DARFON

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HOW TO USE H5000 AS EMERGENCY POWER IN PUERTO RICO

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1. The Off-Grid Solution: H5000 Hybrid Inverter

During September of 2017, hurricane Maria rendered most Puerto Ricans without power at home, possibly for many months to come. Night satellite images of Puerto Rico before and after hurricane Maria are shown in the images below.

Here Darfon presents an energy solution for immediate application to Puerto Rico during the blackout period, and for future prevention of power loss at home.

When the utility grid is down, the best solution for continuous home power is to use photovoltaic (PV) modules coupled with a hybrid inverter and a battery array. Darfon's H5000 hybrid inverter can operate in an off-grid environment. It can accommodate up to 6.5kW of PV modules, and has a built-in charger for charging 48V battery banks.

The H5000 hybrid inverter is nominally 5kW of AC output and allows a short burst up to 7kW. It can accommodate 2 strings of PV modules with individual MPPT for maximum power. The built-in battery charger can charge at 60A and discharge at 150A. The inverter is bidirectional which allows charging the battery from the grid.

For more specifications of the H5000 please refer to the datasheet below.

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H5000 Hybrid Inverter

H5000 SPECIFICATIONS

SOLAR DC INPUT	
Max Power	6500W
Operation/MPPT Voltage Range	120 to 500VDC / 250 to 430VDC
Min Start Voltage	150 VDC
Max Input Current	13A / 13A (Two String Input)
INVERTER AC OUTPUT	
Continuous Output Power @ 25°C	5000W
Overload 40sec/5sec/1sec @ 25°C	5500W/6500W/7500W
Rated Output Current (RMS)	21A (@120V and 240V)
Output Frequency (Auto Sensing)	50/60 Hz
Output Voltage	L-N: 120V ± 3%; L-L: 240V ± 3%
AC INPUT FROM GRID	
Automatic Transfer Relay Rating / Typical Transfer Time	33A / 20ms
AC Input Voltage Range	L-L: 180 to 280V (240V Nominal)
AC input Frequency Range	55 to 65 Hz
AC OUTPUT TO GRID	
Grid Feed-In Current Range	0 to 24A (@240V)
Grid Feed-In Voltage Range	L-L: 211 to 264V ± 3.0V
Grid Feed-In Frequency Range	59.4 to 60.4Hz ± 0.05Hz
EFFICIENCY	
Peak/CEC Weighted (PV to Grid)	96%/95.5%
DC BATTERY CHARGER	
Max Charge/Discharge Current	60A/150A
DC Voltage Range	42 to 60V (48V Nominal)
Compatible Battery Types	AGM (default), Gel, Li-ion, $LiFePO_4$, Custom
GENERAL SPECIFICATIONS	
Product Weight	35.0kg (71.2lb)
Product Dimensions (HxWxD)	690x445x150mm (27.2x17.5x5.9in)
Protection Rating	NEMA 1 Indoor / IP20
Operating Temperature	0 to 55°C (power derated above 40°C)
Storage Temperature	-25 to 70°C (-13 to 158°F)
Compliances	UL 1741, IEEE 1547, FCC Class B

The Darfon H5000 features a true hybrid design with power sharing between various power sources. This hybrid inverter prioritizes the energy flow and direction from the batteries, PV modules and utility. The H5000 also comes with system monitoring and generator support. It was designed to accommodate both wall or rack mounting options. The H5000 Hybrid Inverter supports a wide range of applications, including off-grid, self-use, net-metering, backup and time-of-use optimization.

- Up to 6.5kW of input power with built-in MPPT solar charger
- Compatible with Lithium or lead-acid based batteries
- Six (6) preset modes: backup, backup w/o grid feed-in, residential, residential w/o grid feed-in, TOU, and TOU w/battery feed-in
- Transformerless inverter design with true sine-wave AC output and auxiliary port for generator support
- System monitoring and management via the control panel
- Five (5) year standard warranty

MODE DEFINITION

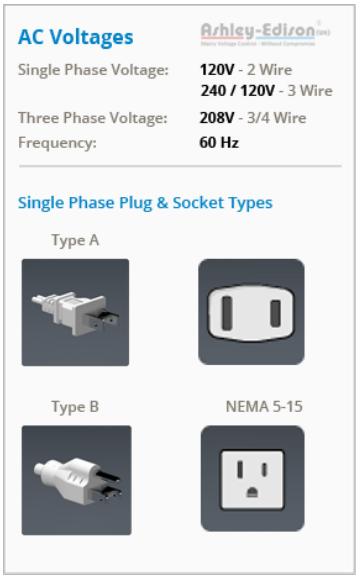
		CHARGE SOURCE		GRID FEED-IN FROM		PRIORITY FOR PV INPUT TO			PRIORITY FOR LOAD FROM		
		PV	Grid	PV	Batt.	Load	Batt.	Grid	PV	Grid	Batt.
1. Back-up (default)		Yes	Yes	Yes	No	2	1	3	1	2	3
2. Residential		Yes	No	Yes	No	1	2	3	1	3	2
3. Back-up w/o Feed-in		Yes	Yes	No	No	2	1	X	1	2	3
4. Residential w/o Feed-in		Yes	No	No	No	1	2	X	1	3	2
5. TOU	Off-Peak Period	Yes	Yes	Yes	No	2	1	3	1	2	3
	Peak Period	Yes	No	Yes	No	1	2	3	1	3	2
6. TOU w/Batt. Feed-in	Off-Peak Period	Yes	Yes	Yes	No	2	1	3	1	2	3
	Peak Period	Yes	No	Yes	Yes	1	3	2	1	3	2

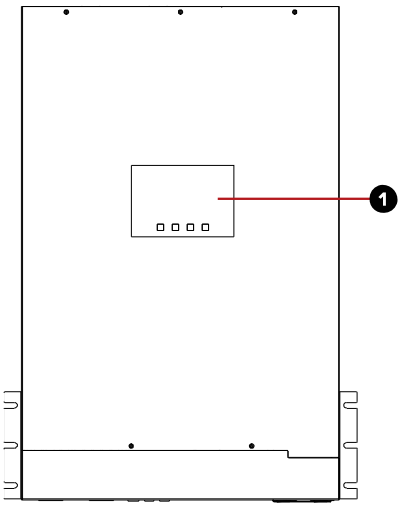
For more information, visit/contact us at www.darfonsolar.com or pvsales@darfon.com

2. H5000 for Puerto Rico Homes

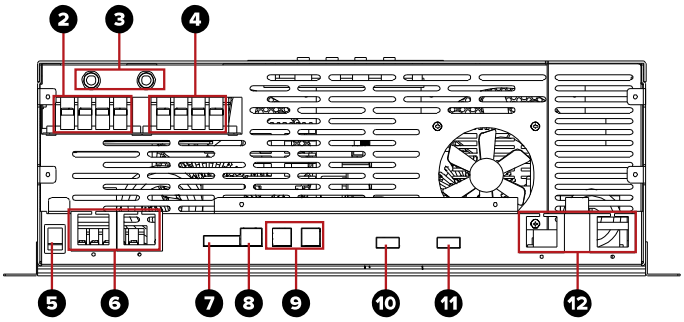
Puerto Rico uses 60 Hz, 3-wire 240V split-phase electrical system for residential power. The 240V splits into 120V 2-wire single phase for most of the home appliances and loads.

The H5000 is compatible with Puerto Rican homes since it is a 3-wire inverter which can operates in 240V and 60Hz. Cables from PV modules, grid, load, battery and communication enter on the bottom side of the H5000. Positions of all the H5000 connection ports and terminals are shown in the drawings below. There is also a dry contact for remote generator startup.





Front View of Hybrid Inverter



Bottom View of Hybrid Inverter

1. Display Panel
2. AC Grid Connectors
3. Breaker for Grid Power
4. Output Load Connectors
5. On/Off switch
6. PV Connectors
7. AUX 12V/Dry Connectors
8. External Display Connectors
9. Multi-inverter Communication Port
10. RS485_MS Communication Port
11. RS485_SL Communication Port
12. Battery Connectors

3. PV Modules for H5000

To reduce transportation and installation cost in Puerto Rico, it is recommended that 300~350W solar panels are used. Low voltage mono or multi-crystalline silicon modules are to be used, in either 60 or 72-cell formats. Most of PV module makers would have 300~350W models available. Below table is an example from Neosolar.

MODEL	D6P310B4A	D6P315B4A	D6P320B4A	D6P325B4A	D6P330B4A
Maximum Rating Power (Pmax)	310 W	315 W	320 W	325 W	330 W
Module Efficiency	16.0%	16.2%	16.5%	16.7%	17.0%
Open Circuit Voltage (Voc)	45.68 V	45.91 V	46.15 V	46.38 V	46.62 V
Maximum Power Voltage (Vpm)	37.01 V	37.18 V	37.36 V	37.52 V	37.68 V
Short Circuit Current (Isc)	8.92 A	9.01 A	9.10 A	9.19 A	9.28 A
Maximum Power Current (Ipm)	8.39 A	8.49 A	8.58 A	8.68 A	8.78 A

As an example, consider the 325W model which is a 72-cell multi-crystalline module. At STC, 10 of such modules would form a series string of 3.25kWdc Pmax, 375.2Vdc Vpm and 463.8Vdc Voc. The H5000 inverter can accommodate two PV strings simultaneously, each 3.25kWdc and MPPT voltage ranges between 250 to 430Vdc, while operating voltage ranges between 120 to 500Vdc, and maximum of 13A per string. To pair with the H5000, one may design a system with 20 PV modules of around 325W each.

4. Lead-Acid Batteries for H5000

Lead-acid batteries can be used for storing the extra energy that the PV modules produce. AGM valve regulated batteries such as the Deka Unigy I 12AVR100ET (see spec sheet below) are recommended.

The H5000 has a nominal charging voltage of 48V (ranges from 42 to 60V) so the 12V Deka batteries would be serially connected in groups of 4 to form 48V.

Lead-acid batteries typically have a depth-of-discharge (DOD) at round 50%, so more batteries are recommended to run a home for longer hours. It is recommended that a minimum battery array of 4 x 4, i.e. 16 batteries, are used for a typical Puerto Rican home.

A guide table below shows the approximate hours of running a home at various load demands (kW) when various battery array capacities (kWh) are installed. For convenience, 48V and 50% DOD are assumed for the battery array.

It is advisable to reduce the loads at home to just critical loads for emergency use. After sunset where the PV modules are not generating and home power relies on just the batteries, it is better to be able to run the critical loads for around 3 to 4 hours at night. A suggested practice is to connect the H5000 to a subpanel with two breakers of 20A each, but try to only run approximately 2kW of appliances on the circuits for approximate 4 to 5 hours of night time use.

MORE POWER – LESS SPACE™

Deka® unigy I®

12AVR100ET

- **Exclusive IPF™ technology optimizes power capacity, cell consistency, and long-term reliability**
- Space saving Absorbed Glass Mat (AGM) construction (48 volt system fits in 19" racks)
- Reinforced case resists bulging and meets safety requirements (UL94 V-0)
- Computer-aided design and manufacturing control processes and standards to ensure quality products
- All batteries meet or exceed IEEE 485 and Telcordia capacity requirements
- Battery design and construction meet UL recognition requirements
- I.C.A.O., I.M.D.G., I.A.T.A., and D.O.T. air transport approved

SPECIFICATIONS

Nominal Voltage: 12-Volt/96 ampere-hours @ 8 hr. rate to 1.75 final volts/cell
Positive Plate: Pure lead, low-calcium, high-tin alloy
Negative Plate: Lead Calcium Alloy
Post Seal: Epoxy-sealed
Terminal: Inserted post, 1/4" x 20 brass insert
Container/Cover: Flame-retardant, polypropylene - UL 94 V-0/>28% L.O.I.
Safety Vent: Low positive pressure, self-sealing w/ flame arrestor

Float Voltage: 2.27 volts per cell ± 0.01 vpc (Range: 13.56 to 13.68 volts per 6-cell unit)
Design Life: 10 years in float applications at 77°F/25°C
Dimensions: 20.12" (511mm) L x 4.33" (110mm) W x 9.44" (240mm) H
Weight: 75 lbs (34.0 kg)

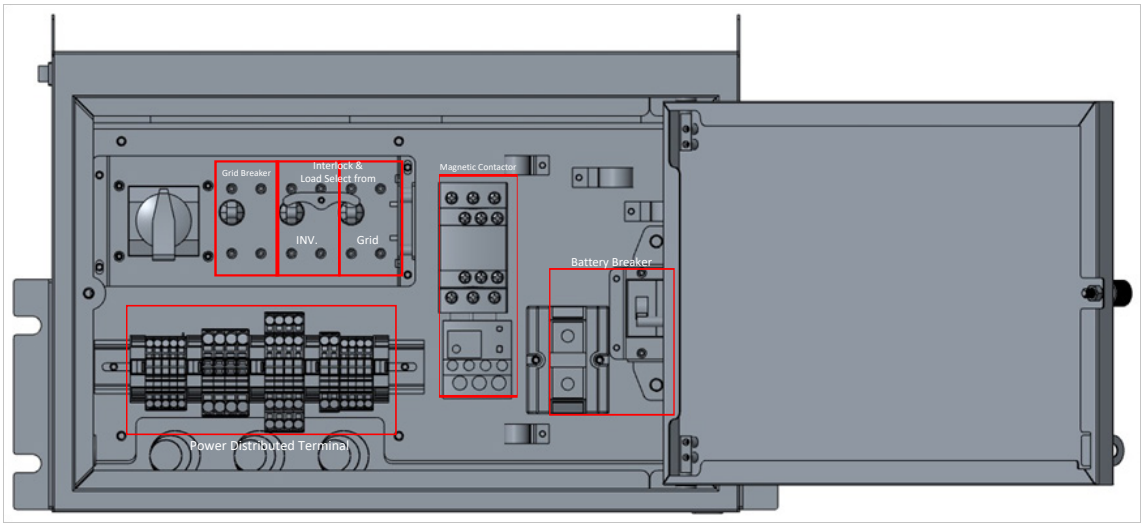
12AVR100 RATINGS IN AMPS @ 77°F

Volts Per Cell (V.P.C.)	1 HR.	3 HR.	5 HR.	8 HR.	10 HR.	12 HR.	20 HR.	24 HR.
1.75	63.3	27.0	17.6	12.0	10.0	8.5	5.4	4.6
1.80	62.5	26.8	17.4	11.9	9.9	8.4	5.4	4.5
1.85	60.8	26.2	17.1	11.7	9.7	8.3	5.2	4.4
1.88	58.8	25.5	16.7	11.4	9.4	8.1	5.1	4.3
1.90	57.2	24.8	16.3	11.1	9.2	7.8	5.0	4.2

BATTERY ARRAY INSTALLED				HOURS OF USE AT VARIOUS LOADS				
Array	V	Ah	kWh	1 kW	2 kW	3 kW	4 kW	5 kW
4 x 1	48	96	4.6	2.3 hrs	1.2 hrs	0.8 hrs	0.6 hrs	0.5 hrs
4 x 2	48	192	9.2	4.6 hrs	2.3 hrs	1.5 hrs	1.2 hrs	0.9 hrs
4 x 3	48	288	13.8	6.9 hrs	3.5 hrs	2.3 hrs	1.7 hrs	1.4 hrs
4 x 4	48	384	18.4	9.2 hrs	4.6 hrs	3.1 hrs	2.3 hrs	1.8 hrs
4 x 5	48	480	23.0	11.5 hrs	5.8 hrs	3.8 hrs	2.9 hrs	2.3 hrs

5. Distribution Box for H5000

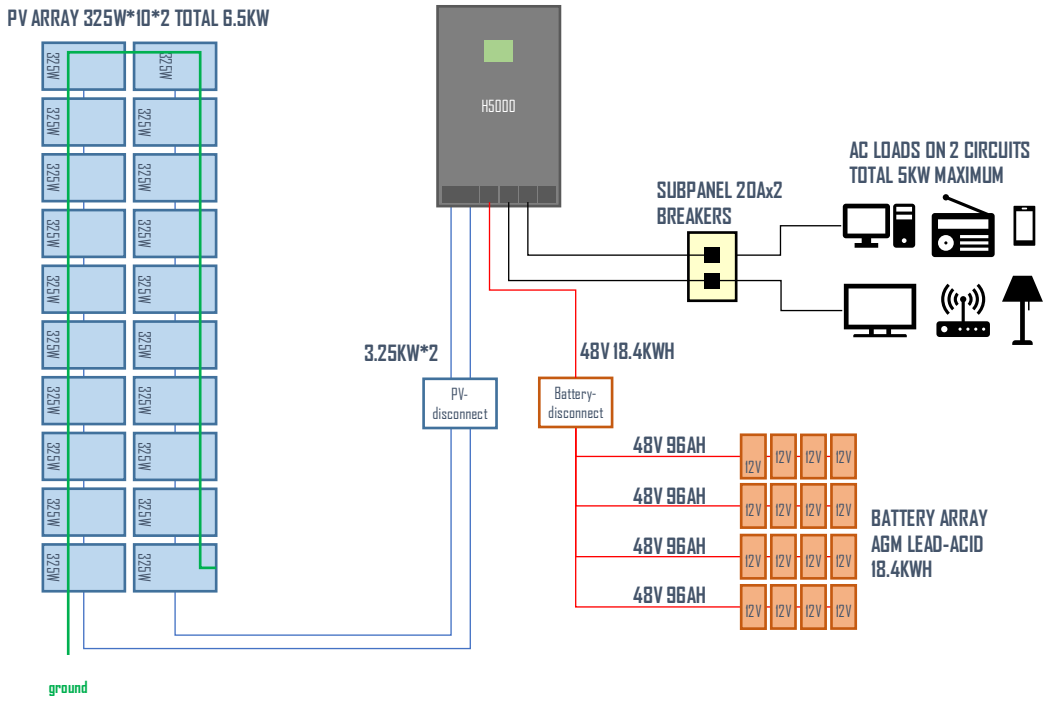
Most countries have national electric codes, including NA and LATAM, that require disconnects and breakers to be connected to the power lines in a PV energy storage system (ESS) for safety. This usually requires installers to install subpanels and distribution boxes. This additional work may take up to 4 man-days to complete, including time taken for designing, measuring, purchasing, fabrication and installation. Darfon has designed a pre-integrated distribution box, D05, which is designed specifically for the H5000. The D05 pre-wires the battery and PV disconnects, load and grid breakers, all the DC and AC terminals and generator (or other inverter) connection in a metallic enclosure with lockable access door, as seen below.



Definition of Power Distribution Terminals:

	PIN DEFINITION	DETAIL DESCRIPTION
Utility Grid Terminals	L1 (Black)	AC input Voltage: 240V/120V. Maximum Current: 21 Amp
	N (Gray)	
	L2 (Red)	
Critical Load Terminals	L1 (Black)	AC output Voltage: 240/120V Maximum Output Current: 21Amp
	N (Gray)	
	L2 (Red)	
AC Input (AC Module or Generator)	L1 (Black)	Acceptable AC power supply (ex: Grid-tied inverter or Generator) Input Voltage: 240V/120V. Maximum Current: 21 Amp
	L2 (Red)	
	12VDC	12VDC source: Max. 240mA output.
	Signal GND	
	Dry Con.	Dry connector: Max. 8 Amp current pass though.
	Dry Con.	

6. Final Design for Puerto Rico Off-Grid Power



Major materials list:

MATERIAL	SPEC	QTY	REMARKS
PV module	325 Wdc mc-Si	20	6.5 kWac
H5000 hybrid inverter	6.5 kWdc / 5 kWac	1	5 kWac
D05 distribution box		1	preassembled
AGM 12V battery	96 Ah Deka Unigy I	16	18.4 kWh
PV disconnect	DC 20A	1	
Battery disconnect	DC 150A	1	
Subpanel		1	
AC Breakers	20A AC	2	
Balance-of-System			Designed by installer