Vacon® 100X & Vacon® 20X

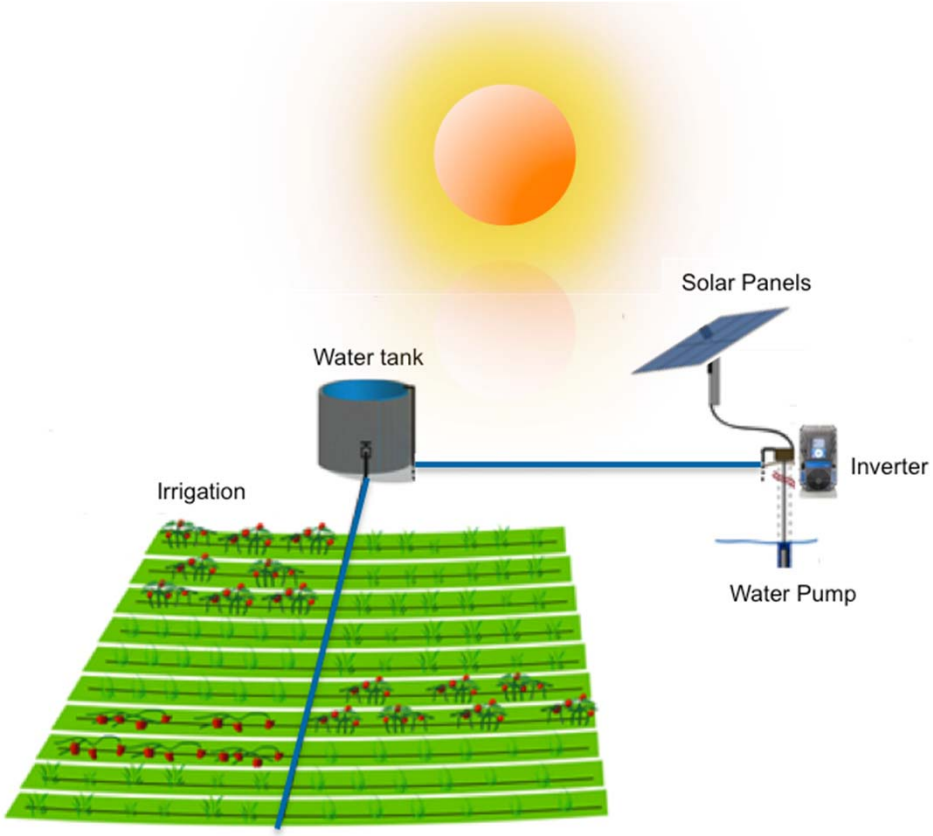
Solar Pump Drive - IP66 Solution

Solar Pump: What is it?

A **Solar Pump** is a pump running on electricity generated by photovoltaic panels. It is useful in areas where grid electricity is unavailable or frequently missing.

In principle the needed components are a pump, a motor, an array of solar photovoltaic panels, and a few devices in the line between the panels and the motor.

Basically those devices include a **mains switch**, a **lightning protection** and an **Inverter** to convert the DC voltage from the panels to AC voltage, to supply the motor.



A key differentiator in the Inverter selection should be its ability to run the motor pump at the optimal working point (voltage and power) in order to make the solar panels deliver the highest possible power in different irradiation and ambient temperature conditions (**MPPT control**).

Solar Pump: key benefits

- **Key benefits:**
  - Reduced Carbon footprint
  - Ideal for remote areas, where electricity is not available
  - Clean energy and Eco-friendly solution
  - Non dependent from conventional energy
  - Uninterrupted supply for irrigation during the day time.

- **Areas of use:**
  - Irrigation (flood irrigation, drip irrigation)
  - Cattle watering system
  - Community water supply
  - Animal farming

Solar Pump installation: the usual way

- A Solar Pump Inverter is usually an IP20 device installed inside a cabinet where there are also a few other components, such as fuses, power switch, lightening protection, door LEDs/bulbs.
- It requires a cabinet with an adequate airflow to cool down the temperature inside (heat produced by the drive).
- As the cabinet is often put in the middle of nowhere, a proper protection against dirt and heavy rain is mandatory, it has to be IP55 at least!
- Almost all the Solar Pump inverter suppliers in the market are offering a unit to be mounted inside a cabinet.

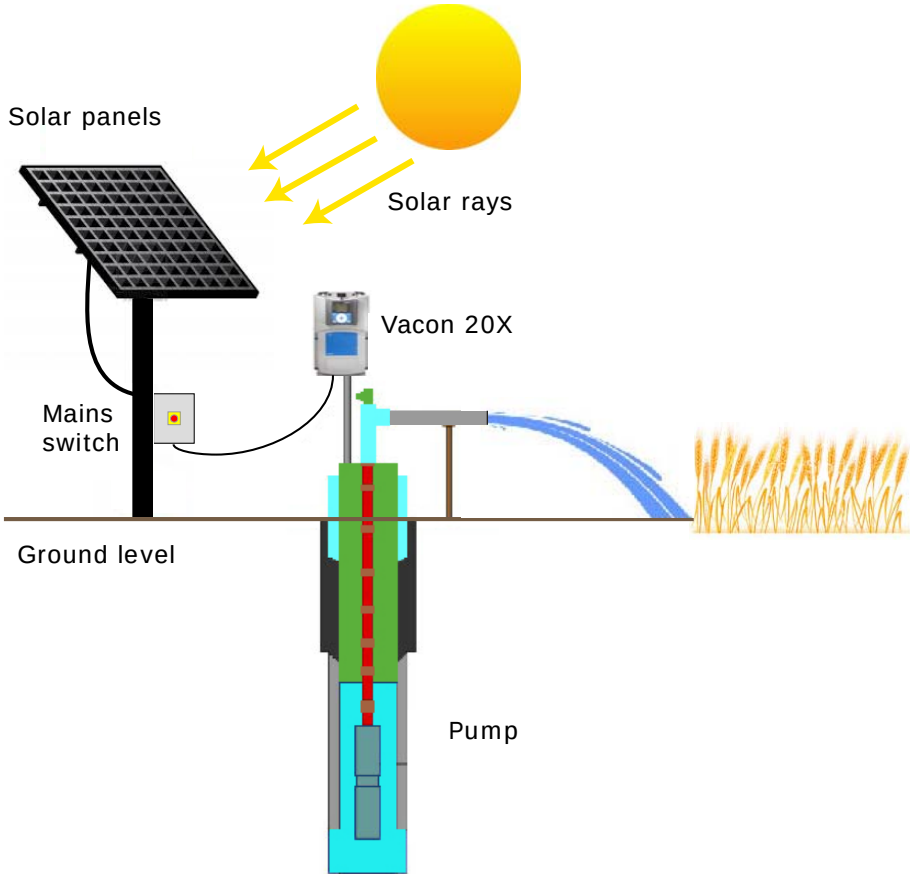
Solar Pump Drive in cabinet: critical points

- Airflow filters need maintenance. It is a cost. Also, it has to be done by people with some technical skill, as it is dangerous: inside the cabinet there is always the high DC voltage generated by Solar Panels.
- Sometimes, in odd cases when spares are not available, filters are removed by the user after a recurrent over-temperature trip. This leads to catastrophic effects on the electronics inside the cabinet.
- As the electrical panel is usually installed outdoors, the electronic components suffer from the moisture that comes into the cabinet through the airflow filters. Possible solutions to overcome the problem are difficult to manage:

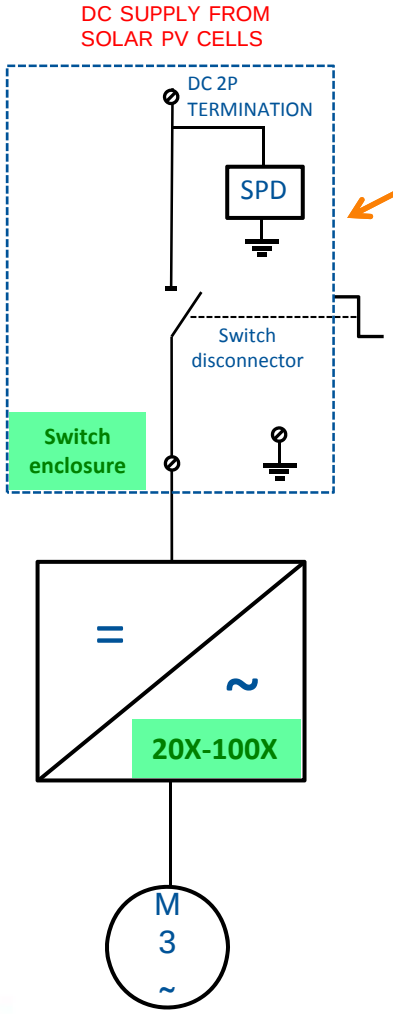
- A heater element inside the cabinet supplied by the solar panels cannot be effective, as during the night there is no energy. If the grid is available for the heater, then there is an additional wasted energy consumption.
- A vent to block the moisture mounted on the metal side would not work, as the moisture will go through the easier way: the aiflow filters.

Solar Pump Drives: the VACON IP66 Solution

- The Vacon IP66 Solution is innovative from both the HW and the SW Control Strategy point of view.
- A small enclosure where to place the mains switch and the surge protection device replaces the usual big cabinet, as the Inverter is placed outside.
- The Vacon IP66 Drive can be installed outdoors without any reliability risk. It doesn't require maintenance, as there are no filters to clean/replace.
- Condensation inside the drive is prevented by a GORE® vent which blocks the moisture without the need of any heater.
- Correct operation of the drive is visible from outside thanks to 4 LEDs showing the operating conditions: Power-ON, Run, Ready, Fault. An IP66 display panel can also be connected to get detailed information when needed, or kept permanently installed on the drive to show several variables (running speed, MWh counter, etc.)

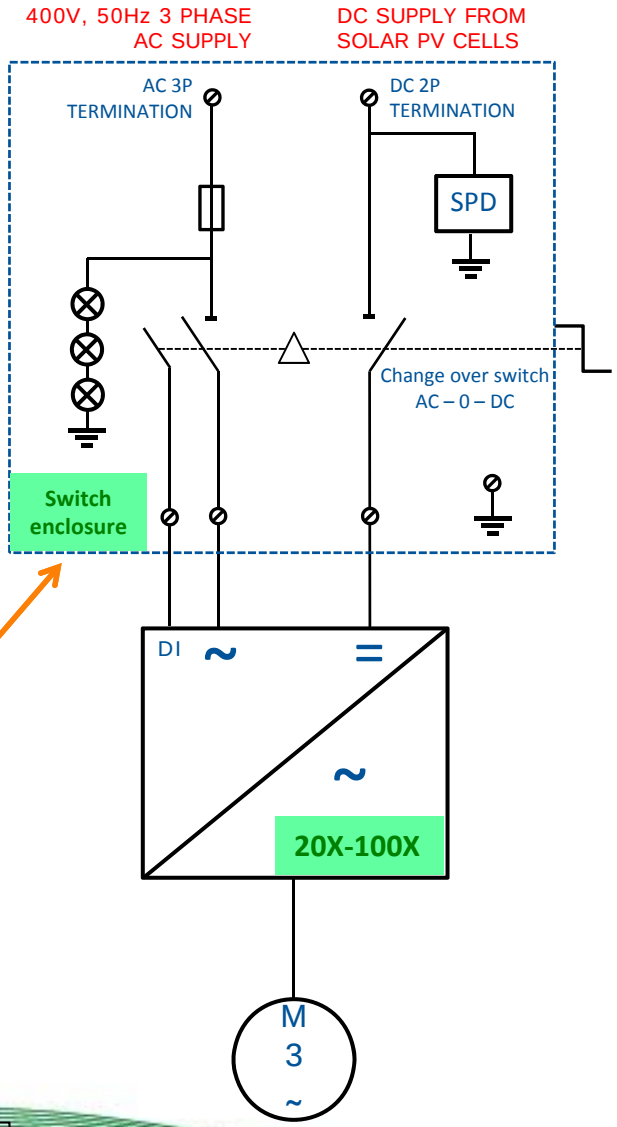


Solar Pump Drive: examples of supply modes



- **Solar panel connection mode:**
  - Stand-alone solution: inverter supplied by Solar Panels DC voltage.
  - Completely independent from the mains supply and self-sufficient installation.

- **Solar panel or Grid connection mode:**
  - With an external changeover switch, inverter can be supplied either by mains or solar panels.
  - Useful during night or panel maintenance operations.
  - The Vacon 20X-100X can have a “hot commutation” from grid to PV and vice-versa, as they recognize the supply source (solar panels or grid) by a digital input, selecting the appropriate control SW.



NOTE: submersible pumps require a filter between the drive output and the motor. Refer to the pump supplier for more information.

The VACON IP66 Solution: switch enclosure

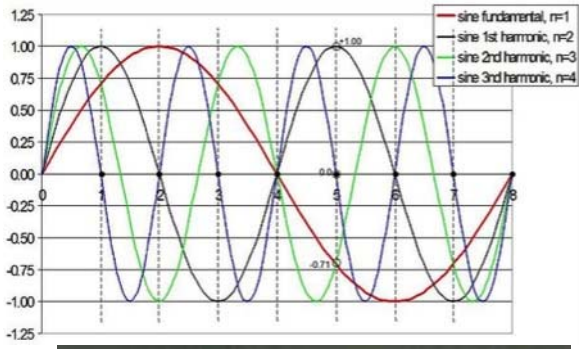
- System integrator (or local Vacon partner) needs a very small IP66 enclosure where to place the few electro-mechanical components needed to run the system (Mains switch, surge protection,…). As those devices do not produce heat, they can be put in a sealed small enclosure with no cooling (maintenance free).

- That enclosure, separated from the drive, will be equipped with the basic components needed by the required configuration, plus all the other options wanted by the user. This allows the installer to be very flexible, designing a cabinet suitable to run a pump in different layouts:

  - Inverter supplied only by **Solar Panel** only.
  - Inverter supplied by selectable source, **Solar Panel or grid**, simply using the appropriate mains switchover.
  - **By-pass** operation, to run the pump directly from the grid.

The VACON IP66 Solution

- With both 20X and 100X it is possible to supply the Inverter alternatively with Solar Panels array or with a conventional grid, when available (Dual Mode supply).
- When a Dual Mode supply is used, the Vacon 100X built-in choke heavily lowers the harmonics in the 3Ph input. Low harmonics in the supply line give two simultaneous benefits:
  - Reduced voltage distortion in the supply line, particularly important when the grid is weak, with long distance from the nearest line transformer.
  - Heavily reduced energy losses in the supply lines, which means higher efficiency of the system.



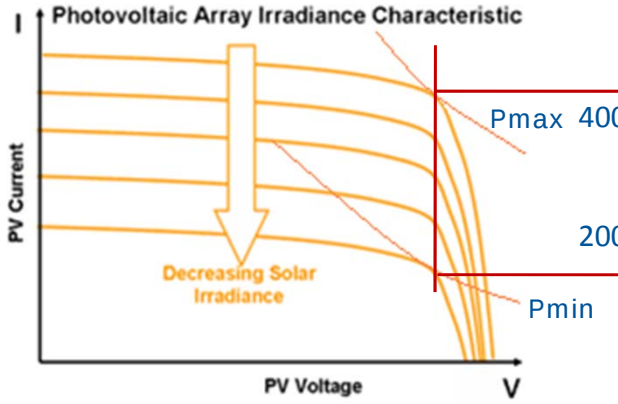
- The Vacon 20X and 100X drives are very robust IP66 units, designed for very harsh environments. They can bear dirt, dust, water jets, oil.
- The only recommendation is to avoid direct sunlight, in order to prevent a de-rating due to high temperature. For instance, an ideal positioning is the underside of the solar panels array.

Solar Pump Drive control: how does it work?

Simpler controllers (under-voltage regulators) work reducing the pump speed (thus reducing the absorbed power) once the DC voltage hits a minimum set level, meaning that the solar panels are not producing enough energy to keep the requested speed. In that situation the solar panels usually work at a non-optimal voltage.

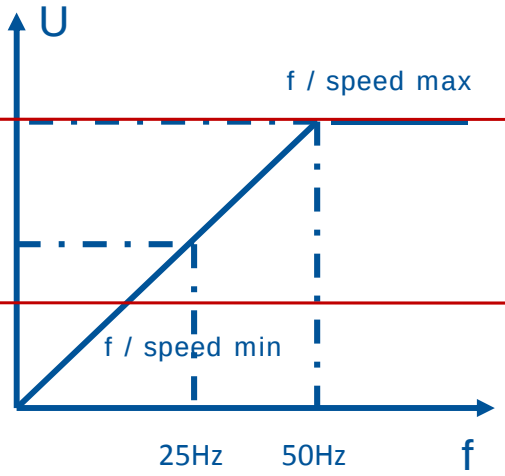
In the most advanced controllers the drive tries to get the maximum power from solar panels by keeping the DC voltage at the optimum point (MPP=Max Power Point).

PV panels



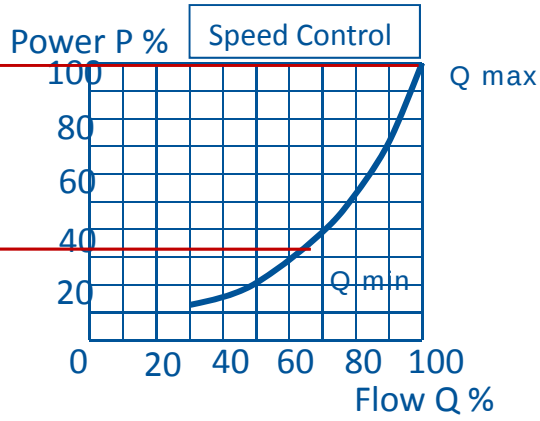
Energy from solar

Motor Inverter



MPP Tracking U / f / P control

Pump



Water pumping

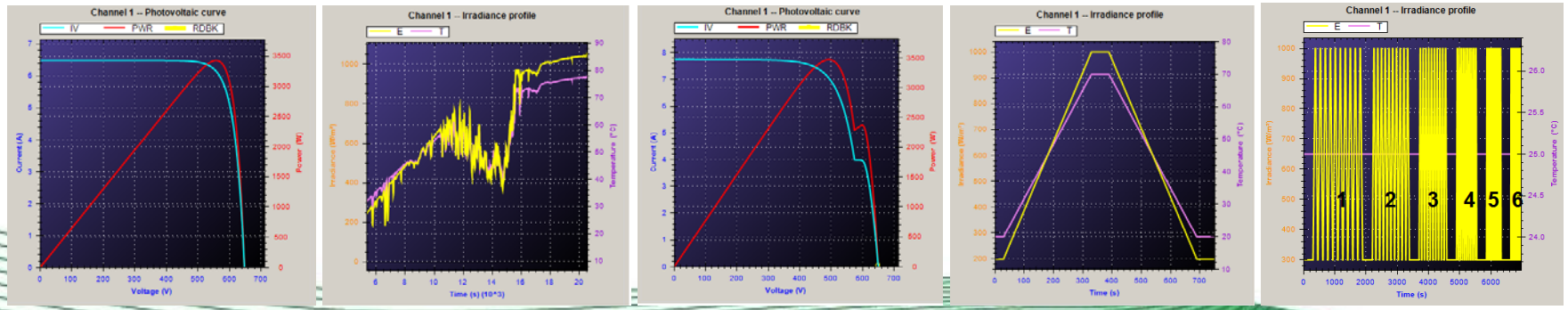
Solar Pump Drive: the VACON MPPT^4 control strategy

- A dedicated application SW was developed to drive a Solar Pump with an optimized multiple algorithm MPPT (Maximum Power Point Tracking) for 20X & 100X supplied by Solar Panels.
- The unique controller Vacon **MPPT^4** 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)

- Analysis over other similar Solar Inverters showed that regulators called "MPPT" are often simple under-voltage regulators with corrections. Our simulations indicate that using a control based on under-voltage regulator the actual average power (and therefore liters of pumped water) generated by the solar panels can be 30% to 40% lower than the output power generated with Vacon **MPPT^4**!

Basic PV curve | Cloud perturbation | Partial irradiation | Irrad. + temp. variation | Irradiance



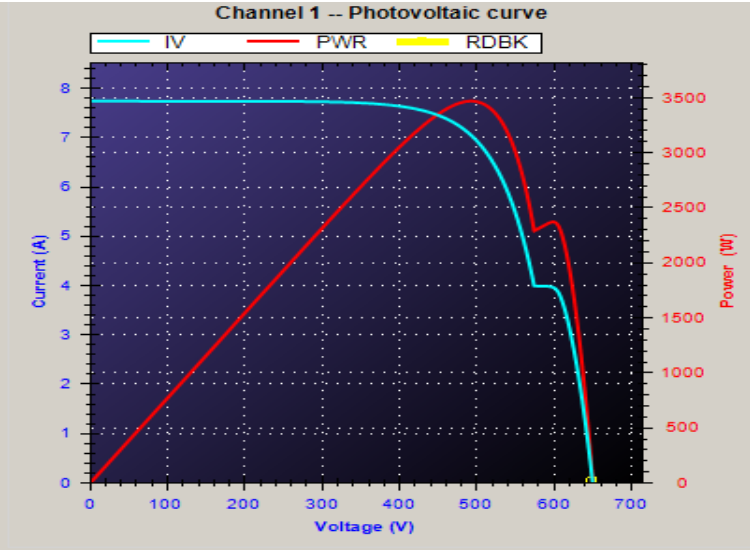
Solar Pump Drive Control: the Local Maxima Bypass logic

Unique to this class of products, Vacon Solar Pump Drive features a specific MPPT logic to bypass “local maxima”:

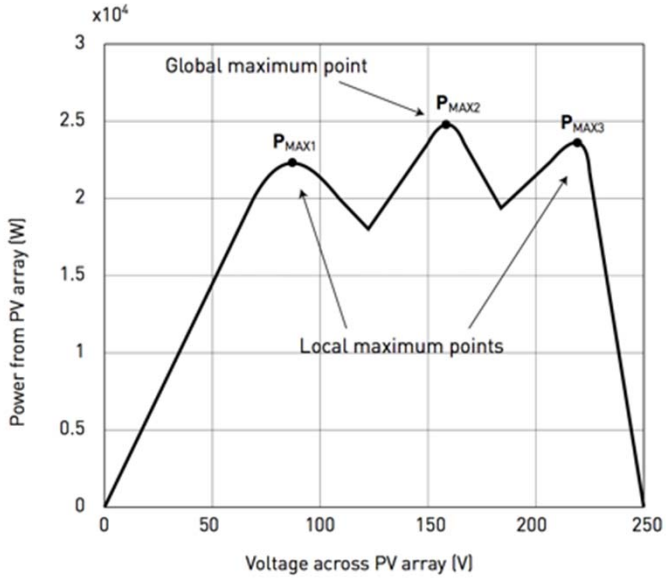
Panels degradation, partial irradiation (a shadow from surrounding buildings) or other cause may result in a PV field showing a “notch” in its characteristic that may trap most MPPT controllers to an operating point which may be way below the real MPP.

- Vacon **MPPT 4** Local Maxima logic allows to skip this point and reach the overall maximum thus delivering all available power.

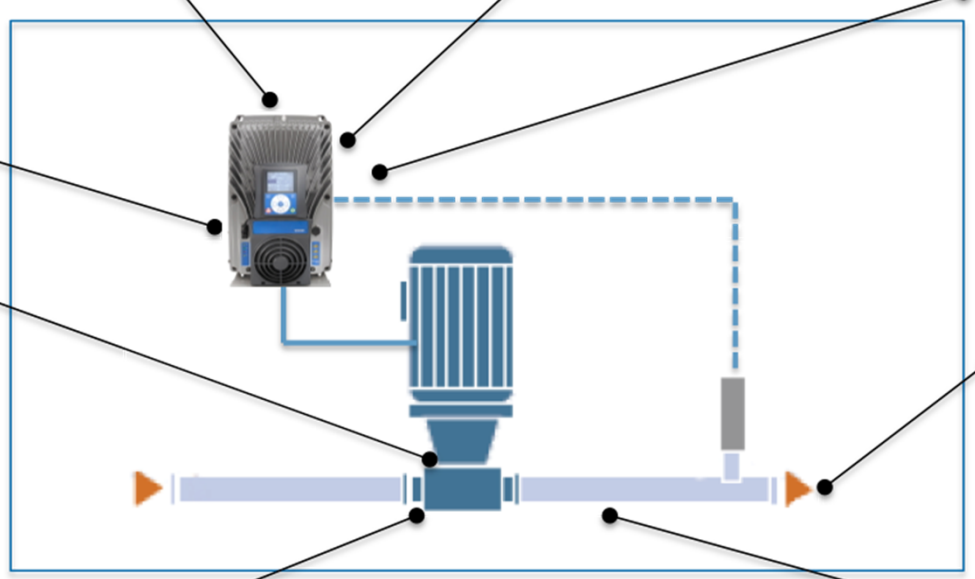
Partial irradiation



Partial irradiation simulation



Solar Pump Drive Control: Intelligent features



Sleep Mode (20X & 100X)
Stops the pump/drive automatically during periods of low demand. Restarts when pressure drops below threshold

Optional battery back-up (100X)
Real time clock with calendar functionality

2 x PID controller (100X)
Controls pressure, flow, temperature etc. based on measurement signal from sensor 2nd controller e.g for valve control

Start Boost (20X & 100X)
Increases starting torque to ensure pump starts in all conditions

Dry Pump protection (20X & 100X)
Stops the pump when there is too low torque on the motor shaft

Pressure loss compensation (100X)
Compensates pressure reference for drop in pressure in piping or ducting after the measurement sensor

Auto-cleaning / Anti-ragging (100X when grid supply is available)
Detects abnormal increase in torque when pump is blocked and runs cleaning sequence

Soft filling of pipes (100X)
Runs the pump at a lower fixed speed until a pressure increase indicates that the pipe is full

Vacon IP66 offer: Vacon 20 X & Vacon 100 X

20X: for solar supply up to 800VDC in low power applications up to 7,5 kW, and where maximum ambient temperature (with derating) is 50°C

100X: for solar supply up to 840VDC, motor power up to 37kW, and where maximum ambient temperature (with derating) is 60°C

Vacon 20 X – Technical overview

- **Dual mode supply connection:**
  - AC Mains: 380-480V (+/-10%), 47…66Hz
  - Solar Supply: up to 800 V DC
  - AC Mains: 208-240V (+/-10%), 47…66Hz
  - Solar Supply: up to 400 V DC
- **Enclosure rating:**
  - IP66/Type 4X enclosure: maintenance free
  - Large capacitors bank for its category, so that sudden changes in solar power availability during operation are smoothed, avoiding annoying trips.
- **Built-in MPPT^4 :**
  - MPPT (Maximum power point tracker): a real **4-algorithms** control scheme to to obtain maximum power for any given environmental conditions
- **EMC:**
  - Built-in EMC filter according to EN61800-3 Category C2 (for Mains supply)

Motor pump voltage	DC Solar Supply	MU3
380-480V	Up to 800 VDC	Up to 7.5 kW
208-240V	Up to 400 VDC	Up to 4.0 kW

Vacon 20 X – Technical overview

- **Ambient conditions:**
  - Operating temperature: ambient -10…+40°C (max. temperature **up to +50°C** with de-rating)
  - Equipped with **pressure equalizer vent (Gore® vent)**: a barrier **against condensation**
  - Altitude: 100% load capacity up to 1000m, (max. altitude 3000m with de-rating)
  - Resistant to **2g vibration / 25g shock**: 3M6 according to IEC 60721-3-3
- **Motor pump connections:**
  - High overload capability: 150% In (1 min / 10min)
  - Motor types: standard AC and PM motors
  - Inverter – pump cable length: 30m (use chokes with longer cables)
- **Software application features:**
  - PID controller with automatic sleep and wake-up functions
  - Supervisions and actual value measurement
  - Multiple start mode
  - Automatic and repeated starting attempt at sunrise
  - **Dry-run** protection

Vacon 20 X – Technical overview

- **Communication:**
  - RS485 Modbus RTU connection integrated as standard
  - Drive status indicators on top side (LEDs)
    - Power on
    - Run
    - Fault
    - Ready

  - Optional text keypad with non-volatile memory for:
    - Parameter Copy/Paste to clone the drive settings
    - Diagnostics
    - Monitoring
    - Parameter setting

  - PC connection
  - A wide range of option cards including all fieldbusses

Vacon 20 X option cards

Option Board	Function
OPT-B1	6 DI/DO
OPT-B2	2xRO+Thermistor
OPT-B4	Galvanic isolation 1xAI+2xAO
OPT-B5	3xRO
OPT-B9	1xRO+5xDI (42-240VAC)
OPT-BF	1xAO, 1xDO, 1xRO
OPT-BH	PT100, PT1000 Ni1000, KTY84

Vacon 100 X – Technical overview

- **Dual mode Supply connection:**
  - AC Mains: 380-480V (+/-10%), 47…66Hz
  - Solar Supply: up to 840 V DC
  - AC Mains: 208-240V (+/-10%), 47…66Hz
  - Solar Supply: up to 400 V DC
- **Enclosure rating:**
  - IP66/Type 4X enclosure with large cooling ribs
  - Plastic foil capacitors (maintenance free)
- **Built-in MPPT^4 :**
  - MPPT (Maximum power point tracker): a real **4-algorithms** control scheme to to obtain maximum power for any given environmental conditions
- **EMC:**
  - Built-in EMC filter according to EN61800-3 C2 (Mains supply)

Motor pump voltage	DC Solar Supply	MM4	MM5	MM6
380-480V	Up to 840 VDC	Up to 5.5 kW	Up to 15 kW	Up to 37 kW
208-240V	Up to 400 VDC	Up to 3 kW	Up to 7.5 kW	Up to 15 kW

Vacon 100 X – Technical overview

- **Ambient conditions:**
  - Operating temperature: ambient -10…+40°C (max. temperature **up to +60°C** with de-rating)
  - Equipped with **pressure equalizer vent (Gore® vent)**: a barrier **against condensation**
  - Altitude: 100% load capacity up to 1000m, (max. altitude 3000m with de-rating)
  - Resistant to **3g vibration / 25g shock**: 3M7 according to IEC 60721-3-3
- **Motor pump connections:**
  - High overload capability (up to 30kW): 150% In (1 min / 10min)
  - Motor types: standard AC and PM motors
  - Inverter – pump cable length: 100m (use chokes with longer cables)
  - Thermistor input as standard
- **Software application features:**
  - PID controller with automatic sleep and wake-up functions
  - Supervisions and actual value measurement
  - Multiple start mode
  - Automatic and repeated starting attempt at sunrise
  - **Dry-run** protection

Vacon 100 X – Technical overview

- **Communication:**
  - RS485 Modbus RTU connection and Ethernet Modbus TCP integrated as standard
  - Drive status indicators on top side (LEDs)
    - Power on
    - Run
    - Fault
    - Ready
  - Optional Graphical keypad with non-volatile memory for:
    - Parameter Copy/Paste to clone the drive settings
    - Diagnostic
    - Monitoring
    - Parameter setting
  - PC connection
  - A wide range of option cards with all fieldbusses

Vacon 100 X option cards

Option Board	Function
OPT-B1	6 DI/DO
OPT-B2	2xRO+Thermistor
OPT-B4	Galvanic isolation 1xAI+2xAO
OPT-B5	3xRO
OPT-B9	1xRO+5xDI (42-240VAC)
OPT-BF	1xAO, 1xDO, 1xRO
OPT-BH	PT100, PT1000 Ni1000, KTY84

Solar Pump Drive: Competitors comparison

VACON® DRIVEN BY DRIVES

	 ABB ACS 355	 Schneider ATV 312	 Grundfoss/ Solartech (China)	 Lorentz	 Setec (China)	 Vacon 20X	 Vacon 100X
AC Voltage	480 / 240	400 / 230	380	NO (DC only)	380 / 220	480 / 230	480 / 230
IP degree	IP 20 IP66 (not declared as suitable for outdoor) up to 5,5 kW	IP 20	IP 41	IP 54	IP 41	IP 66	IP 66
Installation	Cabinet	Cabinet	Cabinet	Rainproof-enclosure required	Cabinet	Outdoor (NEMA 4X)	Outdoor (NEMA 4X)
Max power	18,5 (5,5 kW IP66)	5,5	9,2	21	75	7,5	37
Max DC voltage	800 / 400	777 / 373	750	375	750 / 430	800 / 400	840 / 400
Harmonics reduction	NO	NO	NO	N/A (DC only)	NO	NO	YES (built-in choke)
Protected agaist condensation	NO (no frost allowed, max humidity 95%)	NO (no frost allowed, max humidity 95%)	NO (no frost allowed, max humidity 95%)	NO (no frost allowed, max humidity 95%)	NO (no frost allowed, max humidity 95%)	Yes (GORE vent)	Yes (GORE vent)
Ambient temperature	40°C (50°C with derate) [30°C outside cabinet]	50°C [40°C outside cabinet]	50°C [40°C outside cabinet]	55°C	50°C [40°C outside cabinet]	40°C (50°C with derating)	40°C (60°C with derating)
Control strategy	MPPT	MPPT	MPPT	MPPT	MPPT	**MPPT 4** (4 algorithms)	**MPPT 4** (4 algorithms)

Stronger Together!

THANK YOU !!