

Instruction manual

PWM 230 3-Basic

Ver. 1.2



WaCS s.r.l.

<http://www.wacs.it>

Via Barducci n.30 - 56030 Calcinaia (PI) Italy

We would like to thank you for having chosen a product of the **PWM** series, ideal solution for pressure regulation and building of booster set systems.

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Conventions used in this manual

In the manual the following symbols will be used:



Generic danger. Failure to comply with the safety regulations that follow can irreparably damage the equipment.



Electric shock risk. Failure to comply with the safety regulations that follow can cause risk to personal safety.

WARNINGS

Read this manual carefully before any operation.

Please keep this instruction manual for future use.



The Electrical and Hydraulic connections must be carried out by competent, skilled personnel in possession of technical qualification required by the specific legislation in force.

The term **skilled personnel** means persons that, because of their training, experience and instruction, as well as their knowledge of the relevant standards, regulations and accident prevention rules and working conditions, have been authorized by the person responsible for safety of the plant to perform all the appropriate activities required, and thereby are able to recognize and prevent potentially dangerous situations.

(For the definition of skilled personnel see IEC 364).

The technician must ensure that the installation of power supply is provided of an efficient earthing system, conforming to the regulations in force in the country where the product is installed.

For installation of the power supply, we recommend to use a high sensitivity residual current device with $\Delta=30$ mA (class A or AS).

To improve immunity to the possible noise radiated on other equipments we recommend to power the PWM with a separate wire.

Failure to comply with the safety regulations not only causes risk to personal safety and damage to the equipment, but also invalidates every right to assistance under warranty.

DECLARATION OF CONFORMITY

The company, Wa.C.S. s.r.l. - Via Barducci, 30 56030 Calcinaia (PISA) -ITALY-

Under its own exclusive responsibility declares that the products listed above comply with:

Directive on Electromagnetic Compatibility 89/336 and subsequent modifications.

Directive on Low Voltage 73/23 and subsequent modifications.

RoHS directive 2002/95/CE

WEEE directive 2002/96/CE

Conformity to the following CE regulations:

CE EN 55014-1 (2001/11) CEI EN 55014-2 (1998/10) CE EN 61000-3-2 (2002/04)

CEI EN 61000-3-3 (1997/06) CE EN 60335-1 (2004/04)

Basic Regulation: EN 61000-6-2 (2002/10) Rif: CE EN 61000-4-2 (1996/09)

Rif: CE EN 61000-4-3 (2003/06)
Rif: CE EN 61000-4-5 (1997/06)
Rif: CE EN 61000-4-8 (1997-06)

Rif: CE EN 61000-4-4 (1996/09)
Rif: CE EN 61000-4-6 (1997/11)
Rif: CE EN 61000-4-11 (1997/06)



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.

The Manufacturer reserves the right to make any modifications to products that it may consider necessary or useful, without affecting the essential characteristics.

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. 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 3-Basic drives electro pumps with standard three-phase asynchronous motors (230V configuration) even if a single-phase 230 V line supplies it.

1.1 Applications

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 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 3-Basic
Max. current	4,5 A
Power supply voltage	230 V single-phase tolerance :+10% ; -20%
Minimum voltage	184 V
Maximum voltage	264 V
Pump motor type	230 V three-phase
Unit weight (packing not included)	3,7 Kg.
Installation Position	Any
Max. fluid temperature	50°C
Max working temperature	60°C
Max pressure	16 bar
Set Pressure range	from 1 to 9,0 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
Protections	Dry run Over temperature 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.

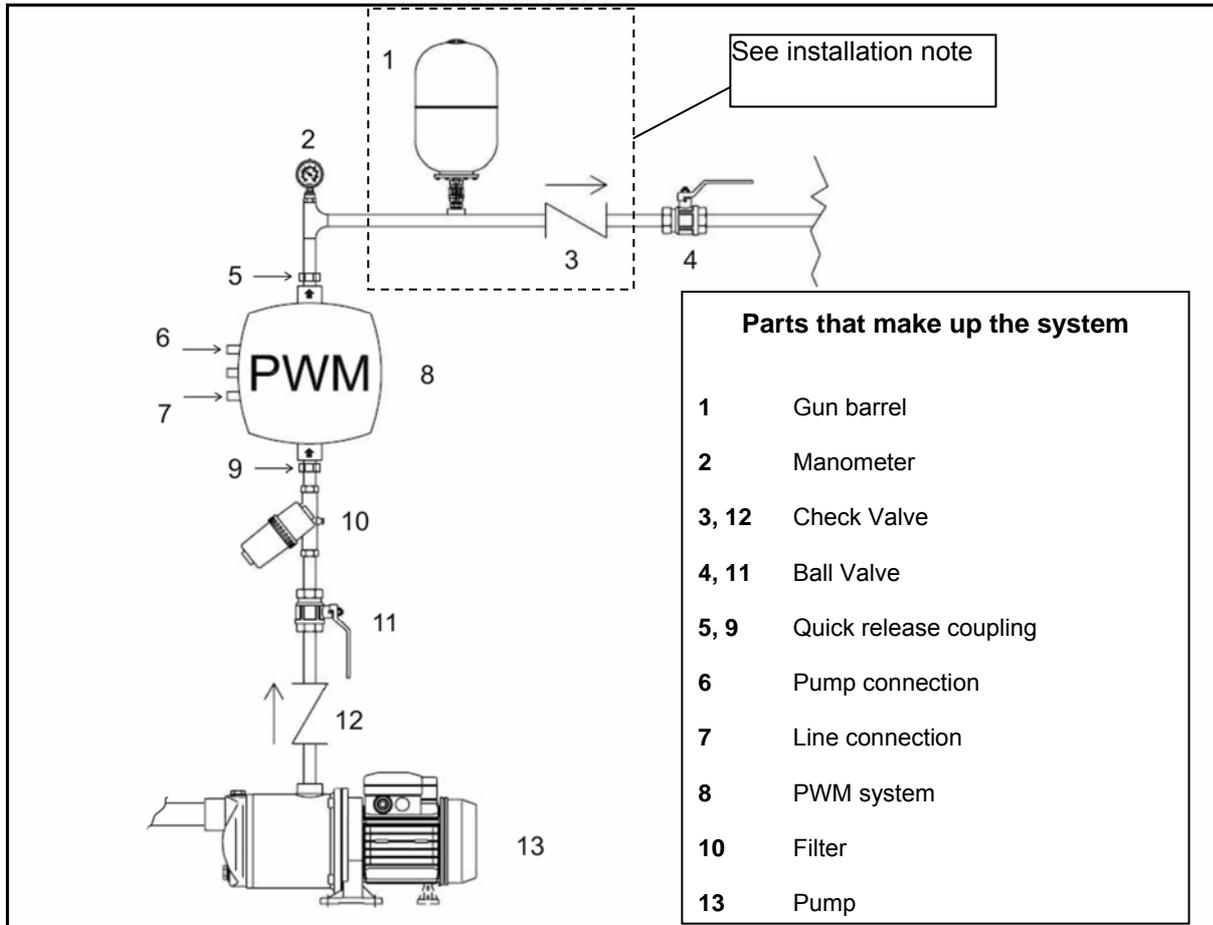


Figure 1: Hydraulic diagram

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 Figure 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.



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. 5.1.3.7).



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

Power supply to the PWM 230 3-Basic 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: 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 5 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 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).

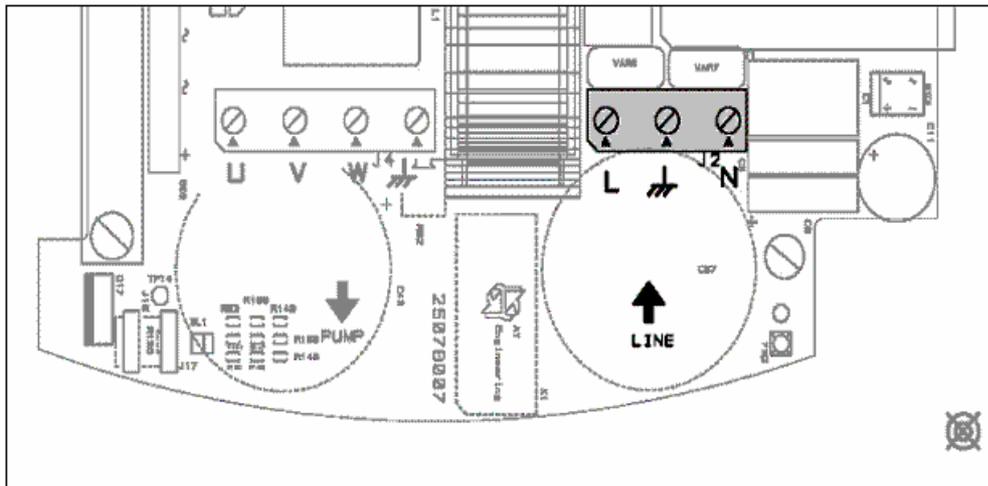


Figure 2: Power supply terminal

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. **Errore. L'origine riferimento non è stata trovata.** shows the minimum wires' section as a function of the cord's length.

Length (meters)	Minimum section (mm ²)
0 - 20	1,5
20 - 90	2,5

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

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 3-Basic 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 3-Basic 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

The supply voltage of the motor of the installed electro pump must be 230V three-phase.

The current absorbed by the pump connected to PWM 230 3-Basic must not exceed 4,5 A.

The three-phase motors with rated supply voltages that differ from 230V, cannot work with PWM 230 3-Basic. 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.

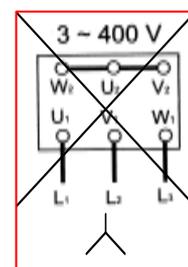


Figure 3: Wrong connection

The delta connection is typically the one used to work at 230V (see Figure 4)

Normally PWM devices are equipped with a cable for connection to the motor. The connection between PWM 230 3-Basic 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 mm² for any length.

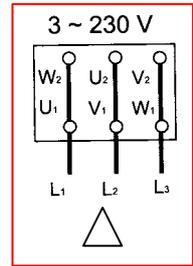


Figure 4: Right connection

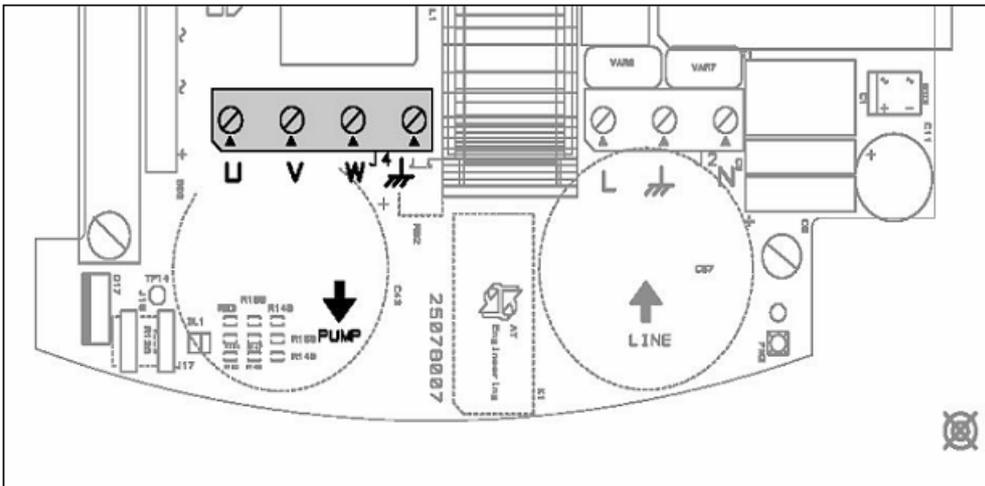


Figure 5: Three-phase electro pump output terminal



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



Wrong connection of the power supply line on output terminals intended for the load may cause irreparable 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.

3 THE KEYPAD AND THE DISPLAY

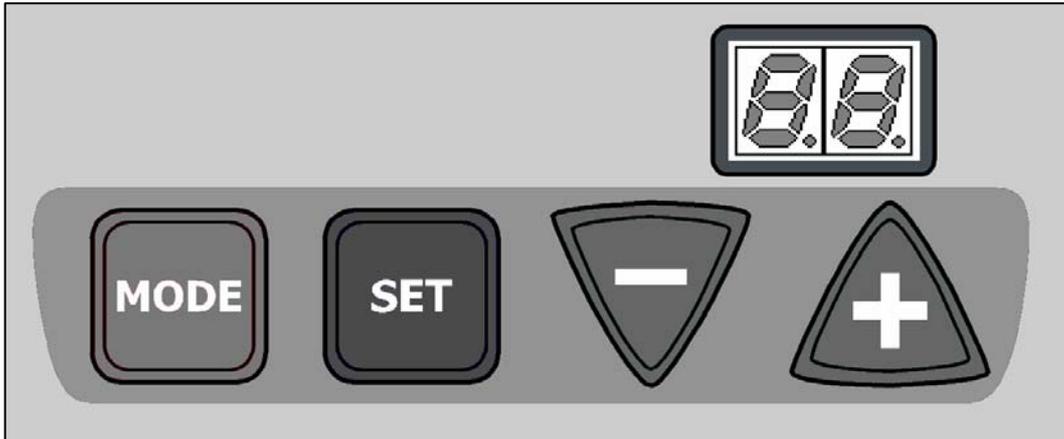


Figure 6: PWM's Keypad and Display

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 is used to pass to the next item of the current menu
	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.  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 4. 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 (as UP) the digit is displayed for values up to 9,9, while when this value is exceeded only tens and units 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
EC	Blockage due to incorrect setting of the rated frequency (Fn)
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
E0...E7	Internal error 0...7
Display of the main values ( key)	
Fr	Display of the current rotation frequency [in Hz]
UP	Display of pressure [in bar] (duplicated in manual mode)
UE	Display of the software version with which the appliance is equipped

User displays and settings ( &  keys for 2 seconds)	
SP	Setting the set-point pressure [in bar]
Installer displays and settings ( &  &  keys for 5 seconds)	
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]
Technical assistance displays and settings (keys  &  &  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
AE	Setting of enabling of anti-block/anti-frost function
DISPLAY (keys  &  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]
GS	Display of running status
FF	Display of fault and block history queue
Access to manual mode (keys  &  &  5 seconds)	
FP	Setting of manual mode test frequency (in Hz). Must be ≤ to the current FS value
UP	Display of pressure [bar]
rt	Setting of direction of rotation
UF	Display of flow
ZF	Display of zero flow
Restoring the factory settings (keys  &  for 2 sec when turning on)	
EE	Saving and reading back of factory settings on the EEPROM
System reset (keys  &  &  & )	
ZF	General reset (ZF appears when leaving reset and the system is restarted)

Table 4: Meaning of the messages shown on the display

4 START AND FIRST OPERATION

4.1 Start up operation

After a craftsmanlike installation of the hydraulic and electric systems (see sec. 2.1 and sec. 2.2), we can turn on the PWM.

“ZF” will appear on the display and after a few seconds the error code “EC” will be displayed. The PWM doesn’t start, since it is necessary to set the value of the frequency (in Hz) of the electrical pump being used. The procedures needed to set the main parameters and to perform the first start-up are described below:

a) Setting the rated frequency Fn

In the standard operation mode, press the    buttons at once and hold down until the text “Fn” is displayed

Set the frequency “Fn” with by pressing the  and  keys until the selected value matches the electro pump’s rated one (e.g.: 50Hz).

A further pressure of  or  activates the set values of frequency and PWM unblocks (provided that no errors or lock conditions are present).



Wrong setting of the electro pump’s rated frequency may irreparably damage the electro pump.

b) Setting the direction of rotation.

From "Fn" parameter, press the  key once. The frequency settings is activated and the current parameter becomes "rt"; the PWM is now operating.

Open a user to make the pump start rotating. Check direction of rotation of the electro pump.

If the direction is correct, you may proceed setting the set-point pressure (point c), otherwise reverse the

direction of rotation of the motor with the  and  keys (this function is active also when the motor is turned on). An arrow on the electro pump's motor case is generally used to indicate direction of rotation.

When it is not possible to directly observe the direction rotation of the motor, this can be found by one of the following methods:

Maximum head method

- Press the  key in order to get to the normal display menu ("Go" or "Sb" is displayed, provided that no errors or lock conditions are present).
- Enter manual mode menu by holding the    keys simultaneously pressed until "MA" appears on display (see chap.7).
- Start-up the pump by pressing    at the same time for 2 seconds and take note of the pressure. (if no manometer is available, you may display the "UP" parameter value by pressing the  key multiple times)
- Revert the running rotation by holding  and  pressed for 2 seconds and take note of the pressure again.

The direction of rotation that allows obtaining a higher pressure is the right one.

- Press  to stop rotation and press it a second time to exit from manual mode menu.

Rotation frequency "Fr" observation method

- Press the  key in order to get to the normal display menu ("Go" or "Sb" is displayed, provided that no errors or lock conditions are present).
- Open a user and take note of the frequency (press the  key, so that "Fr" and the frequency value are displayed alternatively).
- Change the "rt" parameter (as described above) without changing the drawing and take note of the frequency Fr again.
The rt value that corresponding to the lower rotation frequency (Fr) is the right one.

c) Setting the set-point pressure.

From normal operation status keep the  and  keys both pressed until “SP” appears on the display. In these conditions the  and  keys allow to increase or decrease the desired pressure value.

Set-point pressure may range from 1,0 to 9 bar.

Press  to go back to normal operation status.

4.2 First installation troubleshooting

PWM message	Possible causes	Solution
EC	Frequency (Fn) of the pump not set	Set “Fn” parameter (see sec.4.1)
bL	1) Lack of water 2) Pump unprimed 3) Pump blocked 4) Reverse rotation direction	1-2) Prime the pump and check there is no air in the pipeline. Check that suction pipe and filters are not occluded. Check that the pipeline from the pump to PWM is not broken and has no serious leakages. 3) Check that neither the rotor or the motor are jammed or stopped by foreign matter. Check the motor phase connection 4) Check the direction of rotation (see sec. 5.1.2.2)
OF	1) Excessive current absorption 2) Pump blocked	1) Check the connection type, delta or star. Check that the current absorbed by the motor does not exceed the maximum current the PWM can deliver 2) Check that no foreign body is opposing to the impeller or the motor's motion. Check the phases' connection of the motor.
E1	1)) Low power voltage 2)) Large volt drops on line	1) Check line voltage is correct. 2) Check power lead section is correct (see par. 2.2)
bP	Disconnected pressure sensor	Check the pressure sensor is properly connected
SC	Short circuit between the phases	Ensure the motor is properly working and check its connections to PWM

Table 5: Problems solving

If the problems persist, we suggest taking contact with the distributors or Area agent (see all details on web <http://www.wacs.it>)

5 PARAMETER MEANINGS

5.1 Configurable parameters

5.1.1 User's parameters (MODE & SET access keys)

WARNING: If during this phase an error or a malfunctioning occurs, the display will not be modified. Depending on the kind of error, the electro pump can be stopped. Nevertheless, it is still possible to make the desired calibration. In order to know which kind of error occurred, you must go back to the mode where you can see the operation status by pushing the SET button.

5.1.1.1 **SP: Setting the set-point pressure**

From normal operation status keep the "MODE" and "SET" keys simultaneously pressed until "SP" appears on the display. In these conditions the + and - keys allow to increase or decrease the desired pressure. Set-point pressure may range from 1,0 to 9,0 bar. Press "SET" to go back to normal operation status.

The PWM restart pressure is set through the "rP" parameter that represents the pressure decrease (measured in bar), with respect to "SP", that causes the pump to start (see sec.5.1.2.4)

Example: SP = 3,0 bar; rP = 0,5 bar:
During normal operation the system will be pressurized at 3,0 bar.
The electro pump will restart, when pressure goes under 2,5 bar.

5.1.2 Installer's parameters (access keys MODE & SET & -)

Warning: If an error of malfunctioning occurs during this phase, the display is not changed. Depending on the type of error, the electro pump may turn off. However, it is still possible to make the desired calibration. To know which type of error occurred you must press the SET key in order to return to the mode in which the operating status is displayed.

From normal operating status, hold down the "MODE" & "SET" & "-" (minus) keys simultaneously pressed, until "Fn" appears on the display. In these conditions the + and - keys allow you to increase and decrease the value of the parameter respectively, while the MODE key allows you to move to the next parameter in cyclic mode. Press SET to return to normal operating status.

5.1.2.1 **Fn: Setting the rated frequency**

This Parameter represents the rated frequency of the electro pump and can range from 50Hz to 130 Hz (default is "--", i.e. not set). By pressing the "+" or "-" keys a frequency of 50Hz or 60 Hz can be selected. Holding these keys pressed for at least 3 sec allows changing the frequency at steps of 1 Hz inside the above mentioned range.



A wrong setting of the rated frequency can damage the electro pump.

Note: each modification of Fn is interpreted as a system change; hence FS, FL and FP will automatically take the default value.

5.1.2.2 rt: Setting the direction of rotation

Possible values: 0 and 1

If direction of rotation of the electro pump is wrong, it is possible to invert it by changing this parameter. If you cannot check the direction of rotation of the motor directly, proceed as follows:

- Open a user and take note of the frequency (parameter Fr with MODE key from Go/Sb).
- Without changing the amount of water taken, change the rt parameter and take note of the frequency Fr again.
- The correct rt parameter is the one that requires a lower Fr frequency, with the same amount of water taken.

5.1.2.3 od: Setting the operating mode of the PWM

Possible values: 1 and 2

The factory setting mode is 1, which adapts to most installations. If pressure oscillates and a change of GI and GP parameters is ineffective (see sec. **Errore. L'origine riferimento non è stata trovata.** and **Errore. L'origine riferimento non è stata trovata.**), a switch to mode 2 can be helpful.

Important note. GP and GI parameter values change when switching from one operating mode to the other one. Moreover, the GP and GI values set in mode 1 are contained in a separate memory area from the GP and GI values set in mode 2. So for example, when you switch from mode 1 to 2, the GP value will be replaced by the one that was set in mode 2, but the GP value set in mode 1 will be restored when switching back to mode 1. The same value has a different weight in one or in the other mode because the control algorithm is different.

5.1.2.4 rP: Setting the restart pressure drop

This parameter represents the pressure drop, with respect to the SP parameter value, that makes the pump restart.

Normally rP may be set from a minimum of 0.1 to a maximum of 1.5bar. In particular conditions (see sec. 5.1.1.1) this parameter can be automatically limited.

5.1.3 Technical assistance Displays and settings (access keys MODE & SET & +)

5.1.3.1 tB: Setting of reaction time of the water lack blockage

Setting of the reaction time of the water lack blockage allows selecting the time (in seconds) taken by the PWM system to indicate the lack of water in the electro pump. Changing this parameter may be useful if it is known that there is a delay between the moment in which the electro pump is turned on and the moment in which it actually starts delivering. An example could be that of a system where the suction pipe of the electro pumps is particularly long and has some little leakages. In this case it can happen that the suction pipe unloads when the system is in stand by, even if there is water, and that the electro pump takes some time to reload, to deliver flow and to bring pressure to the system.

5.1.3.2 GP: Setting the proportional coefficient of the PI

Typically, the proportional term must be increased for systems characterized by elasticity (for PVC and wide pipelines) and decreased in case of rigid installation (iron and tight pipelines).

In order to have a constant pressure in the system, PWM performs a PI control action on the measured pressure error. The power that must be supplied to the electro pump is calculated as a function of the mentioned error values. The control action's behaviour depends on the values of the GP and GI parameters. In order to adapt to behaviour of the various hydraulic system types, PWM allows selecting different parameter values that differ from the ones set by the factory. **For most systems, the factory default values of GP and GI parameters are the optimal ones.** If there are some regulation problems, these settings may be modified.

5.1.3.3 GI: Setting the integral coefficient of the PI

If a big pressure fall happens due to a quick increase of the flow, or to a slow response of the system, the GI value should be increased. Vice versa, pressure oscillations around the set point value may be reduced by decreasing the GI value.

Note: If the PWM is far away from the electro pump hydraulic elasticity affects the PI control and, as a consequence, pressure regulation.
This is a typical case in which a decrease of the GI value is needed.

Important: To obtain a satisfactory pressure regulation, you usually need to adjust both GP and GI.

5.1.3.4 FS: Setting the maximum rotation frequency of the electro pump

FS sets the maximum rotation frequency of the pump; values can range between $F_n - 20\%$ and $F_n + 20\%$ (absolute max. rating = 154 Hz). It can be useful to obtain a greater hydraulic power (though for a limited time) or to set an upper limit to the rotating frequency.

FS automatically aligns to F_n each time a new F_n value is set.

Overdriving of the electro pump is useful to cover high flow requests without the pressure of the system dropping below the set-point one. This operation condition cannot last too long because the temperature increase it causes could damage the motor.

Anyway, to allow overdriving to be exploited, PWM allows to set a maximal frequency of operation higher than the rated one. Thanks to a thermal model of the installed motor, the highest frequency supplied to the electro pump can be limited in case of excessive increase of the temperature. The value of the highest rotation frequency (FS) can be therefore be reached only when the motor is cold and it drops down to F_n (the rated frequency) as the windings' temperature increases.

On the other hand, if necessary, PWM allows setting a maximum frequency of operation lower than F_n . In this case, in any condition of regulation, the electro pump will never be driven at a frequency higher than FS.

5.1.3.5 FL: Setting the min. frequency

With FL we set the min operating frequency of the pump. FL values may range between 0 Hz and 60% of F_n ; for example, if $F_n = 50$ Hz, FL can be chosen between 0 and 30 Hz.

FL is reset to the default each time we set a new F_n value.

5.1.3.6 Ft: Setting the low flow rate threshold

The parameter "Ft" allows to set a minimum flow rate under which the PWM turns off the pump.

5.1.3.7 AE: Enabling the anti-frost/anti-block function

This function helps to avoid mechanical blocks in case of long inactivity or in case of low temperature and is obtained by running the pump.

When the anti-frost function is enabled, if the PWM measures a temperature that is too low, with a risk of frost, it automatically starts running the electro pump at low speed. Keeping water in movement reduces frost risks in the pump. In this way breaking risks due to ice are reduced in the PWM also, thanks to power dissipation. Vice versa, if the temperature is in a safe range, a long inactivity can prevent the mechanical parts from operating or cause formation of residuals inside the pump; to avoid this an anti-block cycle is performed every 23 hours.

5.2 Display-only parameters

From normal operation status the following quantities can be displayed by pressing the MODE key:

5.2.1 User's parameters (accessed by the MODE key)

From normal operation status (Sb or Go on the display) after pressing the MODE key once, "Fr" appears on the display.

All the following quantities can be displayed at further MODE key pressures.

5.2.1.1 Fr: Display of the current rotation frequency (in Hz)

5.2.1.2 UP: Display of pressure (measured in bar)

If pressure exceeds 15 bar, the display keeps showing "15".

5.2.1.3 UE: Display of the version of the software with which the appliance is equipped

5.2.2 MONITOR menu (accessed by SET & - keys)

From normal operating status hold down the "SET" and "-" (minus) keys simultaneously until "UF" appears on the display.

Now it is possible to display all the following parameters, by pressing each time the MODE key.

5.2.2.1 UF: Display of the flow

Display of the instantaneous flow in uncalibrated internal measure unit.

5.2.2.2 ZF: Display of zero flow

Display of the value read by the flow sensor on which zero was acquired (with electro pump turned off). During normal operation the PWM will use this parameter to turn off the electro pump.

5.2.2.3 FM: Display of the maximum rotation frequency (in Hz)

5.2.2.4 tE: Display of the temperature of the power stages' temperature (measured in °C)

5.2.2.5 GS: Display of running status

SP pump is maintaining pressure "SP"

AG anti-frost/anti-block procedure is being performed

5.2.2.6 FF: Display of fault history queue (+ & - to scroll)

There is a queue of 16 positions for containing the last 16 faults that have occurred during system operation. By pressing the "-" key you can go back in history and stop at the oldest fault, whereas by pressing the "+" key you can go forward in history and stop at the most recent fault.

The decimal point identifies the last fault that occurred in chronological order.

The history queue contains at most 16 positions. Each new fault is inserted in the most recent position (decimal point). Each fault after the sixteenth overwrites the oldest one in the queue. The fault history queue is updated as new faults occur, but never erased. Manual reset and turning off of the appliance do not erase the fault history queue.

6 PROTECTION SYSTEMS

PWM is equipped with protection systems that preserve the pump, the motor, the power line and the PWM self. If one or more protections act, the one with higher priority is signalled on the display. According to the error type, the electro pump can be turned off, but when normal operating conditions are restored, the error status can be cancelled either immediately or after a certain time.

In case of block due to a lack of water (bL), of block due to overcurrent condition of the output stage (oF), or of block due to direct short circuit between the phases of the output terminals (SC), we can try to manually exit the error condition by pressing and releasing the + and – keys simultaneously. If the error condition persists, it is necessary to remove the cause of the anomaly.

In case of overcurrent, the protection acts in two ways:

- Maximum frequency limiting as temperature increases over a potentially dangerous value

The second type of protection is used on:

- power devices
- supply capacitor

It acts when a potentially dangerous temperature is reached, by gradual decrease of the maximum frequency of rotation FS. The purpose is that of reducing power dissipation thus protecting the PWM against overheating. Once the alarm cause disappears, the protection is automatically disabled and normal operation conditions are restored. Intervention of one or more of these protections can only decrease the frequency FS by no more than 20%.

The three protection systems don't cause a block and don't produce any error message, but keep track of their intervention by insertion of an alarm in the fault history (see sec 5.2.2.6).

Note: during intervention of such protections a FR frequency of rotation smaller than the expected one could be displayed.

If the temperature of the final output stage or of the printed circuit is not successfully limited by the mentioned protections, an overtemperature blockage will occur.

Warning on the fault history queue	
Display indications	Description
Lt	Overtemperature on the power devices alarm (tE > 85°C)
LC	Overtemperature on capacitor alarm

Table 6: Warning on the fault history queue

Error conditions	
Error and status conditions	
Display indications	Description
bL	Blockage due to lack of water
bP	Blockage due to disconnected pressure sensor
ot	Blockage due to overheating of the power output stages (tE > 100°C)
oF	Blockage due to overcurrent in the output stages
SC	Blockage due to direct short circuit between the phases of output terminals
EC	Blockage due to incorrect setting of the rated current (rC) or rated frequency (Fn)
E0...E7	Blockage due to internal error 0...7

Table 7: Error conditions

“bL” Blockage due to lack of water

In no flow conditions the system turns off the pump. If the pressure is lower than the set point one, the display shows a lack of water message.

If you wrongly set a pressure set point higher than the pressure that the electro pump is able to supply, the system will sign “lock due to lack of water” (bL) even if there is no lack of water. So you should lower the set-point pressure at a reasonable value that usually does not exceed 2/3 of the of the installed electro pump’s head.

Note: The PWM system operates at constant pressure. This regulation is appreciable if the hydraulic system downstream from the system is properly sized. Systems with too narrow pipes lead to a pressure loss that the system cannot compensate. The result is that pressure is constant on the PWM device but not on the user.

“bP” Blockage due to a fault of pressure sensor

If the PWM does not detect the presence of a pressure sensor the pump blocks and the “bP” error is signalled. This error condition begins as soon as the problem is detected and ends automatically 10 sec after the correct conditions are restored.

"SC" Blockage due to direct short circuit between the phases of the output terminal

PWM is equipped with protection against short circuit that may occur between the phases U, V, W of the "PUMP" output terminal. When this block status is indicated, you should remove the short circuit and carefully check the wiring integrity and the installation in general. Once these checks have been made you can try to recover from the error by simultaneously pressing the “+” and “-“ keys; **anyway, this will have no effect until 10 seconds have elapsed from the moment in which the short circuit occurred.**

Whenever a short circuit occurs, an event counter is increased and saved in the permanent memory (EEPROM).



AFTER THE HUNDREDTH SHORT CIRCUIT THE MACHINE BLOCKS PERMANENTLY AND IT WILL NO LONGER BE POSSIBLE TO UNBLOCK IT!

6.1 Manual reset of error condition

In error status the operator can recover from the error by forcing a new attempt, which is obtained by simultaneous pressure of the “+” and “-“ keys.

6.2 Automatic reset from error conditions

The system automatically attempts to recover from the following error conditions:

- "bL" Blockage due to lack of water
- "ot" Blockage due to overheating of the power output stages
- "oF" Blockage due to overcurrent in the output stages

For example, if the electro pump blocks due to lack of water, the PWM will automatically start a series of tests in order to ensure that the machine really has no water and that this condition is permanent. If a recovery attempt succeeds (e.g. if water has come back), the tests will stop and the PWM will return to normal operation.

The following table shows the procedures performed by PWM when different error conditions occur.

Automatic reset of error conditions		
Display indications	Display indications	Display indications
bL	Blockage due to lack of water	- One attempt every 10 min. for a total of 6 attempts - One attempt every 1 hour for a total of 24 attempts - One attempt every 24 hours for a total of 30 attempts
ot	Blockage due to overheating of the power stages (tE > 100°C)	- Recovery happens when the power stages' temperature falls below 85°C
oF	Blockage due to overcurrent in the output stages	- One attempt every 10 min. for a total of 6 attempts

Table 8: Automatic reset of error conditions

7 SWITCHING TO MANUAL MODE

A greater flexibility is achievable by using the system in manual mode. In this operating mode the PWM performs no pressure control action and the user can force it to perform some actions, according to the possibilities listed in this chapter.

To access to this operating mode, hold down the    keys simultaneously for at least 5 seconds. Activation of manual mode is signalled by a blinking display.

In this operating mode the  key allows to scroll through all parameters and the  and  keys increase and decrease the modifiable parameters.

The functions of the keys and their combinations are summarized in Table 9 and explained in the sections that follow.

Warning: In this mode all controls and protection systems of the PWM are disabled and any device connected to the PWM (PWM or controller board) cannot control regulation!

Use of the keys.	
Pressed keys	Action
“SET” & “-” & “+”	Press them together until the display shows “MA” (5 sec.)
“+”	Increases the parameter’s value if it does not yet equal the maximum allowed one (only frequency and rotation direction of the pump)
“-”	Decreases the parameter’s value if it does not yet equal the minimum allowed one (only frequency and rotation direction of the pump)
“MODE”	Moves to the next item in the following menu: FP Setting of the frequency (measured in Hz); must be ≤ than the FS value. UP Display of pressure (in bar) rt Setting of the direction of rotation UF Display of flow ZF Display of zero flow
“MODE” & “-”	The electro pump runs at the set frequency as long as the keys are held down
“MODE” & “-” & “+” (2 secondi)	The electro pump remains operating at the set frequency The electro pump may be turned off by pressing “SET” (if “SET” is pressed one more time, PWM will exit manual mode)
“SET” & “-”	Change the rotation direction of the electro pump (active only if the electro pump is operating)
“SET”	Press it to stop the pump or to exit manual mode

Table 9: Keys usage in manual mode

Note: In manual mode, error recovery, obtained by pressure of the   keys, is effective only on "BI" and "OF" error conditions.

7.1 Parameters in manual mode

7.1.1 FP: test frequency setting

The test frequency in Hz it is displayed and can be modified by pressing the "+" and "-" keys. The default value is $F_n - 20\%$ and values cannot exceed FS.

7.1.2 UP: Display of pressure (in bar)

7.1.3 rt: setting the direction of rotation

The "rt" parameter allows to revert the pump's rotating direction by pressing the  and  keys and to display two possible status codes: "00" or "01". The function is active also when the motor is running.

Note: in manual mode, irrespective from the current menu item, it is always possible to revert the direction of rotation by simultaneous pressure of the  and  keys for 2 seconds; this feature is available only while the pump is running.

An arrow on the pump's motor frame is normally used to show direction of rotation. If you cannot check the direction of rotation of the motor you may proceed as described in sec. 5.1.2.2 or switch to manual mode and proceed as follows:

1st method

- Open a user, start the pump with    keys and take note of the pressure.
- If a manometer is not available, press  until the pressure "UP" is displayed.
- Without changing the amount of water taken, change the direction of rotation directly by simultaneously pressing the  and  keys (see sec. 7.2.3) and take note of the pressure again while the pump is running.
- The right direction of rotation is obtained when pressure is maximized.
- Press  to stop the pump.

2nd mode

- Open a user, start the pump by simultaneously pressing the    keys and take note of the pressure (if a manometer is not available, you can display the pressure "UP" by scrolling the menu with the  key).
- Without changing the amount of water taken, change the rotating direction "rt" with the  and  keys while the pump is taking water from the user circuit and the pump is running. Take note of the pressure again.

- The right value of “rt” is obtained when the pressure is maximized.

7.1.4 UF: display of the flow

7.1.5 ZF: display of Zero Flow

7.2 Controls

When PWM is in manual mode, it is always possible, irrespective from the displayed parameter, to perform some controls as described in the following sections.

7.2.1 Temporary start of the electro pump



Simultaneous pressure of the   keys causes the pump's start at FP frequency and the running status persists as long as the two keys remain pressed.

When the pump is ON the display blinks quickly (200mSec ON, 100mSec OFF).

When the pump is OFF the display blinks slowly (400msec ON, 100mSec OFF).

7.2.2 Quick-start of the pump



Simultaneous pressure of the    keys for 2 seconds causes the pump's start at FP

frequency. The running status persists until the  key is pressed.

When the pump is ON the display quickly flashes (200mSec ON, 100mSec OFF).

When the pump is OFF the display slowly flashes (400msec ON, 100mSec OFF).

Note: in manual mode if the pump is stopped pressure of the  key restores normal operating mode, but if the pump is running pressure of the key only stops the pump.

7.2.3 Direction of rotation reversal



By simultaneous pressure of the   keys for at least 2 seconds, the pump's rotating direction is reverted (this function is active only while the motor is running). To understand which is the right direction of rotation, see sec.5.1.2.2 and 7.1.3.

8 RESET AND FACTORY SETTINGS

8.1 General system reset

To restart the appliance without disconnecting the power supply, press the 4 keys simultaneously.

8.2 Factory settings

The PWM leaves the factory with a set of default parameters' values (shown on Table 10).

Name	Description	Factory parameters
SP	Set-point pressure	3.0 bar
rt	Direction of rotation	00
Fn	Rated frequency	00
od	Operating mode	01
rP	Restarting pressure	0.5 bar
tb	Reaction time of the water lack blockage	10 s
GP	Proportional coefficient	1,0
GI	Integral coefficient	1,0
FS	Max. Rotation frequency	00
FL	Min. Rotation frequency	00
Ft	Low flow rate threshold	15
AE	Enabling anti-blockage function	01
FP	Manual mode test frequency	Fn – 20%

Table 10: Factory settings

8.3 Restoring of factory settings

To reset factory values turn off the system, press and keep the SET and + keys pressed while the system turns on again and release them only when the "EE" appears on the display.

This way PWM automatically restores all parameters to their factory values (factory settings permanently saved in flash memory are copied on EEPROM and verified).

After having set all parameters, PWM goes back to normal operation.

9 APPENDIX

9.1 Pressure loss

Pressure loss diagram of PWM

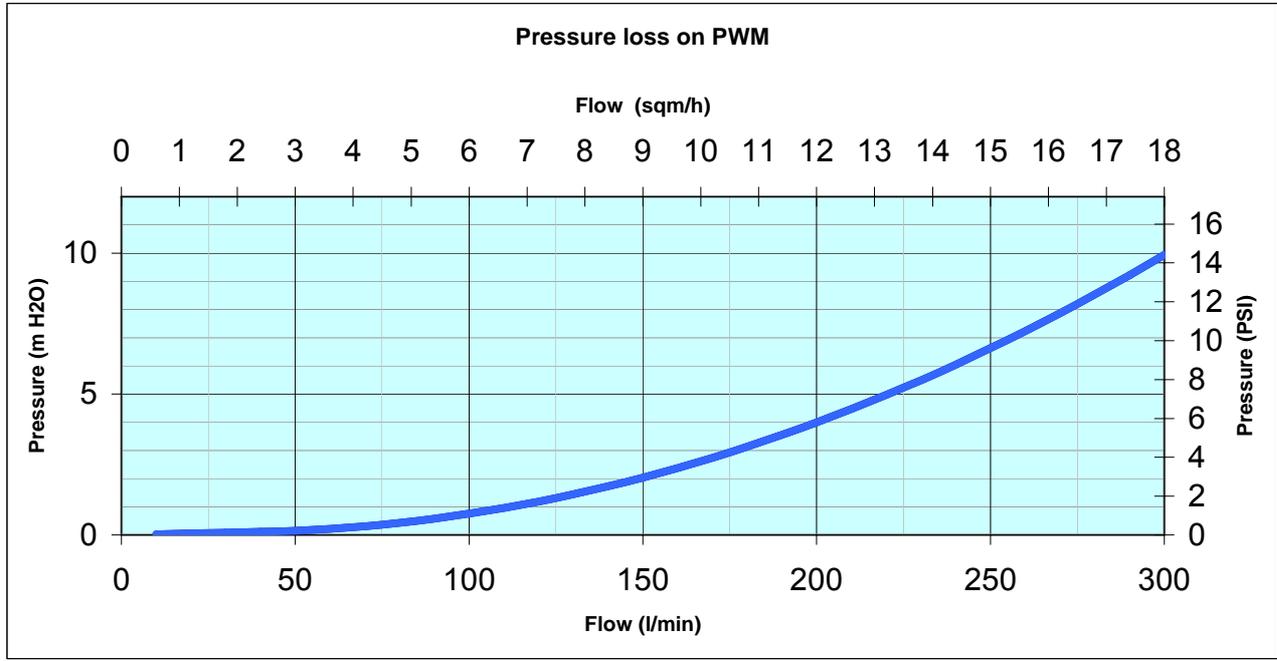


Figure 7: PWM's pressure loss

9.2 Risparmio energetico

Use of the PWM system instead of traditional On/Off systems drastically reduces energy consumption. To show this, an example that represents the consumption of a 1 kW pump in the two cases follows. The comparison is done with the same yearly flow demand.

Test performed with a 1 KW electro pump and prevalance set to 30 mH2O					
Flow (l/min')	Statistic use of flow	Direct insertion consumption (KW)	Consumption with PWM (KW)	Power difference (KW)	Energy saved in one year (8760 hours) (Kwh)
5	20%	0,855	0,122	0,733	1.284
10	40%	0,916	0,366	0,549	1.925
20	20%	0,977	0,488	0,488	856
40	9%	1,038	0,733	0,305	241
70	6%	1,184	1,036	0,148	78
100	5%	1,221	1,221	0,000	0
Total yearly saving (KWh)					4.383

Table 11: Energy saving