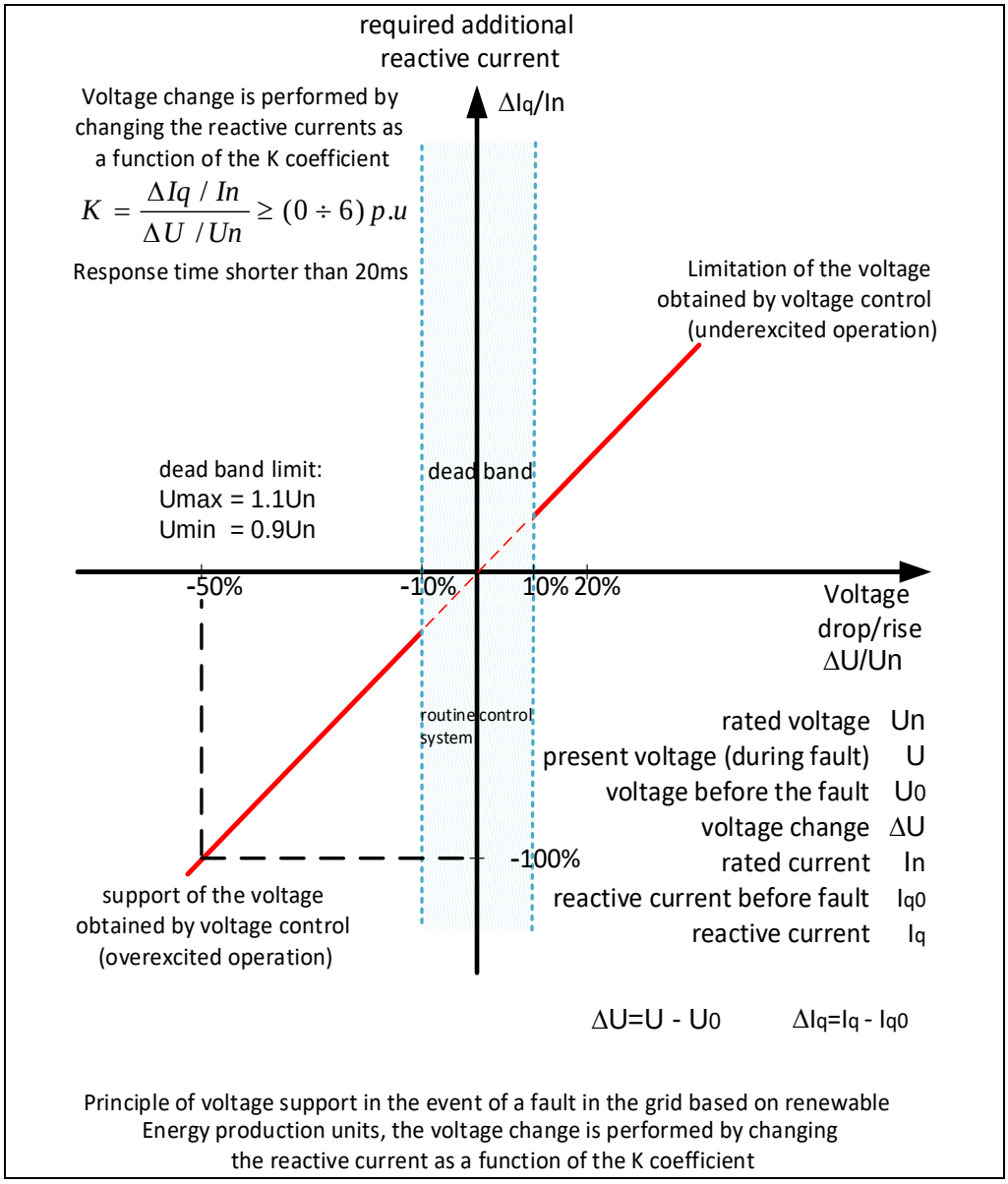

Diagram 3: Dynamic response principle of the inverter

For example: K-FACTOR = 2 defines that when voltage going out of the defined limits - for every 1% decrease in voltage, the reactive current injection will increase by an addition of about 2% of the nominal current.

b. The inverter voltage control is required to operate within 20 ms of the disturbance detection unless otherwise specified by IECo.
c. The inverter should allow the injection of a reactive current up to100% of the rated current (according to the required response - see Diagram 3).

d. After the voltage returns to normal operation range, the voltage control will support the grid for another 500 ms.
e. The default - K-FACTOR value is set to 0.
f. If the inverter has "Restricted dynamic network stability" capability, the K-FACTOR value will be coordinated with IECo.
g. The K-FACTOR coefficient and each of the two ranges (U<Un-Δ, U>Un+Δ) will be adjustable and modified according to the instructions of IECo.

3. Requirements relating to frequency:

3.1 Frequency withstand capability:

a. Continuous operation: the inverter will operate continuously in the frequency range between 47 Hz and 52 Hz (47 Hz < f < 52 Hz).
b. Minimum value of frequency: at a frequency equal to or lower than 47 Hz (f ≤ 47 Hz), the inverter will reduce the output active power to 0 MW after a delay of 1 second.
c. Maximum value of frequency: at a frequency equal to or higher than 52 Hz (f ≥ 52 Hz) the inverter will reduce the output active power to 0 MW in about 0.2 second.
d. The connection of the inverter after its disconnection and the increase of the output active power, will be carried out in accordance with section 8.
e. Rate of Change of Frequency (ROCOF): the inverter will operate normally for Rate of Change of Frequency that is less than or equal to 3 Hz/s.

3.2 Frequency Response:

a. The inverter will have active power frequency response, according to a measurement accuracy of -/+ 0.01 Hz or less. For this purpose, the inverter will be equipped with a frequency-power regulator or a similar regulator that allows a response to the frequency change.
b. The System Operator will determine the operating regime of the facility by remote control:

   1. Basic operating mode - LFSM (Limited Frequency Sensitive Mode)

   2. Operating mode sensitive to frequency changes - FSM (Frequency Sensitive Mode)

c. Inverter regulation in basic operation mode - LFSM (Limited Frequency Sensitive Mode):

   1. In the frequency range [(50 - DB_{UF}) < f < (50 + DB_{OF})] the inverter will produce maximum available active power up to the nameplate active power rating of the inverter or according to $P_{set\text{-}point}$ determined by the System Operator.

   2. When the frequency increases above 50 Hz, the inverter will reduce the active power output.

   3. When the frequency decreases below 50 Hz, the inverter will increase the active power output (subject to the available power).

   4. The inverter will decrease/increase the active power output according to the following formula:

when the frequency is higher than 50Hz + DB_{OF}:

$$\Delta P = -\frac{P_{ref}}{R_{OF}} \cdot \frac{f - (50 + DB_{OF})}{50}$$

when the frequency is lower than 50Hz - DB_{UF}:

$$\Delta P = -\frac{P_{ref}}{R_{UF}} \cdot \frac{f - (50 - DB_{UF})}{50}$$

provided that the frequency is between 47 Hz < f < 52 Hz.

Where:

ΔP - is the active power change in response to the frequency change.

f - is the actual system frequency (Hz)

$P_{available}$ – is the available power depending on the solar radiation and the state of the inverter.

R_{UF}, R_{OF} - regulation constants for Under-Frequency (UF) an Over-Frequency (OF) (frequency droop).

P_{ref} - active power output of the inverter when exceeding the deadband (DB) range.

$P_{set\text{-}point}$ - operating active power of the inverter at the connection point, determined by the System Operator.

5. The default deadband (DB_{OF}, DB_{UF}) settings are DB_{UF} = 0.2 Hz DB_{OF} = 0.1 Hz, or another value between 0 and 0.5 Hz to be determined by the System Operator.

6. The default frequency droop setting is 3% (R_{UF}, R_{OF} = 0.03 p.u.) or another value between 2% and 5% to be determined by the System Operator.

7. Droop and deadband settings will be adjustable.

8. The frequency control of the inverter is required to operate continuously and immediately.

9. The $T_{Response90\%}$ response time to a step-type disturbance, defined as the time required to reach 90% of the set-point value, including the frequency measurement time, will not exceed 2 seconds.

10. The inverter will allow the regulation of the output active power, throughout the hours of the day according to the capacity of the inverter and the available power, by setting of operating point $P_{set\text{-}point}$ specified by the System Operator and IECo in order to maintain the reserve power:

RP (RESERVE POWER) - the reserve power that the facility is required to maintain, according to the requirements of the System Operator: $P_{available} - P_{set\text{-}point}$.

See example in Diagram 4:

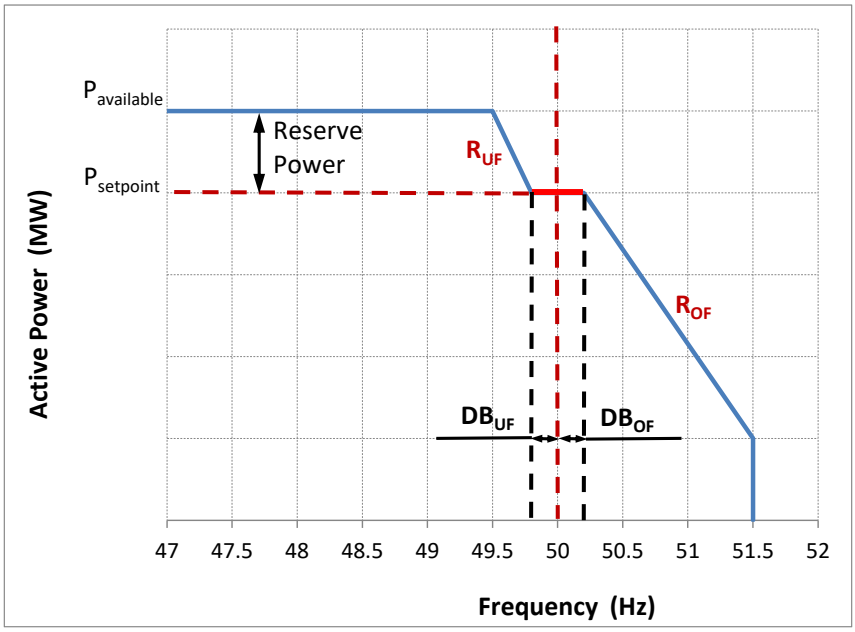

Diagram 4: An example of a power-frequency regulation characteristic

It should be noted that: the indicated power levels, regulation constants and frequency values will be determined by IECo and the System Operator during the technical coordination phase of the facility. The values marked in Diagram 4 are used as an example only.

d. Inverter regulation in operating mode sensitive to frequency changes - FSM (Frequency Sensitive Mode):

In the FSM operating mode, the inverter will allow a continuous response to the frequency, deadband = 0.

The operating regime of FSM will be set by remote control in accordance with the instructions of the System Operator, and subject to the future regulatory framework.

4. The inverter will meet the requirements for harmonics according to the Israeli standard # 50160, for flickers according to IEC 61000-3-7 standard and the requirements defined for PV installations.

5. The inverter will have the ability to synchronize to the grid under the following conditions:

a. System frequency in the range of 47 Hz < f < 52 Hz.
b. Voltage at the point of connection to the grid is within the normal operation range.

6. The inverter will provide capability to operate in the following power factor range at the point of connection to the grid:

a. In the "overexcited" and "underexcited" regimes: in the range between ($-0.43*S_{nom}$) kvar and ($+0.43*S_{nom}$) kvar, where S_{om} is the nameplate apparent power of the inverter.

b. Below in Diagram 5, can be observed a P/Q characteristic that illustrates this capacity:

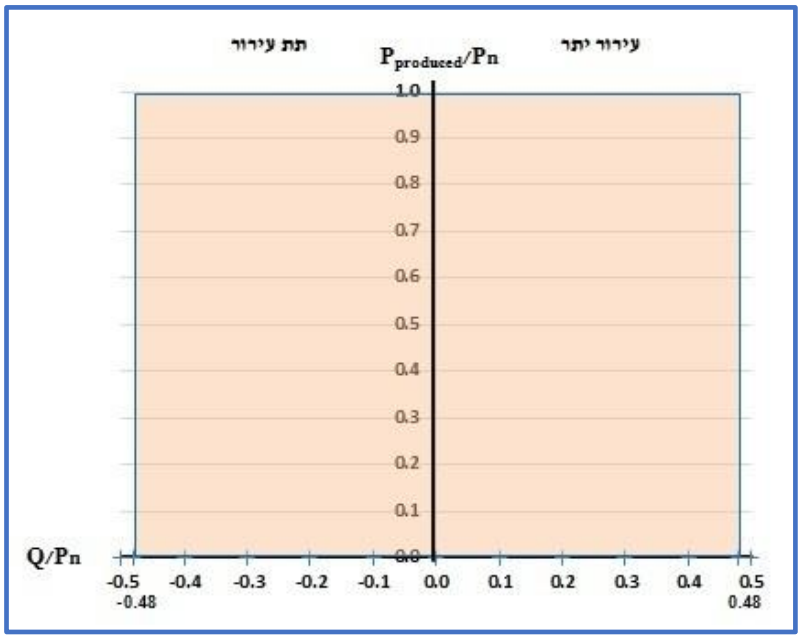

Diagram 5: P / Q characteristic of the inverter

c. The inverter will have capability to provide reactive power in darkness hours and at all hours of the day independent of active power output.

7. The inverter should disconnect from the grid at the moment of detection of an electrical islanding conditions (Anti-Islanding Detection) and according to the conditions below:

Table 3: Passive anti-islanding voltage limits

Function	Default setting	Delay time	Maximum time to disconnect
Under-Voltage 2 (U<<)	30% Un	2s	3s
Under-Voltage 1 (U<)	85% Un	10s	11s
Over-Voltage 1 (U>)	110% Un	15s	16s
Over-Voltage 2 (U>>)	120% Un	-	0.2s

Table 4: Passive anti-islanding frequency limits

Function	Default setting	Delay time	Maximum time to disconnect
Under-Frequency (*f*<)	47 Hz	2s	3s
Over-Frequency (*f*>)	52 Hz	0.2s	0.4s

After the failure is over, the inverter should operate in accordance with the instructions listed in section 8.

(*) It should be noted that in a facility connected to the medium voltage grid of IECo, L.O.M. (Loss of Main) protection will also be installed in the main circuit breaker of the generation facility.

8. Conditions for connecting the inverter to the grid:

The reconnection of the inverter after being disconnected from the power grid due to operational action or automatic protection, will be possible when the grid voltage is within the normal operation voltage limits, and the grid frequency is between 47.0 Hz and 50.1 Hz (47 Hz < f < 50.1 Hz). After disconnecting the inverter from the grid, the inverter will be connected to the system with a delay of 5 minutes (or another period of time determined by IECo) as long as the voltage and frequency conditions specified in this section are met.

The active power increase rate after connecting the inverter or after the inverter returns to supply active power, will be adjustable by the System Operator and not more than 40% and not less than 10% of the rated power per minute. The default value is 20% of the rated power per minute.

9. The inverter will provide voltage control capability with following operating modes:

a. Constant power factor
b. Power factor as a function of the active power
c. Constant reactive power
d. Reactive power as a function of the voltage

The inverter will able to change by remote the control mode and the required value of the control parameter up to the limits specified in the reactive power range detailed in section 6. If necessary, the System Operator may require other control function.

10. Compliance of the inverters with international standards

The inverters must meet international standards.

11. The inverter is required to be linked & connected to the facility's general control system, which will interface with the future ADMS system in accordance with the guidelines of IECo.

12. Inverters that will be combined with storage: will be in accordance with the requirements of the System Operator and IECo - the System Operator and IECo should be contacted regrading this matter.