

Datasheet

VA89 – BBL329P/N – 94A

Product name: VA89 – BBL329P/N – 94A
Fan diameter: Ø 305 mm
Nominal voltage: 24 V
Part number: 30107081



Revision: 002

03.04.2014

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2 Units and acronyms

Unit		Physical Quantity	Prefix	Dimension	
%	percent	Proportionality	M	10 ⁶	mega
Ω	Ohm	Electrical Resistance	k	10 ³	kilo
°C	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			
Hz	Hertz	Frequency	p	10 ⁻¹²	pico
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 table

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

Table 2: acronyms table

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3 General conditions

The below conditions are assumed:

- $T_{AMB} = 20\text{ °C} \pm 5\text{ °C}$ and
- $U_B = 26.0\text{ V} \pm 0.2\text{ V}$ at the Drive connector

unless otherwise specified.

4 Air performance

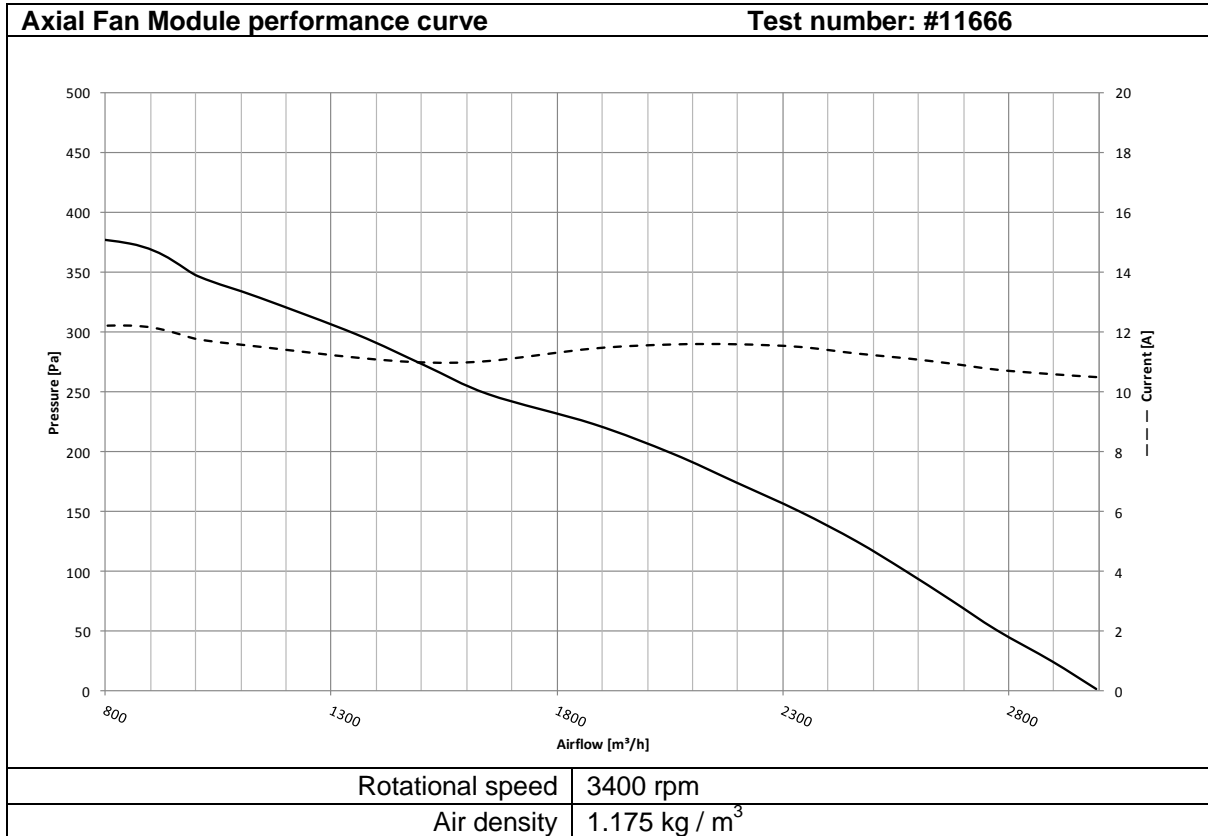


Table 3: Axial Fan Module VA89 – BBL329P/N – 94A Air performance table

5 Noise performance

Sound pressure level	75.1 dBA
Distance of the microphone	$1\text{ m} \pm 0.005\text{ m}$ from the centre of gravity of the fan module

Table 4: Axial Fan Module VA89 – BBL329P/N – 94A Noise performance table

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6 Mechanical data

6.1 Dimensions

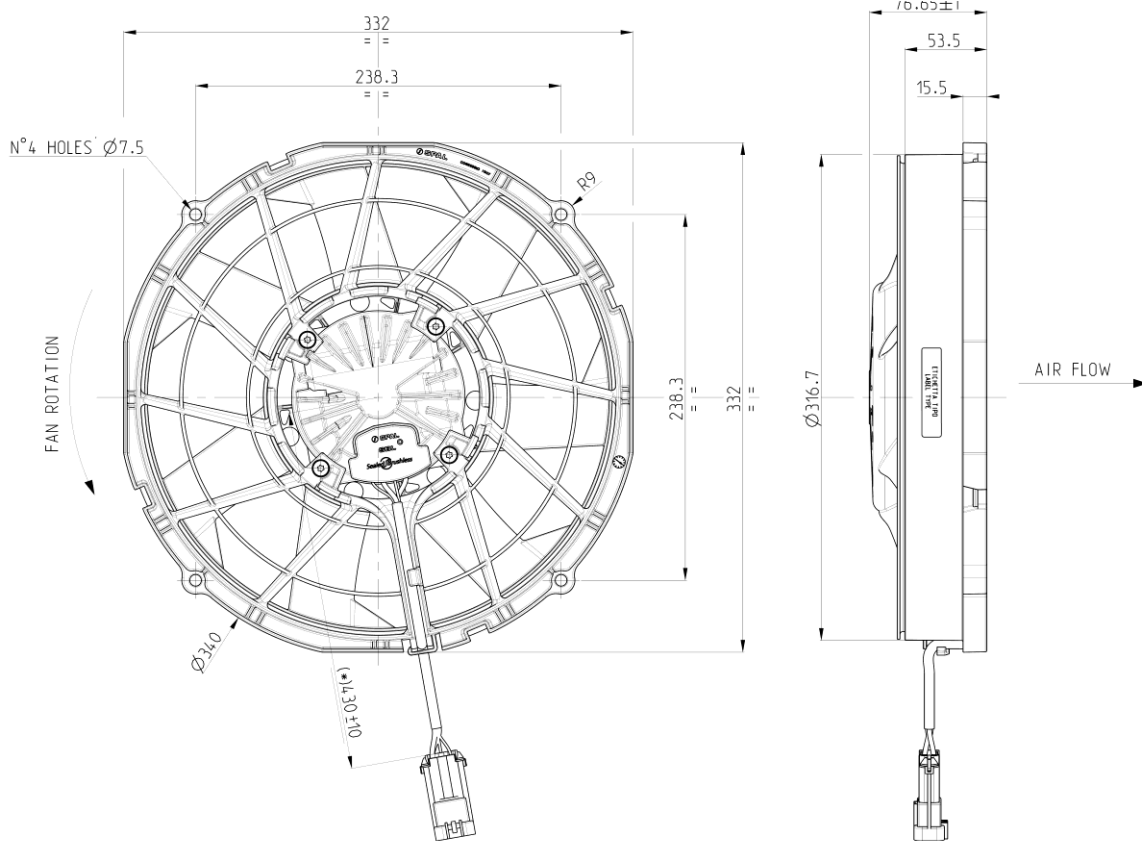


Figure 1: Axial Fan Module VA89 – BBL329P/N – 94A 2D technical scheme

All dimensions are expressed in mm. Use M6 screws for fixing – nominal tightening torque 3 Nm

6.2 Weight

Parameters	Typical	Unit
Weight of the Axial Fan Module VA89 – BBL329P/N – 94A (approximate)	2.2	kg

Table 5: Axial Fan Module VA89 – BBL329P/N – 94A Weight

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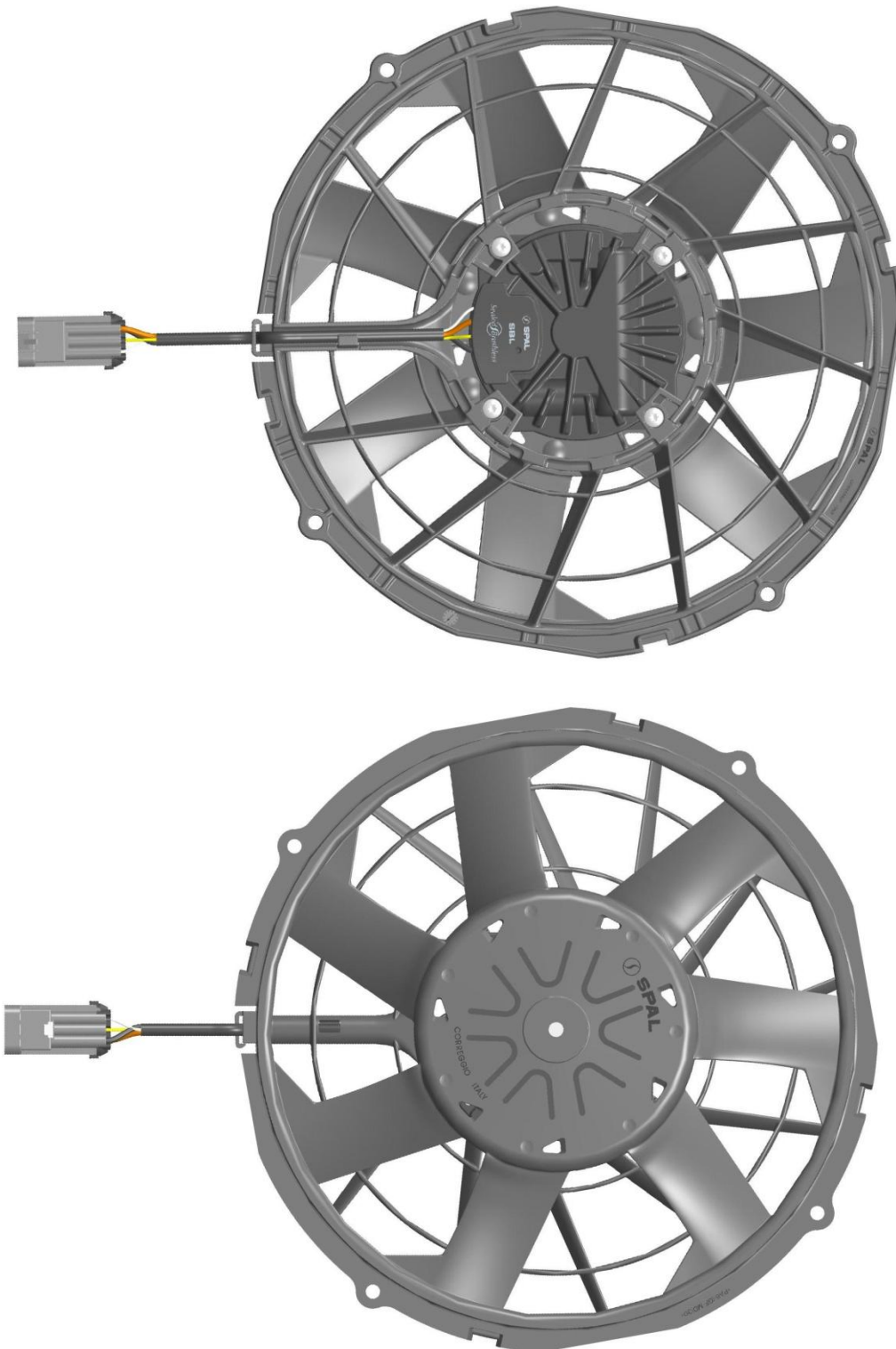
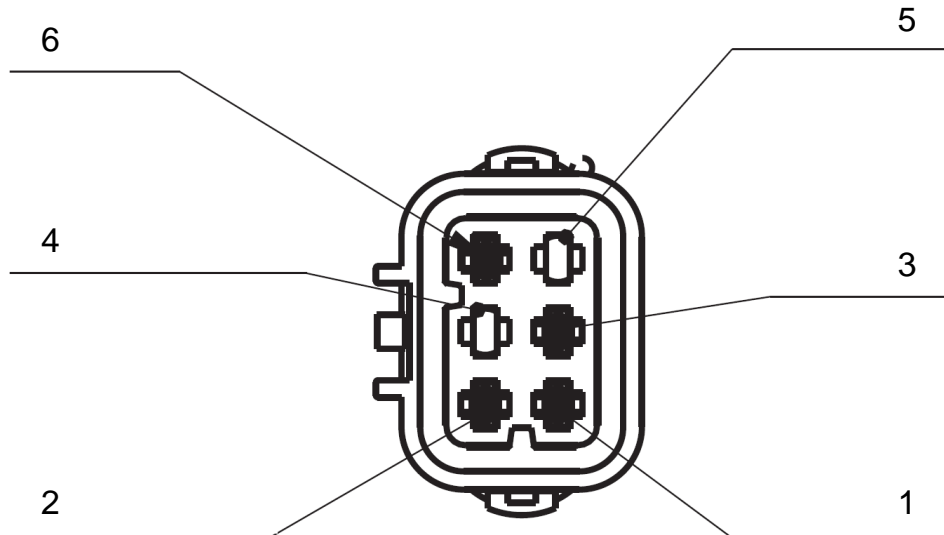


Figure 2: Axial Fan Module VA89 – BBL329P/N – 94A 3D rendering

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7 Connector and wires



05.12.2013
12185126.vsd

Figure 3: Connector with pinout

Connector:DELPHI Ducon 2.8 Waterproof				
Part number: 12185126				
Identification (*)	+D	-D	PWMA / E	FO
Pin number	1	2	3	6
Wire Color	black	brown	yellow	white
Sealing p/n	15324973	15324973	15324974	15324974
Pin p/n	12185237	12185237	12185129	12185129
Section [mm ²]	2.5	2.5	0.5	0.5

Table 6: pinout description

NOTE: Never handle the fan module via the cable harness. Pin #4 and #5 are not used.

(*) For abbreviations see chapter 8.2.

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8 Hardware functions

The below following characteristic values are valid under the conditions

- $T_{AMB} = 20\text{ °C} \pm 5\text{ °C}$ and
- $U_B = 26\text{ V} \pm 0.2\text{ V}$ at the connector,

unless not otherwise specified.

8.1 Drive diagram

In Figure 4 the Drive diagram is shown.

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

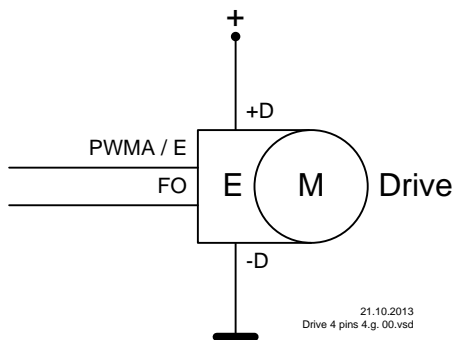


Figure 4: Drive diagram

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: analog-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 (see chapter 9.1), it is the control input.

It is called analog-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 (>1 kHz).

Because of the analog nature of the signal processing also an analog signal can be used to control the Drive mode (see chapter 9.1).

The signal pin FO is used to notify the Drive status (see chapter 9.2).

8.3 Drive interface

The Drive interface, the connections between the CCU and the Drive, is depicted in Figure 5.

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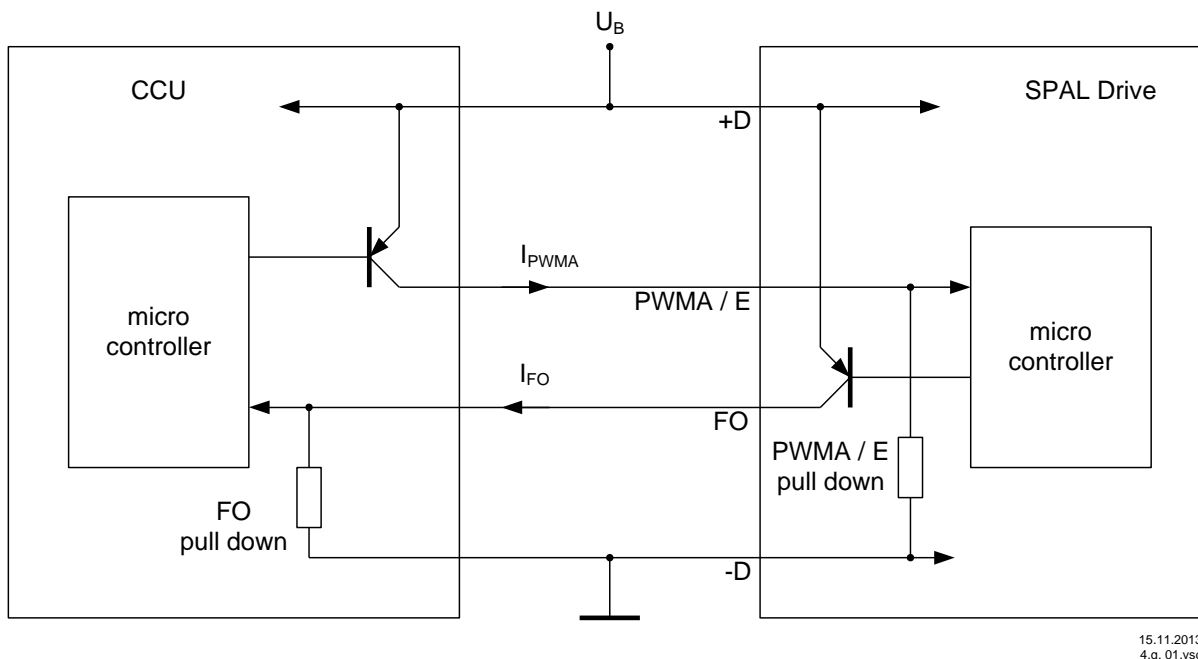


Figure 5: Drive interface

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

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

This pull down resistor function is connected to the supply voltage minus: -D / GND.

The dominant level on the input PWMA / E is high level, provided by the switching to plus stage depicted in Figure 5 as a bipolar pnp transistor in the CCU.

See also the chapter 10 Application notes.

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 Figure 5 as a bipolar pnp transistor in the Drive.

8.4 PWMA / E: analog-digital PWM input / active high

The input PWMA / E wakes up the Drive from the Quiescent current mode. The time to wake up depends either from the duty cycle of the applied PWM or from the voltage level of the applied analog voltage on the input PWMA / E. After maximum 500 ms the Drive wakes up from the Quiescent current mode by applying any signal to wake up which yields into a equivalent voltage U_{Eact} on the input PWMA / E.

It has to be noted that the electronics activation level U_{Eact} and the PWM thresholds U_{PWH} and U_{PWL} are independent (see also Figure 6).

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Parameters	Min	Typical	Max	Unit	Denomination
PWMA / E digital control frequency range	100		50000	Hz	f_{PWMA}
PWMA / E duty cycle range	0		100	%	$dc_{min} \dots dc_{max}$
PWMA high level voltage	12			V	U_{PWMH} 1)
PWMA low level voltage			1	V	U_{PWML} 1)
PWMA / E analog control voltage range	0		10	V	U_{PWMA}
E activation level	2			V	U_{Eact} 2)
PWMA / E current		5		mA	I_{PWMA}

Table 7: PWMA / E: analog-digital PWM input / active high parameters

- 1): the PWM thresholds consider a temperature range of -40 °C to 130 °C in the electronics
- 2): the activation level U_{Eact} considers a temperature range of -40 °C to 130 °C in the electronics

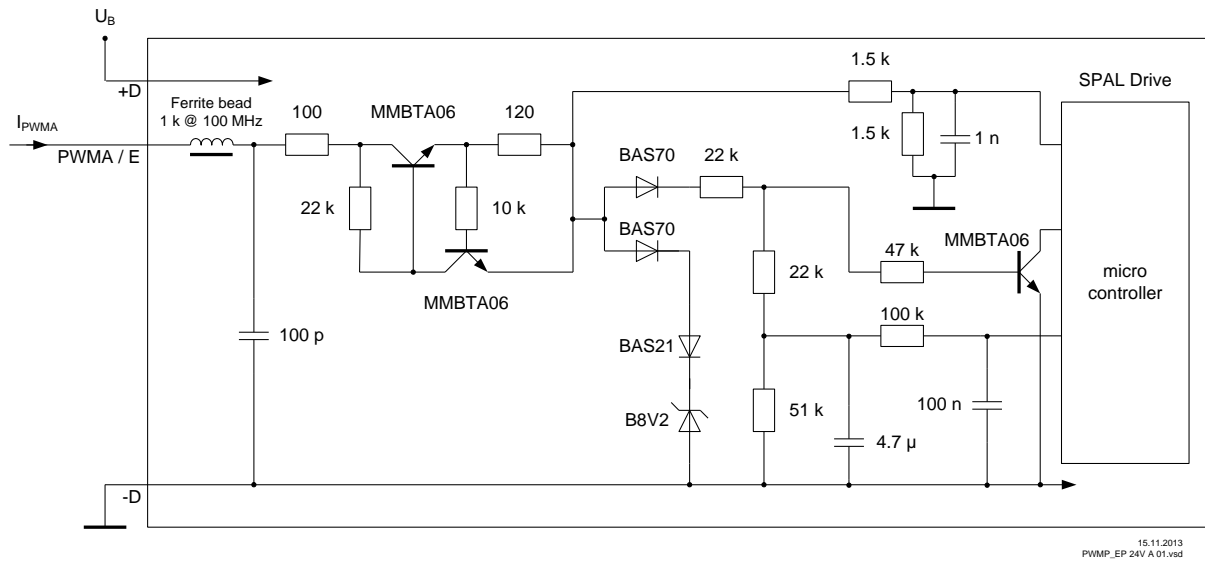


Figure 6: PWMA / E: analog-digital PWM input / active high implementation

8.5 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}

Table 8: FO: feedback output / active high parameters

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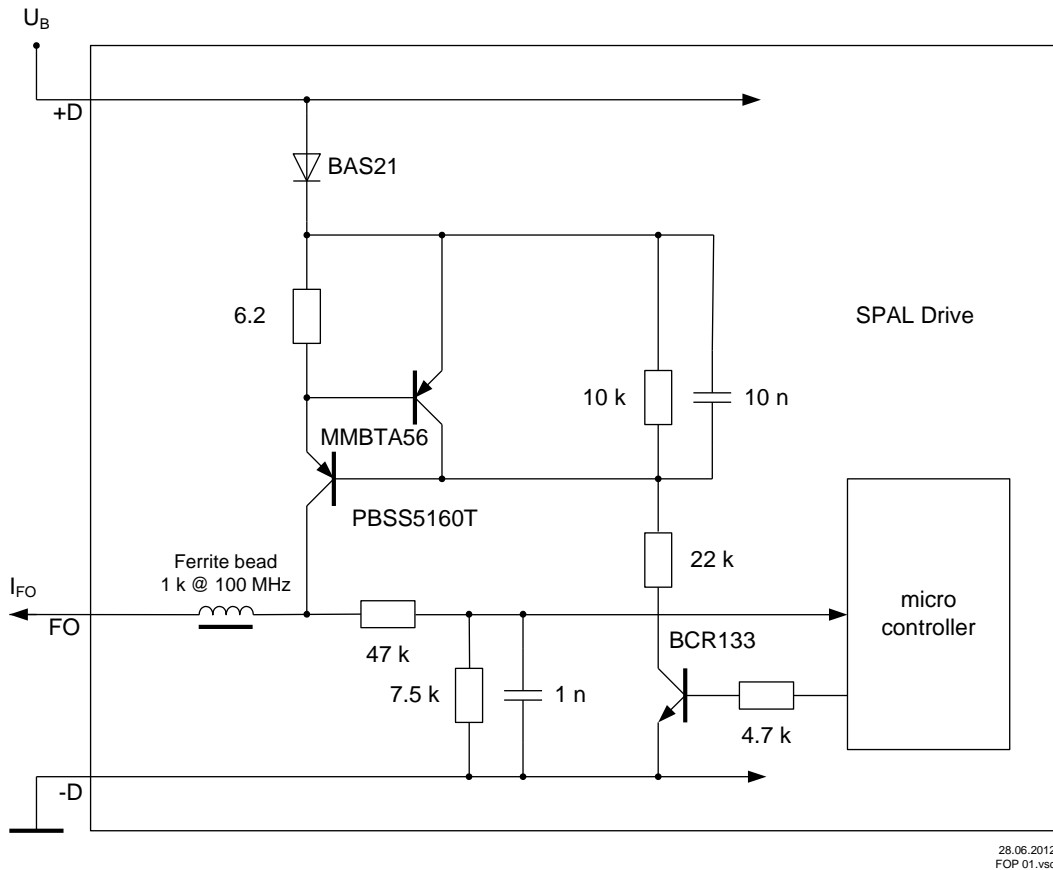


Figure 7: FO: feedback output / active high implementation

9 Software functions

9.1 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 (see Table 9 and Figure 9).

No.	Drive mode	Current consumption	Drive speed
1	Quiescent current mode	< 100 μ 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
4	Failure mode	< 40 mA	Depending on the failure / warning

Table 9: Drive modes

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The Quiescent current mode is entered when the pin PWMA / E is longer than 600 ms \pm 2 % on 0 % duty cycle (recessive level) below the activation level U_{Eact} .

The Electronics active mode is entered according the conditions of chapter 8.4.

The Run mode is entered if the PWM duty cycle has a value where the Drive is asked to run (see Figure 9 and chapter 9.3) and the PWM duty cycle value is valid according to the chapter 9.3.

The Failure mode is entered in case of failures of the Drive (see chapter 9.2).

9.2 Drive mode Failure mode

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

1. Drive blocked
2. Drive overheated
3. Drive overloaded
4. Under voltage
5. Over voltage
6. Over current
7. Internal Drive failure

9.2.1 Failure mode Drive overloaded

If the current draw is higher than the expected current draw derived from the fan curve plus a tolerance margin the Drive will reduce the speed. In this way also the case of a soft stall condition is covered.

This behavior of the Drive can be interpreted also as a speed dependent current limiting.

In general the Failure mode Drive overloaded is entered when the Drive cannot reach the requested speed.

9.2.2 Failure mode Drive blocked

The reason for the Failure mode Drive blocked can be (unlikely) Drive internal or (more likely) Drive external. E. g. snow could block the fan module. This failure can disappear after a certain time due heating up of the application because of missing fan function. But then the fan can run again. In order to provide a high fan module availability the following recovery strategy is used.

After the first detection of the Failure mode Drive blocked 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.

The maximum delay time is set in such a way that the Drive is not overheating due to the start attempts under the condition of the maximum ambient temperature.

9.2.3 Failure mode Drive overheated

Two cases of overheating have to be distinguished:

1. Overheating but the Drive can still run at a reduced speed respect to the requested speed
2. Overheating and the Drive cannot run anymore

9.2.4 Failure mode Under voltage and Over voltage

If the supply voltage is outside the specified range the Drive will stop.

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If the supply voltage is below the design voltage of the Drive the speed might be lower than the requested speed.

Both cases are not Drive failures and therefore will not be notified on the feedback output / active high FO line.

9.2.5 Failure mode Over current

Beside the mentioned speed dependent current limiting (see chapter 9.2.1) also an Over current protection function is implemented which switches off the Drive.

9.2.6 Failure mode Internal Drive failure

Under the Failure mode Internal Drive failure the following possible internal failures summarized:

- Voltage measurement chain defect
- Current measurement chain defect
- Temperature measurement chains defect
- Rotor position signal measurement chain defect
- MOS FET driver circuitry failures

9.2.7 Failure mode notification

In the Drive mode Quiescent current mode, Electronics active mode and Run mode the output FO is set to recessive level.

In case of the Drive mode Failure mode the output FO is pulled to dominant level.

If the Failure mode disappears the pin FO is pulled to recessive level again.

Any failure is notified earliest after 30 s.

Exception:

In the case of the Failure modes Under voltage and Over voltage no Failure mode notification is done because the reason for stopping the Drive is not an issue of the Drive but an external reason.

9.2.8 Failure recovery strategy

The Drive is designed with the following fundamental and mandatory requirement:

In any case any failure in the Drive MUST NOT generate follow up failures in the vehicle with catastrophic results.

Nevertheless directly after the above mentioned requirement for safety comes the requirement for maximum availability of the Drive.

This means that in all cases of failures a certain restart procedure or method is implemented.

In all cases the Drive tries to recover from failures when a valid PWMA / E signal is detected which asks the Drive to run. If a certain failure does not exist anymore the Drive goes immediately out of the Failure mode.

9.3 Transfer function Drive speed versus PWM duty cycle

The transfer function is the relation between the Drive speed and the PWM duty cycle on the pin PWMA / E.

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The duty cycle is defined according to Figure 8. It is called "positive logic duty cycle definition".

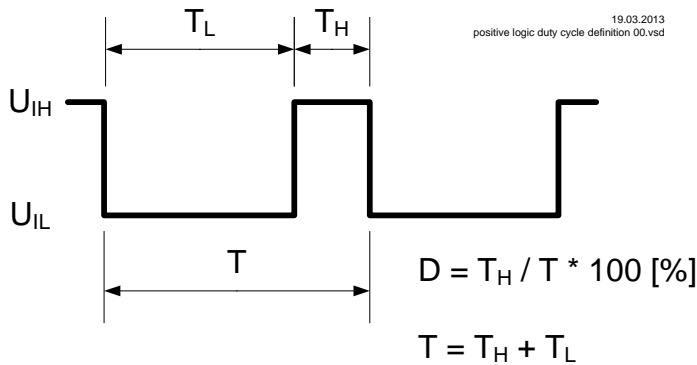


Figure 8: Duty cycle definition "positive logic duty cycle definition"

Considering this definition and the behavior of the input PWMA / E,

- 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 PWM input transfer function is shown in Figure 9.

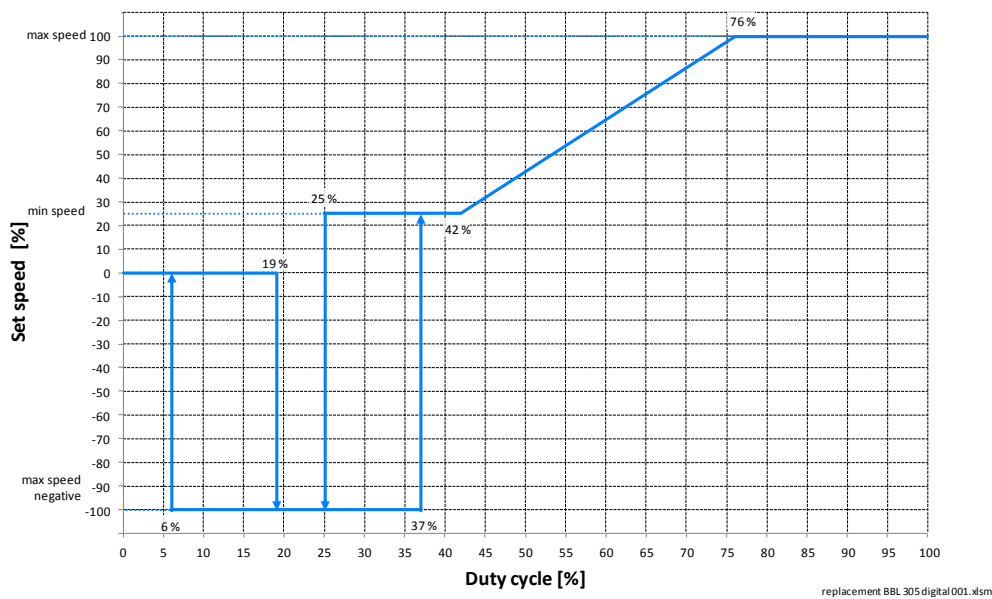


Figure 9: Transfer function Drive speed versus PWM duty cycle

The values for the PWM duty cycle are nominal values. Due to the analog nature of the PWM signal processing the speed depends also the applied voltage levels of the PWMA / E signal and the ambient temperature.

Due to the nature of the signal processing of the analog-digital PWM input / active high PWMA / E being analog (see chapter 8.2) it is proposed to apply for the negative speed 23 % duty cycle. In this

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way it can be made sure, that the Drive goes to negative speed also under the analog processing typical tolerances.

9.4 Transfer function Drive speed versus analog voltage

If the input PWMA / E is used in the pure analog way the transfer function Figure 10 applies.

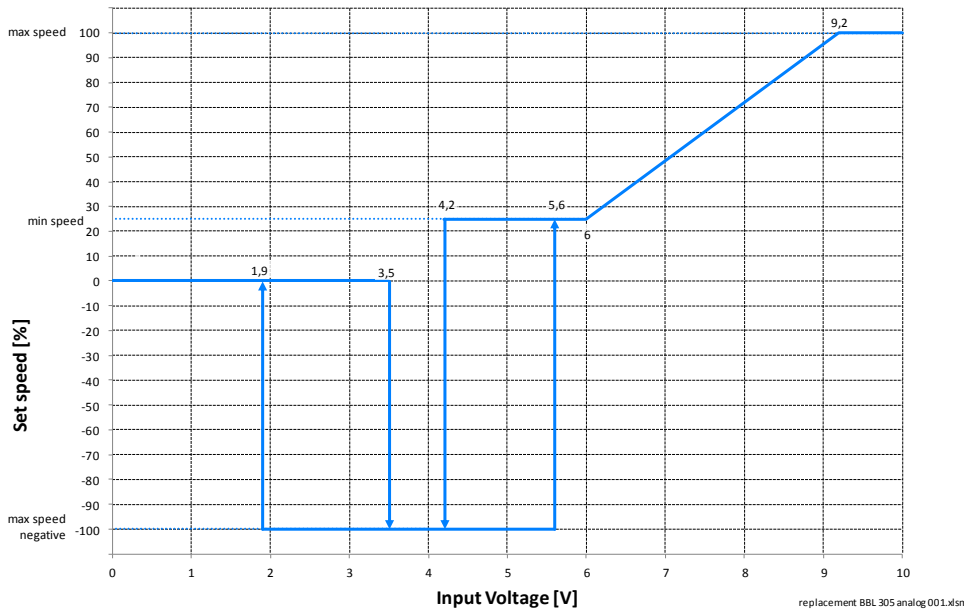


Figure 10: Transfer function Drive speed versus analog voltage

The voltage values are nominal values. Due to the analog nature of the PWM signal processing the speed can depend also in ground level shifts between the reference ground for the analog signal and the Drive internal ground and also the ambient temperature.

Due to the nature of the signal processing of the analog-digital PWM input / active high PWMA / E being analog (see chapter 8.2) it is proposed to apply for the negative speed 3.8 V to 3.9 V. In this way it can be made sure, that the Drive goes to negative speed also under the analog processing typical tolerances.

9.5 Speed direction change behavior

In case the Drive is at speed zero it starts in any direction according to the PWMA / E signal request. In case the Drive is running already and a direction change is requested by the appropriate PWMA / E signal request, the Drive stops and spins down according the energy in the inertia and the friction. If the speed is at zero, the start in the other direction can happen.

This means, the reaction time till the Drive reaches the requested speed depends on the previous state of the Drive.

10 Application notes

The input PWMA / E has two purposes (as mentioned in chapter 8.2):

1. Controlling the Drive speed

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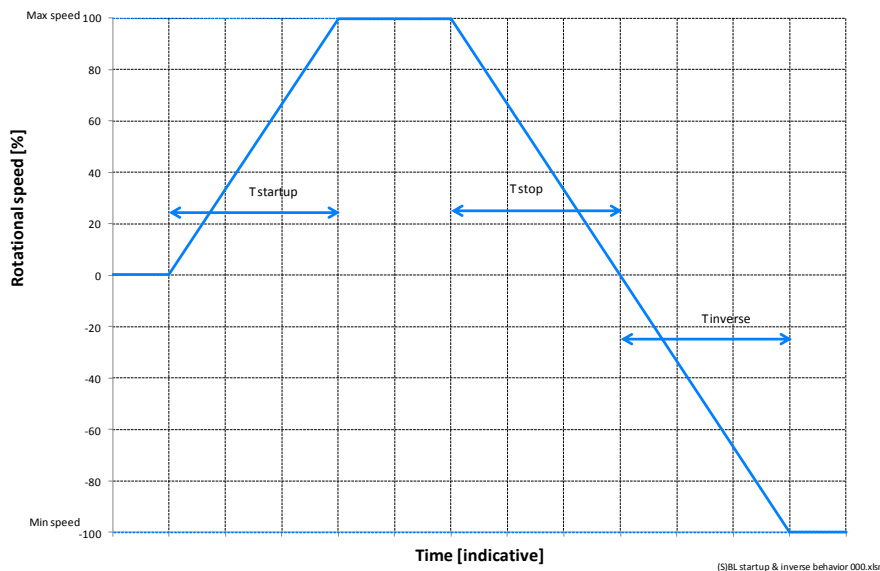
2. Activating the Drive

Due to the analog nature of the signal processing of the signal PWMA / E and the need of activating the Drive also with an analog signal the input is designed in such a way that activating the electronics is done at a low voltage level on the PWMA / E input pin (U_{Eact}).

In order to not accidentally start the Drive the CCU has to make sure that the PWMA / E input pin is driven with a low impedance also for the recessive level and not relying only on the PWMA / E pull down function in the Drive. It is important that also when the CCU is off the recessive level of the PWMA / E line is kept below the activation threshold U_{Eact} .

In this way parasitic resistances anywhere in the application between the PWMA / E line and the supply voltage will not yield into malfunction of the overall system where the Drive is involved. Those parasitic resistances can happen by various effects like moisture intrusion in the wiring harness / connectors anywhere on the application side or any other effect that generate leakage currents from the supply voltage to the PWMA / E line.

11 Startup behavior



Parameter	Min.	Typ.	Max.	Unit
T startup (speed ramp up time from 0 rpm to max. forward speed)	10.4	10.9	11.8	s
T stop (speed ramp down time from max. forward speed to 0 rpm)	15.1	15.1	16.5	s
T inverse (speed ramp up time from 0 rpm to max. backward speed)	10.4	10.9	11.8	s

Table 10: Startup behavior

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12 Supply Voltage

Parameter	Min.	Typ.	Max.	Unit
Nominal supply voltage		24.0		V
Operating supply voltage range (measured at Drive connector)	16.0		32.0	V
Supply voltage at which the Axial Fan Module can deliver the maximum speed (measured at Drive connector)	26.0		32.0	V

Table 11: supply voltage specifications (measured at Drive connector)

13 Fuse protection

An automotive fuse according ISO8820 part 3 must be used in the application wire harness. Depending on the application of the fan, it will be necessary to define and verify the correct fuse level by the customer (due to the length of the vehicle cable harness, cross section of the power wires, fuse type).

14 Power supply residual ripple

The maximum value of power supply rms ripple acceptable for the Drive is 1 %. In case of application with high residual ripple values, please contact SPAL in order to find the suitable solution for your specific requirements.

15 Reverse polarity protection

The electronic unit is protected against either temporary or permanent application of a reverse polarity on the power supply line. In this situation, the motor remains stopped without feedback output signal activation. Functional status class C as defined in ISO 16750-1 (device fully functional after the test and after correcting the polarity). Prescriptions of chapter 13 must be applied.

Reverse polarity testing parameters		
Parameter	Value	Unit
Reverse supply voltage	-27.0	V
Temperature	Room temperature	K
Time	2	min

Table 12: reverse polarity test parameters

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16 Load dump protection

Capability for limited load dump according to ISO16750-2:2010 specifications, chapter 4.6.4.2.2.

Load dump testing parameters		
Pulse type: 5b (suppressed)		
Parameter	Value	Unit
Pulse peak voltage (U_S^*)	65	V
U_A	28 ± 0.2	V
Internal resistance (R_i)	6	Ω
Impulse duration (t_d)	350	ms
Rising slope (t_r)	10 (0 / -5)	ms
Pulses number	10	#
Time interval between pulses	60	s

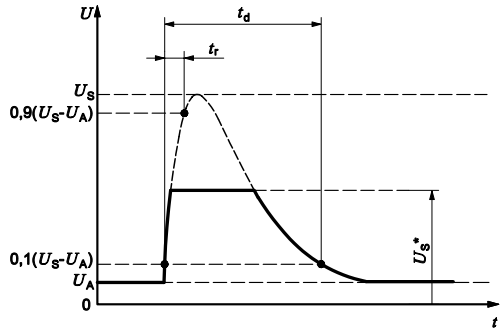


Table 13: load dump parameters

Typical ratings

- Operating temperature range: $-40 \div +120$ °C
- Storage temperature range: $-40 \div +125$ °C
- Lifetime: up to 40000 hours depending on mission profile

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17 Thermal derating curve

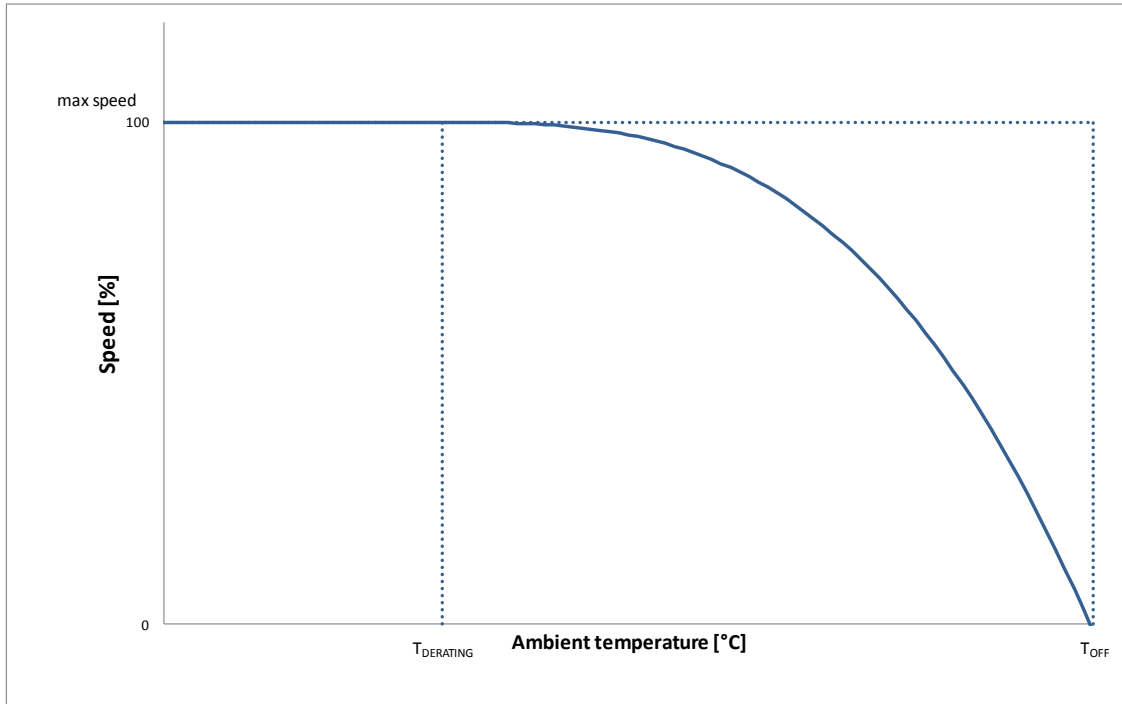


Figure 11: Thermal derating curve

Parameters	Typical	Unit
T _{DERATING}	+95	°C
T _{OFF}	+120	°C

Table 14: Indicative normalized derating curve for Axial Fan Module VA89 – BBL329P/N – 94A

The Figure 11 is only depicting the behavior.

The values for the starting of the derating T_{DERATING} and for the point when the Axial Fan Module VA89 – BBL329P/N – 94A is switching off T_{OFF} are nominal values.

Few minutes ambient temperature transients do not engage the derating curve of Axial Fan Module rotational speed, owing to the thermal inertia of the system.

NOTE: above data assume “nominal” fan load at those temperatures. Overloads will anticipate thermal derating of the Axial Fan Module rotational speed.

18 Rotational speed range

Parameters	Typical	Unit
Min speed	800	rpm
Max speed	3400	rpm

Table 15: Rotational speed range for Axial Fan Module VA89 – BBL329P/N – 94A

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19 Standards and Directives

The product complies with the following standard / directives

Standard Code	Description
72/245/EC and updates	Automotive EMC directive
ECE Reg. 10-03 and updates	Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility
2002/95/EC RoHS	Restriction of Hazardous Substances Directive
2000/53/EC and updates	End-of Life Vehicle 2000/53/EC

Table 16: standards and directives

20 Sealing

Motor designed for IP6K9K and IP68 protection

21 Document change history

Initial document author: Boschesi Roberto / ☎ +39 0522 731 311

Latest revision: 002

Document author	Date	Revision	Comment
Boschesi Roberto	04.12.2013	000	Initial Version The Hardware and Software functions are copied from the document: "RS (S)BL interface replacement BBL 305 001"
Boschesi Roberto	11.02.2014	001	<ul style="list-style-type: none"> - Added BBL329P airflow performance (Table 3) - Corrected Table 6: Sealing connector part number - in chapter 9.2.6 the following failure sources added: <ul style="list-style-type: none"> o Temperature measurement chains defect o Rotor position signal measurement chain defect o MOS FET driver circuitry failures - under Figure 9 proposal added for duty cycle for negative speed - under Figure 10 proposal added for voltage for negative speed - in chapter 9.2.4 feedback output line logic corrected - E activation level changed from 1.5 V to 2 V - PWMA / E digital control frequency range corrected to 50000 Hz - PWMA high level voltage changes to 12 V from 8.7 V - Figure 9, Figure 10 adapted to real values - Corrected derating temperature T_{MAX}
Boschesi Roberto	03.04.2014	002	- Added Part number

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Document author	Date	Revision	Comment
			<ul style="list-style-type: none"> - Changed 2D and 3D view (see Figure 1 and Figure 2) - Added chapter 5:Noise performance - Added chapter 6.2:Weight - Changed chapter 17: <ul style="list-style-type: none"> o Figure 11 o Table 14 o Derating description - Added chapter 18:Rotational speed range

Table 17: Document change history

Document status: released

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