

VACON® 100

VACON® 100 X

VACON® 20 X

Solar pump drive – IP21, IP54 and IP66 solution

Solar Pump: Overview

- Pump running on electricity generated by photovoltaic panels
- Key benefits:
 - Ideal solution for remote areas, where electricity is not available
 - It is independent from conventional energy (off-grid solution)
 - It is supplied by uninterrupted energy during day time
 - It is supplied by “clean energy” and it is an Eco-friendly solution
- Opportunity:
 - Many Governments are subsidizing the swap from old fossil-fuel-powered generators to solar-supplied systems



Solar Pump: Overview

- Water means life (more crop/food and better quality of life)
- This solution can make a remarkable progress in reducing poverty and sustaining economic growth
- Typical areas of use:
 - Agriculture
 - Flood, drip or furrow irrigation
 - Rural community water supply
 - access to clean drinking water
 - hygienic and sanitation access
 - Animal farming
 - improve livestock breeding
 - cattle watering system



Solar Pump with IP20/21 drive

IP20/21 drive inside a cabinet

- Additionally fuses, power switch, lightening and/or surge protection, door LEDs/bulbs/buttons

Challenges:

- Cabinet required with adequate airflow for cooling
 - With IP55 rating at least!
- Proper protection required against dirt and heavy rain
- Airflow filters need maintenance
- Electronic components suffer from moisture and condensation



- Due to the power range with IP66 drives Danfoss also offers IP21/54 VACON 100 platform with solar pump application

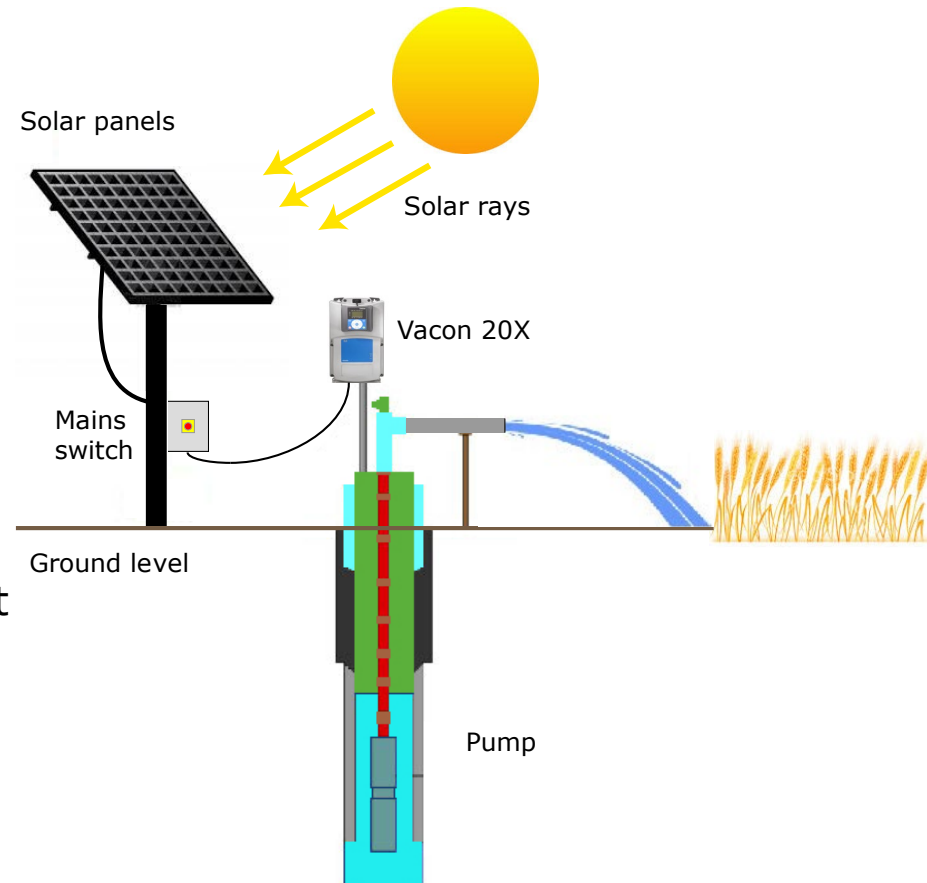
Solar Pump with IP66 drive

IP66/Type 4X outdoor drive without cabinet

- Special application software with MPPT⁴ algorithm integrated into the drive
- All water-treatment functionalities available as for standard Vacon drive

Benefits:

- **stand-alone** full feature factory tested solution
- Compact and **maintenance free** solution: no air filter to replace/clean
- Gore vent **against moisture and condensation**: no heater needed and very well protected in harsh environment
- Mains switch, surge protection, fuses and any other electronic components required can be placed together with the string box **in smaller sealed cabinet** that does not require additional cooling



Dual supply mode (power blending)

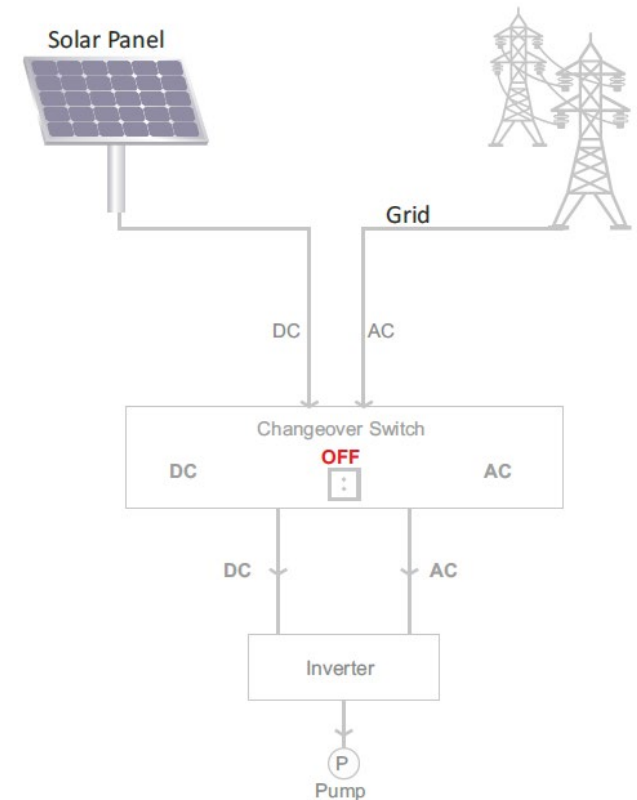
- Dual supply mode (power blending) is used when there is needed full water flow also in night time or weak day light
- In practice this means that AC from mains is used when there is not enough DC voltage available from solar panels
- Danfoss solar pump drives are industrial drives and can be supplied normally from grid as standard
- There are two ways of doing this:
 - Using switchover switch with delay from AC to DC
 - Dual supply (AC and DC) are connected into drive continuously at the same time

NOTE!

- In dual supply must be take care of safety in case of drive rectifier fault and AC supply power is down
- When this happens it is possible that dangerous DC voltage from solar panels can go as far as galvanically possible
- System must have a way to prevent this (built by system supplier)

Dual supply mode using changeover switch

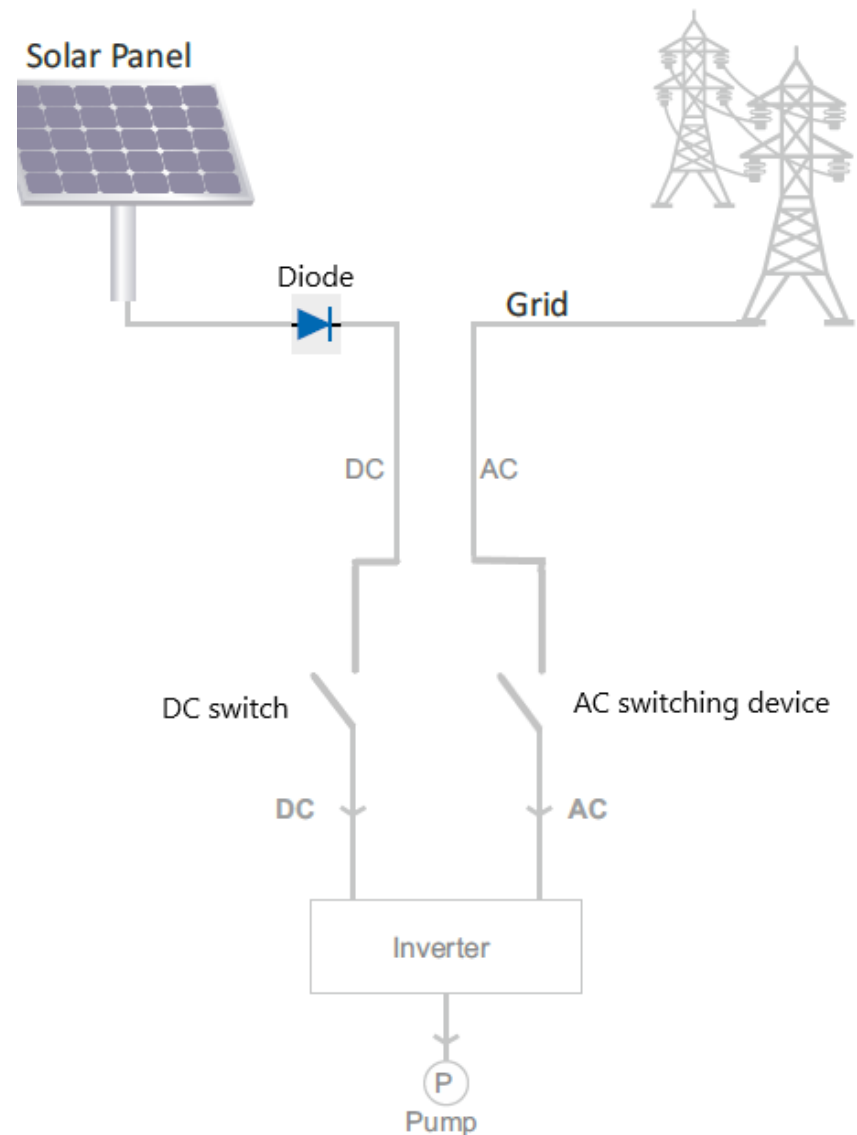
- This is easy, safe and reliable way to ensure safety
- When AC and DC are always separated and other is disconnected when other is connected it is not possible to have dangerous voltage coming out
- Delay between switchover is needed to wait that drive voltage drops low enough to ensure charging switch operation when connecting into power supply



	Danfoss recommends to use a two-pole disconnect switch as well for photovoltaic input (suitable for DC) as for grid input (AC switch) to completely isolate the equipment. Only one of these switches is allowed to be on at a time and delay time must be respected when changing from one switch to the other.
	The terminals are live when the VACON® 100 X Drive is connected to a photovoltaic system. Photovoltaic cells generate DC voltage even at low intensity of sunlight.
	Wait 30 seconds until the drive is discharged, before switching between AC and DC supply (photovoltaic system) and vice versa.
	The terminals are live when the VACON® 20 X Drive is connected to a photovoltaic system. Photovoltaic cells generate DC voltage even at low intensity of sunlight.
	Wait 60 seconds until the drive is discharged, before switching between AC and DC supply (photovoltaic system) and vice versa.

Dual supply mode using power supply blending

- Sometimes is required uninterrupted water flow and break caused by changeover switch is unwanted
- In that case AC and DC supply needs to be connected together at the same time
- When that is done there must be something to monitor AC supply that is used to separate drive from mains in case AC supply is down
- On functional point of view standard drive can be used with blocking diode to prevent voltage from mains affecting solar panels
- Note! Danfoss has given instructions on manual not to connect AC and DC at the same time because this is the safe way and also 100X certification is based on that comment.
- If/when customer wants to do the power blending by connecting AC and DC at the same time customer has to take responsibility of the safety



Danfoss Drives Offering for Solar Pump

- VACON® 20 X
 - For solar supply up to 800 VDC
 - Power **up to 7,5 kW/10HP**
 - With maximum ambient temperature up to **50°C** (with derating)
- VACON® 100 and 100 X
 - For solar supply up to 800 VDC
 - Power **up to 630 kW/1000HP**
 - With maximum ambient temperature up to **50/60°C** (with derating)



VACON® 20 X – Technical Overview

- Dual mode supply connection:

AC Supply	DC Supply	MU2	MU3
3AC 380-480 V	Up to 800 VDC	-	Up to 7.5 kW/10HP
3AC 208-240 V	Up to 400 VDC	-	Up to 4.0 kW/5HP
1AC 208-240V	Up to 400 VDC	Up to 1.5 kW/2HP	-

- Enclosure rating:
 - **IP66/Type 4X outdoor enclosure** -> maintenance free
 - Large capacitors bank for its category, so that sudden changes in solar power availability during operation are smoothed, avoiding annoying trips.
 - 2g / 25g vibration and shock
 - **50°C max ambient temperature**
- Built-in MPPT (Maximum power point tracker) -> a real 4-algorithms control scheme to obtain maximum power for any given environmental conditions
- EMC: built-in EMC filter according to EN61800-3 Category C2 or C1



Vacon 100 X – Technical Overview

- Dual mode Supply connection:

AC Supply	DC Supply	MM4	MM5	MM6
3AC 380-500V	Up to 800 VDC	Up to 5.5 kW/ 7.5HP	Up to 15 kW/ 20HP	Up to 37 kW/ 50HP
3AC 208-240V	Up to 400 VDC	Up to 3 kW/ 4HP	Up to 7.5 kW/ 10HP	Up to 15 kW/ 20HP

- Enclosure rating:

- **IP66/Type 4X outdoor enclosure**
- Plastic foil capacitors (maintenance free)
- 3g / 25g vibration and shock
- **60° C max ambient temperature**



- EMC: Built-in EMC filter according to EN61800-3 C2 (AC supply)
- Built-in MPPT (Maximum power point tracker) -> a real 4-algorithms control scheme to obtain maximum power for any given environmental conditions

Vacon 100 – Technical Overview

- Dual mode Supply connection:

AC Supply	DC Supply	MR5	MR6	MR7
3AC 380-500V	Up to 800 VDC	Up to 15 kW/ 20HP	Up to 30 kW/ 40HP	Up to 55 kW/ 75HP
3AC 208-240V	Up to 400 VDC	Up to 7,5 kW/ 10HP	Up to 15 kW/ 20HP	Up to 30 kW/ 40HP
MR8	MR9	MR10	MR11	MR12
Up to 110kW/150HP	Up to 200kW/300HP	Up to 315kW/500HP	Up to 400kW/600HP	Up to 630kW/1000HP
Up to 55kW/75HP	Up to 90kW/125HP	-	-	-

- Enclosure rating:

- **IP21/Type 1 and IP54/Type 3**
- Plastic foil capacitors (maintenance free)
- **50° C max ambient temperature**
- EMC: Built-in EMC filter according to EN61800-3 C2 (AC supply)
- Built-in MPPT (Maximum power point tracker) -> a real 4-algorithms control scheme to obtain maximum power for any given environmental conditions



Solar Pump Drive: how does it work?

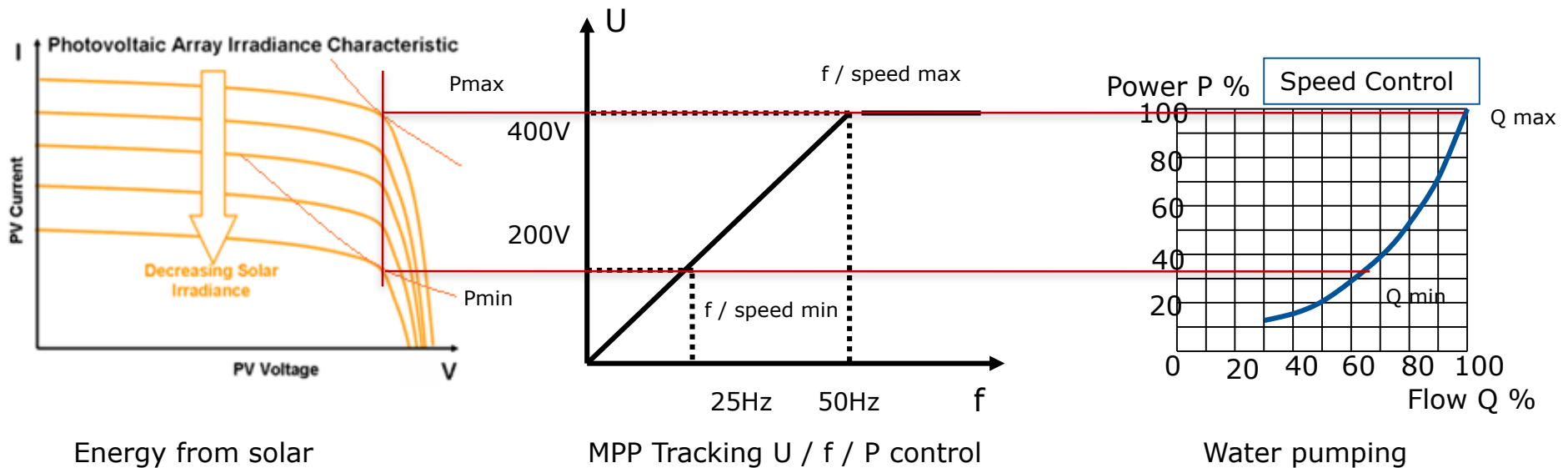
- Simpler controllers (under-voltage regulators)
 - Reduce the pump speed (thus reducing the absorbed power) once the DC voltage hits a minimum set level
 - Solar panels are not producing enough energy to keep the requested speed
 - The solar panels usually work at a non-optimal voltage
- The most advanced controllers
 - The drive tries to get the maximum power from solar panels by keeping the DC voltage at the optimum point (MPP=Max Power Point)

Solar Pump Drive: how does it work?

PV panels

Motor Inverter

Pump



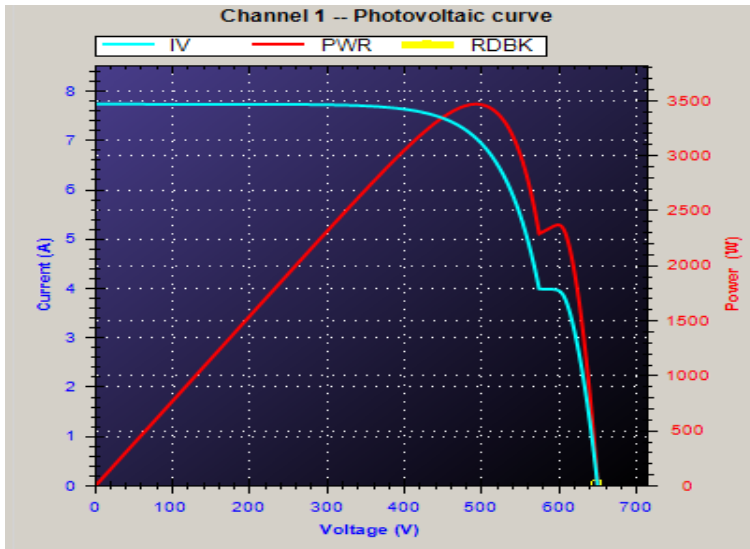
Solar Pump Drive: Danfoss Drives MPPT⁴

- A dedicated application SW for Solar Pump with an optimized multiple algorithm MPPT (Maximum Power Point Tracking) for VACON 20 X and VACON 100 X
- The unique Vacon MPPT⁴ controller implements 4 concurrent algorithms:
 - Feed-Forward controller (to follow the radiation variations)
 - Correction controller (to compensate the temperature variations)
 - Oscillation Damping regulator (to catch-back the panels entering in the “current source mode”)
 - Local Maxima Bypass logic (to skip the “false” maximum point in case of partial irradiation)

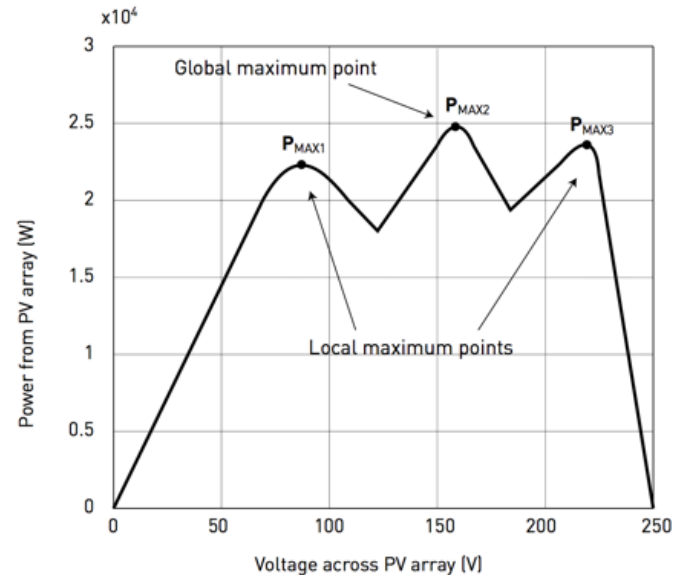
The Danfoss Drives Local Maxima Bypass Logic

- Specific logic (unique on the market) to bypass “local maxima” (below the real MPP) caused by Panels degradation, partial irradiation
- MPPT⁴ Local Maxima logic allows to skip this point and reach the overall maximum

Partial irradiation



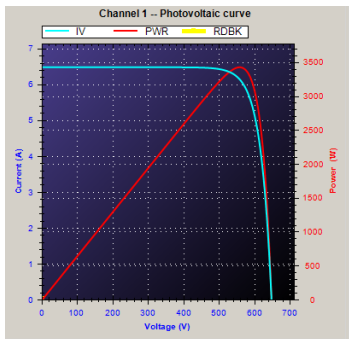
Partial irradiation simulation



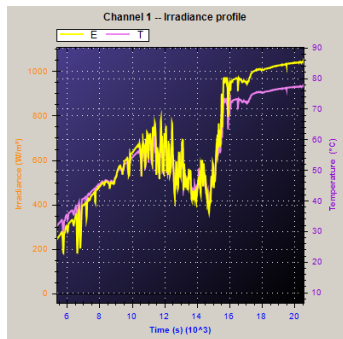
Danfoss Drives MPPT⁴ vs. Claimed "MPPT"

- MPPT⁴ provides more generated output power
 - This increases the amount of pumped water
 - This extends the pump working time during day time
 - This shows that other regulators called "MPPT" are often simple under-voltage controller with corrections

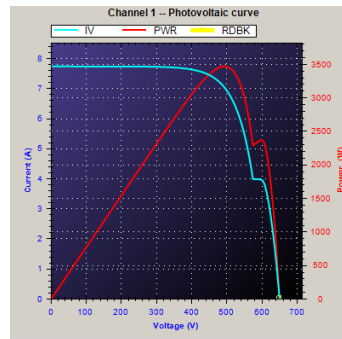
Basic PV curve



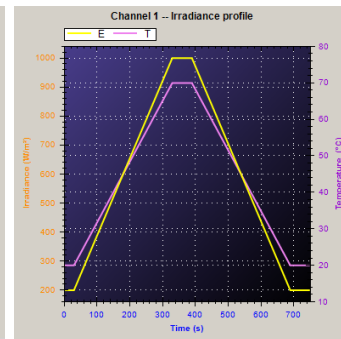
Cloud perturbation



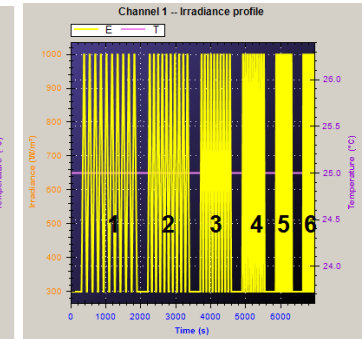
Partial irradiation



Irrad. + temp. variation



Irradiance



Summarizing

- Assuming that the overall lifetime cost of a pump system is made by:
 - 5% installation (initial investment)
 - 10% maintenance (service and maintenance)
 - 85% energy consumption

It's easy to understand how big impact has in the investment return a MPPT control able to increase the efficiency of the system by a double-digit.

Solar pump project in Morocco – VACON 100 X



Use case

- Solar-powered pump for citrus trees irrigation at farm between Marrakech and Casablanca

Customer Needs

- Replace the gas engine with a more reliable and safe drive system
- Reduce operating costs
- Reduce maintenance efforts

Customer Benefits

- Clear savings due to better system efficiency and less operating costs
- Extended pump lifetime due to smooth operation
- No risk of gas explosion

Irrigation system in Spain – VACON 100



Use case

- Solar-powered irrigation at farm close to Portuguese border

Customer Needs

- High power pumps up to 110kW needed
- Several drives connected into same solar field

Customer Benefits

- Minimized operating and maintenance costs



**ENGINEERING
TOMORROW**

How to order

- Solar pump applications available from factory
 - VACON 100 INDUSTRIAL and VACON 100 X can be ordered with plus code +A1181 (VACON 100 FLOW does not support solar pump)
 - VACON 20 X must be ordered with plus code +A1163
- Solar pump application (AMIT1181) can be also downloaded afterwards into VACON 100 INDUSTRIAL and VACON 100 X by license code. License can be created using VACON KEY tool free of charge.
- VACON 20 Cold Plate can be also delivered with same power ratings as 20 X with +A1163 application when there is bigger OEM case

Output filters

- Same rules are valid in solar panel supply as in AC supply with drives
 - In old installations motor winding insulation can be weak
 - With long cables same rules apply than with AC supply

Dimensioning 20X

Input voltage U_{in}	3AC 208...240V 1AC 208...240V 3AC 380...480V
Input voltage tolerance	-15%...+10% continuously
Input frequency	50/60 Hz

Table 58. VACON[®] 20 X (208...240V 3AC 50/60Hz) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MU3	0011	234 ... 400V _{DC} No tolerance permissible, 0%	4.4
	0012		6.0
	0017		8.0

Table 59. VACON[®] 20 X (208...240V 1AC 50/60Hz) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MU2	0004	234 ... 400V _{DC} No tolerance permissible, 0%	1.5
	0005		2.2
	0007		3.0

Table 60. VACON[®] 20 X (380...480V 3AC 50/60Hz) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MU3	0009	436 ... 800V _{DC} No tolerance permissible, 0%	8.0
	0012		11.0
	0016		14.0

Dimensioning 20X

- Additionally needed
 - DC switch
 - DC fuse
 - Protection diode

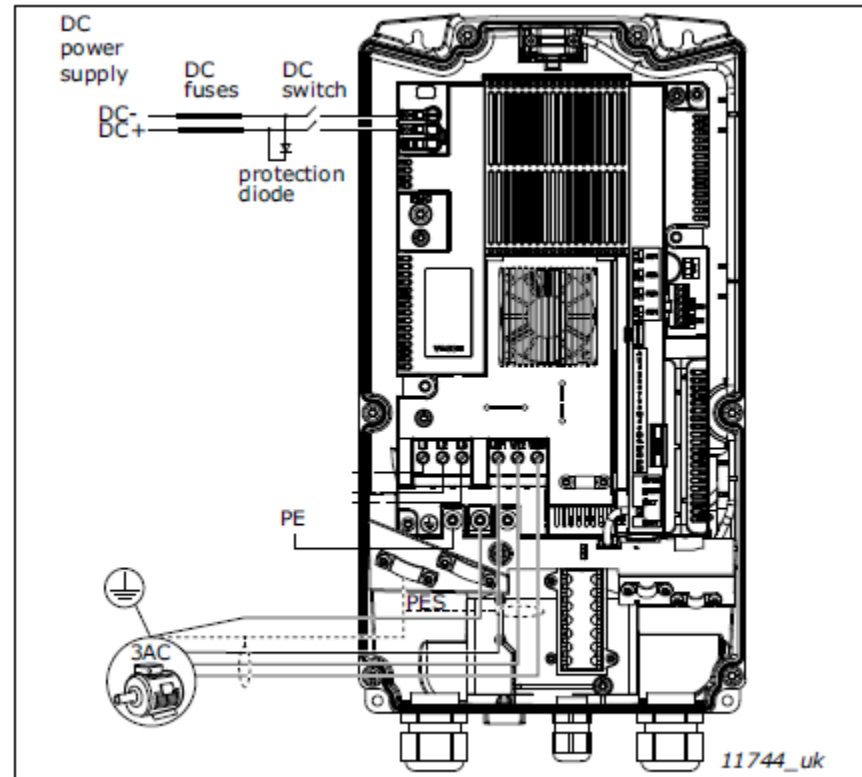


Figure 77. Example of the power connections: MU3

20X ratings

Table 27. Power ratings of VACON® 20 X, supply voltage 208-240V.

Mains Voltage 3AC 208-240V, 50/60 Hz						
AC drive type	Input current [A]	Loadability			Motor shaft power	
		Rated continuous current I _N [A]	50% overload current [A]	Max current I _S	230V	240V
					[kW]	[HP]
0004	4.3	3.7	5.6	7.4	0.75	1.0
0005	6.8	4.8	7.2	9.6	1.1	1.5
0007	8.4	7.0	10.5	14.0	1.5	2.0
MU2	0011	13.4	11.0	16.5	22.0	3.0
	0012	14.2	12.5	18.8	25.0	4.0
	0017	20.6	17.5	26.3	35.0	5.0

Table 28. Power ratings of VACON® 20 X, supply voltage 1AC 208-240V.

Mains Voltage 1AC 208-240V, 50/60 Hz						
AC drive type	Input current [A]	Loadability			Motor shaft power	
		Rated continuous current I _N [A]	50% overload current [A]	Max current I _S	230V	230V
					[kW]	[HP]
MU2	0004	8.3	3.7	5.6	7.4	1.0
	0005	11.2	4.8	7.2	9.6	1.5
	0007	14.1	7.0	10.5	14.0	2.0

Table 29. Power ratings of VACON® 20 X, supply voltage 380-480V.

Mains Voltage 3AC 380-480V, 50/60 Hz						
AC drive type	Input current [A]	Loadability			Motor shaft power	
		Rated continuous current I _N [A]	50% overload current [A]	Max current I _S	400V	480V
					[kW]	[HP]
0003	3.2	2.4	3.6	4.8	0.75	1.0
0004	4.8	3.3	5.0	6.7	1.1	1.5
0005	5.6	4.3	6.3	8.6	1.5	2.0
MU2	0006	7.3	5.6	8.4	11.2	3.0
	0008	9.6	7.6	11.4	15.2	4.0
	0009	11.5	9.0	13.5	18.0	5.0
MU3	0012	14.9	12.0	18.0	24.0	7.5
	0016	20	16.0	24.0	32.0	10.0

Dimensioning 100X

Input voltage U_{in}	3AC 208...240V 3AC 380...480V 3AC 380...500V
Input voltage tolerance	-15%...+10% continuously
Input frequency	50/60 Hz

Table 56. VACON® 100 X (208...240V 3AC 50/60Hz, up to 400V in VDC) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MM4	0007	234 ... 400V _{DC} No tolerance permissible, 0%	2.2
	0008		3.0
	0011		4.4
	0012		6.0
MM5	0018		8.0
	0024		11.0
	0031		15.0
MM6	0048		22.0
	0062		30.0

Table 57. VACON® 100 X (380...480/500V 3AC 50/60Hz, up to 800V in VDC) DC-link input ratings

Enclosure size	AC drive type	DC supply [V]	Max. Recommended PV Array Power [kW]
MM4	0003	436 ... 800V _{DC} No tolerance permissible, 0%	2.2
	0004		3.0
	0005		4.4
	0008		6.0
	0009		8.0
	0012		11.0
MM5	0016		15.0
	0023		22.0
	0031		30.0
MM6	0038		37.0
	0046		44.0
	0061		60.0
	0072	74.0	

Dimensioning 100X

- Additionally needed
 - DC switch
 - DC fuse
 - Protection diode

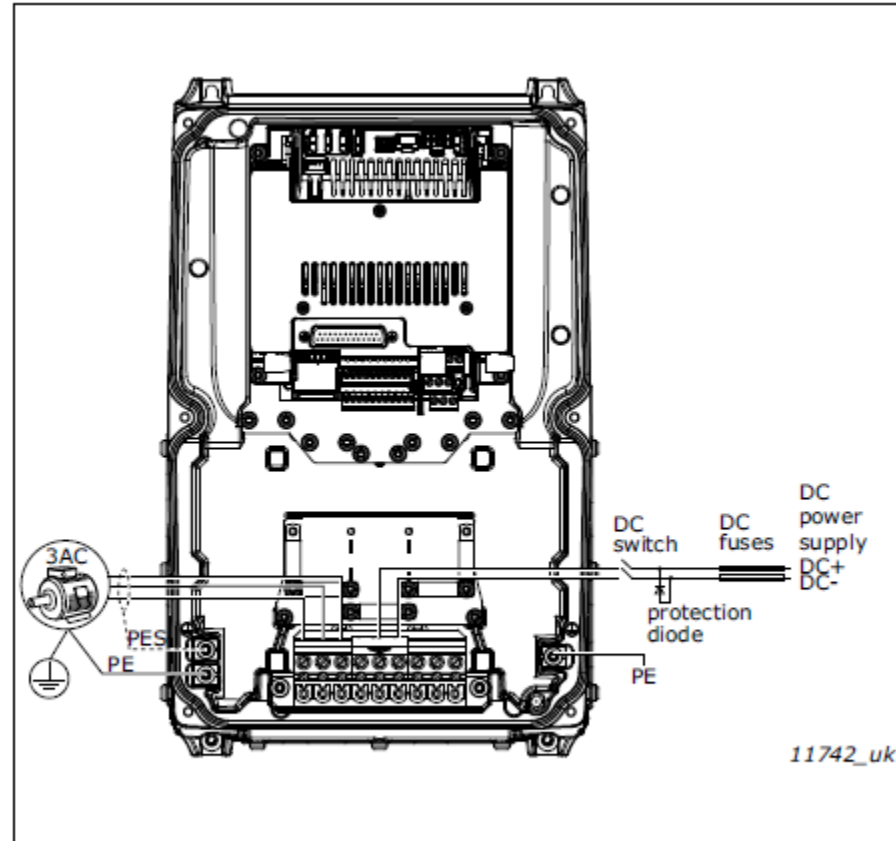


Figure 96. Example of the power connections: MM4/MM5

100X ratings

Table 28. Power ratings of VACON® 100 X, supply voltage 3AC 208-240V.

Mains voltage 3AC 208-240V, 50/60 Hz							
	AC drive type	Input current [A]	Loadability			Motor shaft power	
			Rated continuous current I_N [A]	50% overload current [A]	Max current I_S	230V supply	
						[kW]	[HP]
MM4	0007	6.0	6.6	9.9	13.2	1.1	1.5
	0008	7.2	8.0	12.0	16.0	1.5	2.0
	0011	9.7	11.0	16.5	22.0	2.2	3.0
	0012	10.9	12.5	18.8	25.0	3.0	4.0
MM5	0018	16.1	18.0	27.0	36.0	4.0	5.0
	0024	21.7	24.2	36.3	48.4	5.5	7.5
	0031	27.7	31.0	46.5	62.0	7.5	10.0
MM6	0048	43.8	48.0	72.0	96.0	11.0	15.0
	0062	57.0	62.0	93.0	124.0	15.0	20.0

Table 29. Power ratings of VACON® 100 X, supply voltage 3AC 380-480/500V, high overload.

Mains voltage 3AC 380-480/500V, 50/60 Hz							
	AC drive type	Input current [A]	Loadability			Motor shaft power	
			Rated continuous current I_N [A]	50% overload current [A]	Max current I_S	400V	480V
						[kW]	[HP]
MM4	0003	3.4	3.4	5.1	6.8	1.1	1.5
	0004	4.6	4.8	7.2	9.6	1.5	2.0
	0005	5.4	5.6	8.4	11.2	2.2	3.0
	0008	8.1	8.0	12.0	16.0	3.0	5.0
	0009	9.3	9.6	14.4	19.2	4.0	5.0
	0012	11.3	12.0	18.0	24.0	5.5	7.5
MM5	0016	15.4	16.0	24.0	32.0	7.5	10.0
	0023	21.3	23.0	34.5	46.0	11.0	15.0
	0031	28.4	31.0	46.5	62.0	15.0	20.0
MM6	0038	36.7	38.0	57.0	76.0	18.5	25.0
	0046	43.6	46.0	69.0	92.0	22.0	30.0
	0061	58.2	61.0	91.5	122.0	30.0	40.0

Table 30. Power ratings of VACON® 100 X, supply voltage 3AC 380-480/500V, low overload.

Mains voltage 3AC 380-480/500V, 50/60 Hz							
	AC drive type	Input current [A]	Loadability			Motor shaft power	
			Rated continuous current I_N [A]	10% overload current [A]	Max current I_S	400V	480V
						[kW]	[HP]
MM6	0072	67.5	72.0	80.0	108.0	37.0	50.0