1 General

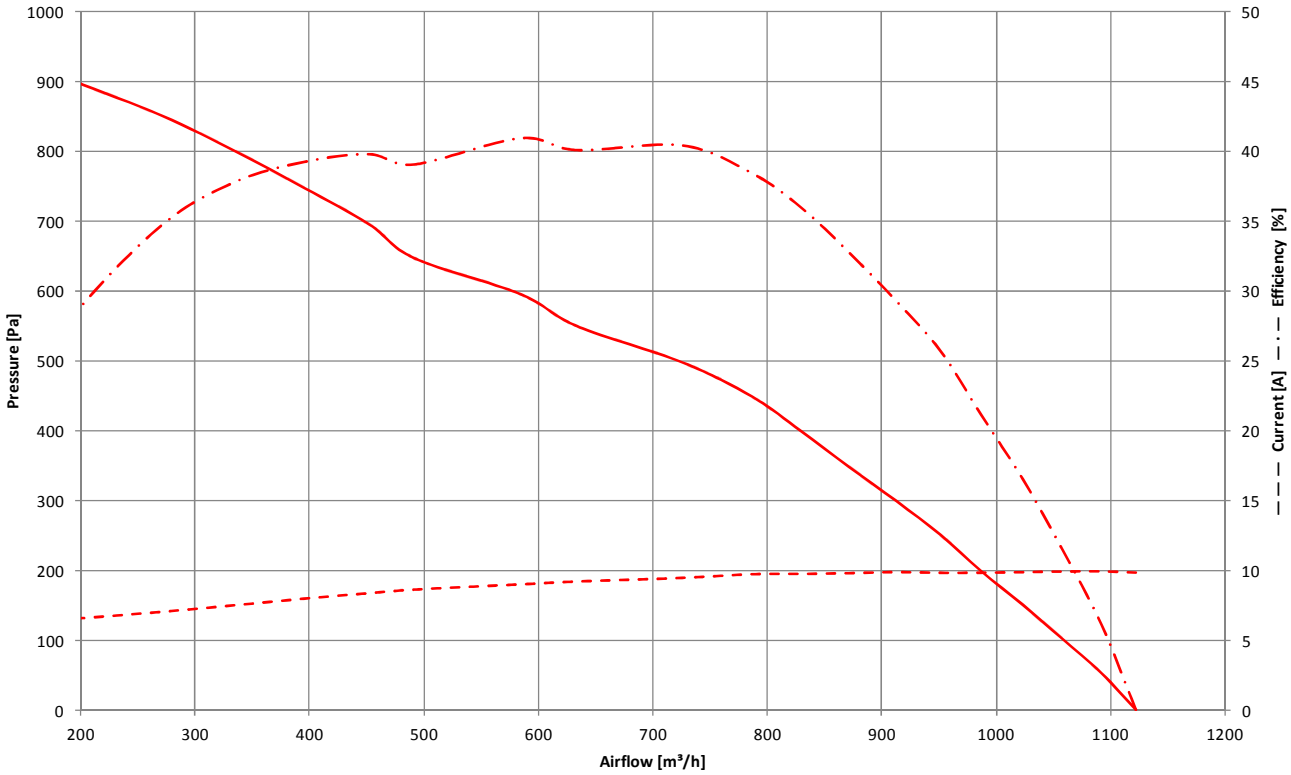
Fan diameter Ø: 98 mm
Nominal voltage: 24 V
Drive family SBL300

Part number: 30007037

2 Features

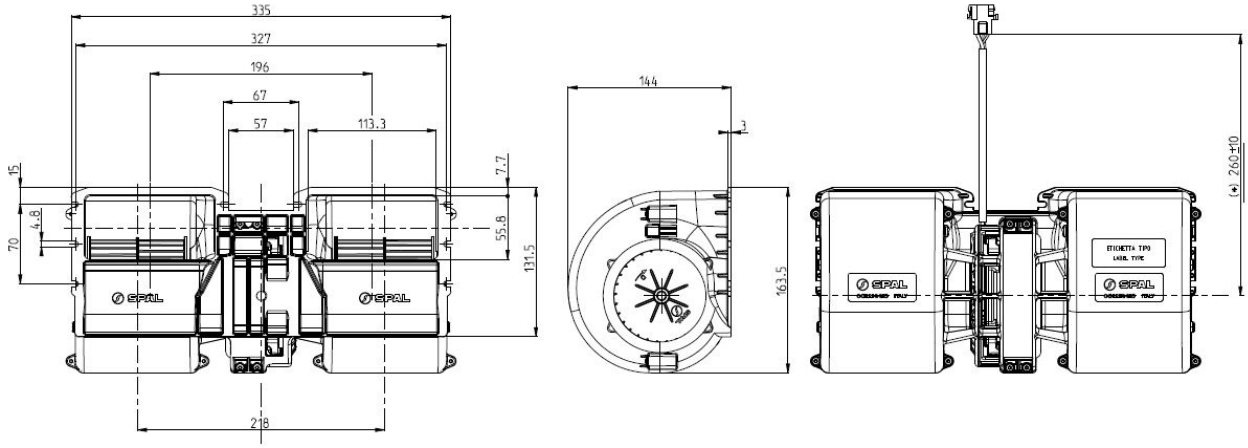
Max fan speed @ 0Pa	rpm	3400
Min fan speed @ 0Pa	rpm	900
Sound pressure level at max speed	dBA	72.6 – at 1 m from the fan module - lateral side
Weight	kg	2.4
Operating supply voltage range	V	16.0 .. 32.0 at the Drive connector
Supply voltage to reach max speed	V	26.0 .. 32.0 at the Drive connector
Operating ambient temperature range	℃	-40 .. +95
Max operating ambient temperature @ max fan speed	℃	+95
Storage temperature range	℃	-40 .. +95
Lifetime	h	up to 40000 hours depending on mission profile
Time from 0 rpm to max speed	s	14
Load dump protection (Pulse 5b)	V	65 - Pulse peak voltage (U_S*) - 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.		

3 Air performance at maximum speed



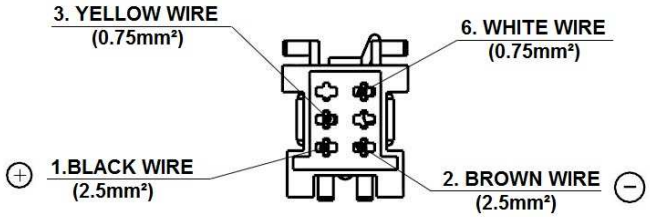
Air density 1.18 kg / m3 - Test number: #5510 – Test bench compliant to ANSI AMCA 210
TAMB = 23 ℃ ± 5 ℃ - UB = 26.0 V at the Drive conn ector

4 Mechanical data



Fixing recommendation: use M4 bolts for fixing. Nominal tightening torque 3 +1/0 Nm
Nominal torque defined for brand new, clean and lubricant-free bolts.

5 Connector and wires



Connector part number : AMP 929505-2						
Pin number	1	2	3	4	5	6
Identification	+D	-D	PWMA / E	-	-	FO
Wire Color	Black	Brown	Yellow	-	-	White
Pin	AMP 0-928781-2	AMP 0-928781-2	AMP 0-928930-2	-	-	AMP 0-928930-2
Sect. [mm^2]	2.5	2.5	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		ECE Reg. 10-04 and updates - Automotive EMC directive
		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:

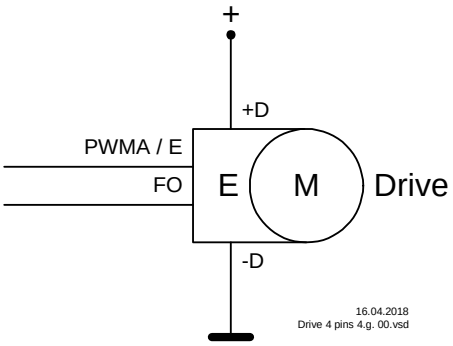
- T_{AMB} = 20 ℃ ± 5 ℃ and
- Supply voltage **UB** = 26.0 V at the **Drive** connector

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 high: PWMA / E
2. Output: feedback output / active high: FO

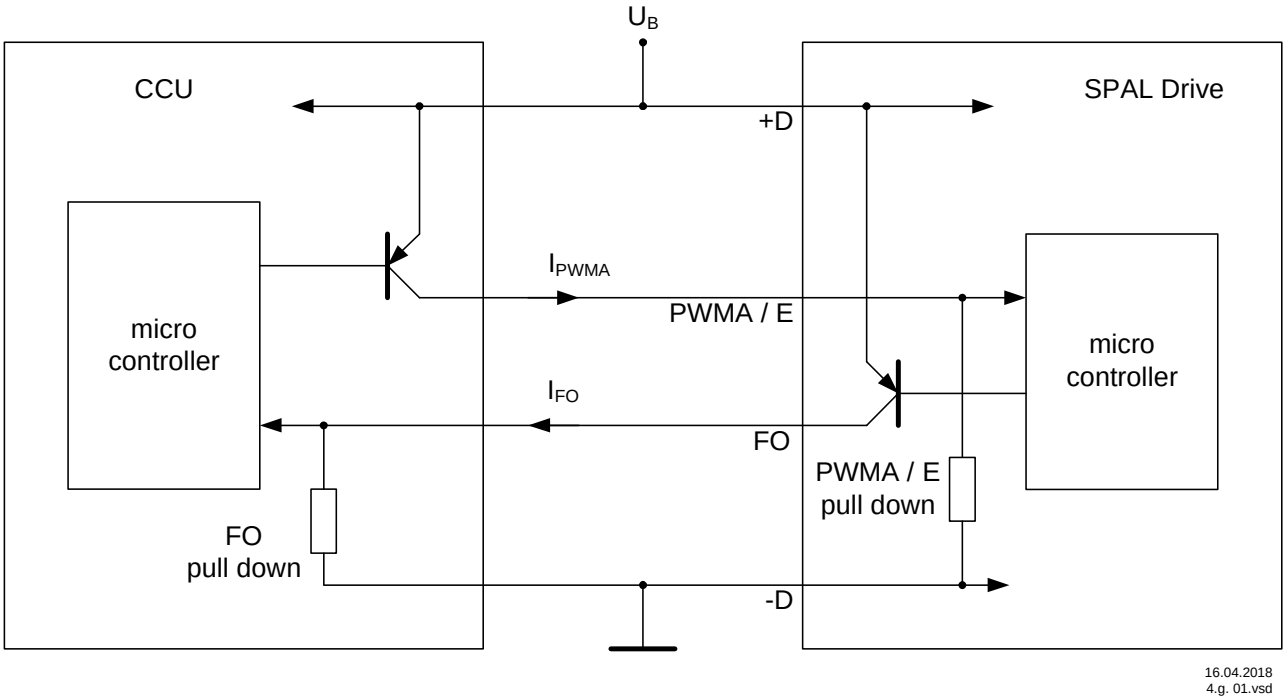
The signal pin PWMA / E is used to control the Drive mode.
PWMA / E can be a digital PWM active high signal or an Analog signal.

It is called digital PWM input / active high because the signal processing of a PWM signal applied to the input PWMA / E is done in such a way that the PWM signal is filtered and then read with an analog input by the microcontroller of the Drive electronics. In this way also relatively high PWM base frequencies can be used (>100Hz).

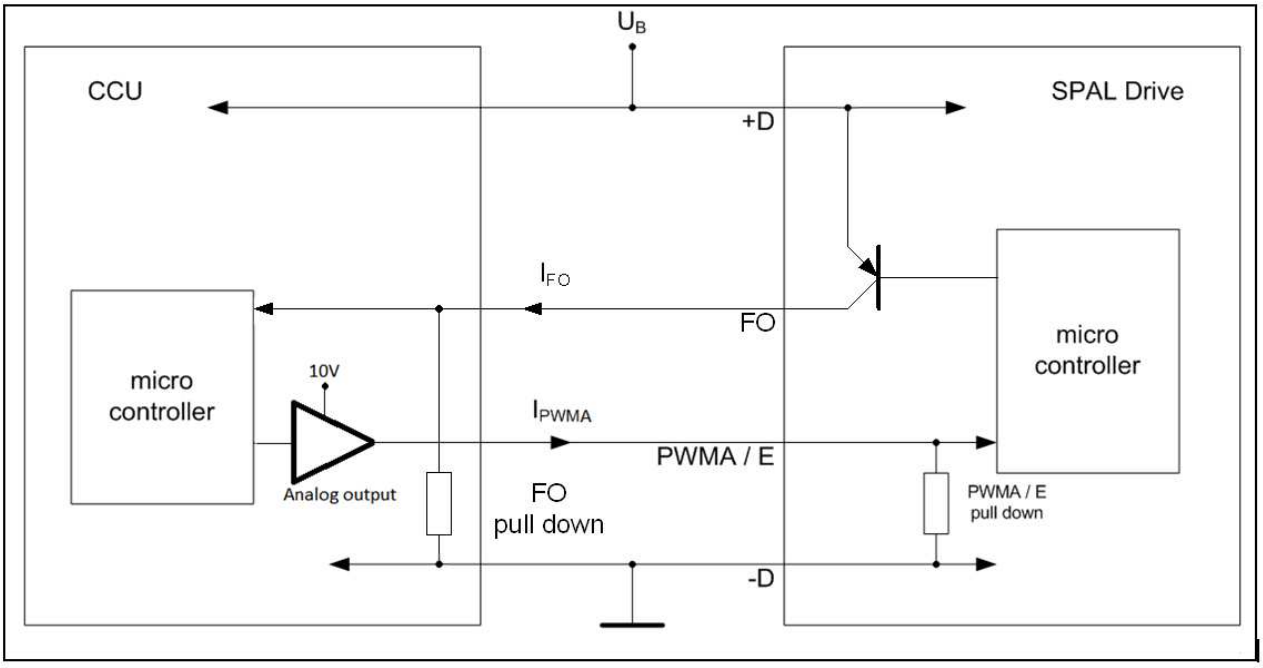
The signal pin FO is used to notify the Drive status.

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.



Connection with digital PWM signal active high



Connection with Analog signal

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

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

This pull down resistor is connected to the supply voltage minus: -D / GND.
The dominant level on the input PWM / E is high level, provided by the switching to plus stage depicted in above figure**.** as a bipolar pnp transistor in the CCU.

The output FO comes from the Drive electronics and uses a pull down resistor (FO pull down) located in the CCU electronics.
The dominant level on output FO is high level, provided by the switching to high stage depicted in above figure as a bipolar pnp transistor in the Drive.

10 Interface hardware

10.1 Digital control: pin PWMA / E

The input PWMA / 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_{wakeup} will wake up the Drive electronics.

Parameters	Min	Typical	Max	Unit	Denomination
PWMA / E frequency range	50		50000	Hz	f_{PWM} 3)
PWMA / E duty cycle range	0		100	%	dc_{min} .. dc_{max} 4)
PWMA / E high level voltage	12			V	U_{PWMH}1)
PWMA / E low level voltage			1	V	U_{PWML}1)
PWMA / E resolution		±1		%	dc_{resol}
PWMA / E accuracy		±3		%	dc_{accu}
PWMA / E current	-10 %	0.45	+10 %	mA	I_{PWMA}
PWMA activation level	4	7	9	%	dc_{Eact} 2)
PWMA / E leakage (quiescent) current			4	µA	
PWMA / E wake up voltage	1.4			V	DC_{PWMA}1)
PWMA / E duration for wakeup	150			µs	T_{wakeup}

1): the PWMA thresholds consider a temperature range of -40 ℃ to 120 ℃ in the electronics
2): the activation level dc_{Eact} considers a temperature range of -40 ℃ to 120 ℃ in the electronics
3): for SPAL production line internal reasons there is a test mode implemented which is activated at a PWM frequency range from 6 Hz to 20 Hz with dedicated duty cycles for various test modes.
The application must not use this frequency range!
4): for dc around the Min level the fan can be power-on or power-off, see dc_{Eact}. For dc more than Max level must consider the maximum speed

10.2 Analog control: pin PWMA / E

The input PWMA / E is used to wake up the Drive from Quiescent current mode. Any Analog signal that guarantees a voltage more than DC_{PWMA} will wake up the Drive electronics.

Parameters	Min	Typical	Max	Unit	Denomination
PWMA / E nominal voltage range	0		10	V	
PWMA / E current	-10 %	0.25	+10 %	mA	I_{PWMA} at 10V
PWMA / E absolute maximum voltage	-32		35	V	
PWMA / E leakage (quiescent) current			4	µA	
PWMA / E wake up voltage	1.4			V	DC_{PWMA} 1)

1): the PWMA thresholds consider a temperature range of -40 ℃ to 120 ℃ in the electronics

11 FO: feedback output / active high

Parameters	Min	Typical	Max	Unit	Denomination
FO dominant voltage	U_B – 2 V		U_B	V	U_{FO}
FO current			50	mA	I_{FO}

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 PWMA / E and the voltage level on the same input PWMA / E.

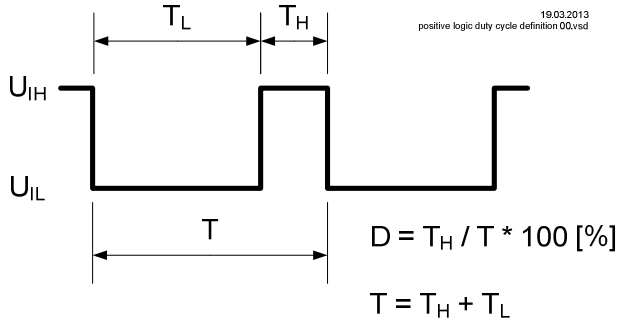
No.	Drive mode	Current consumption	Drive speed	FO
1	Quiescent current mode	< 100 µA	0	Recessive
2	Electronics active mode	< 40 mA	0	Recessive
3	Run mode	depending on the requested speed and on the load	depending on the PWM duty cycle or the analog input voltage level	Recessive
4	Failure mode	< 40 mA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

The Quiescent current mode is entered when the pin PWMA / E is on 0 % duty cycle (recessive level The Electronics active mode is entered with any PWM duty cycle > dc_{Eact} if the condition from chapter 10 is fulfilled (T_{wakeup}).
The Run mode is entered if the PWM duty cycle on pin PWMA / E has a value where the Drive is asked to run (see chapter 12.2)

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: PWMA / E.

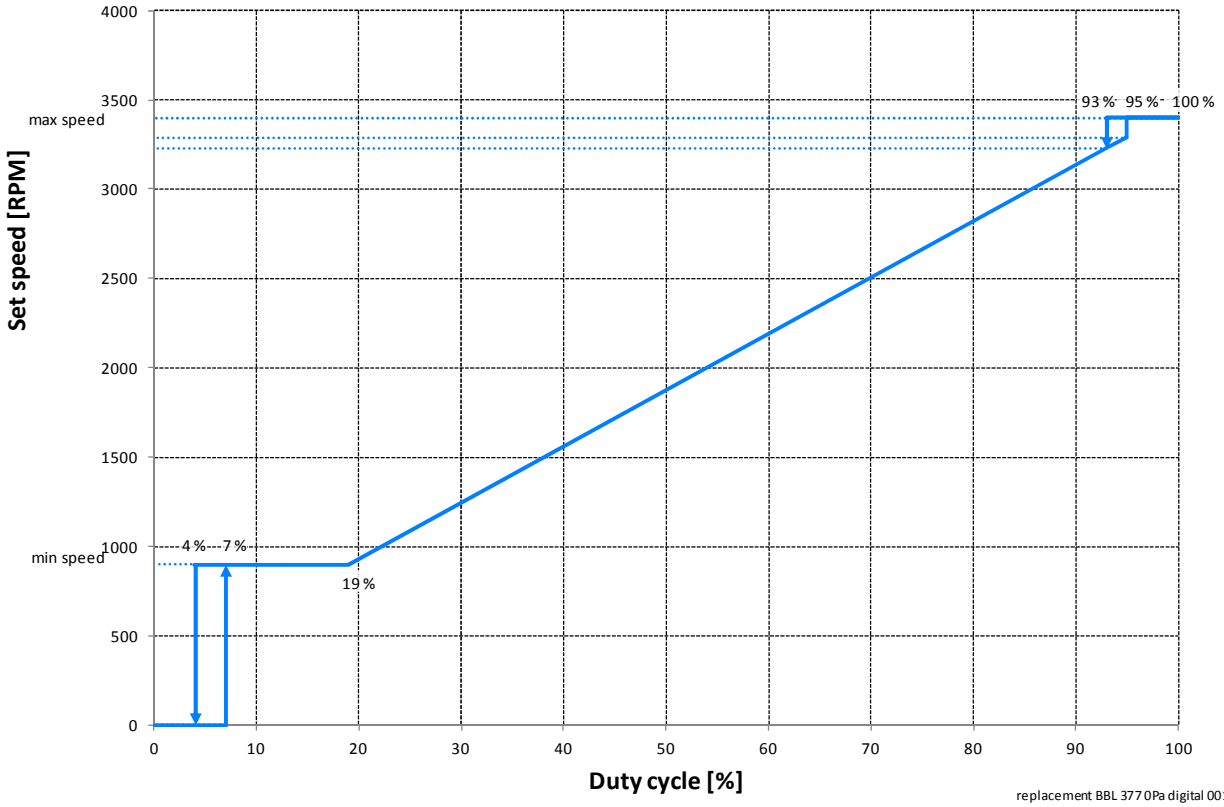


It is called ”positive logic duty cycle definition”.

Considering this definition,

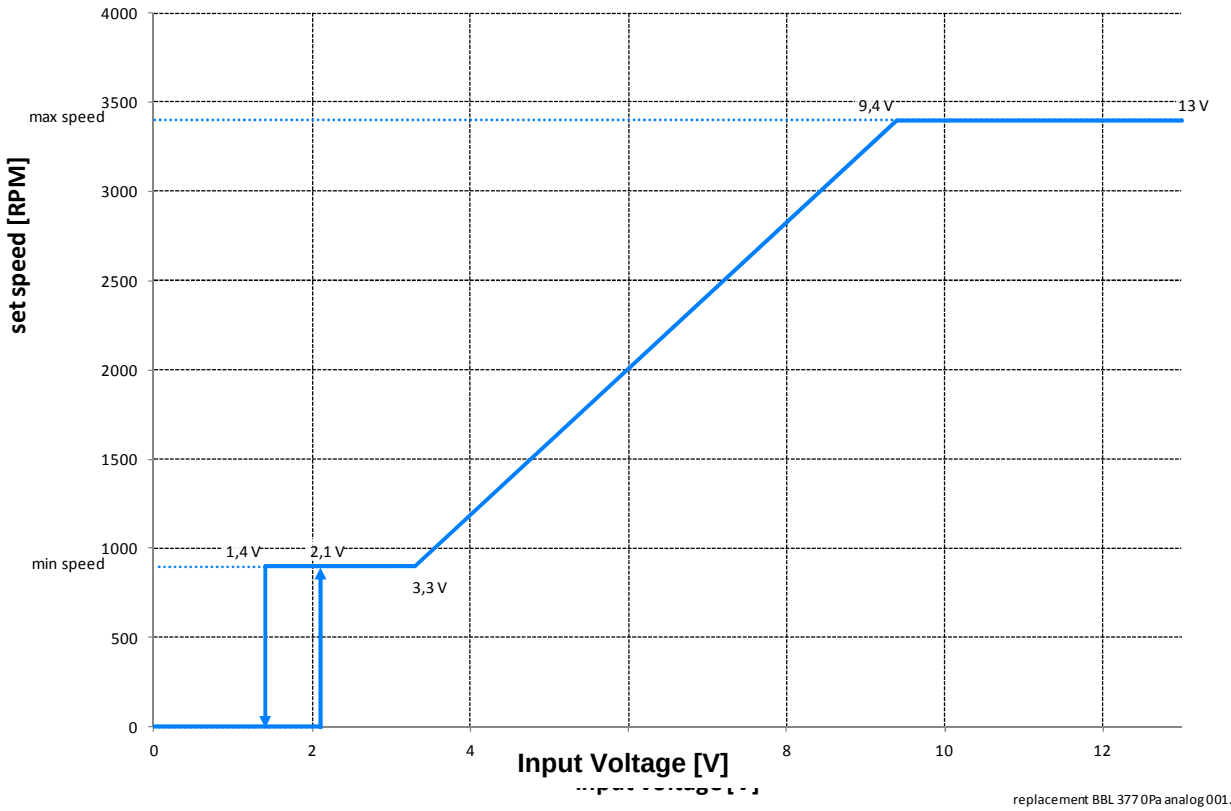
- continuous low voltage is 0 % duty cycle (recessive level)
- continuous high voltage is 100 % duty cycle (dominant level)

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



replacement BBL 377 0Pa digital 001.xlsm

Digital PWM input (0 Pa)



replacement BBL 377 0Pa analog 001.xlsm

Analog input (0 Pa)

12.3 Drive speed set point with Digital control

The PWM signal on the control input PWMA / 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 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 3 s till the next start attempt is introduced. If this start attempt fails again a delay increased by further 3 s till the next start attempt is introduced. This delay increase is repeated till the delay between the attempts is 30 s after which no further attempts are made.	FO is set to dominant level
Drive overloaded	Fan speed is reduced in case of overload detection by means of current draw measurement.	FO set to recessive
Over current	The Drive will stop if the over current safety threshold is reached.	FO is set to dominant level
Drive overheated	Fan speed is reduced in case of overheating detection (derating). Over the max operating temperature, the Drive will stop.	Over the max operating temperature FO is set to dominant level
Under and Over voltage	If the supply voltage is outside the specified range the Drive will stop.	FO set to recessive
Internal Drive failure	The Drive will stop if a failure is detected during the startup self check procedure.	FO is set to dominant level

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

13 Units and acronyms

Unit		Physical Quantity	Prefix	Dimension	
%	percent	Proportionality	M	10^{6}	mega
Ω	Ohm	Electrical Resistance	k	10^{3}	kilo
℃	degree Celsius	Temperature	m	10^{-3}	milli
A	Ampere	Current	µ	10^{-6}	micro
h	hours	Time	n	10^{-9}	nano
dBA	deciBel (A-weighting)	Sound pressure level	p	10^{-12}	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_i	Input Resistance
SBL	Sealed brushless
T	Temperature
T_{AMB}	Ambient Temperature
U_B	Supply voltage
U_n	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	30.05.2018	000	Initial Version.

Table 2: Document change history

Document status: released