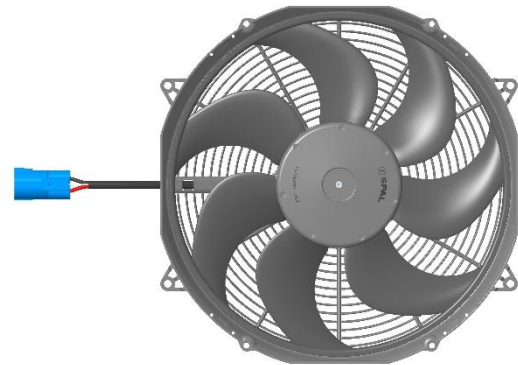
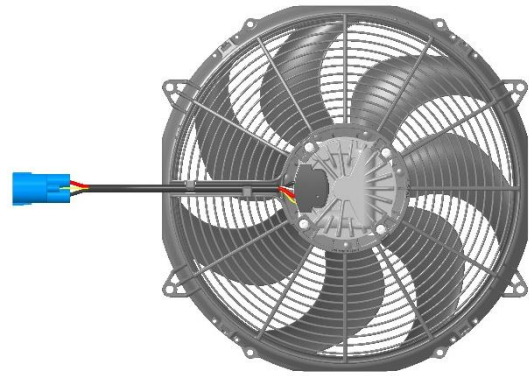


## 1 General

Fan diameter Ø: 385 mm  
 Nominal voltage: 12 V  
 Drive family: SBL500

Part number: 30107328

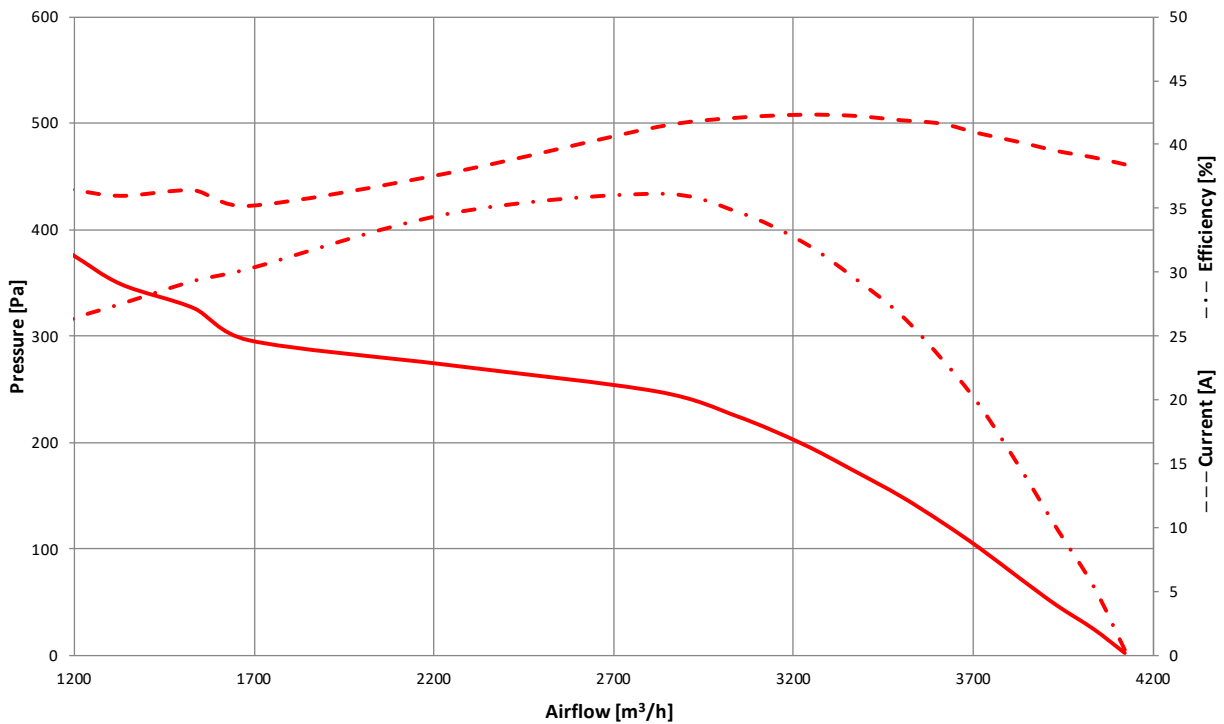


## 2 Features

Max fan speed forward	rpm	3150
Max fan speed reverse	rpm	3150
Min fan speed	rpm	850
Sound pressure level at max speed	dB(A)	83 dbA - at 1 m from the fan module - lateral side
Weight	kg	2.9
Operating supply voltage range	V	9.0 .. 16.0 at the Drive connector
Supply voltage to reach max speed	V	13.0 .. 16.0 at the Drive connector
Operating ambient temperature range	°C	-40 .. +120
Max operating ambient temperature @ max fan speed	°C	+85 (1)
Storage temperature range	°C	-40 .. +125
Lifetime	h	up to 40000 hours depending on mission profile
Time from 0 rpm to max speed	s	15
Load dump protection (Pulse 5b)	V	35 - Pulse peak voltage (U <sub>s</sub> <sup>*</sup> ) - ISO16750-2:2010
Reverse polarity protection		ISO 16750-1 functional status class C - device fully functional after correcting the polarity
Notes: (1) Few minutes ambient temperature transients do not engage the derating owing to the thermal inertia of the system. Overloads may anticipate derating.		

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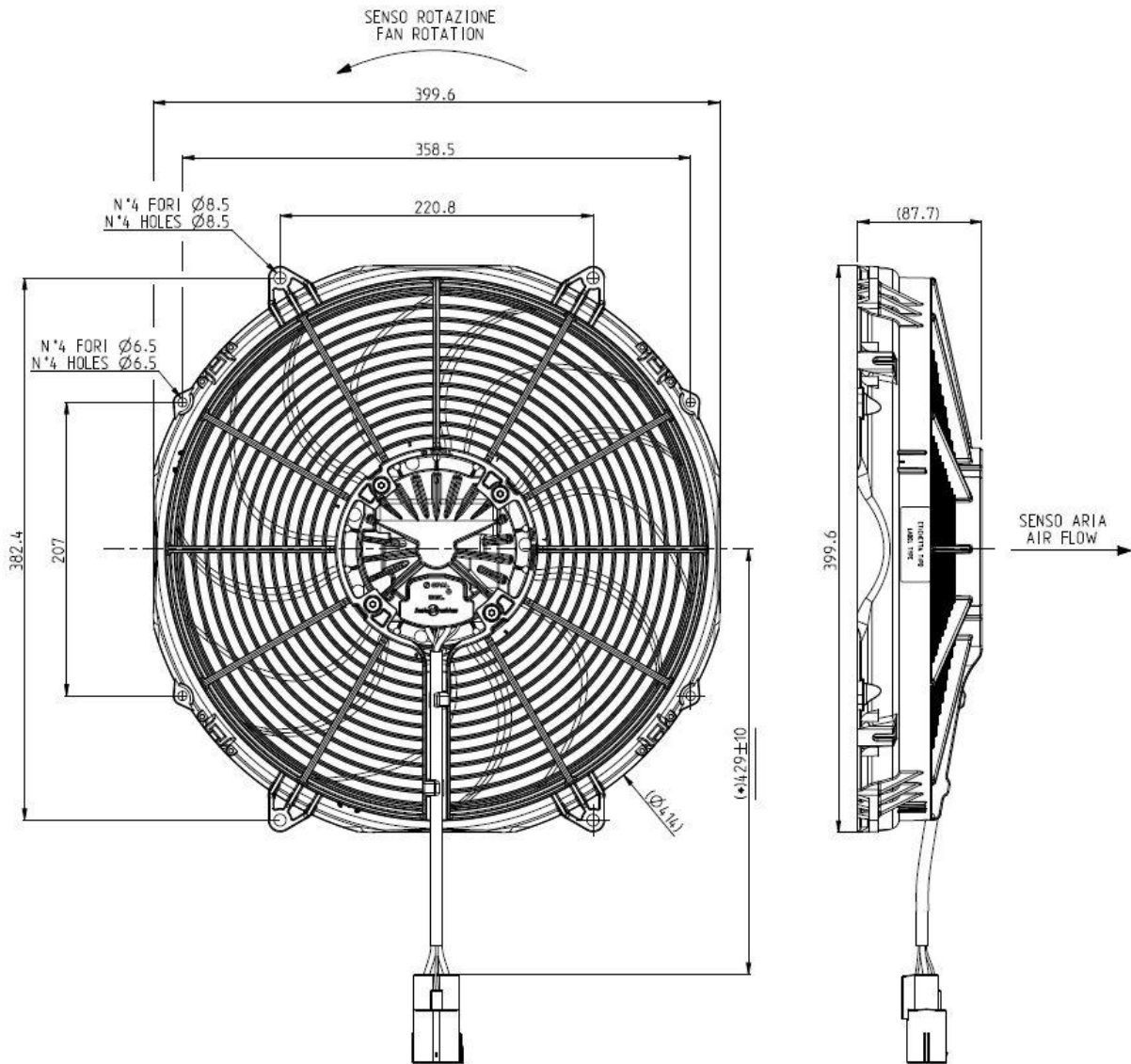
### 3 Air performance at maximum speed



Air density 1.20 kg / m<sup>3</sup> - Test number: #17367 – Test bench compliant to ANSI AMCA 210  
 TAMB = 20 °C ± 5 °C - UB = 13.0 V at the Drive connector

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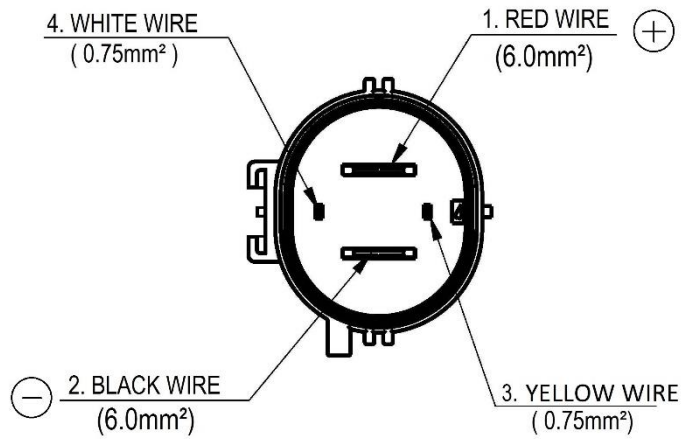
4 Mechanical data



Fixing recommendation: use M6 bolts for fixing. Nominal tightening torque 3 +1/0 Nm  
Nominal torque defined for brand new, clean and lubricant-free bolts.

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5 Connector and wires



Connector : YAZAKI HYBRID (USCAR-2 compliant) - Part number: 7282-8497-90				
Identification (*)	+D	-D	A	PWM* / E*
Pin number	1	2	3	4
Wire Color	red	black	yellow	white
Sealing p/n	7158-3035	7158-3035	7158-3031-90	7158-3031-90
Pin p/n	7114-3250	7114-3250	7114-4103-02	7114-4103-02
Section [mm <sup>2</sup> ]	6.0	6.0	0.75	0.75

For abbreviations see chapter 8.2 Drive pin functions

NOTE: Never handle the fan module via the cable harness

## 6 Further Features

Compliance		2002/95/EC RoHS - Hazardous Substances
		2000/53/EC and updates - End-of Life Vehicle
Ingress Protection		IP 68 and IP6K9K design
Allowed power supply max ripple	rms	1 % - contact SPAL for special needs
Fuse protection		An automotive fuse according ISO8820 must be chosen and used by the customer in the application wire harness. Each drive must be protected by the unique proper fuse (e.g. in case of double fan modules, two fuses are needed)

## 7 Measurement conditions

The below conditions are assumed:

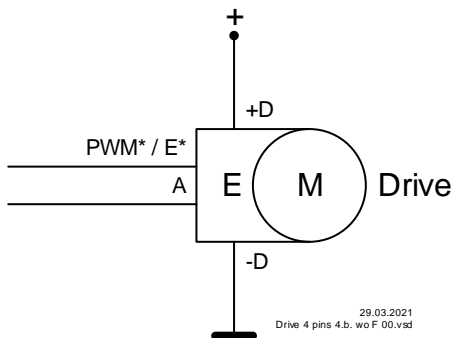
- $T_{AMB} = 20\text{ °C} \pm 5\text{ °C}$  and
- Supply voltage **UB** = 13.0 V at the **Drive** connector

unless otherwise specified.

## 8 Hardware functions

### 8.1 Drive diagram

The Drive diagram is shown below.



E stands for integrated electronics. M stands for motor. Drive stands for motor with axial integrated electronics.

### 8.2 Drive pin functions

The electrical Drive interface consists of 4 pins:

Power pins:

- supply voltage plus: +D
- supply voltage minus: -D

Signal pins:

1. Input: digital PWM input / active low: PWM\* / E\*
2. Input: analog input: A

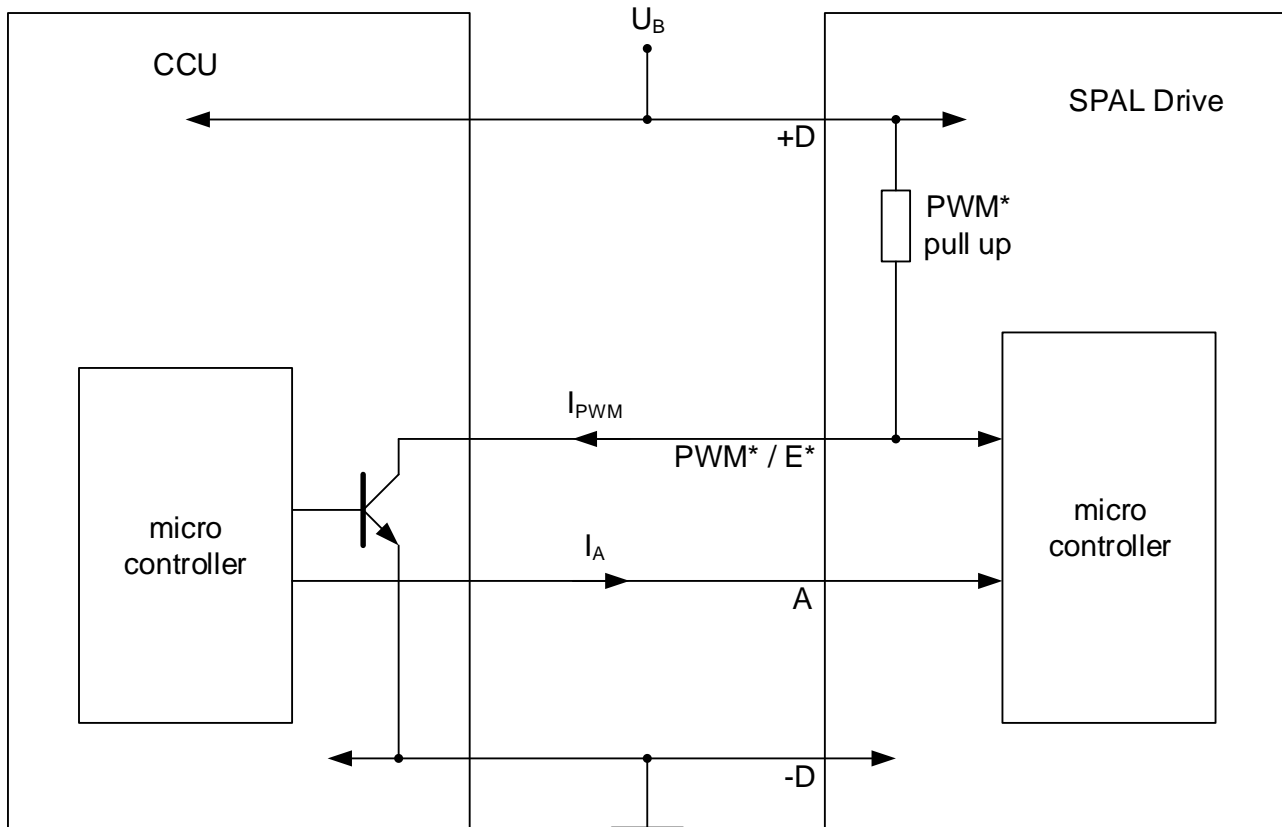
The signal pin PWM\* / E\* is used to control the Drive mode, it is the control input.

The signal pin A can be used to control the speed of the Drive.

## 9 Drive interface

The Drive interface, i.e. the connections between the CCU (Custom Control Unit) and the Drive, is depicted in the following picture.

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The CCU electronics and the Drive electronics are connected via two unidirectional lines.

The PWM signal for the input PWM\* / E\* comes from the CCU electronics and uses a pull up resistor (PWM\* / E\* pull up) located in the Drive electronics to determine the recessive level.

This pull up resistor is connected to the supply voltage plus: +D / UB.

The dominant level on the input PWM\* / E\* is low level, provided by the switching to ground stage depicted in above figure. as a bipolar npn transistor in the CCU.

### 10 Interface hardware for Digital control: pin PWM\* / E\*

The input PWM\* / E\* is used to wake up the Drive from Quiescent current mode. Any PWM duty cycle that guarantees a pulse going to the dominant level for more than T<sub>wakeup</sub> will wake up the Drive electronics.

Parameters	Min	Typical	Max	Unit	Denomination
PWM* / E* frequency range	50	100	500	Hz	f <sub>PWM 1)</sub>
PWM* / E* duty cycle range	0		100	%	dc <sub>min</sub> .. dc <sub>max</sub>
PWM* / E* high level voltage	U <sub>B</sub> * 0.65			V	U <sub>PWMH</sub>
PWM* / E* low level voltage			U <sub>B</sub> * 0.40	V	U <sub>PWML</sub>
PWM* / E* resolution		1		%	dc <sub>resol</sub>
PWM* / E* accuracy		1		%	dc <sub>accu</sub>
PWM* / E* current	-10 %	3.8	+10 %	mA	I <sub>PWM*</sub>
PWM* / E* leakage (quiescent) current			300	µA	
PWM* / E* wake up voltage	U <sub>B</sub> - 2 V			V	U <sub>PWMWU</sub>
PWM* / E* wakeup pulse	150			µs	T <sub>wakeup</sub>
PWM* pull up		3.4		kΩ	

### 11 Interface hardware for Analog control: pin A

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Parameters	Min	Typical	Max	Unit	Denomination
A voltage range	0		10	V	$U_A$
absolute maximum A voltage	-32		35	V	$U_{Amax}$
A current range	0		0.32	mA	$I_A$
A maximum current	-1.8		1.8	mA	$I_{Amax}$

## 12 Software functions

### 12.1 Drive modes

The Drive has different working modes related mainly to the Drive current consumption:

1. Quiescent current mode
2. Electronics active mode
3. Run mode
4. Failure mode

The Drive mode changes accordingly to the control input duty cycle on pin PWM\* / E\* and the voltage level on analog input A.

No.	Drive mode	Current consumption	Drive speed
1	Quiescent current mode	< 100 $\mu$ A	0
2	Electronics active mode	< 40 mA	0
3	Run mode	depending on the requested speed and on the load	depending on the PWM duty cycle or the analog input voltage level
4	Failure mode	< 40 mA	depending on the failure

The Quiescent current mode is entered when the pin PWM\* / E\* is on 100 % duty cycle (recessive level). The time to go into Quiescent current mode depends on the actual PWM base frequency and the number of samples for the plausibility check (see chapter 12.3). Additionally 2 s are waited after the detection of the absence of the PWM signal before finally going into Quiescent current mode.

The Electronics active mode is entered with any PWM duty cycle value between 0 % and < 100 % if the condition from chapter 10 is fulfilled ( $T_{wakeUp}$ ).

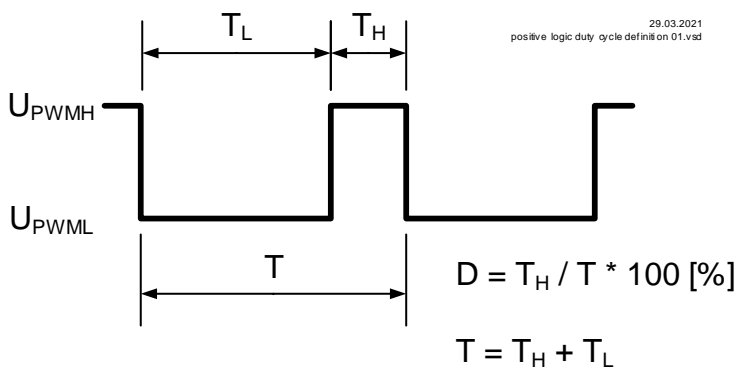
The Run mode is entered in the following cases:

- if the PWM duty cycle on pin PWM\* / E\* has a value where the Drive is asked to run (see chapter 12.2)
- if the analog signal on pin analog input A has a value where the Drive is asked to run (see chapter 12.4).

The Failure mode is entered in case of failures of the Drive (see chapter 12.5).

### 12.2 Digital control: transfer function PWM input

The transfer function PWM input is the relation between the Drive speed and the duty cycle on the pin digital PWM input / active low: PWM\* / E\*.



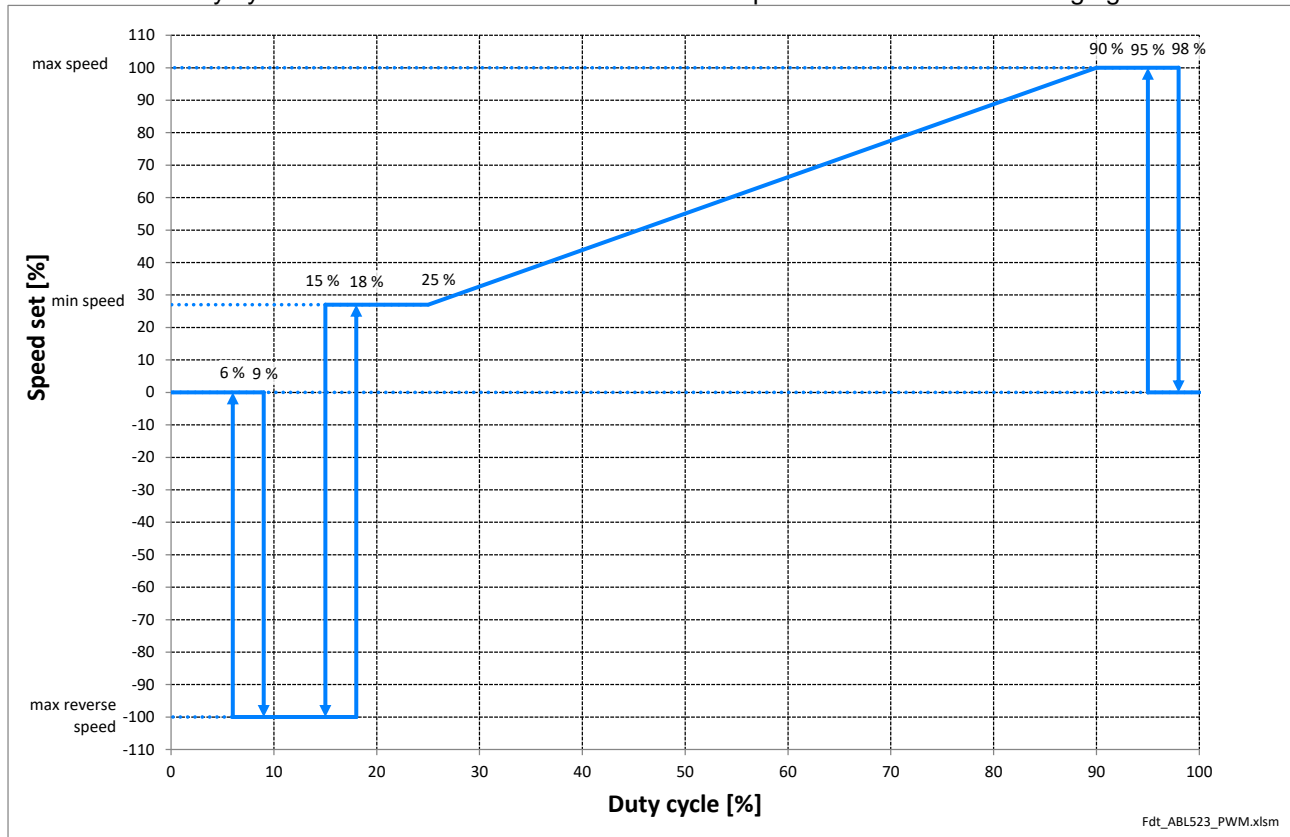
It is called "positive logic duty cycle definition".

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Considering this definition,

- continuous low voltage is 0 % duty cycle (dominant level)
- continuous high voltage is 100 % duty cycle (recessive level)

Based on this duty cycle definition the transfer function PWM input is shown in the following figure.



### 12.3 Drive speed set point with Digital control

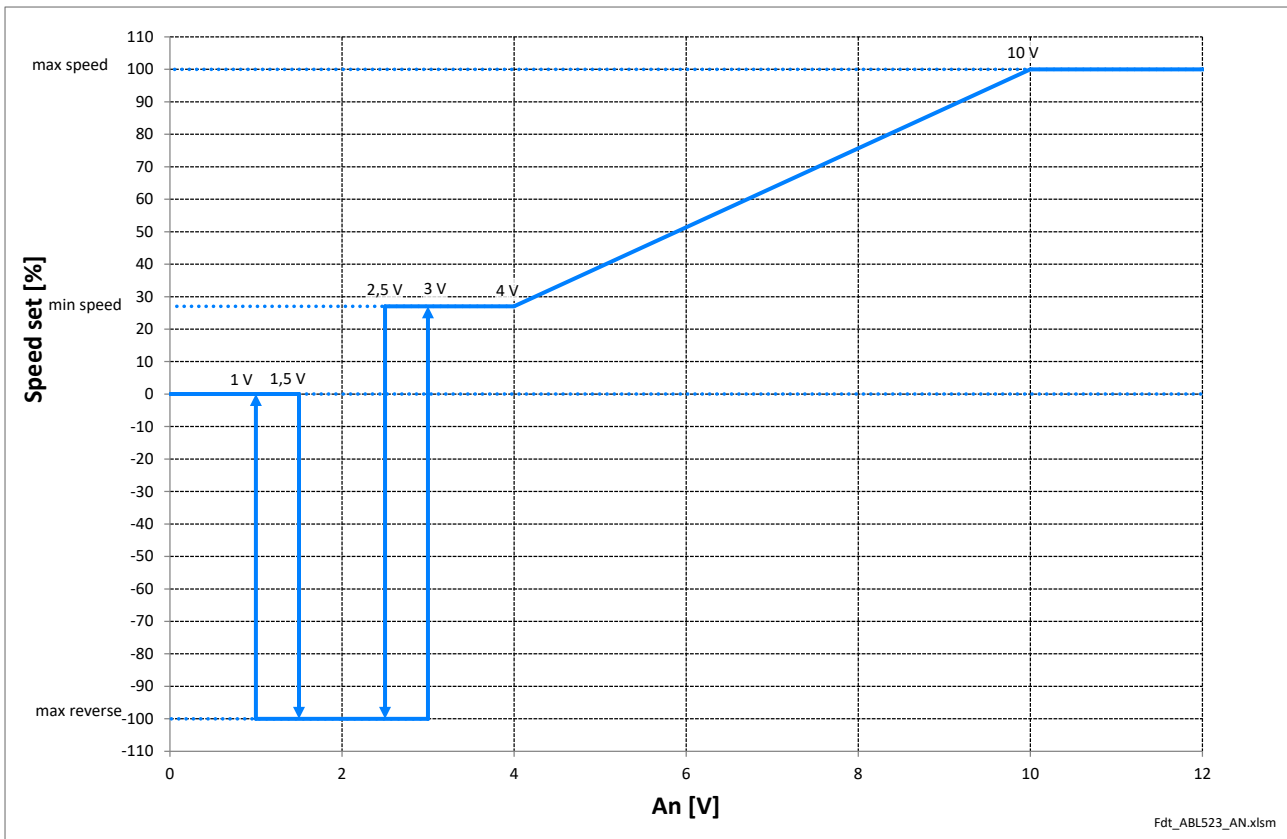
The PWM signal on the control input PWM\* / E\* is measured by the Drive electronics. For improving noise to signal ratio the PWM signal becomes only valid and is only used to set the speed of the Drive when a sufficient number of consecutive duty cycle measurements are equal.

This plausibility test slightly delays the response to the change of the duty cycle PWM value. This delay is in the range of 0.2 s or less.

### 12.4 Analog control: transfer function analog input

The transfer function analog input is the relation between the Drive speed and the duty cycle on the pin analog input A (see following figure).





### 12.5 Drive mode Failure modes

There are the following cases where the Drive will go into Failure mode and stop the Drive:

Failure modes	Handling of the failure	Notification (*)
Drive blocked	In case of detection of a rotor locked the following strategy is used: a delay of 5 s till the next start attempt is introduced. If this start attempt fails again a delay increased by further 5 s till the next start attempt is introduced. This delay increase is repeated till the delay between the attempts is 25 s. Then this delay is kept for ever as long a valid PWM duty cycle is detected which asks the Drive to run	n/a
Drive overloaded	Fan speed is reduced in case of overload detection by means of current draw measurement.	n/a
Over current	The Drive will stop if the over current safety threshold is reached.	
Drive overheated	Fan speed is reduced in case of overheating detection (derating). Over the max operating temperature, the Drive will stop.	n/a
Under and Over voltage	If the supply voltage is outside the specified range the Drive will stop.	n/a
Internal Drive failure	The Drive will stop if a failure is detected during the startup self check procedure.	n/a

In all cases the Drive tries to recover from failures when a valid PWM signal is detected which asks the Drive to run.

(\*) Notification is not available as no feedback is provided to the CCU.

### 13 Units and acronyms

Unit	Physical Quantity	Prefix	Dimension
------	-------------------	--------	-----------

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%	percent	Proportionality	M	10 <sup>6</sup>	mega
Ω	Ohm	Electrical Resistance	k	10 <sup>3</sup>	kilo
°C	degree Celsius	Temperature	m	10 <sup>-3</sup>	milli
A	Ampere	Current	μ	10 <sup>-6</sup>	micro
h	hours	Time	n	10 <sup>-9</sup>	nano
dBA	decibel (A-weighting)	Sound pressure level	p	10 <sup>-12</sup>	pico
Hz	Hertz	Frequency			
min	minute	Time			
Pa	Pascal	Pressure			
rpm	Revolutions per minute	Rotation frequency			
s	second	Time			
V	Volt	Voltage			
W	Watt	Power			

Table 1: Units of measurements

Key Word	Description
AMPL_IN	Amplitude PWM input signal
CCU	Custom Control Unit
Drive	Motor with axially integrated electronics
IGN	Ignition (KL15)
PWM	Pulse Width Modulation
R <sub>i</sub>	Input Resistance
SBL	Sealed brushless
T	Temperature
T <sub>AMB</sub>	Ambient Temperature
U <sub>B</sub>	Supply voltage
U <sub>n</sub>	Nominal supply Voltage
rms	root mean square

## 14 Document change history

Initial document author: document author

Latest revision: 000

Document author	Date	Revision	Comment
SPAL TEAM	29.03.2021	000	Initial Version.

Table 2: Document change history

Document status: released

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<b>15</b>	<b>Sommario</b>	
<b>1</b>	<b>General</b>	<b>1</b>
<b>2</b>	<b>Features</b>	<b>1</b>
<b>3</b>	<b>Air performance at maximum speed</b>	<b>2</b>
<b>4</b>	<b>Mechanical data</b>	<b>3</b>
<b>5</b>	<b>Connector and wires</b>	<b>4</b>
<b>6</b>	<b>Further Features</b>	<b>5</b>
<b>7</b>	<b>Measurement conditions</b>	<b>5</b>
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