Instruction manual
PWM230
PWM400
PWM400/7.5

Ver. 2.3

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RESPONSIBILITY

The manufacturer is not liable for malfunctioning if the product has not correctly been installed, damaged, modified, and/or run outside the recommended work range or in contrast with other indications given in this manual.
The Manufacturer declines all responsibility for possible errors in this instructions manual, if due to misprints or errors in copying.
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The responsibility of the manufacturer is limited to the product and excludes costs or greater damages caused by incorrect installations.

1   INTRODUCTION

The PWM system is installed downstream from a pump. Operation of the pump is regulated by the PWM so that a constant water pressure is maintained. Moreover, depending on conditions and usage needs of the hydraulic system, the pump is turned on or off and malfunction conditions are managed.
The end user sets the parameters using the keyboard, and the PWM manages the pump according to the user's needs (to do this, particular algorithms are used to control frequency of rotation). The PWM system turns on the pump when there is a water demand and turns it off when there is no more demand of water.
PWM has many operation modes designed to protect the pump and the hydraulic and electric installations.
PWM has several configurable inputs and outputs and it can adapt to the demands of the various plants.
Section 5.1 describes all configurable quantities (pressure, protections, frequency of rotation, etc) and the possible pressure regulation modes (as a function of flow, inputs, exchange with other PWM, etc).
An important feature that makes the difference between PWM and the common On/Off systems is the considerable energy saving that can exceed 85% in some usage conditions. In Appendix an energetic and economic comparison between direct-insertion and PWM systems is made.
The PWM allows a longer lifetime of the pump.
Noise emitted by the pump managed by a PWM system is generally much lower than that emitted by the same one in direct insertion.

The model PWM 230 drives electro pumps with standard three-phase asynchronous motors (230V configuration) even if a single-phase 230 V line supplies it.
The PWM 400 and PWM 400/7.5 models drive electro pumps with standard three-phase asynchronous motors (400V) and a three-phase line supplies them.

Note: This manual is related to the following products: PWM 230, PWM 400 and PWM 400/7.5; for simplicity sake the term "PWM" will be used when talking about characteristics that are common to all the versions. Otherwise the specific names of the products will be used.

1.1   Applications

PWM systems are useful in all cases we need to control one or more pumps managing their turn-on and turn-off. The PWM system maintains a constant pressure by changing the frequency of rotation of the pump. Normally, the pump takes water from a basin or a well.

Typical usage scenarios include:
- Houses
- Flats
- Holiday houses
- Farms
- Water supply from wells
- Irrigation of greenhouses, gardens, agriculture
- Rain water reuse
- Industrial plants

PWM systems can be connected to the "Da Vinci" controller board to form a system together with up to 4 PWM in the same installation. The controller allows setting the working parameters and controls the whole system, thus widening usage possibilities of the PWM. PWM works with drinking water, domestic water or clean water without solid particles or suspended abrasive material.

⚠   PWM cannot be used with: feed liquid, inflammable fluid, by-products of the hydrocarbons, aggressive, corrosive or viscous fluids.

1.2   Technical features

The following chart shows all technical features of the PWM series systems

	PWM 230	PWM 400	PWM 400/7.5
Max. current	9,3 A	13,3 A	7.5 A
Power supply voltage	230 V single-phase tolerance: +10%; -20%	400 V three-phase tolerance: +10%; -20%	400 V three-phase tolerance: +10%; -20%
Minimum voltage	184 V	320 V	320 V
Maximum voltage	264 V	457 V	457 V
Pump motor type	230 V three-phase	400 V three-phase	400 V three-phase
Unit weight (packing not included)	3,7 Kg.	5,0 Kg.	5,0 Kg.
Installation Position	Any	Vertical	Vertical
Max. fluid temperature	50°C		
Max working temperature	60°C		
Max pressure	16 bar		
Set Pressure range	1 - 15 bar		
Max. Flow	300 l/min		
Dimensions (LxHxD)	22x28x18 cm		
Hydraulic Joint Inlet	1 ¼" male		
Hydraulic Joint Outlet	1 ½" female		
Degree of protection	IP 55		
Connectivity	RS 485 serial interface		
Protections	Dry run Overcurrent Overtemperature Abnormal supply voltage Direct short circuit of output phases		

Table 1: Technical features

For further details about pressure loss of PWM, please see the appendix.

2 INSTALLATION

2.1 Hydraulic connection

Always install a check valve on the pipe between pump and PWM as shown in Figure 1 part n° 12.

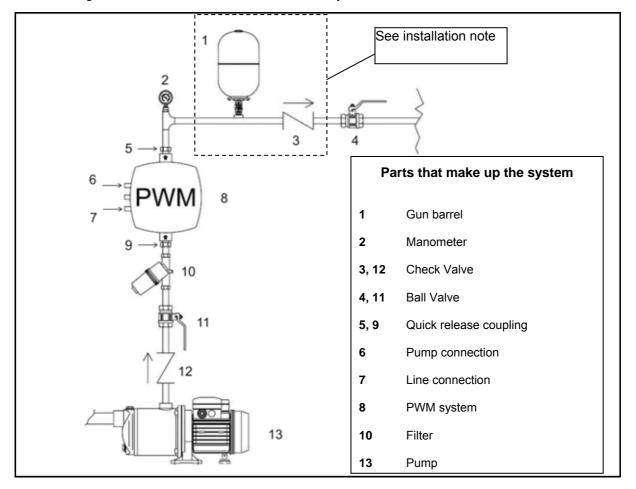The following Picture shows the scheme of a correct Hydraulic installation.

	Parts that make up the system
1	Gun barrel
2	Manometer
3, 12	Check Valve
4, 11	Ball Valve
5, 9	Quick release coupling
6	Pump connection
7	Line connection
8	PWM system
10	Filter
13	Pump

Figure 1: Hydraulic diagram

We recommend installing a little gun barrel downstream from the PWM.

We recommend installing another check valve after PWM and an expansion Tank between the check valve and PWM (see Picture 1 part n°1 and 3), on all Installation on which there's a possibility to have water hammering (e.g. irrigation whose flow is unexpectedly blocked by the check valve). The check valve between pump and PWM mentioned above (12) **is necessary.**

The hydraulic connection between PWM and pump must not have any derivation.
A pipe of adequate size must feed the pump.

The hydraulic connection between pump and PWM should be shorter and more rigid. In fact, when this connection is too long or deformable, oscillations on regulation can happen, which can be solved by modification of the "GP" and "GI" control parameters (see sec. 5.1.3.2 and 5.1.3.3)

Note: The PWM system works at constant pressure. This regulation is appreciable if the hydraulic system downstream from the PWM system is correctly installed. Systems made with too narrow pipes cause pressure losses which the appliance cannot compensate; the result is that the pressure is constant on the PWM device but not on the user.

PWM400 and PWM400/7.5 must be installed only in vertical position, while PWM230 can be installed in any position. Internal pipe where water flows shows horizontal or vertical direction, while the arrows on the same pipe show flow direction.

Ice/Frost danger: Pay attention to the environmental conditions where the PWM will be installed and to the electrical connection in the cold months. Two types of usage precautions should be observed in case that environment temperature drops below 0°c.
- If PWM is working it is absolutely necessary to protect it adequately from the cold and to keep it constantly fed.
- If PWM is not working it should be disconnected both from power supply and from the pipes and any water inside it should be removed. To ease this procedure a quick release coupling is advisable.
Please note that removing pressure from the pipeline is not enough, since after doing that some water still remains inside the PWM.

Note: If PWM is disconnected from power supply, the anti-freeze protection does not operate (see sec. 5.1.3.8).

Foreign bodies in the pipeline: the presence of dirt inside the fluid can obstruct the duct or stop the flow valve, thus jeopardizing correct operation of the system. In case that the PWM is installed on a pipeline through which foreign bodies (e.g. gravel in case of submersibles pumps) can transit, it is necessary to install a special filter upstream from the PWM. A coarse porosity one (100 μm) will be suitable as well.

2.2   Electrical connection PWM 230

Power supply to the PWM 230 should meet the following requirements:

Rated voltage	230 V (+ 10% / - 20%)
Minimum absolute voltage	184 V (230 V - 20%)
Maximum absolute voltage	264 V (240 V + 10%)
Frequency	50 / 60 Hz

Table 2: PWM 230 power supply requirements

DANGER   Electric shock risk
Before carrying out any installation or maintenance operation, the PWM should be disconnected from the power supply and one should wait at least 2 minutes before opening the appliance.

Ensure that rated voltage and the frequency values of the PWM match those of the Power supply.

WARNING
Power supply voltage can change when the pump is turned on by the PWM device.
The power line voltage can change, due to connection of other devices and to the quality of the power line self.

2.2.1   Connection to the PWM 230 power supply line

Normally PWM devices are equipped with a power cord to connect the device to a 220V-240V single-phase electric line, but some versions are not. In those versions the electric line must be connected to the 3 ways terminal "J2" with "LINE" silk-screened on it (see Figure 2).
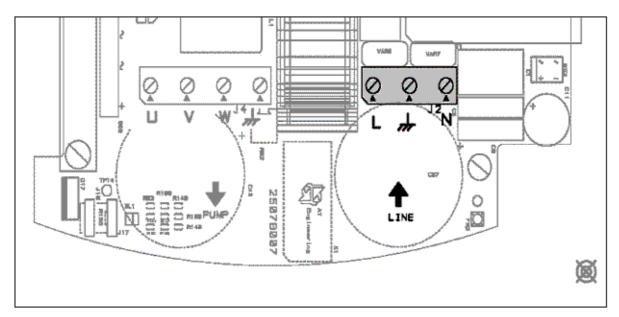
Figure 2: Power supply terminal

If the installed electro pump's power equals the PWM's maximum allowed one, the power cord wires' section should be greater than a given value, depending on the cord's length. Table 3 shows the minimum wires' section as a function of the cord's length.

Length (meters)	Minimum section (mm^2)
0 – 30	2.5
30 – 60	4

Table 3: Minimum section as a function of power cord's length for PWM 230

If the installed pump's power is lower than the maximum allowed one, the power cord wires' section can be reduced proportionally to the power decrease (for example if the total power halves, the section will be halved).
PWM 230 already provides internal current protections. If a thermal magnetic circuit breaker is installed, its rated current must be 16 A.

Connection of the power line to PWM 230 must include a ground wire whose impedance must comply with the safety regulation in force in the country of use. The total grounding resistance must not exceed 100 Ohm.

2.2.2 Electrical connection to the electro pump for PWM 230 device

The supply voltage of the motor of the installed electro pump must be 230V three-phase.
The current absorbed by the pump connected to PWM230 must not exceed 9,3A rms.

The three-phase motors with rated supply voltages that differ from 230V, cannot work with PWM 230. Check the motor connection rating values to fulfil the condition above.
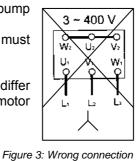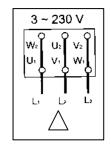Three-phase electric machines generally have two types of connection as shown in Figure 3 and Figure 4.
The delta connection is typically the one used to work at 230V (see Figure 4).

Figure 3: Wrong connection   *Figure 4: Right connection*

Normally PWM devices are equipped with a cable for connection to the motor. The connection between PWM 230 and the electro pump is made with a 4-wire cable (3 phases + ground).
For versions not equipped with the cable mentioned above the connection is made on the 4-ways terminal "J4" with "PUMP" silk-screened on it and an arrow at the output (see Figure 5). The section of the wire must be at least 1.5 mm^2 for any length.
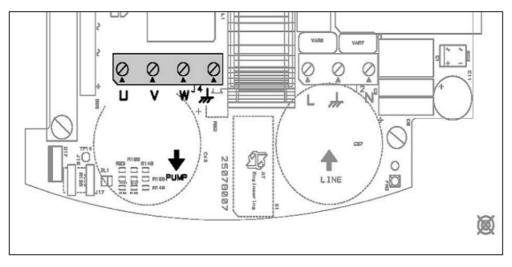
Figure 5: Three-phase electro pump output terminal

⚠ **Wrong connection of the earth line to a terminal other than the earth one may cause irremediable damage to the whole appliance.**

⚠ **Wrong connection of the power supply line on output terminals intended for the load may cause irremediable damage to the whole appliance.**

Once the electric and hydraulic connections are completed, turn on the system and configure it, as described in chapter 4.

2.3 Electrical connection of PWM 400 and PWM 400/7.5

Power supply to the PWM 400 and PWM 400/7.5 devices should meet the following requirements:

Rated voltage	400 V (+ 10% / - 20%)
Minimum absolute voltage	320 V (400 V - 20%)
Maximum absolute voltage	457 V (415 V + 10%)
Frequency	50 / 60 Hz

Table 4: PWM 400 power supply requirements

⚡ DANGER   Electric shock risk
Before carrying out any installation or maintenance operation, always disconnect the PWM from the power supply and wait at least 2 minutes before opening the appliance.

⚠ WARNING
Ensure that the voltage and frequency values of the PWM rating plate match those of the Power supply.

WARNING
Power supply voltage can change when the PWM device turns on the pump.
Power line voltage can change, due to connection of other devices and to quality of the line self.

2.3.1 Connection of the PWM 400 – PWM400/7.5 to the power supply line

Normally PWM devices are equipped with a power cord labelled "Line" to connect to a 380V-415V 50-60Hz three-phase electric line. For versions that are not, the line must be connected to the 4-ways terminal "J2-J8" with "LINE" silk-screened on it (see Figure 6).
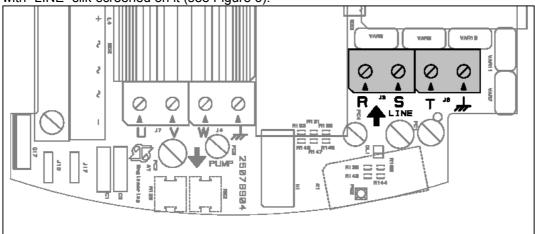

Figure 6: Power supply line input terminals

If the installed electro pump's power equals the maximum allowed one, the power cord wires' section should be greater than a given value, depending on the cord's length. Table 5 shows the minimum wires' section as a function of the cord's length.

Length of the line (meters)	Min. section of every conductor (mm^2)
0 - 50	1.5
50 - 85	2.5
85 - 140	4

Table 5: Minimum section as a function of power cord's length for PWM 400

If the installed pump's power is lower than the maximum allowed one, the power cord's wire section can be reduced proportionally to the power decrease (for example if the total power halves, the section will be halved).

PWM 400 and PWM400/7.5 already provide internal current protections. If a thermal magnetic circuit breaker is installed, its rated current must be 16 A.

Connection of the power line to PWM must include a ground wire whose impedance, must comply with the safety regulation in force in the country of use. The total grounding resistance must not exceed 100 Ohm.

2.3.2 Electrical connection of the electro pump to PWM 400 – PWM400/7.5 devices

The supply voltage of the motor of the installed electro pump must be 400V three-phase.
Phase current absorbed by the utility connected to PWM400 must not exceed 13A rms and 7.5A rms for PWM 400/7.5.
Three-phase motors whose rated voltage differs from 400V cannot be operated with PWM 400 and PWM 400/7.5.
Check the motor connection ratings to fulfil the above condition.
Typically, when line voltage is 400V, if the pump's power is lower than 5.5 kW, a star wiring is used.
Conversely, if the pump's power exceeds 5.5 kW, a delta wiring is used.
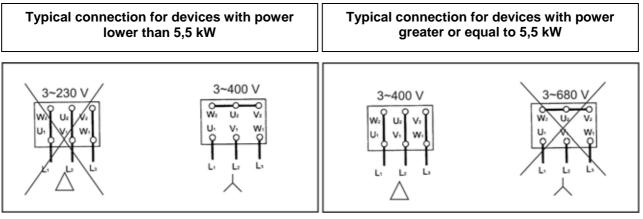Figure 7 shows how to make the proper connections.

Typical connection for devices with power lower than 5,5 kW	Typical connection for devices with power greater or equal to 5,5 kW

Figure 7: Connection to be made on a motor managed by PWM 400

Normally the PWM devices are equipped with a cable labelled "Pump", for connection to the motor. Connection between PWM 400 – PWM400/7.5 and the electro pump is made with a 4-wire cable (3 phase + ground) and is made on the 4 ways terminal "J7-J4" with "PUMP" silk-screened on it and an arrow at the output (see Figure 8). The section of the wire must be greater or equal to 1.5 mm^2 for any length.
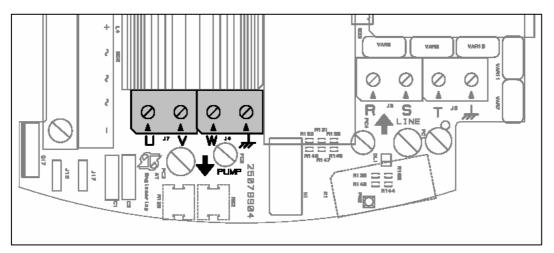

Figure 8: Three-phase electro pump output terminal

⚠ **Wrong connection of the earth line to a terminal other than the earth one may cause irremediable damage to the whole appliance.**

⚠ **Wrong connection of the power supply line on output terminals intended for the load may cause irremediable damage to the whole appliance.**

Once the electric and hydraulic connections are completed, turn on the system and perform the operations described in chapter 4.

2.4 Electrical connection of user inputs and outputs of PWM230 PWM400 PWM400/7.5

All PWMs are equipped with 3 inputs and 2 outputs used to connect to other devices.
Figure 9 and Figure 11 show the logical-functional schemes of possible connections.
Figure 10 and Figure 12 show, as an example, two possible inputs and outputs configurations.
The installer will just need to connect the desired input and output contacts as desired and to configure related functionality (see section 5.1.3.9).

⚠️   **The +12Vdc voltage supplied to the pin 1 and 7 of J22 can supply max. 50mA.**

Output contacts features:
- Relay switch OUT 1: Pin 8 and 9. Relay switch OUT 2: Pin 10 and 11.
- Potential-free contact ratings: 250 Vac, 6 A max resistive load, 3 A max inductive load.
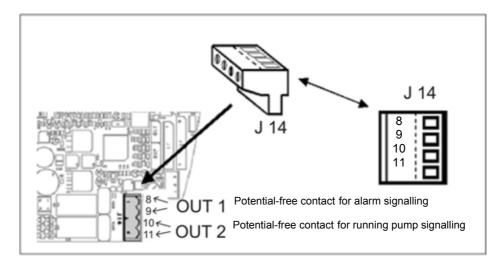

Figure 9: User output terminal

Figure 10: Example application of user outputs

Optocoupled input contacts' electrical features:
- Opto coupler IN 1: Pin 5 and 6.
- Opto coupler IN 2: Pin 2 and 4.
- Opto coupler IN 3: Pin 3 and 4.
- Inputs can be driven with any polarity with respect to their own earth return and they work with alternate or direct current.
- Correct operation is guaranteed if input voltages comply with the following requirements:

	Input DC [V]	Input AC [V rms]
Trigger voltage	8	6
Max turn-off voltage	2	1,5
Max. rated voltage	48	50

Table 6: Optocoupled input contacts ratings

When input voltage is 12VDC input current is 3mA.

Figure 11: User input terminal

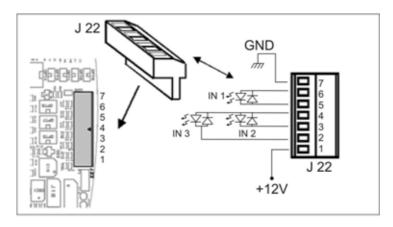| Driving with potential-free contacts	Driving with external Voltage

Potential-free contacts

Jumper

IN 1 usage example

When IN 1 is enabled, the pump is stopped and the display reports "F1".(e.g. IN 1 could be connected to a float switch). for setting details see sec. 5.1.3.9.1"I1: Setting function of input 1 (external float)."

Direct Voltage supply (Max 48V) or alternate Voltage (Max 50Vrms)

Potential-free contacts

Jumper

IN 2 usage example

When IN 2 is enabled the set point pressure becomes "P1". (see sec. 5.1.3.9.2 "I2: Setting function of inlet 2 (active set-point selection: "SP" or "P1")")

Direct Voltage supply (Max 48V) or alternate Voltage (Max 50Vrms)

Potential-free contacts

Jumper

IN 3 usage example

When IN 3 is enabled the pump is stopped and the display reports "F3"
(e.g. it could be connected to a safety manually reatriggerable pressure switch) for configuration details see sec. 5.1.3.9.3 "I3: Setting function of input 3 (general system enabling)"

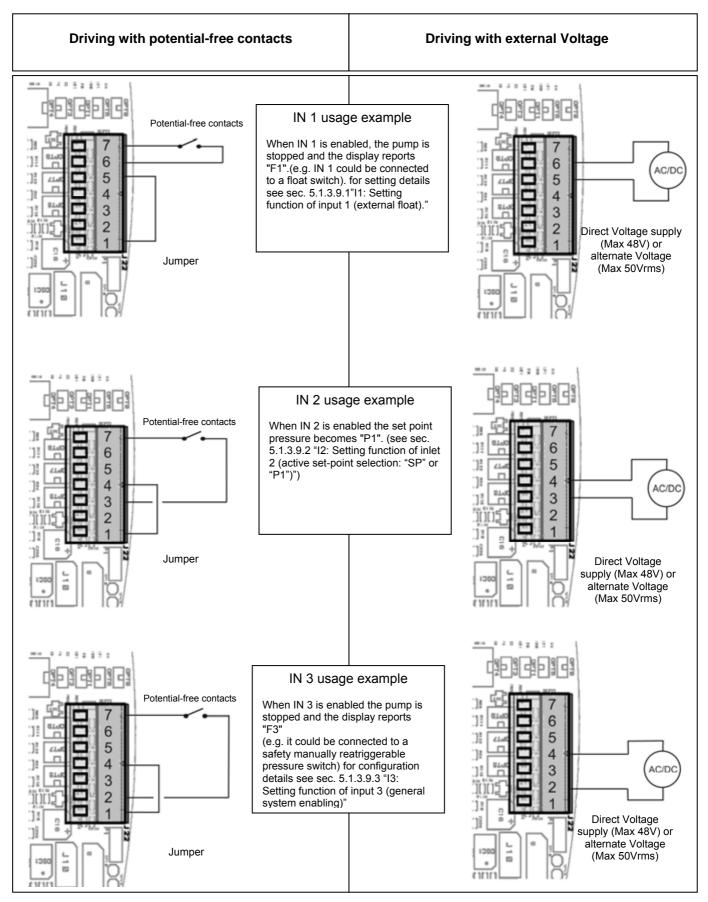Direct Voltage supply (Max 48V) or alternate Voltage (Max 50Vrms)

Figure 12: User inputs usage example

2.5 Electrical connections for interconnection and exchange

Each PWM has a communication port through which it can be connected by means of a special cable, to another PWM or to a compatible controller board.

WARNING: When interconnection cable's length exceeds 1m, usage of a shielded cable with braid connected to earth (central pin number 2) is recommended on both devices.

2.5.1 Electric wiring for interconnection of two PWM

Two PWM devices may operate in a synchronized way (see sec. 5.1.2.6 "Ad: Setting the interconnection address", 5.1.2.6.1 "Setting the address for booster sets composed by 2 PWM", 5.1.2.7 "Eb: Enable booster" and 5.1.3.7 "CM: Role exchange policy in booster sets").

To use this functionality, two devices must be wired with a three-pole cable trough the terminal block J9, as illustrated on Figure 13.
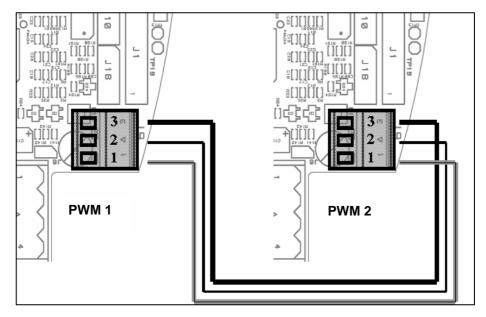

Figure 13: Wiring diagram for two PWM in exchange

2.5.2 Electrical connections for wiring with "Da Vinci" controller board

One or more PWMs can be wired to the "Da Vinci" controller board that monitors the system, controls and manages the PWM's operation (see instruction manual of "Da Vinci" controller board).

Two devices are wired by means of a three-pole cable trough the terminal block J9 as illustrated on Figure 14.

The three PWM Terminals are wired to the controller board as shown on Table 7.

PWM 1 Connection		PWM 2 Connection		PWM 3 Connection		PWM 4 Connection	
PWM terminal	Controller board terminal	PWM terminal	Controller board terminal	PWM terminal	Controller board terminal	PWM terminal	Controller board terminal
1	B1 -	1	B2 -	1	B3 -	1	B4 -
2	SH	2	SH	2	SH	2	SH
3	B1 +	3	B2 +	3	B3 +	3	B4 +

Table 7: Pin out of cable used for communication between PWM and "Da Vinci" controller board
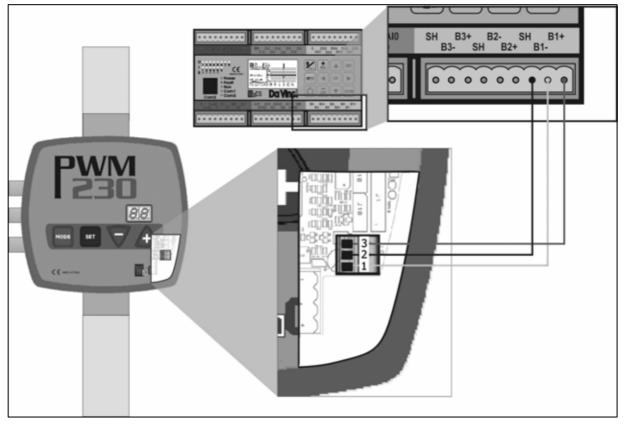
Figure 14: Wiring diagram for connection of PWM to the "Da Vinci" controller board.

Note: For PWM systems wired and configured to work with "Da Vinci" controller board operation of input 2 is disabled (see sec. 5.1.3.9.2), a new menu called "AS" is activated (see sec. 5.2.1.4) and the "rP" parameter becomes unavailable (see sec. 5.1.2.5).
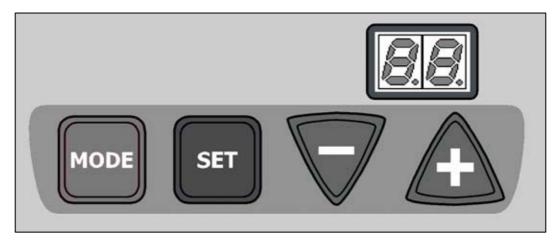
3 THE KEYPAD AND THE DISPLAY

Figure 15: PWM's Keypad and Display.

The PWM front panel is equipped with a control keypad with 4 keys and a two-digit display used to show quantities, numerical values and possible block and protection conditions.

3.1 Keys functionality

MODE	MODE is used to pass to the next item of the current menu
SET	SET is used to quit current menu and to go back to normal display mode
▽ −	Press it to decrease the currently modifiable parameter. Each time you press it, the quantity value is displayed for at least 5 seconds. Thereafter the parameter name appears.
△ +	Press it to increase the currently modifiable parameter. Each time you press it, the quantity value is displayed for at least 5 seconds. Thereafter the parameter name appears.

Note: When "+" or "-" is pressed, the selected quantity will be changed and immediately saved in permanent memory (EEPROM). Hence, the parameter value won't be lost if the device is (even accidentally) turned off. [SET] is just used to return displaying the machine status. It is not necessary to press SET to save the last parameter changes.

3.2 Display conventions

Parameters are identified by an alphanumeric name and by a value. The meaning of parameter names is summarized on Table 8. When a message (e.g., an error) is shown two static characters appear. Conversely, a parameter is shown by alternatively displaying its name (for 1 second) and its value (for 5 seconds).
In order to simplify configuration, only the value is shown as long as either the "+" key or the "-" key is pressed.
Some values need 3 digits to be displayed, e.g. frequency or temperature. In this case the display convention is the following:

The name of the parameter appears at first for a second. Thereafter the hundreds are shown and, finally, the tens and the units are shown. The Hundreds are represented on the right digit, while the left one is off; thereafter the left digit represents the tens while the right digit represents the units. Three-digit numbers are completely displayed for three times in 5 seconds, and then the two-letters parameter name will be displayed for one second. During value modification only tens and units of three-digit parameter values are shown. After value modification has completed, parameter values are displayed on three digits again.

For quantities that contain a decimal digit the digit is displayed for values up to 9,9, while when this value is exceeded only tens and units are displayed.

WARNING: When the PWM is configured for connection to another PWM or to a "Da Vinci" controller board (see sections 5.1.2.6, 5.1.2.6.1 and 5.1.2.6.2) but the communication doesn't work, the display blinks when the "Go" or "Sb" status codes are displayed.

3.3   Meaning of the messages shown on the display

Identifier	Description
Indication on the display in normal operation	
Go	Electro pump operating
Sb	Electro pump not operating
Error and Status conditions	
bL	Blockage due to lack of water
bP	Blockage due to missing pressure sensor
LP	Blockage due to low supply voltage
HP	Blockage due to high supply voltage
EC	Blockage due to incorrect setting of the rated current (rC) or rated frequency (Fn)
oC	Blockage due to current overload in the electro pump motor
oF	Blockage due to current overload in the output stages
SC	Blockage due to direct short circuit between the phases of the output terminal
ot	Blockage due to overheating of the power stages
F1	Input 1: Status / Alarm
F3	Input 3: Status / Alarm
E0...E7	Internal error 0...7
Display of the main values ([MODE] key)	
Fr	Display of the current rotation frequency [in Hz]
UP	Display of pressure [in bar] (duplicated in manual mode)
C1	Display of phase current of the electro pump [in A] (duplicated in manual mode)
AS	Display of PWM configuration status with "Da Vinci" controller board
UE	Display of the software version with which the appliance is equipped

User displays and settings ([MODE] & [SET] keys for 2 seconds)	
SP	Setting the set-point pressure [in bar]
Installer displays and settings ([MODE] & [SET] & [▼] keys for 5 seconds)	
rC	Setting the rated current of the electro pump [A]
Fn	Setting the rated frequency of rotation of the electro pump [Hz]
rt	Setting the direction of rotation (duplicated in manual mode)
od	Setting the PWM operating mode
rP	Setting the pressure drop for restarting [bar]
Ad	Setting the interconnection address (necessary on booster set with more than one pump with exchange)
Eb	Enabling the booster pump
Technical assistance displays and settings (keys [MODE] & [SET] & [+] 5 seconds)	

tb	Setting of lack of water blockage latency time [s]
GP	Setting of proportional gain of the PI
GI	Setting of integral gain of the PI
FS	Setting of the max. rotation frequency of the electro pump [Hz]
FL	Setting of the min. rotation frequency of the electro pump [Hz]
Ft	Setting of low flow rate threshold
CM	Setting of role exchange policy on booster set with 2 pumps
AE	Setting of enabling of anti-block/anti-frost function
i 1	Setting of input 1 function
i 2	Setting of input 2 function
i 3	Setting of input 3 function
P1	Setting of auxiliary set point pressure [bar]
O 1	Setting of output 1 function
O 2	Setting of output 2 function
DISPLAY (keys SET **&** ▽ **for 2 sec.)**	
UF	Display of the flow (duplicated in manual mode)
ZF	Display of zero flow (duplicated in manual mode)
FM	Display of the max. rotation frequency [Hz]
tE	Display of the power output stages temperature [°C]
bt	Display of the printed circuit's temperature [°C]
GS	Display of running status
FF	Display of fault and block history queue
Access to manual mode (keys SET **&** ▽ **&** △ **5 seconds)**	
FP	Setting of manual mode test frequency (in Hz). Must be $\leq$ to the current FS value
UP	Display of pressure [bar]
C1	Display of the electro pump's phase current [A]
rt	Setting of direction of rotation
UF	Display of flow
ZF	Display of zero flow
Restoring the factory settings (keys SET **&** △ **for 2 sec when turning on)**	
EE	Saving and reading back of factory settings on the EEPROM
System reset (keys MODE **&** SET **&** ▽ **&** △ **)**	
ZF	General reset (ZF appears when leaving reset and the system is restarted)

Table 8: Meaning of the messages shown on the display