Pioneering for You

Strategic Business Unit OEM

Wilo-Para **/ iPWM

Technical guide

Table of contents

Index management

Description of content evolution	Version	Date
Initial release	V1.0	*15/09/2020*

INTRODUCTION

For advanced heating systems used on the market it is expected to have agile products able to support the continuous improvement activities of global application performances.

In this context, our customers need products able to offer adjustable performances and also provide information about their setting or status.

For this reason, Wilo, based on application expertise, proposes its full range of pump, from 4m up to 13m head, equipped with bidirectionnal PWM external control usable for OEM application whether for heating, sanitary, solar or geothermal needs.

Features :

Based on the DIN IEC 60469-1, the PWM signal is a well-established standard in the OEM heating industry (for more details about the VDMA 24 224 definition, see "*Referenced Documents*" chapter).

To go further, Wilo has developped the iPWM signal, stands for Intelligent Pulse-Width Modulation, which establishes a bidirectional communication (PWM Input / PWM Output) between pump and application controller.

Benefits:

The iPWM pump becomes the self-evident canditate when adjustable duty point is required to adjust head-flow to just-needed performances and consequently power consumption. But the benefits are also obvious when a step ahead to data sharing is a prerequisite for system optimization by using the pump feedback of current flow rate or power consumption or even pump status.
Thus, taking the benefits of this advanced function, it also opens the doors to appliance architecture optimization via a simplification of flow management, commisionning or maintenance support...
The next pages will provide the detailed description of Wilo pumps' characteristics in order to allow you to implement them in a fast and proper way in your system.

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.

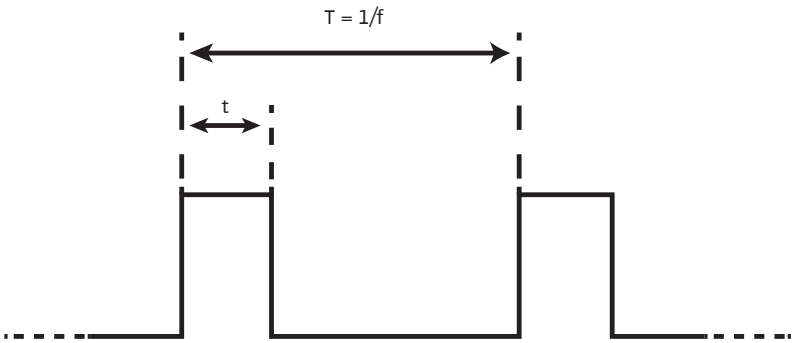

figure n°1

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

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

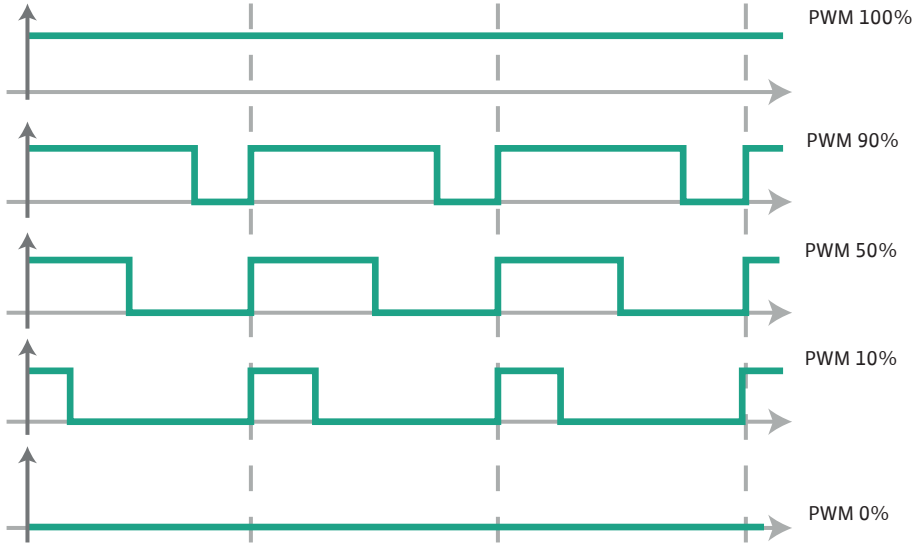

figure n°2

VDMA 24 224 recommendations

What are the specifications of PWM signal ? (according to VDMA 24 224)

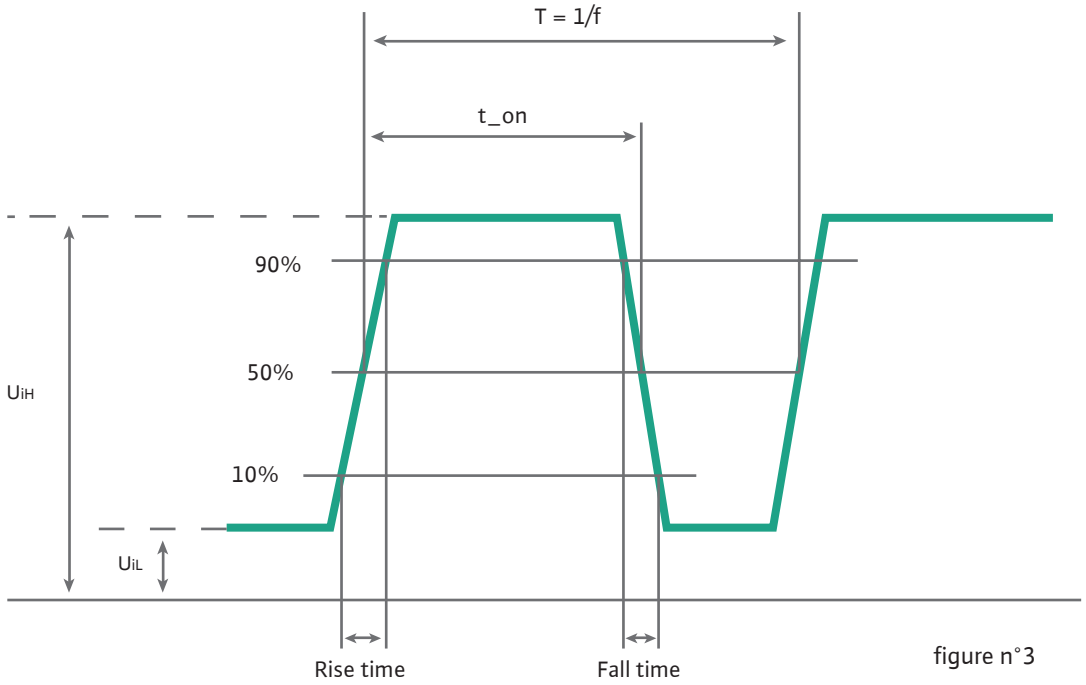

figure n°3

Interface Specification	
Symbol	**VDMA 24 224**
Cable length	< 3 m
Signal cable section	≥ 0.25 mm²
UiH	4.5V – 15V
UiL	≤ 1 V
IH	10 mA
PWM Frequency	100–1000 Hz
PWM %	0–100%
Rise and Fall time	≤ 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 input signal (according to VDMA 24 224)

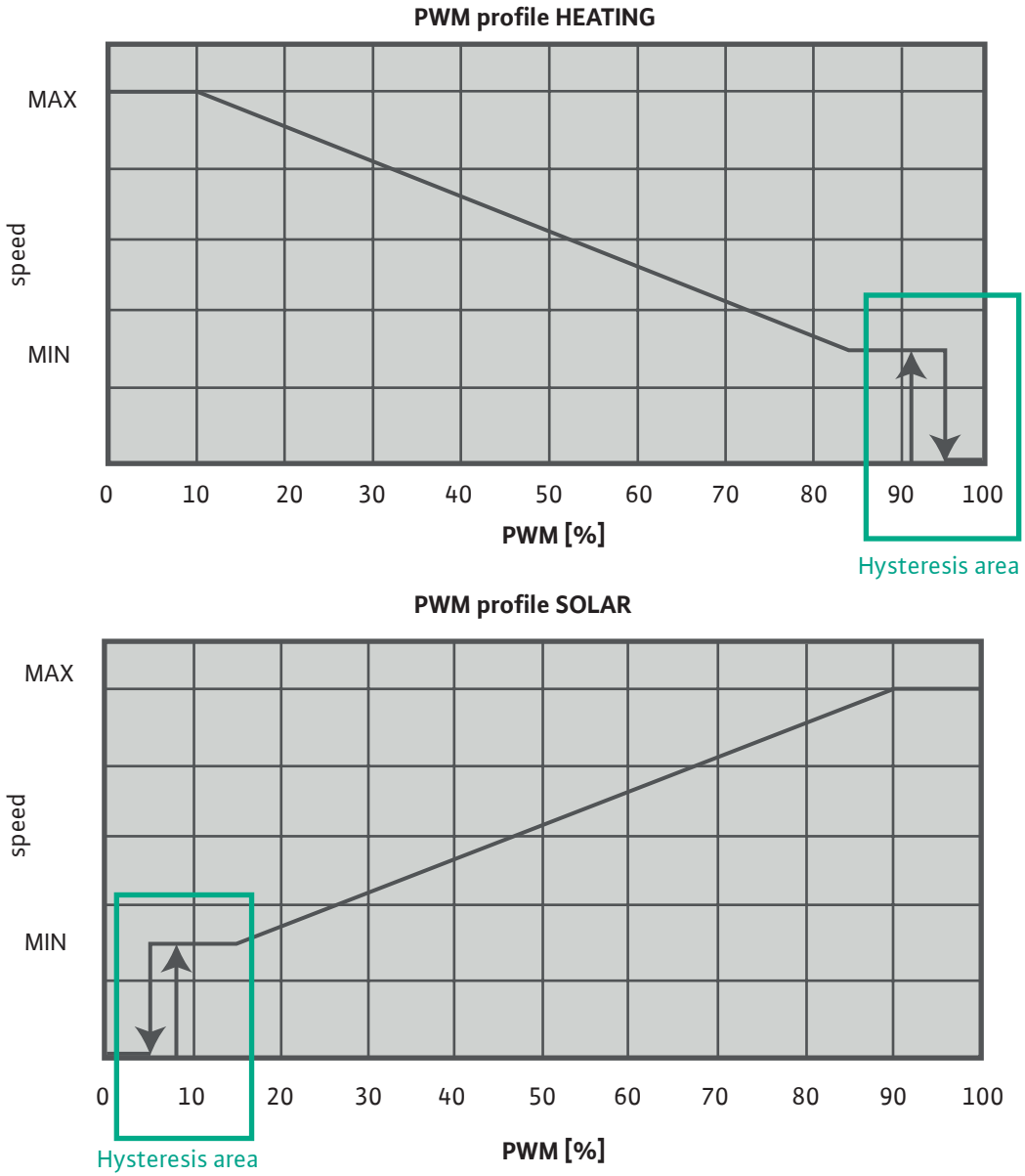

figure n°4

Standby mode

The pump can be switched to standby mode "OFF" by the PWM input signal. An advantage of this, compared to powering OFF the pump, will be a faster restart.

Hysterisis switching – ON/OFF

The pump can be switched between MIN speed and standby mode operation 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.

Hardware definition

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

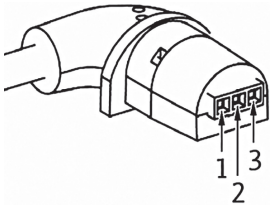

figure n°5

Core no. 1 (brown) → PWM Input
Core no. 2 (blue or grey) → PWM Common
Core no. 3 (black) → PWM Output

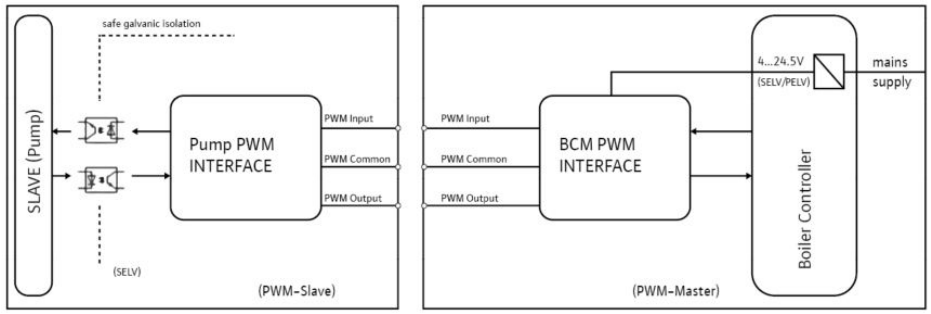

figure n°6

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	**Wilo Specification**
Cable length	< 3m
Signal cable section	≥ 0.25 mm²
Signal polarity	Yes

WARNING !
For Wilo-Para R (with refrigerant gas use), to ensure to not exceed the maximum temperature allowed on the product, the maximum voltage used on the iPWM must not overtake 20V.

PWM Input Master Interface

PWM signal coming from the Master according to :

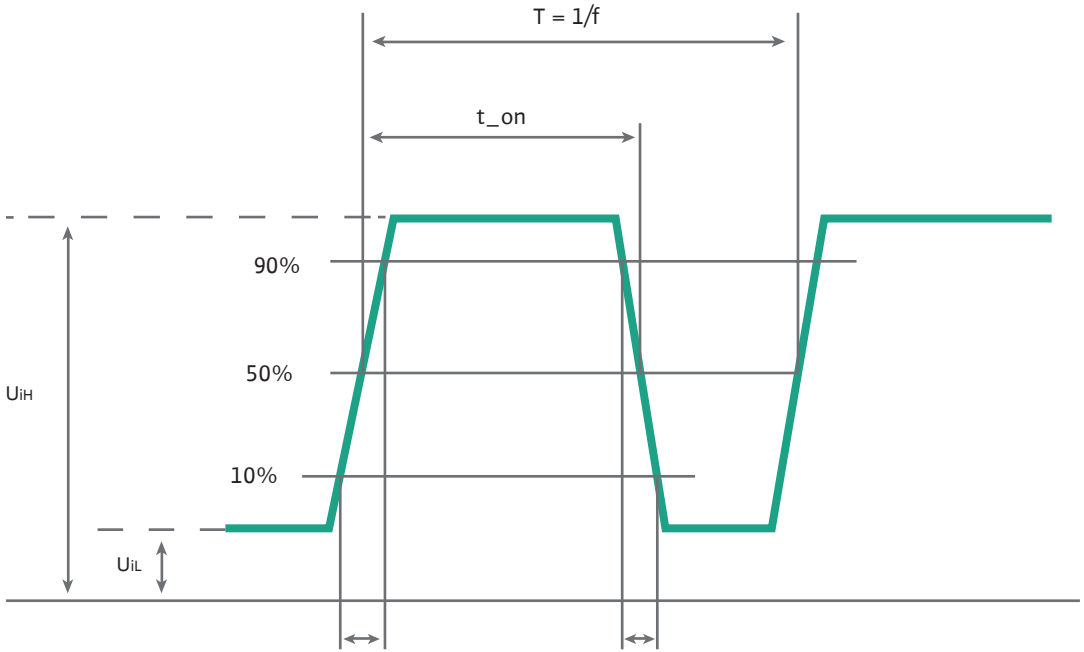

figure n°7

Signal profil description	
Symbol	**Wilo Specification**
UiH	*4V – 24.5V*
UiL	*≤ 1 V*
IH	*3,5mA – 10 mA*
PWM Frequency	*90–5000 Hz*
PWM %	*0–100%*
Rise and Fall time	*≤ T/500*

Recommended PWM Input Master interface

The PWM Input Master Interface should be designed according to :

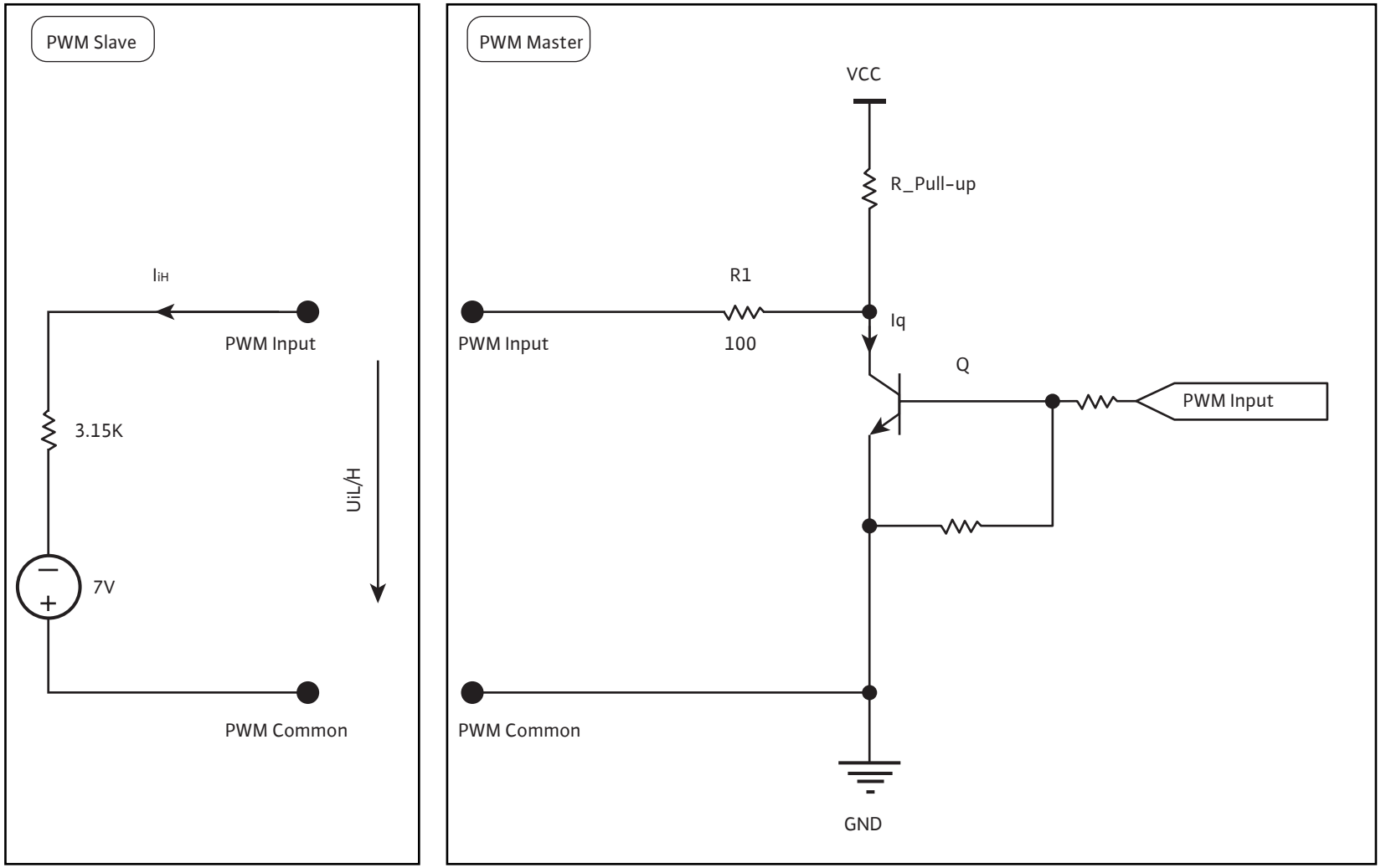

figure n°8

Electrical diagram applicable according to values from *Signal profile description*, see *PWM Input Master Interface* chapter

R_Pull-up 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 R_Pull-up i.e (24V-10V) 3 will give the R_Pull-up max 4
- Define the maximum current in transistor Q. 5
  Intersection with VCC curve i.e 24V 6 will give the R_Pull-up min 7
- 1KΩ < R_Pull-up < 2.5KΩ
  Then the value chosen is R_Pull-up = 2.2KΩ

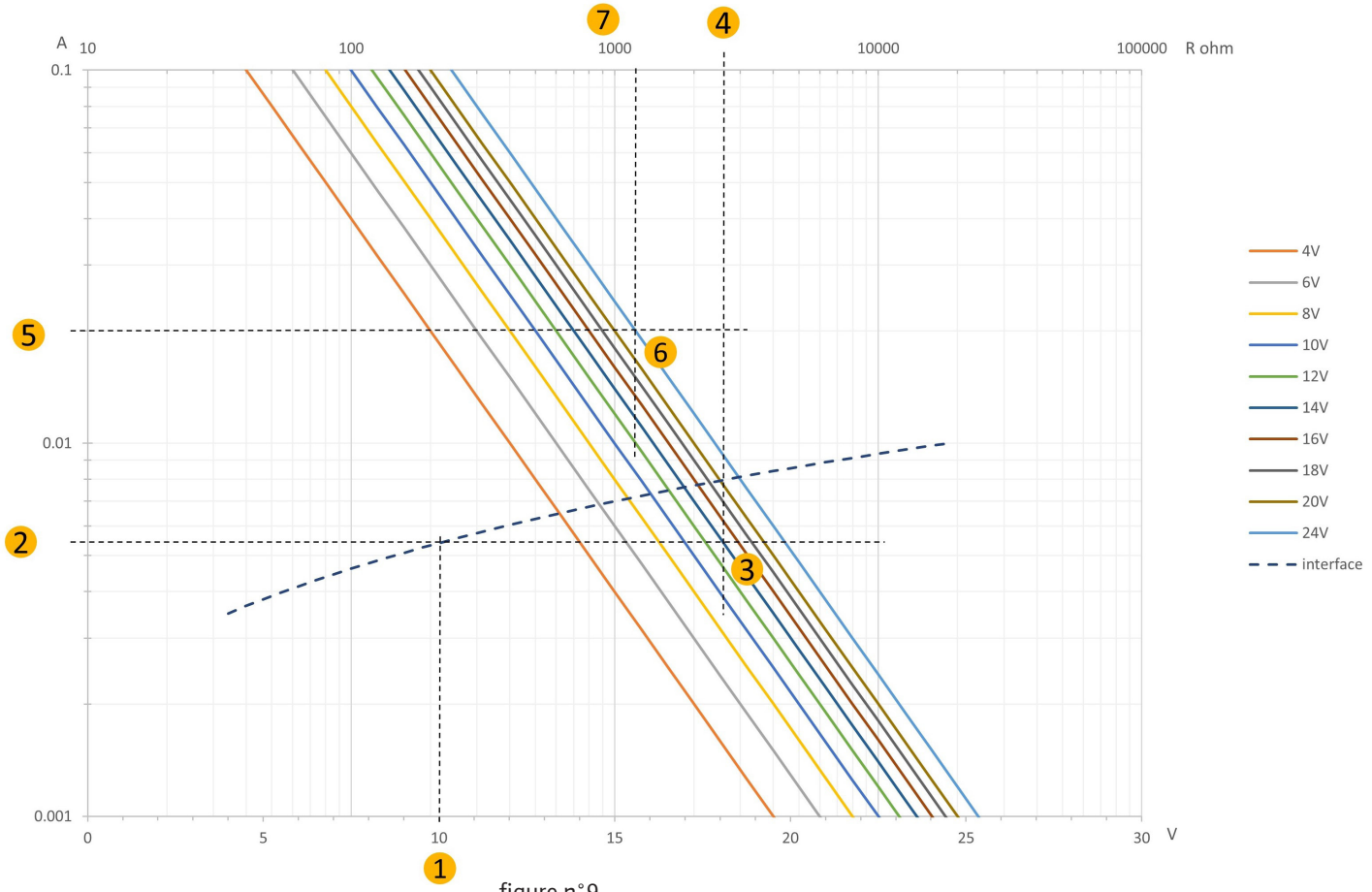

figure n°9

Recommended value:

VCC = 24V
UiH mini = 10V
Iq max = 20 mA
R1 = 100 Ω (ESD protection)

PWM Output Master Interface

PWM signal coming from the Pump according to :

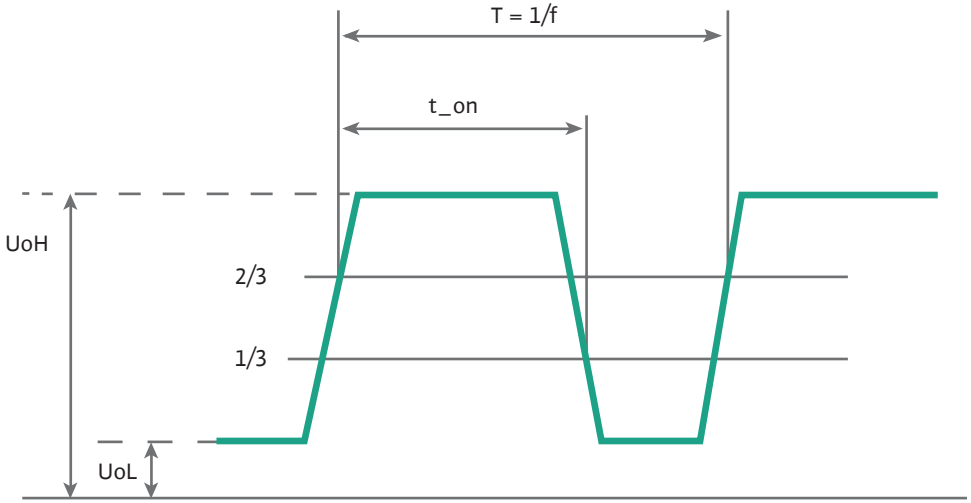

figure n°10

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 resolution of PWM output signal	≤ 1V
Duty cycle accuracy of PWM output signal	± 1% (absolute)
Maximum current iPWM in abnormal operation *(UoL)*	10 mA
Resistor R2 *See figure 11*	470 Ω

Recommended PWM Output Master interface

The PWM Output Master Interface should be designed according to :

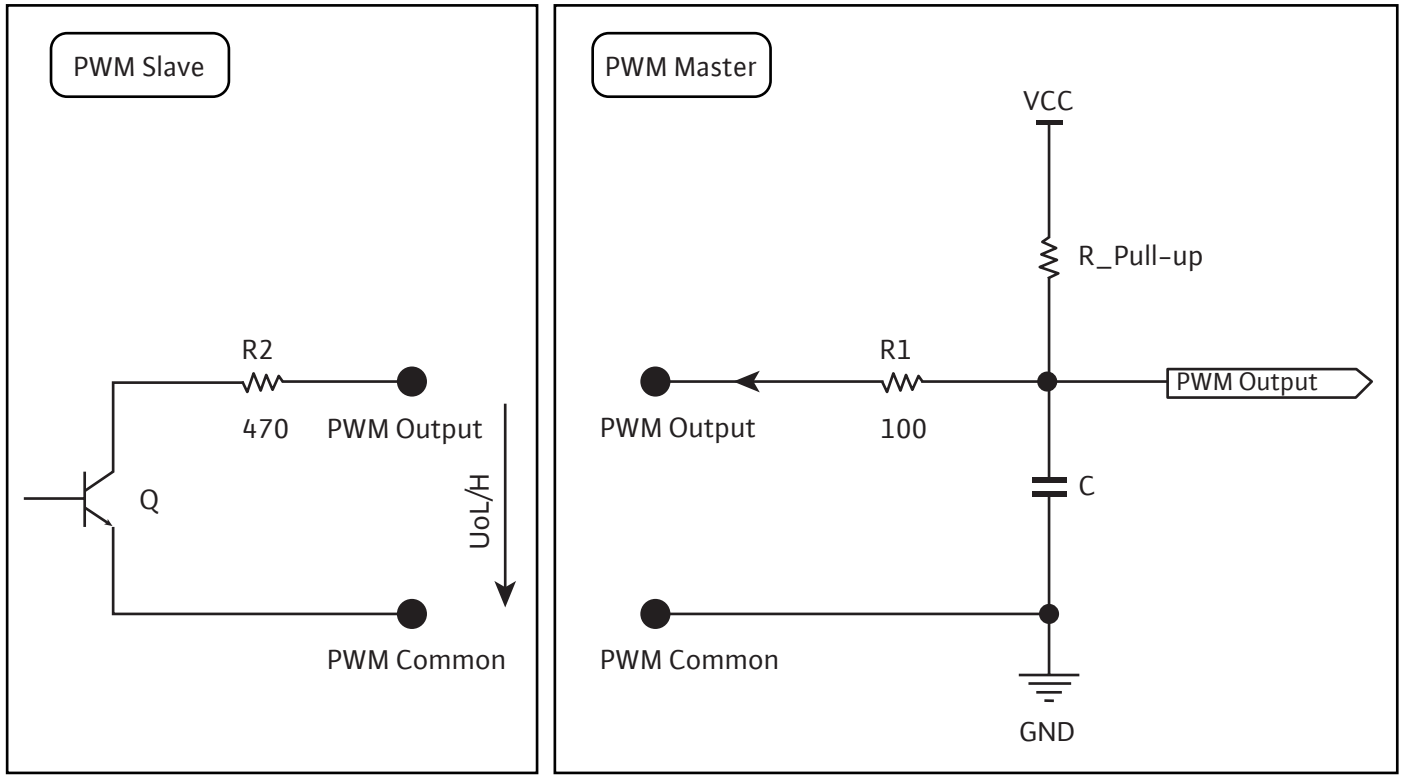

figure n°11

$$R\_Pull\text{-}up = (R1 + R2)\left(\frac{VCC - 0.2}{UoL - 0.2}\right)$$

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

$$C < \frac{1\%}{75\ R\_Pull\text{-}up\ \ln(3)} \qquad C < \frac{1}{8240\ R\_Pull\text{-}up}$$

for rise time impact < 1%

Recommended value:

VCC = 5 V
R1 = 100Ω (ESD protection)
UoL = 0.5V
R_Pull-up = 8k2
C = 10nF

PWM Input strategy

Two command strategies are available according cable break function

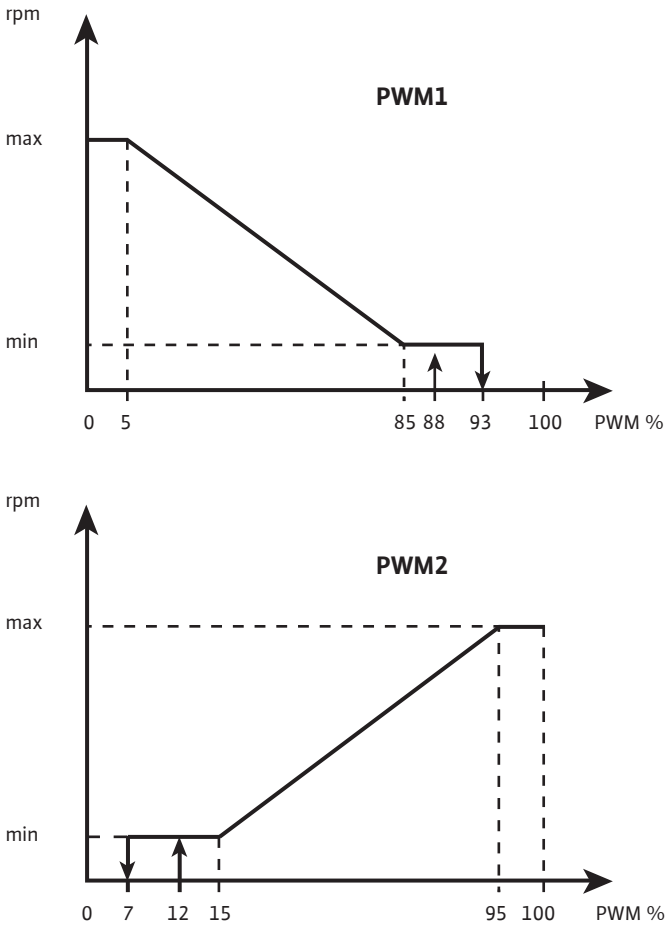

figure n°12

PWM1 transfer function [%]	
% PWM-in	**Status**
Cable break	Pump runs at maximum speed
< 5	Pump runs at maximum speed
5–85	Pump speed decreases linearly from max to min
85–88	Pump runs at minimum speed
88–93	Hysteresis. Pump operations not defined
93–100	Pump stops (Standby)

PWM2 transfer function [%]	
% PWM-in	**Status**
Cable break	Pump stops (standby)
< 7	Pump stops (Standby)
7–12	Hysteresis. Pump operations not defined
12–15	Pump runs at minimum speed (start-up)
15–95	Pump speed decreases linearly from max to min
> 95	Pump runs at maximum speed

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 :

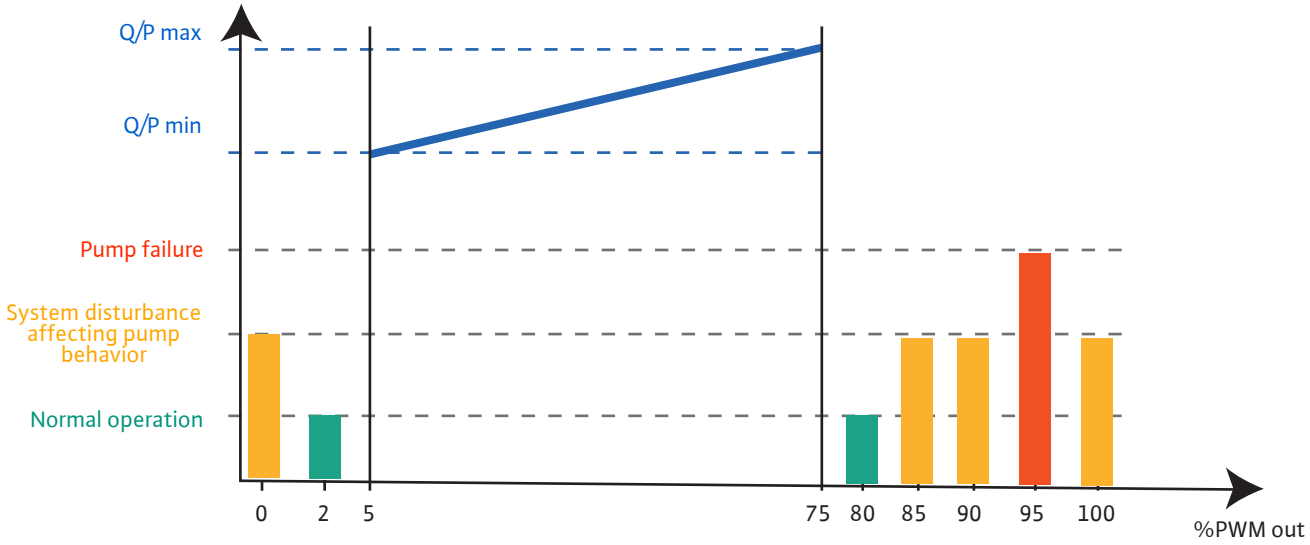

figure n°13

PWM Output signal [%]	
% PWM-out	**Status**
0	PWM output interface damaged
2	Stand-by
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	Abnormal function mode Pump is stopped momentarily but is still functional
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 Z (DHW)	Para ST (Solar)	Para G (Geothermal)
Parameter	**Unit**	**Value**	**Value**	**Value**
Output of Volume Flow	%	5 to 75	5 to 75	
Para 4m	m^3/h	0 to 2.1		
Para 6m	m^3/h	0 to 2.1	0 to 1.4	
Para 7m	m^3/h	0 to 2.1	0 to 1.4	
Para 8m	m^3/h	0 to 2.1	0 to 1.4	
Para 9m	m^3/h	0 to 4.5		
Para 13m	m^3/h		0 to 1.4	
Output of Power Consumption	%			5 to 75
Para 7m	W			5 to 75
Para 8m	W			5 to 75
Para 9m	W			5 to 87
Indication of Invalid Data (*)				
D_INV	%	80	80	Disable
Utrig	V	190	190	
Urelease	V	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 : warning / error information

PWM Warning / Error information overview

%	LED Status	Error code and name	Error type	Short description of warning consequences and/or pump actions
95%		Driver fault	Final error	*The pump is stopped due to internal error* *Action: change the pump*
95%		Missing motor, winding contact or disconnected electronic box	Final error	*Could occur if the plumber disconnects the motor from electronic box or when the motor winding is damaged* *Action: change the pump*
95%		Blocked rotor	Final error	*The pump will try with a routine to unblock itself.* *Action: try to change the fluid or remove the particles blocking the pump*
90%		Loss of synchronization	Error	*Temporary situation. Motor will restart by itself*
90%		Over current	Error	*Motor current exceeding acceptable limits. Most probably temporary state*
90%		Over speed	Error	*Motor speed over the acceptable limits. Most probably temporary state*
85%		Undervoltage Voltage drop **≤ 160 Vac** The pump could stop, but must, after a short time, issue the assigned error code **≥ 170 Vac** Pump able to run and start, but possibly with limitations of performance, but not into the function The pump needs to stop status of voltage of ≥ 170 Vac to start rotation	Error	*Fast voltage drop : this occurs when there is a high voltage dip detected* *If, after the voltage drop, the voltage stays under the restart level, the motor stays stopped* *If the voltage rises above the limit, the motor restarts by itself* *The main voltage has the following influencing factors: kind of high or low impedance power line, tolerances of components and the operation point (main factor)* *Action: check the power supply stability*
85%		Overvoltage **≥ 253 Vac** The pump could stop and, if stopped, must reliably issue the assigned error code – running from 253 Vac > 265 Vac with limitation allowed without stop – if pump is stopped, it must be able to start when voltage reaches < 265 Vac	Error	*The pump could stop until the voltage is back to a standard level* *Action: check the power supply stability*

LED Status : Green constant · Green blinking · Green/Red blinking · Red blinking · Red constant

PWM Warning / Error information overview

%	LED Status	Error code and name	Error type	Short description of warning consequences and/or pump actions
85%		Overload motor	Error	*High friction due to mechanical ageing or particles in the medium* *Action: try to change the fluid or remove the particles blocking the pump*
85%		Over temperature module	Error	*Over temperature: the temperature of the electronical terminal box is too high* *Action: reduce the ambient temperature* *Pump will restart by itself when temperature is back to acceptable level*
85%		Generator operation	Warning	*Generator operation could happen if there is another device pushing in the same direction at the pump.* *Action: check the installation/setup*
85%		Overtemperature Module	Warning	*The temperature of the module is too high. This is especially applicable for pumps where Self-protection module overheat is deactivated. Pump is then running under not allowed condition*
80%		Overload motor	Warning	*Overload motor: high friction due to mechanical ageing or particles in the medium* *Action: clean or change the medium*
80%		Undervoltage	Warning	*According to hysteresis:* *In voltage decrease phase: 160 Vac < U < 190 Vac* *In voltage increase phase: 170 Vac < U < 195 Vac*
2%		Active stop mode	No	*The pump is stopped by the PWM in signal*

NB: The priority is defined according PWM ratio, 95% is the top priority

LED Status : Green constant | Green blinking | Green/Red blinking | Red blinking | Red constant

PWM circulator 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.*
	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

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)

How can Wilo support you ?

Wilo can provide more support to our customers under request.

Please, contact your local sales contact or use our website:

www.wilo-oem.com

wilo

Pioneering for You

Imagine you already had the solutions today that will be needed tomorrow.

With OEM Solutions, what is visionary is just a step away from reality. As the leading original equipment manufacturer, we see ourselves as part of your business and we know exactly how crucial your processes are. We work with you to develop customized innovative solutions making you a pioneer in your market. We produce these solutions for you at the time you choose, to sus-tainable, top quality. This will benefit your entire business. From senior management to purchasing. From logistics to research and development. Thanks to highly committed teamwork for your success. **OEM Solutions. Let's move. Together.**

version V1.0

Wilo Group

Strategic Business Unit OEM

Wilo Intec

50 av. Casella

F – 18700 Aubigny sur Nère

T + 33 2 48 81 62 62

www.wilo-oem.com

oem@wilo.com