Pioneering for You

Strategic Business Unit OEM

Wilo-Para, Wilo-Para MAXO

iPWM Communication Protocol

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Description of content evolution	Version	Date
Initial release	V1.00	*15/09/2020*
Integration of Para MAXO range More details about the LED status behaviour during the deblocking routine Adding automatic deblocking routine description Update iPWM Warning/Error information Adding output details	V1.01	*12/06/2023*

INTRODUCTION

Modern heating systems aim to provide the best possible confort and efficiency to the occupants of a building. For that goal, precise regulation of the flow rate in the system is key.

The PWM control is a well-established standard in the heating industry.
The signal is based on the DIN IEC 60469-1 standard and the implementation in circulators is covered by the VDMA 24 224.

Based on its long-term experience in OEM heating industry, Wilo has developped an iPWM (intelligent Pulse Width Modulation) protocol that greatly helps to improve efficiency and comfort.
This iPWM signal establishes a bidirectional communication (PWM Input / PWM Output) between the pump and the application controller.
It allows the precise control of the pump speed, and the exchange of information like the flow estimation and the pump status.

This document provides detailed description for a fast and proper implementation of iPWM circulators Wilo-Para and Wilo-Para MAXO in an integrated heating system.

IMPORTANT: The implementation in Wilo circulators differs from the VDMA 24 224 in several aspects, therefore it is recommended to refer only to the present document.

Benefits:

The iPWM (intelligent Pulse Witdth Modulation) can provide number of benefits for the heating system :

- **Energy saving :** The application controller becomes able to adjust the speed of the pump in real-time based on the heating load. This represents an important energy saving potential compared to a pump always operating at full speed.
- **Comfort :** The iPWM control allows to improve the comfort of the occupants by adjusting the pump speed to the heat demand of the emitters, and therefore by maintaining a more constant temperature in the building.
- **Easy-to-use :** The iPWM is compatible with a wide range of electronic cards on the market and is easy to implement. It is designed to be user friendly with simple controls and intuitive programming options.
- **Information sharing :** Thank to the bidirectional communication, the circulator is able to provide in real-time an estimation of its flow rate or its power consumption, or the presence of an active fault. This opens the door to a wide range of system optimization.

PWM Generalities

External control via PWM signal

The control signal definition is managed by a master controller. The master controller sends a PWM signal as an actuating variable to the Wilo Pump.

The PWM signal generator gives periodic pulses to the pump, according to DIN IEC 60469-1. The actuating value is determined by the ratio between pulse duration and the pulse period. The duty cycle is defined as a ratio without dimension, with a value bewteen 0 ... 1 or 0 ... 100%.

This is explained in the following figures with ideal pulses which form a rectangular wave.

In the same maner the pump returns information or status to the master by a second PWM signal.

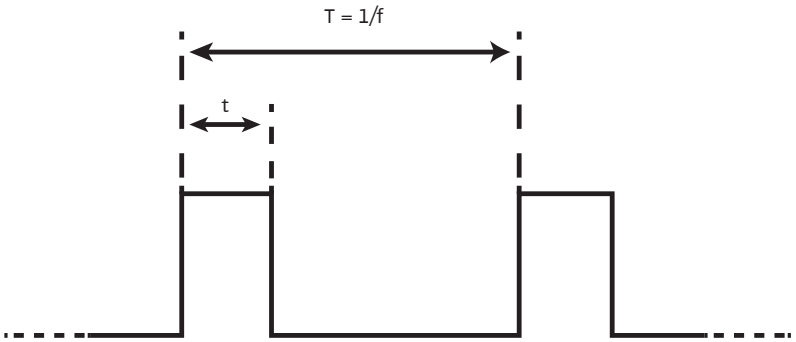


figure n°1

Example:
T = 2ms (500Hz)
t = 0,6 ms

PWM value :
PWM% = 100*t/T
PWM% = 100*0,6/2 = 30%

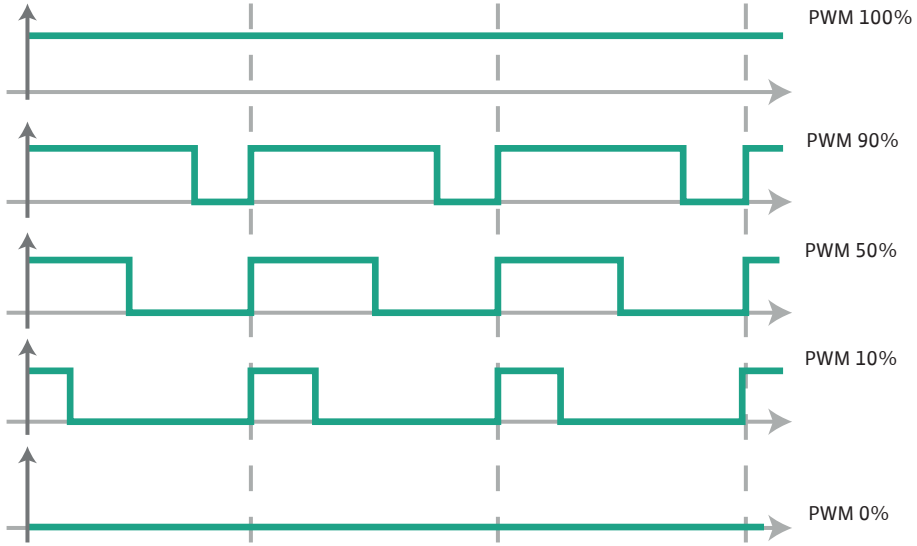
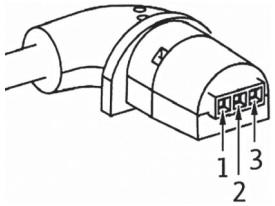


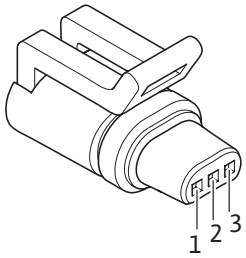
figure n°2

Hardware definition

The pin out for the signal cables used on Wilo pumps is defined as follow :



Para



Para MAXO

figure n°3

Core 1 (brown) : PWM Input
Core 2 (blue or grey) : PWM Common
Core 3 (black) : PWM Output

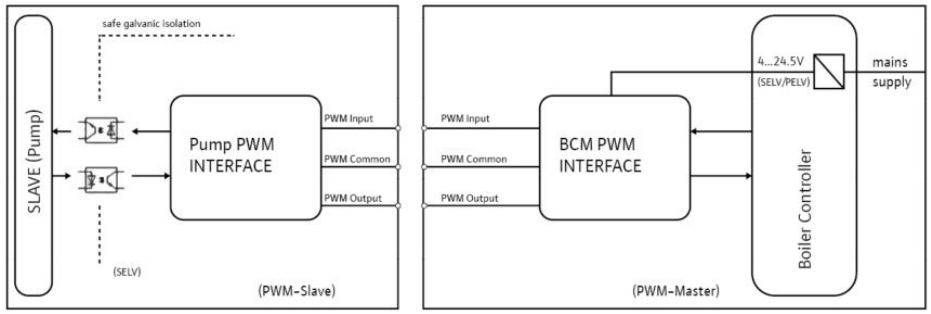


figure n°4

Standard cable length for iPWM : due to EMC requirement the maximum cable length of the iPWM cable shall be limited to 3m.

The pump interface is defined according to VDMA 24224 description (PWM-Slave). So the Master interface (PWM-Master) need to be defined accordingly.

Hardware definition		
Features	**Para**	**Para MAXO**
Cable length	< 3m	< 3m
Signal cable section	0.25 mm² ≤ s ≤ 0.35 mm²	0.5 mm² ≤ s ≤ 1 mm²
Signal polarity	Yes	Yes

PWM Input Master Interface

PWM signal coming from the Master according to :

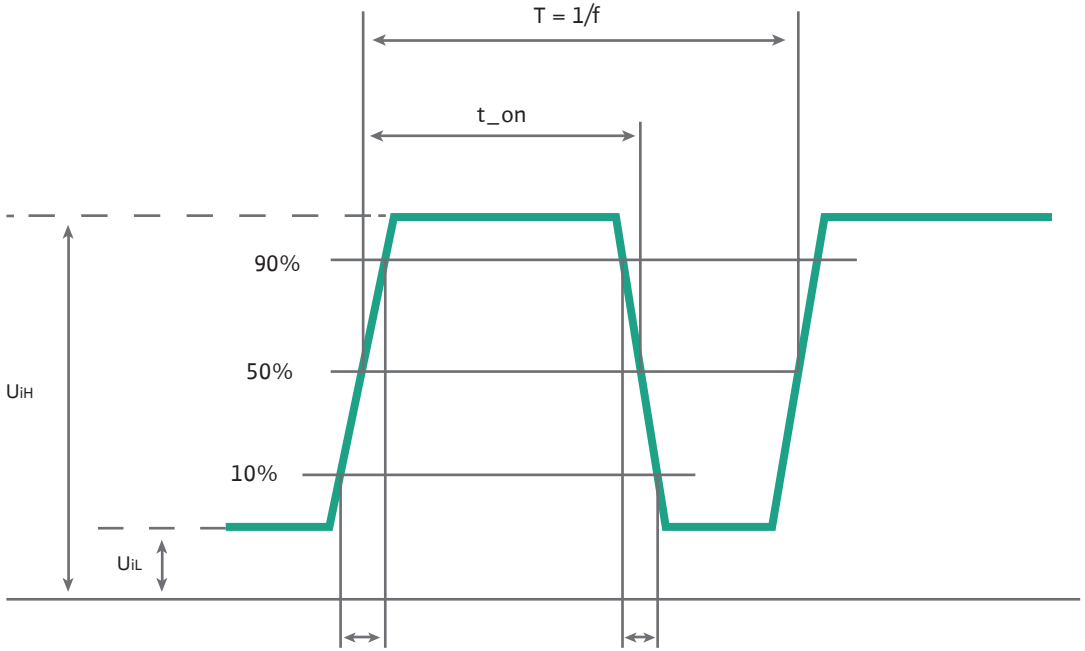


figure n°5

Interface Specification		
Symbol	**VDMA 24 224**	**Wilo Specification**
Cable length	*< 3 m*	*< 3 m*
Signal cable section	*≥ 0.25 mm²*	*≥ 0.25 mm²*
UiH	*4V – 15V*	*4V – 24.5V*
UiL	*≤ 1 V*	*≤ 1 V*
IH	*10 mA*	*3,5mA – 10 mA*
PWM Frequency	*100–1000 Hz*	*90–5000 Hz*
PWM %	*0–100%*	*0–100%*
Rise and Fall time	*≤ T/500*	*≤ T/500*

PWM input frequency f

– f is the frequency at which the input signal is clocked out. It is the inverse of the period T

Input voltage upper value UiH

– The upper value of the input voltage above which the signal is evaluated as "ON"

Input voltage lower value UiL

– The lower value of the input voltage indicates below which voltage the signal is evaluated as "OFF"

Resulting input current IH

– IH is the current sunk by the pump interface according UiH

Rise / fall time

– Maximum admissible rise and fall time according to the period to guaranty the information integrity

PWM Master Interface design example

The PWM Input Master Interface should be designed according to :

R1 dimensioning method

- Define the minimum voltage at PWM input UiH 1 i.e 10V.
  Intersection with interface curve give the associated current IiH 2
- Intersection with voltage drop at R1 (24V-10V) 3 will give the R1 max 4
- Define the maximum current in transistor Q. 5
  Intersection with VCC curve i.e 24V 6 will give the R1 min 7
- 1KΩ < R1 < 2.5KΩ

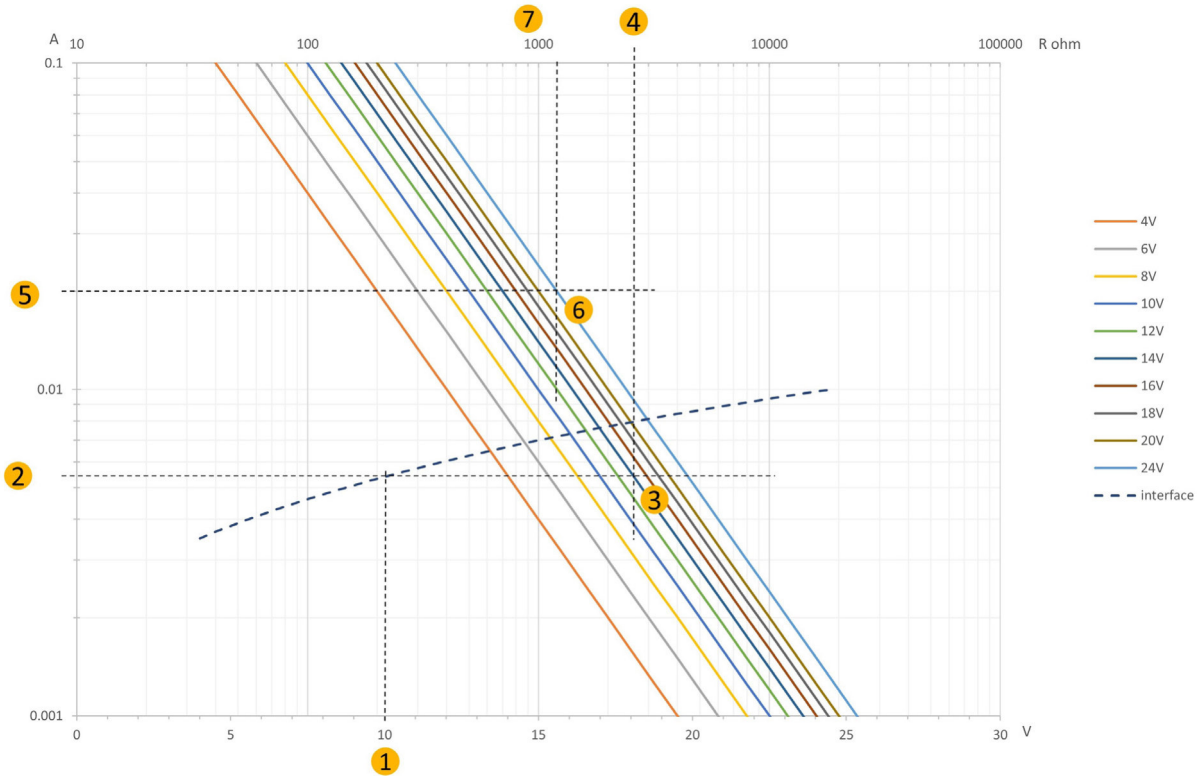


figure n°6

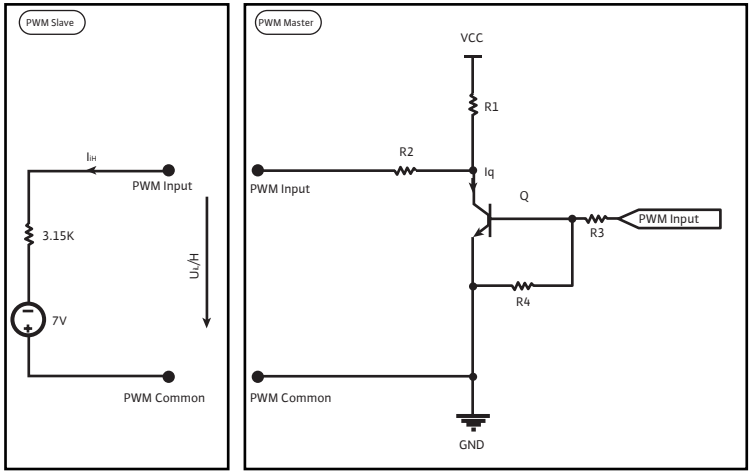


figure n°7

Recommended PWM Input Master interface

Recommended design for 24V system with 5V PWM signal :

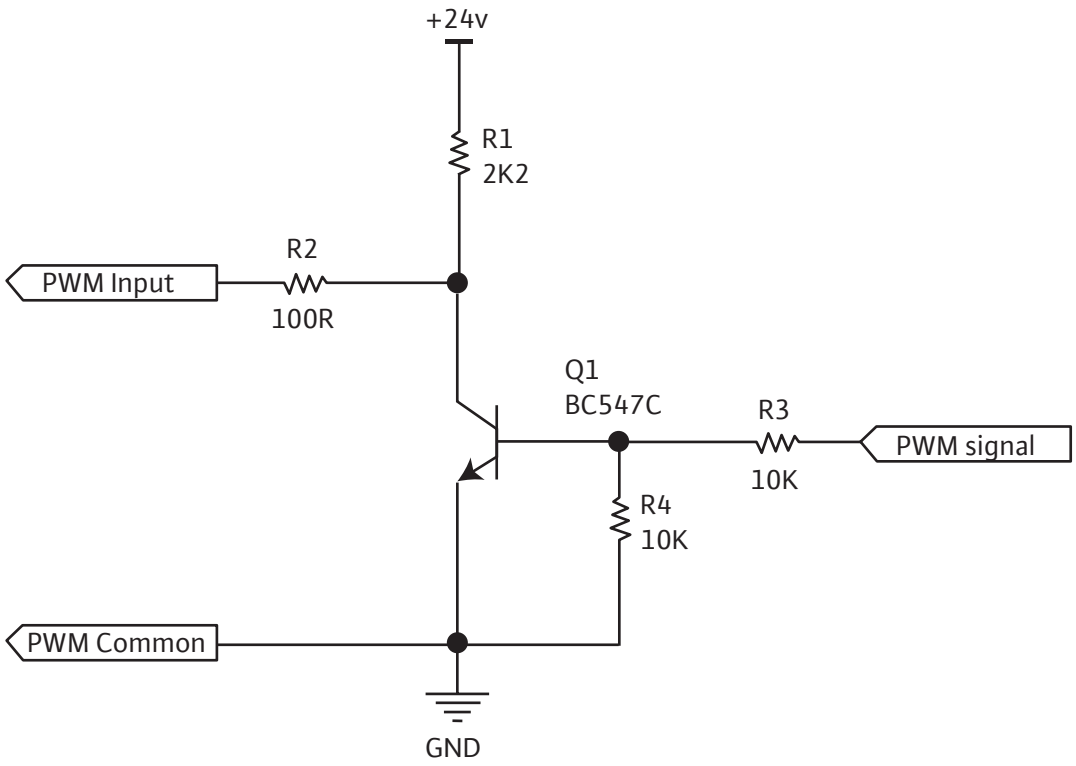


figure n°8

PWM Output Master Interface

PWM signal coming from the Pump according to :

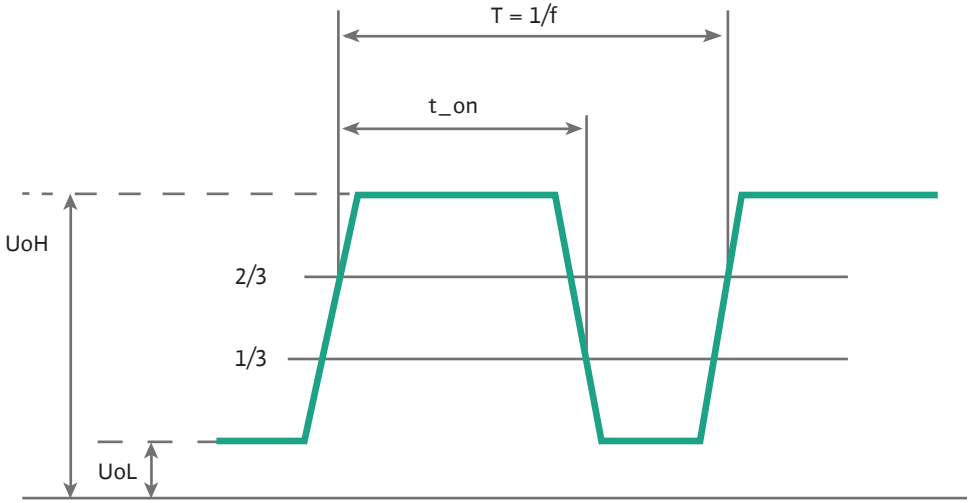


figure n°9

Recommended PWM Output Master Interface	
Output type	Open collector
High-level voltage of PWM output signal	3V min – 25V max
Low-level voltage of PWM output signal *(iPWM ≤ 1 mA)*	≤ 1V
Maximum current iPWM in normal operation *(Low level)*	1 mA (to be ensured by the customer based on its UoH value)
Frequency of PWM output signal	75 Hz (± 2Hz)
Maximum voltage provided by the boiler in abnormal operation *(UoH)*	32V
Duty cycle range of PWM output signal	0...100%
Duty cycle resolution of PWM output signal	≤ 1%
Duty cycle accuracy of PWM output signal	± 1% (absolute)
Maximum current iPWM in abnormal operation *(UoL)*	10 mA
Resistor Rout *See figure 11*	470 Ω

Recommended PWM Output Master interface

The PWM Output Master Interface should be designed according to :

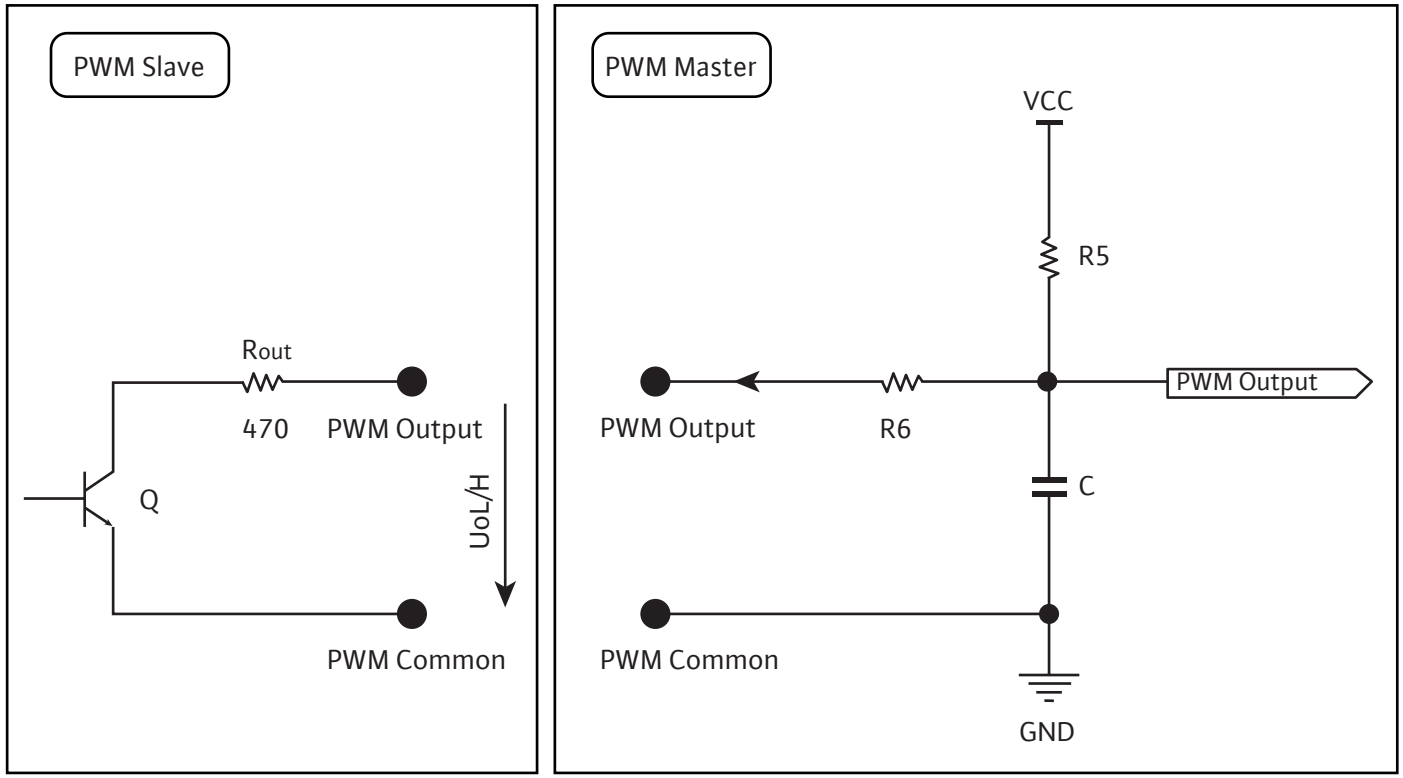


figure n°10

$$R5 = (R6 + R_{out})\left(\frac{VCC-0.2}{UoL-0.2}\right)$$

Assuming that master interface transition levels are 1/3 and 2/3 of UoH

$$C < \frac{1\%}{75\ R5\ \ln(3)}$$

for rise time impact < 1%

Recommended value:

VCC = 5 V
R6 = 100Ω (ESD protection)
UoL = 0.5V
R5 = 8k2
C = 10nF

PWM Input strategy

Two command strategies are available according cable break function

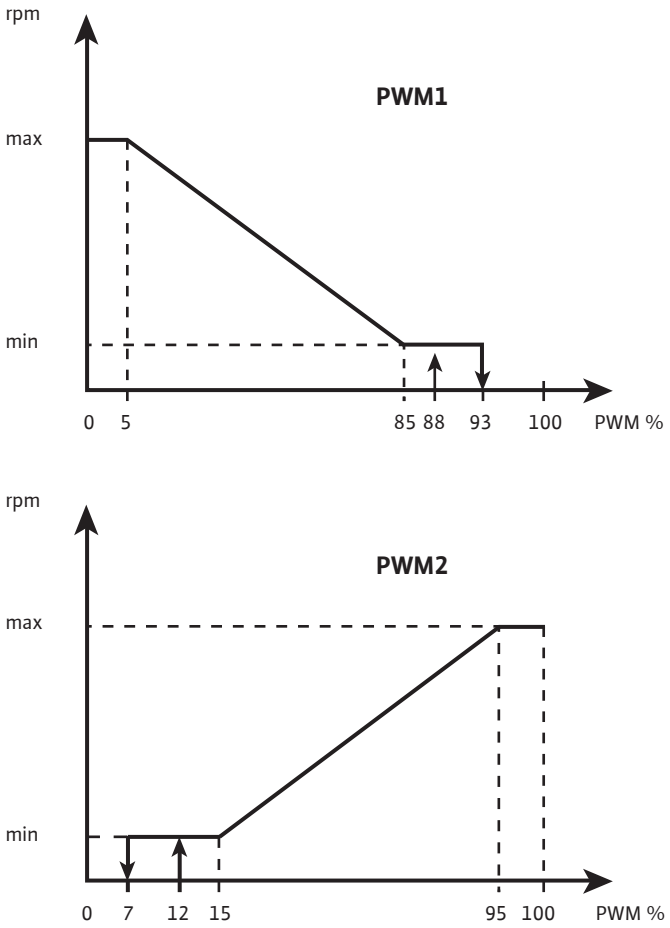


figure n°11

PWM1 transfer function [%]		
Status	**VDMA 24 224 (% PWM In)**	**Wilo (% PWM In)**
Pump runs at maximum speed	**Cable break < 10**	**Cable break < 5**
The speed of the pump decreases linearly from n.. to n..	**10 .. 84**	**5 .. 85**
Pump runs at minimum speed (operation)	**84 .. 95 (operation)**	**85 .. 93 (operation)**
Pump runs at minimum speed (starting)	**84 .. 91 (starting)**	**85 .. 88 (starting)**
Pump stopped in Active mode stop	**95 .. 100**	**93 .. 100**

PWM2 transfer function [%]		
Status	**VDMA 24 224 (% PWM In)**	**Wilo (% PWM In)**
Pump stopped in Active stop mode	**Cable break < 5**	**Cable break < 7**
Pump runs at minimum speed (operation)	**5 .. 16 (operation)**	**7 .. 15 (operation)**
Pump runs at minimum speed (starting)	**9 .. 16 (starting)**	**12 .. 15 (starting)**
The speed of the pump increases linearly from n.. to n..	**16 .. 90**	**15 .. 95**
Pump runs at maximum speed	**> 90**	**> 95**

Active stop mode

The pump is stopped in active stop mode by the PWM input signal. A benefit of this, compared to power OFF, will be faster pump restart.

Hysterisis switching – ON/OFF

The pump can be switched between MIN speed and active stop mode by the PWM input signal.
To prevent instability, an hysteresis area is mandatory. Driving pump with PWM values in this area is not recommended as two pump states are possible.

Heating / Solar

The choice of transfer function profile has to be defined based on application purpose taking care of the expected cable break function

I.e: In heating application, it is normaly expected that the pump runs at full speed when communication is lost (PWM1 profile).
While for solar application, the pump must stops (PWM2 profile)

PWM Output strategy

PWM Output signal strategy is defined as follow :

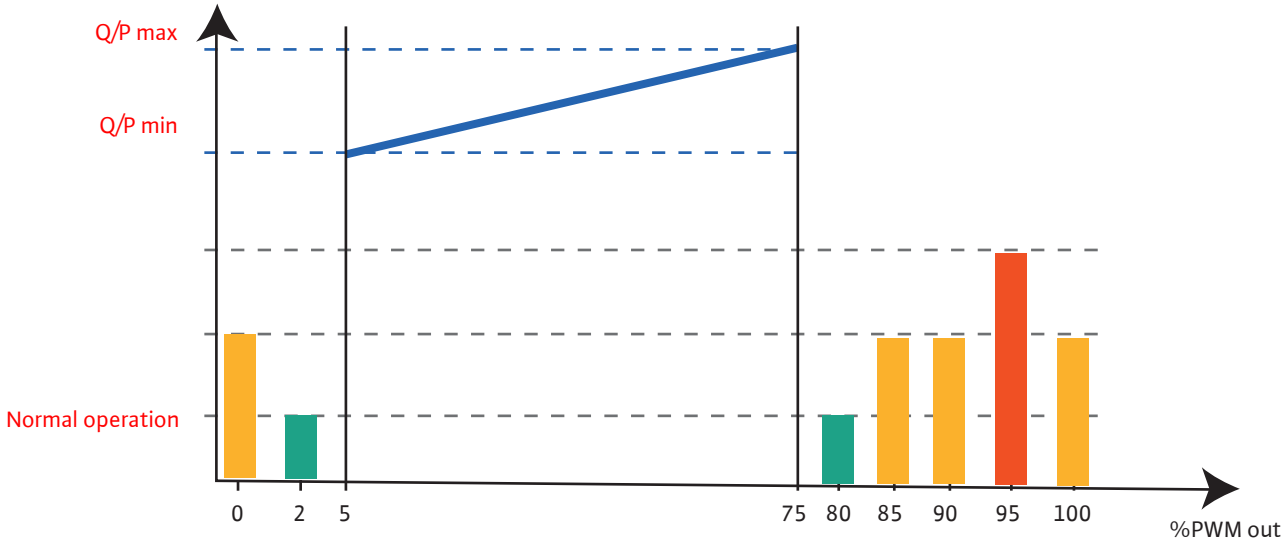


figure n°12

PWM Output signal [%]	
% PWM-out	**Status**
0	PWM output interface damaged
2	" Active Stop mode ", ready to start (with power consumption reduction only for Para)
5-75	Pump is running, flow or power information is returned *(see chapter PWM Output : product characteristics for information range supplied)*
80	Abnormal running mode Pump is running but not at optimal performance
85-90	The pump is stopped due to a temporary error. The pump will restart a soon as the error is corrected.
95	The pump is stopped due to permanent failure
100	Pump power OFF or PWM output interface damaged

PWM Output : product characteristics

		Para (Heating) Para R (Heating)	Para Z (DHW)	Para ST (Solar)	Para G (Geothermal) Para R G (Geothermal)
Parameter	**Unit**	**Value**	**Value**	**Value**	**Value**
Output of Volume Flow	%	5 to 75	5 to 75	5 to 75	
Para 4-20	m^3/h	0 to 2.1	0 to 2.1		
Para 6-43	m^3/h	0 to 2.1		0 to 1.4	
Para 7-50	m^3/h	0 to 2.1	0 to 2.1	0 to 1.4	
Para 8-75	m^3/h	0 to 2.1	0 to 2.1	0 to 1.4	
Para 8-87	m^3/h	0 to 4.5			
Para 9-87	m^3/h	0 to 4.5			
Para 13-75	m^3/h			0 to 1.4	
Output of Power Consumption	%				5 to 75
Para 7-50	W				5 to 75
Para 8-75	W				5 to 75
Para 8-87	W				5 to 87
Para 9-87	W				5 to 87
Indication of Invalid Data (*)					
D_INV	%	80	80	80	Disable
Utrig	V	190	190	190	
Urelease	V	195	195	195	

(*) When the power supply is falling down below *Utrig*, the pump is no more able to provide the accurate data estimation and then, an invalid data *(D_INV)* is returned until the voltage is exceeding *Urelease*.

PWM Output : product characteristics

		F21 / F22	F23
Parameter	**Unit**	**Value**	**Value**
Output of Volume Flow	%	5 to 75	
Para MAXO .. 08	m^3/h	0 to 14	
Para MAXO .. 10	m^3/h	0 to 14	
Para MAXO .. 11	m^3/h	0 to 7	
Output of Power Consumption	%		5 to 75
Para MAXO .. 08	W		5 to 145
Para MAXO .. 10	W		5 to 215
Para MAXO .. 11	W		5 to 145

Warning / Error generalities

Failure reporting is depending on the failure timing and its duration. The following figure gives an overview about the failure reporting depending on different failure timings. The assumption is that a single failure only counts if it lasts at least one second.

- **Failure reporting :** Failures can be reported on PWM and/or LED after a maximum of time called **Treport**
- **Failure cancelation :** Failure reports are canceled if the same error is not repeated within **Trecover**

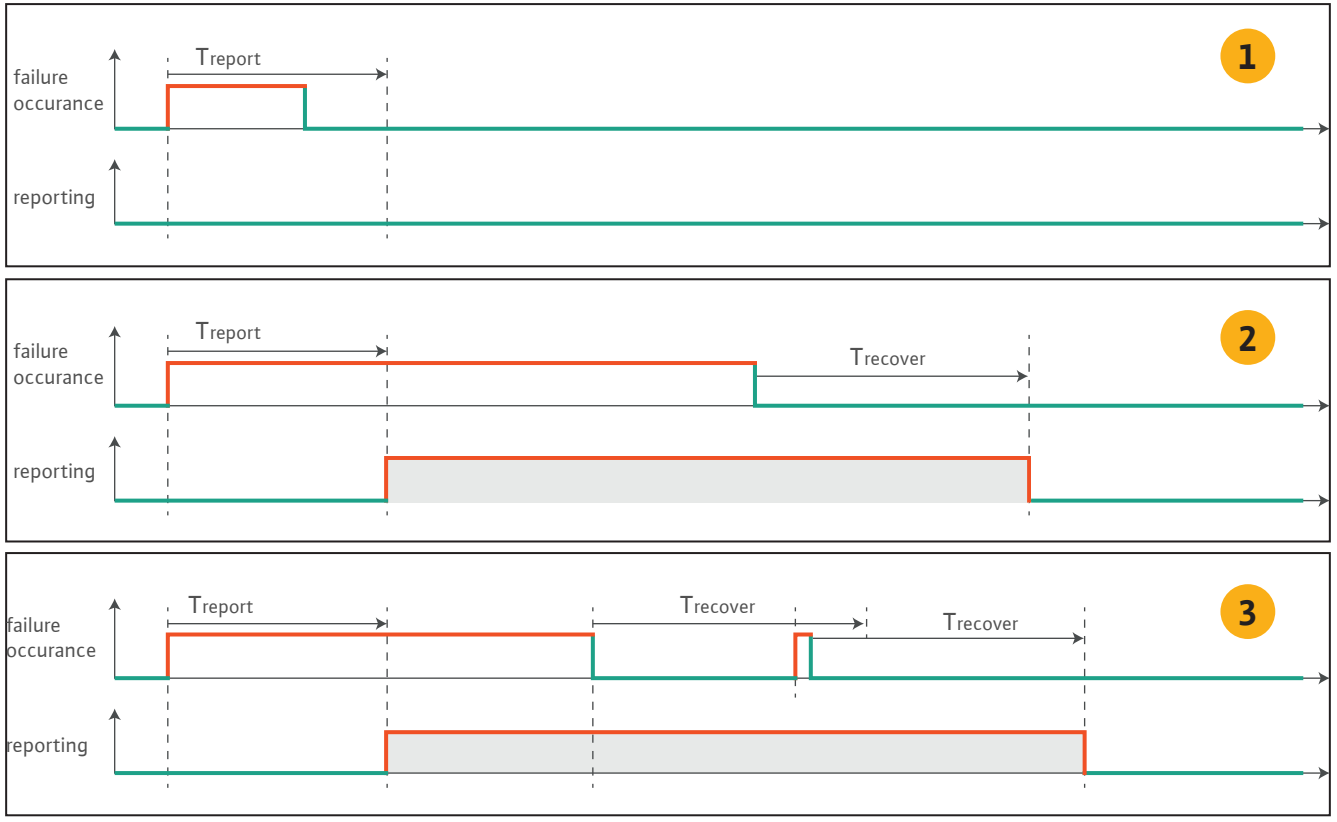


figure n°13

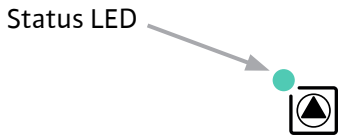


figure n°14

1. No reporting, since failure does not show minimum duration.
2. Failure reported, since pump did not recover within Treport.
3. Failure withdrawing delayed because of an additional failure occurance within Trecover.

Warning / Error management

PWM warning / Error information overview

PWM Out	LED Status	Error name	Error type	Error priority	Short description of warning consequences and/or pump actions	T report (s)	T recover (s)	Para series
95%		Missing motor windings contact or disconnected electronic box	Final error	1	The pump is stopped because the connection between the motor and the inverter is interrupted, or the motor winding is damaged. **Action: Contact customer service.**	≤ 6	≤ 6	
95%		Driver fault	Final error	0	The pump is stopped because the motor is defective. **Action: Contact customer service.**	≤ 6	≤ 6	
90%		Over current	Error	12	The pump is stopped because the motor current exceeds the acceptable limits. **Action: Contact customer service.**	≤ 6	≤ 6	
95%		Blocked rotor	Final error	2	The pump has tried with the routine to unblock without success. **Action : try to change the fluid or remove the particles blocking the pump**	≤ 6	NA	
85%		Overload motor	Error	6	The pump is stopped because the speed is lower than the permissible tolerance. This is caused by high friction due to mechanical ageing or particles in the medium. **Action : try to change the fluid or remove the particles blocking the pump.**	≤ 6	≤ 6	
85%		Overvoltage	Error	5	The pump is stopped because the voltage has risen over Umax. It will restart as soon as the voltage goes back below Umax (Hysteresis not included). **Action: check the power supply stability.**	≤ 8 ≤ 12	≤ 8 ≤ 12	**Para :** Umax = 263VAC **Para MAXO :** Umax = 253VAC

 Green constant

 Green blinking
ON : 100ms – OFF : 5s

 Green blinking
ON : 500ms – OFF : 500ms

 Red – Green blinking
RED : 500ms – GREEN : 500ms

 Red blinking
ON : 500ms – OFF : 500ms

Red constant

PWM warning / Error information overview

PWM Out	LED Status	Error name	Error type	Error priority	Short description of warning consequences and/or pump actions	T report (s)	T recover (s)	Para series
85%		Undervoltage	Error	3	The pump is stopped because the voltage has fallen below 160V. It will automatically restart when the voltage is back over 170V. **Action: check the power supply stability.**	≤ 8	≤ 8	**Para MAXO :** ≤ 6s
90 %		Over speed	Error	13	The pump is stopped because of a positive flow. It can be caused by another device generating an additional flow. It will automatically restart when the external flow stops. **Action: check the installation/setup**	≤ 6	≤ 6	
90 %		Turbine mode	Error	10	The pump is stopped because of a negative flow. It can be caused by another device generating an opposite flow. It will automatically restart when the external flow stops. **Action: check the installation/setup**	≤ 6	≤ 6	**Para :** Not supported (5–75%)
2%* or 5%**		Over temperature motor	Error	7	The pump is stopped because the motor is too hot. After a cool down time, the motor restarts by itself.	≤ 6	≤ 6	**Para MAXO :** Not supported **Para :** * If pump driven in stop ** If pump driven to run

Green constant

Green blinking
ON : 100ms – OFF : 5s

Green blinking
ON : 500ms – OFF : 500ms

Red – Green blinking
RED : 500ms – GREEN : 500ms

Red blinking
ON : 500ms – OFF : 500ms

Red constant

PWM warning / Error information overview

PWM Out	LED Status	Error name	Error type	Error priority	Short description of warning consequences and/or pump actions	T report (s)	T recover (s)	Para series
85%		Over temperature module	Error	8	Over temperature: the temperature of the module is too high, pump stops **Action: reduce the ambient temperature**	≤ 6	≤ 6	
85%		Generator operation	Warning	15	The pump is still operating and detects a positive throughflow. It could happen if there is another device generating direct flow. **Action: check the installation/setup**	≤ 6	≤ 6	**Para MAXO :** Not supported (5–75%)
5%		Dry running	Warning	16	The pump is still operating but there is no fluid in the installation. **Action: fill the installation**	≤ 6	≤ 6	
80%		Overload motor	Warning	17	The pump is still operating but detects an overload of the motor. This is caused by a high friction due to high fluid viscosity or particles in the medium. **Action: clean or change the medium**	≤ 6	≤ 6	
80%		Over temperature module	Warning	18	The pump reduces its performances because the temperature in the electronic module is too high. **Action: reduce the ambient temperature**	≤ 6	≤ 6	**Para MAXO :** Not supported (5–75%)
5%		Blocked rotor	Error	14	The pump is stopped because of a blocked rotor and is trying to unblock itself. **Action: wait (maintain power supply) until the routine is completed or remove the particles that are blocking the pump.**	≤ 6	≤ 6	

Green constant

Green blinking
ON : 100ms – OFF : 5s

Green blinking
ON : 500ms – OFF : 500ms

Red – Green blinking
RED : 500ms – GREEN : 500ms

Red blinking
ON : 500ms – OFF : 500ms

Red constant

Standard state reporting

When none failure or warning are active, 2 possible pump behaviors can be noticed :

PWM information overview

PWM Out	LED Status	Pump status	Short description of pump actions	T report (s)	T recover (s)	Para series
5–75%	●	No error present	The pump is running without issue	–	–	
2%	☼	Active stop mode	Pump is stopped in “ Active Stop mode “, ready to start	≤ 10	–	PWM signal is provided immediatly after pump is driven in “active stop mode”, LED state change after <10 s Para : “Active stop mode” with power consumption reduction

● Green constant

☼ Green blinking
ON : 100ms – OFF : 5s

Specific mode :

- If the rotor is mechanically blocked, the pump will try to unblock itself during around 30mn. The information will be sent to the master by PWM out signal (5%)
- If the automatic deblocking routine is completed without success, information is provided to the master by PWM out signal (95%)
- When the deblocking mode is completed with success, the pump escapes from its automatic deblocking mode, not providing anymore the information about pump blocked and delivering the standard data by PWM out (related to flow or power depending on the type of PWM signal requested)

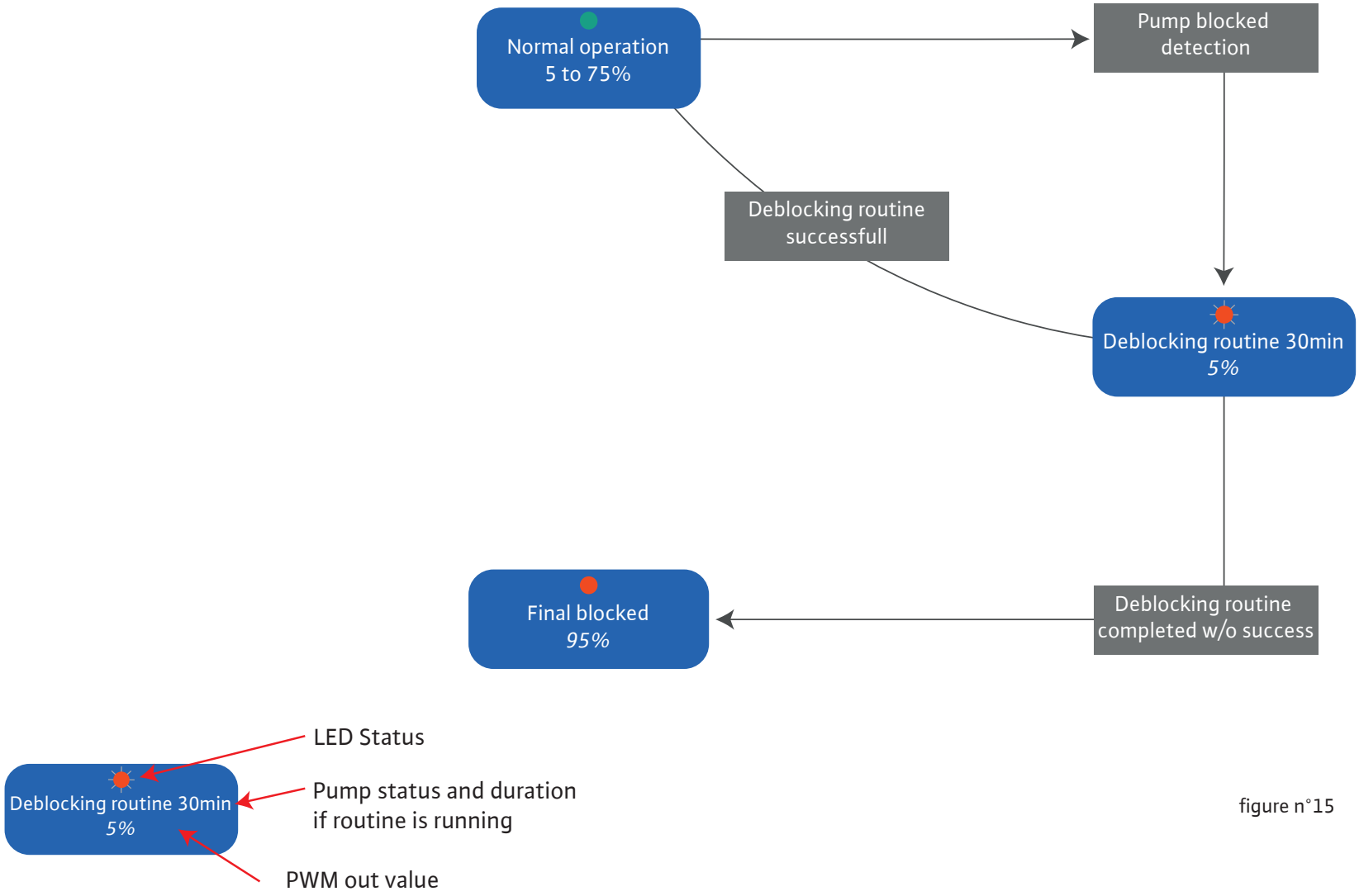


figure n°15

Troubleshooting

Wilo pumps are designed to provide the best efficiency all through the product's lifetime.
If, however, you are facing issues, please check the below table :

PWM circulator troubleshooting overview

Behavior	Please check how is the status LED – Root cause	Remedy
The pump is running but application doesn't reach the performances	If LED blinks green/red, the pump is still operating but not at full performance due to abnormal conditions	*Check if the pump temperature is over the allowed limits* *Check if the power supply voltage is inside the limits (170Vac < U < 253Vac)* *Check if there is no external flow pushing water at the pump* *Check if there is no over current exceeding the limit*
I plugged in my pump, applied the PWM signal and the pump is not running or the pump was running and is now stopped	If LED blinks green, the signal connection is not (or no more) working properly. Maybe the pump is driven in standby mode.	*Check on the master side which PWM signal is provided.* *Check your installation and make sure that the PWM signal is provided to the pump* *Check the signal cable*
	If LED blinks red, the pump is stopped due to external issue. The pump will restart automatically when conditions are ok	*Check if the pump temperature is over the allowed limits* *Check if the power supply voltage is inside the limits (170Vac < U < 253Vac)* *Check if there is no external flow pushing water at the pump* *Check if there is no over current exceeding the limit.* *The deblocking routine is ongoing. Let the pump complete its cycle (30 min duration maximum)*
	If LED is red constant, the pump is stopped due to internal "final" error	*Check on the master side which PWM signal is received from the pump* *Switch OFF the pump, wait 30s before switching ON the pump. Then through the master side try to start the pump.* *If the pump LED is still red after a power reset, replace the pump*

Referenced Documents

VDMA 24224 03/2014	The VDMA is a German Engineering Association
DIN IEC 60469-1 standard	Pulse terms and definition

Glossary

PWM : Pulse-Width Modulation

iPWM : Intelligent Pulse-Width Modulation

with PWM In : from controller to circulator

PWM Out : from circulator to controller

OEM : Original Equipment Manufacturer

DHW : Domestic Hot Water

HMI : Human Machine Interface

EMC : ElectroMagnetic Compatibility

Rpm : Revolution per minute

LED : Light Emitting Diode

Vac : Alternative voltage (= RMS : Root Mean Square)

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version V1.01

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