1 General

Fan diameter Ø:	305 mm
Nominal voltage:	12 V
Drive family	SBL300
Part number:	30107125

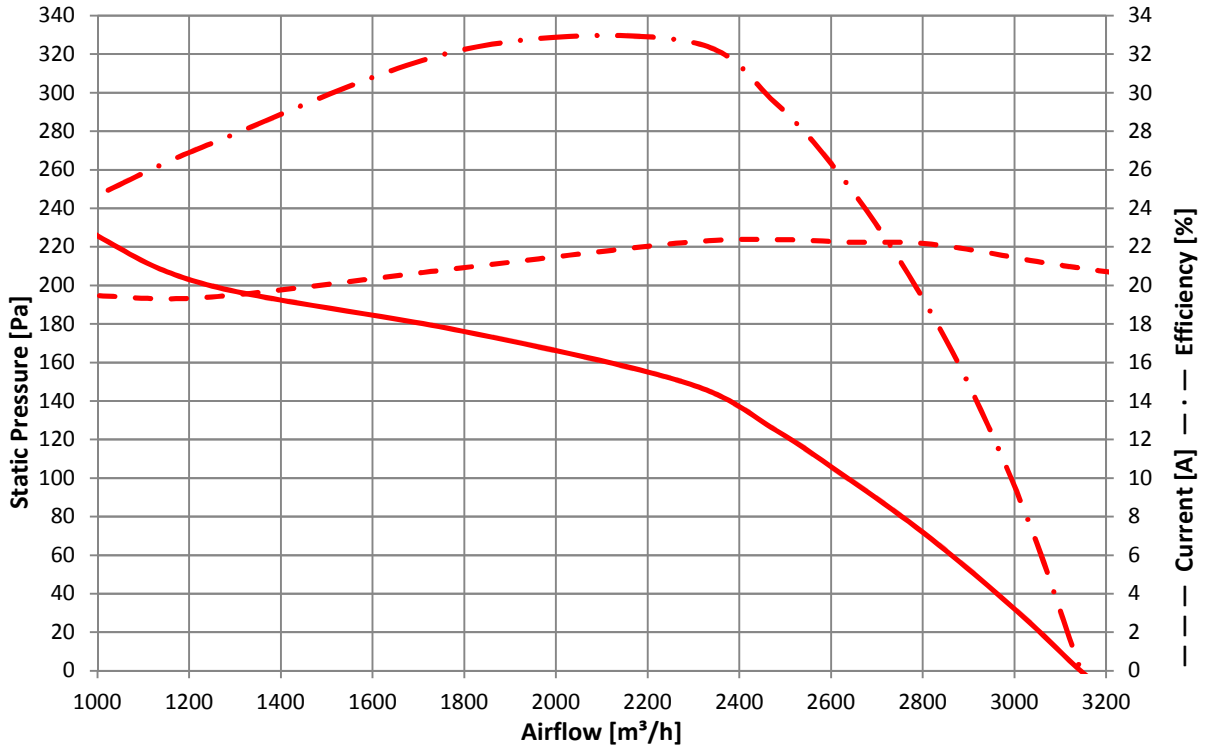


2 Features

Max fan speed	rpm	2500
Min fan speed	rpm	850
Sound pressure level at max speed	dBA	77 – at 1 m from the fan module - lateral side
Weight	kg	2.4 (E. Mollica)
Operating supply voltage range	V	9.0 .. 16.0 at the Drive connector
Supply voltage to reach max speed	V	12.5 .. 16.0 at the Drive connector
Operating ambient temperature range	℃	-40 .. +120
Speed derating threshold	℃	+85 (1)
Storage temperature range	℃	-40 .. +125
Lifetime	h	up to 40000 hours depending on mission profile
Time from 0 rpm to max speed	s	14.5
Load dump protection (Pulse 5b)	V	35 - 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.		

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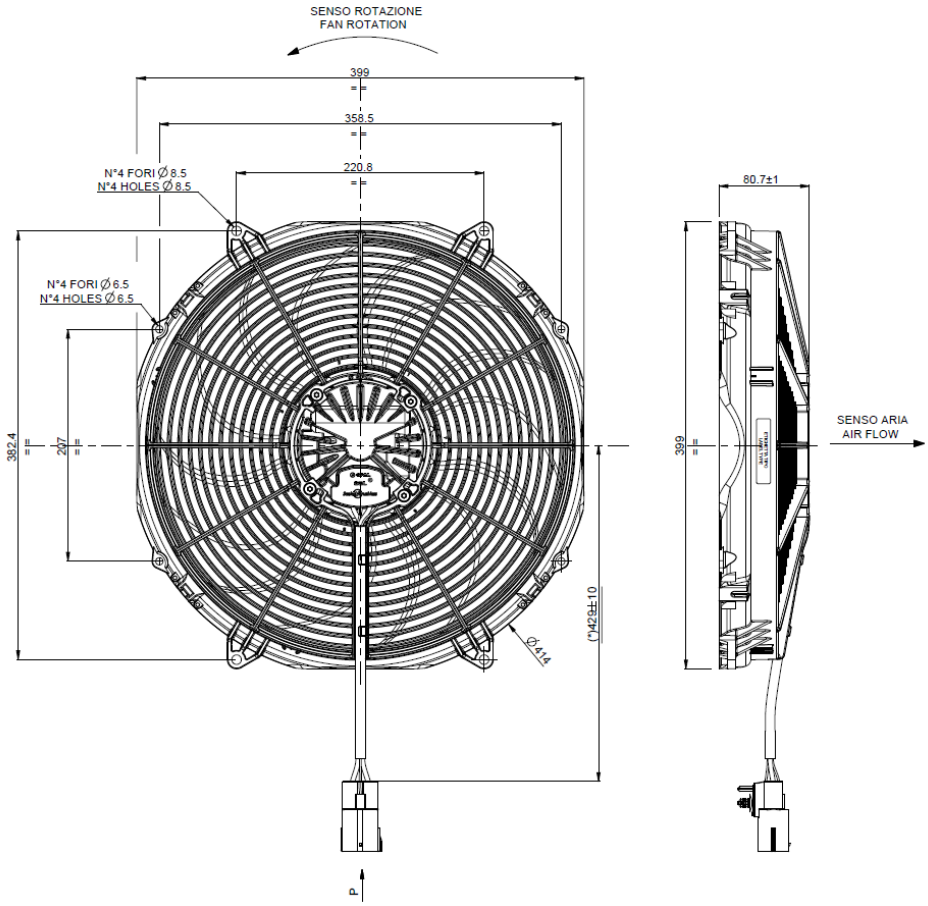
3 Air performance at maximum speed



Air density nnn kg / m3 - Test number: #12207 – Test bench compliant to ANSI AMCA 210
TAMB = 20 ℃ ± 5 ℃ - UB = 13.0 V at the Drive conn ector

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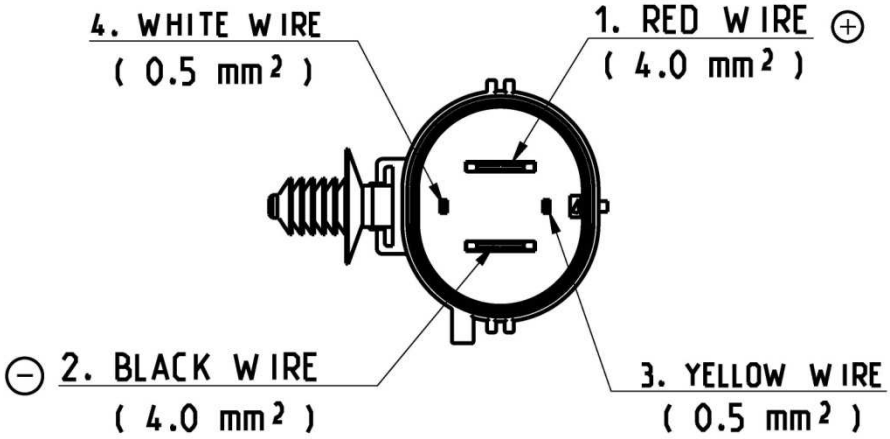
4 Mechanical data



All dimensions are expressed in mm. Use M6 screws for fixing – nominal tightening torque 3+1/0 Nm

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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	7157-3582-90	7157-3582-90	7158-3030-50	7158-3030-50
Pin p/n	7114-3251	7114-3251	7114-4102-02	7114-4102-02
Section [mm^2]	4.0	4.0	0.5	0.5

For abbreviations see chapter **Drive** pin functions
NOTE: Never handle the fan module via the cable harness

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6 Further Features

Compliance		72/245/EC and updates - Automotive EMC directive (P. Rubini)
		ECE Reg. 10-03 - Electromagnetic compatibility (P. Rubini)
		2002/95/EC RoHS - Hazardous Substances (P. Rubini) (
		2000/53/EC and updates - End-of Life Vehicle (P. Rubini)
Ingress Protection		IP 68 and IP6K9K design (P. Rubini)
Allowed power supply max ripple	rms	1 % - contact SPAL for special needs (P. Rubini)
Fuse protection		An automotive fuse according ISO8820 part 3 must be chosen and used by the customer in the application wire harness.

7 Measurement conditions

The below conditions are assumed:

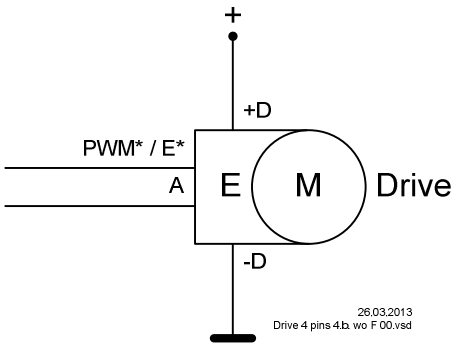
- T_{AMB} = 20 ℃ ± 5 ℃ and
- Supply voltage **UB** = 13.0 V at the **Drive** connector

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:

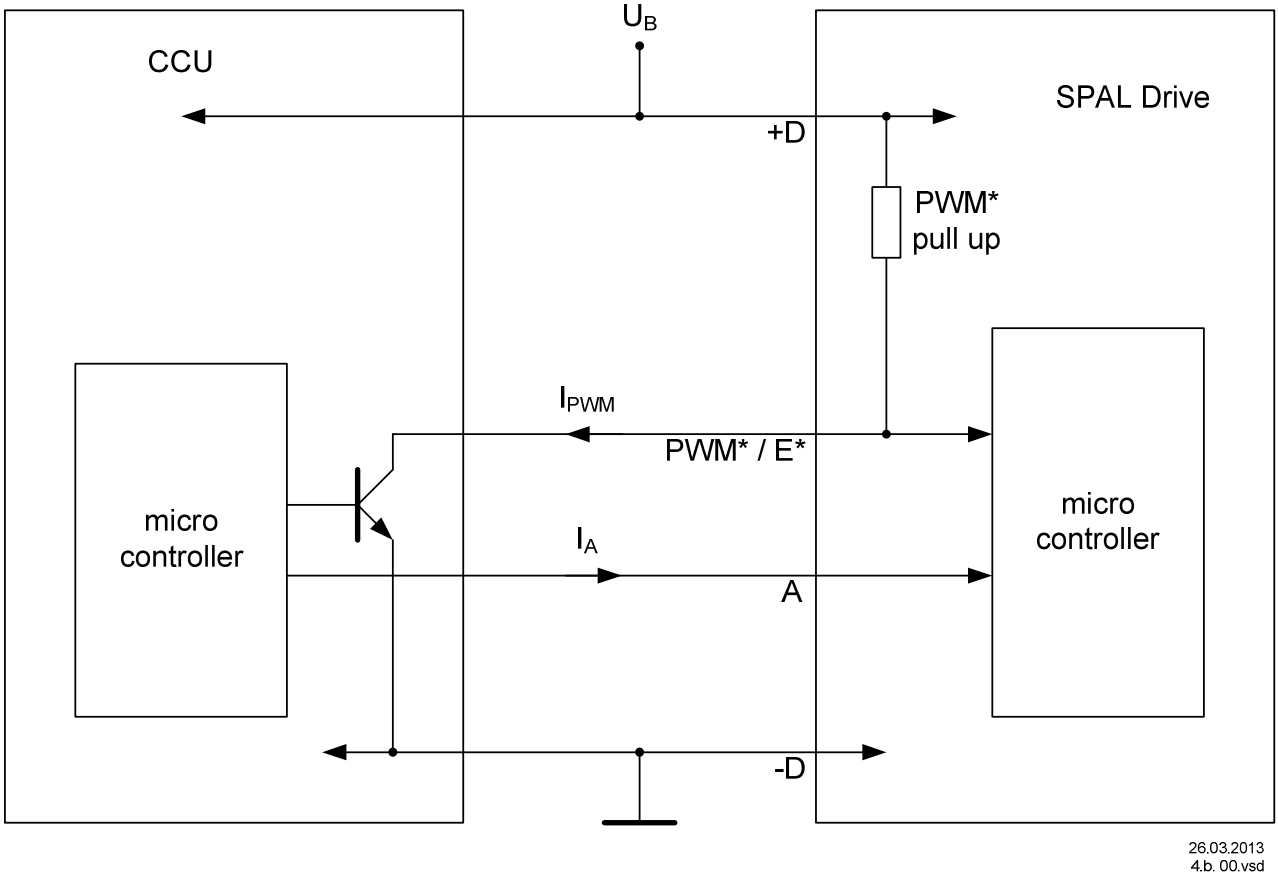
1. Input: digital PWM input / active low: PWM* / E*
2. Input: analog input: A

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* pull up) located in the Drive electronics to determine the recessive level.
This pull up resistor is connected to the supply voltage plus: +D / U_B.
The dominant level on the input PWM* / E* is low level, provided by the switching to ground stage depicted in the above figure as a bipolar npn transistor in the CCU.

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

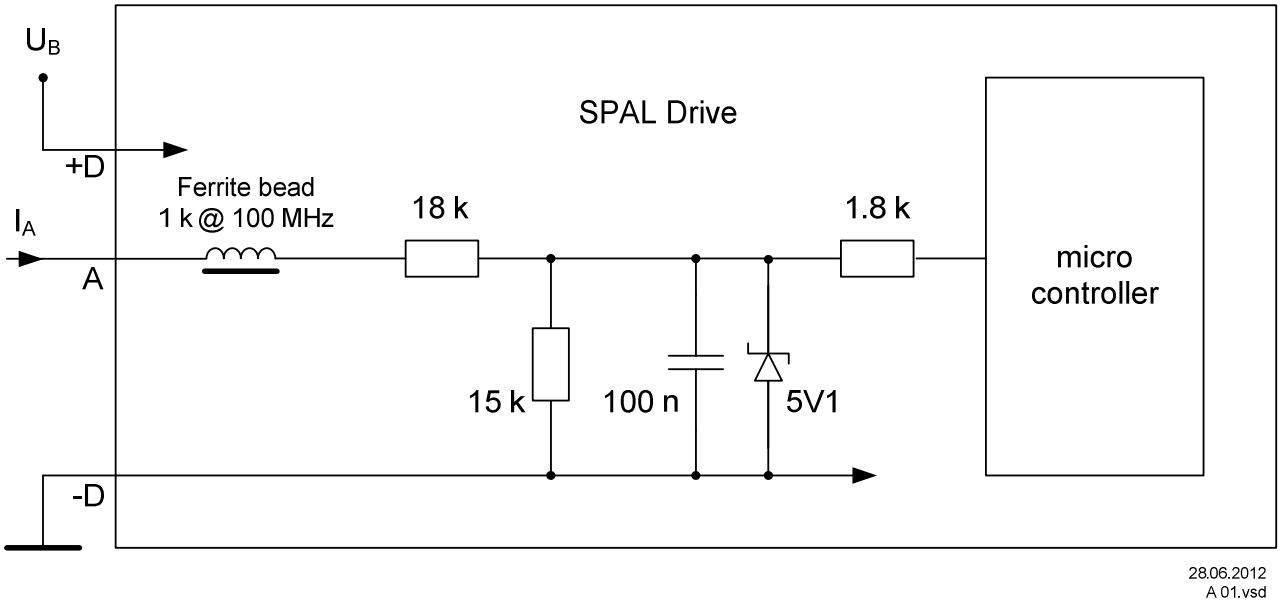
The input PWM* / E* is used to wake up the Drive from Quiescent current mode. Any PWM duty cycle that guarantees a pulse going to the dominant level for more than T_{wakeup} will wake up the Drive electronics.

Parameters	Min	Typical	Max	Unit	Denomination
PWM* / E* frequency range	50	100	500	Hz	f_{PWM} 1)
PWM* / E* duty cycle range	0		100	%	dc_{min} .. dc_{max}
PWM* / E* high level voltage	U_B * 0.65			V	U_{PWMH}
PWM* / E* low level voltage			U_B * 0.40	V	U_{PWML}
PWM* / E* resolution		1		%	dc_{resol}
PWM* / E* accuracy		1		%	dc_{accu}
PWM* / E* current	-10 %	2.7	+10 %	mA	I_{PWM*}
PWM* / E* wakeup pulse	150			µs	T_{wakeup}
PWM* pull up		4.7		kΩ	

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11 Interface hardware for Analog control: pin A

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 µA	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)

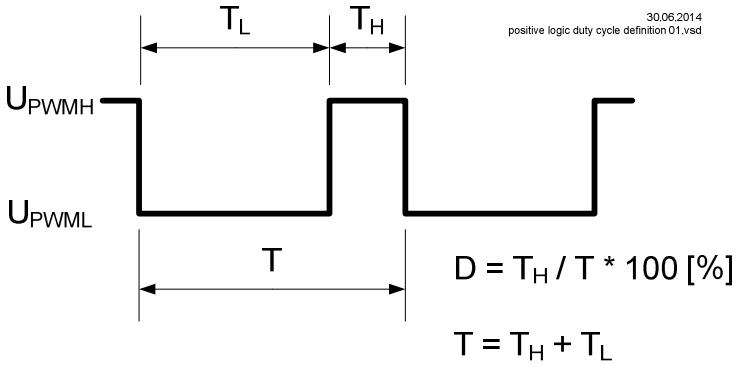
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- if the analog signal on pin analog input A has a value where the Drive is asked to run (see chapter 12.4).

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”.

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

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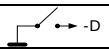
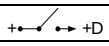
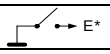
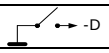
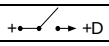
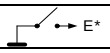
Over current	The Drive will stop if the over current safety threshold is reached.	
Drive overheated	Fan speed is reduced in case of overheating detection (derating). Over the max operating temperature, the Drive will stop.	n/a
Under and Over voltage	If the supply voltage is outside the specified range 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

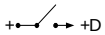
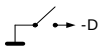
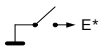
In all cases the Drive tries to recover from failures when a valid PWM signal is detected which asks the Drive to run.
(*) Notification is not available as no feedback is provided to the CCU.

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13 Operating modes

The Drive interface (the connection between the Drive and the user system) can be done in 8 ways depending if and how the two signal inputs PWM* / E* and A are used. See the following table:

Mode description	**Mode**	+D	-D	PWM* / E*	A	**Pins to connect**
On / off to minus	1	+		-	+	4
On / off to plus	2		-	-	+	4
On / off with enable low	3	+	-		+	4
Analog control 1	4	+		-	analog	4
Analog control 2	5		-	-	analog	4
Analog control with enable low	6	+	-		analog	4
Digital control	7	+	-	PWM	n. c.	3
Mixed analog / digital control	8	+	-	PWM	analog	4

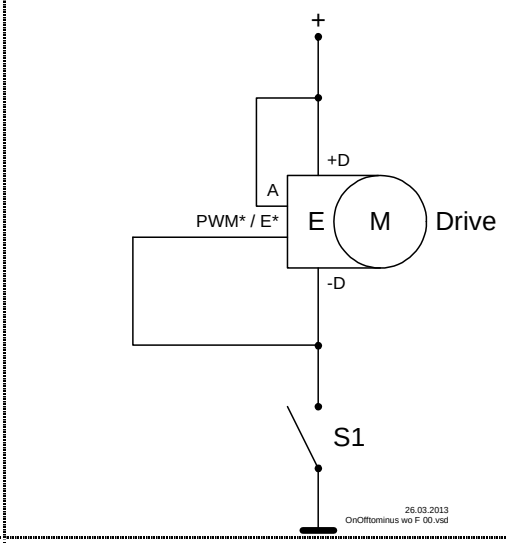
analog : analog voltage signal (input)
PWM : PWM signal (input)
n. c. : not connected
 : switch of the Drive positive supply to plus
 : switch of the Drive negative supply to minus / GND
 : switch active low enable input to minus / GND

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Interface mode 1: On / off to minus

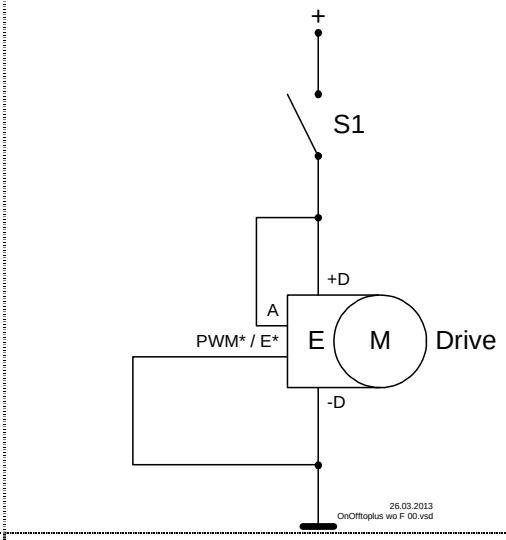
When the switch S1 is switched on the Drive goes after the initialization of the electronics to full speed.

This mode can be used if the CCU which controls the Drive has limited capabilities or does not even exist. The Drive is just switched on and off via any power switch like a relay, MOS FET, or even just a switch.
The appropriate current rating for this “switch” has to be dimensioned according to the current consumption of the Drive.



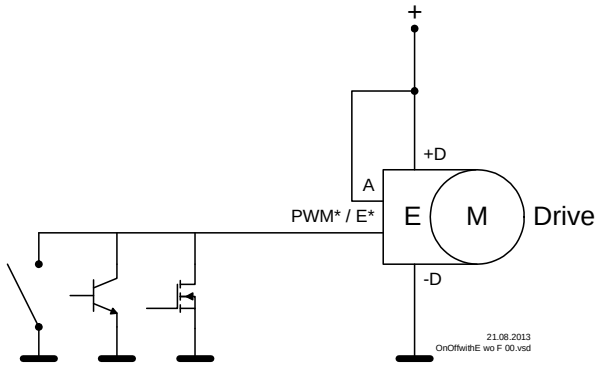
Interface mode 2: On / off to plus

When the switch S1 is switched on the Drive goes after the initialization of the electronics to full speed.
This mode can be used if the CCU which controls the Drive has limited capabilities or does not even exist. The Drive is just switched on and off via any power switch like a relay, MOS FET, or even just a switch.
The appropriate current rating for this “switch” has to be dimensioned according to the current consumption of the Drive.



Interface mode 3: On / off with enable low

The Drive can stay always on supply voltage and is controlled by a low current enable input which can be driven by simple low cost low side signal driver in the CCU.
When the enable input PWM* / E* goes to high, the Drive goes after a short time into the quiescent current mode.
When the enable pin PWM* / E* is driven low, the Drive goes to full speed after the initialization of the electronics.
This mode can be used if the CCU which controls the Drive has limited capabilities or does not even exist. The appropriate sink current rating of the driver for the enable pin PWM* / E* has to be dimensioned according to the current consumption of the pin PWM* / E*.
The circuit structure to drive the pin PWM* / E* can be any active low “open collector”.

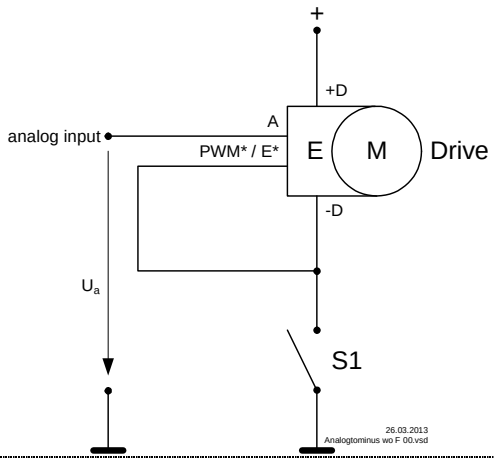


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Interface mode 4: Analog control 1

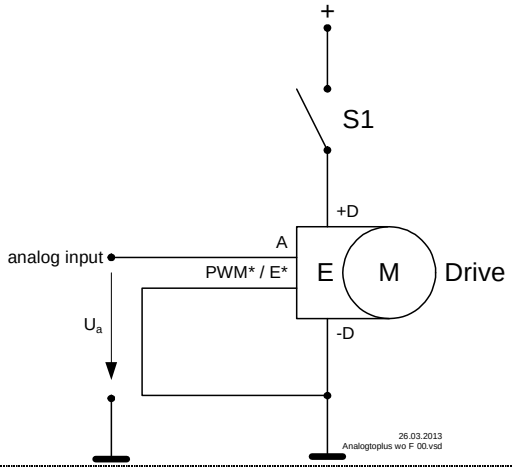
When the switch S1 is switched on the Drive goes after the initialization of the electronics to the speed requested by the analog input A.

The appropriate current rating for this “switch” has to be dimensioned according to the current consumption of the Drive.



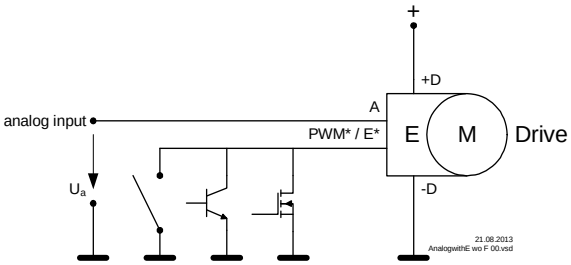
Interface mode 5: Analog control 2

When the switch S1 is switched on the Drive goes after the initialization of the electronics to the speed requested by the analog input A.
The appropriate current rating for this “switch” has to be dimensioned according to the current consumption of the Drive.



Interface mode 6: Analog control with enable low

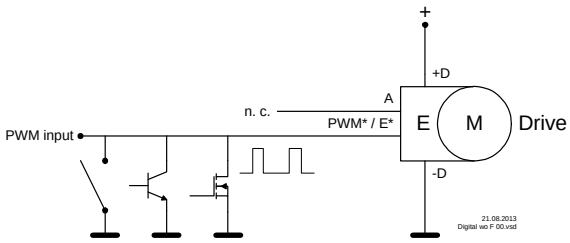
In mode 6 the Drive can stay always on supply voltage and is controlled by a low current enable input which can be driven by simple low cost low side signal driver in the CCU.
When the enable input PWM* / E* goes to high, the Drive goes after a short time into the quiescent current mode.
When the enable pin PWM* / E* is driven low, the Drive goes to the speed requested by the analog input A after the initialization of the electronics.
The appropriate sink current rating of the driver for the enable pin PWM* / E* has to be dimensioned according to the current consumption of the pin PWM* / E*.
The circuit structure to drive the pin PWM* / E* can be any active low “open collector”.
In this operating mode the supply voltage plus is usually connected permanently. To run the Drive first the pin PWM* / E* has to be connected to supply voltage minus and afterwards the Drive speed can be then controlled with an analog voltage on the pin A.



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Interface mode 7: Digital control

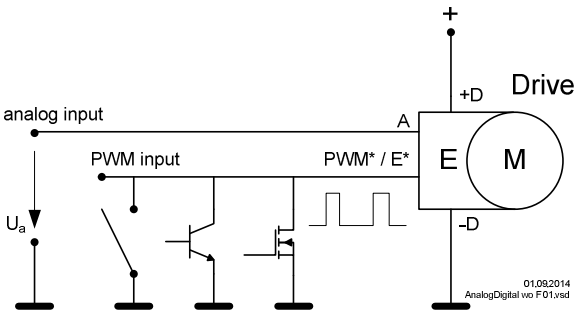
In mode 7 the Drive can stay always on supply voltage and is controlled by a low current PWM and enable PWM* / E* input which can be driven by simple low cost low side signal driver in the CCU.
When the enable input PWM* / E* goes to high, the Drive goes after a short time into the quiescent current mode.
When the enable pin PWM* / E* is driven with PWM, the Drive goes to the speed requested by the duty cycle after the initialization of the electronics.
The appropriate sink current rating of the driver for the enable pin PWM* / E* has to be dimensioned according to the current consumption of the pin PWM* / E*.
The circuit structure to drive the pin PWM* / E* can be any active low “open collector”.
In this operating mode the supply voltage plus is usually connected permanently. To run the Drive on the pin PWM* / E* a PWM signal has to be applied and with the duty cycle of the PWM signal the Drive speed can be then controlled.



Interface mode 8: Mixed analog / digital control
In mode 8 the Drive can stay always on supply voltage and is controlled by a low current PWM and enable PWM* / E* input which can be driven by simple low cost low side signal driver in the CCU.

When the enable input PWM* / E* goes to high, the Drive goes after a short time into the quiescent current mode.

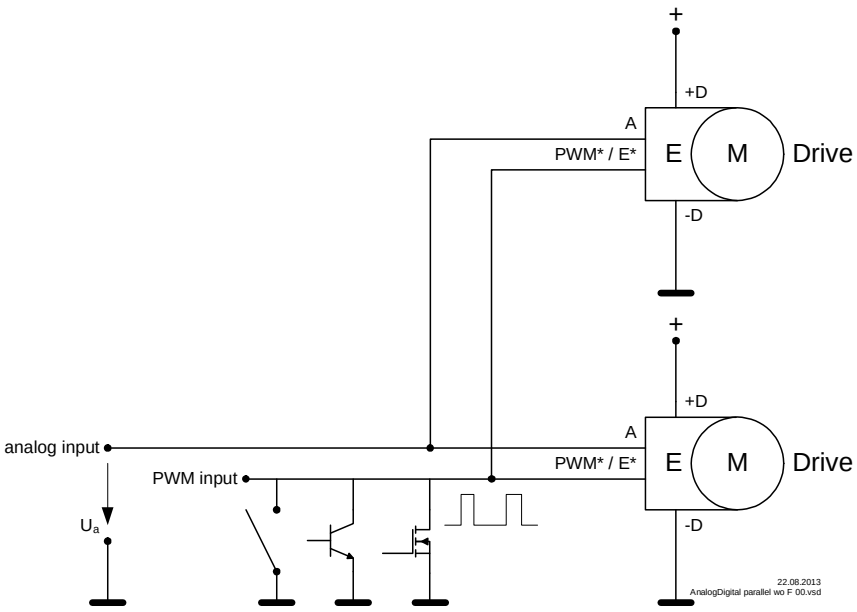
When the enable pin PWM* / E* is driven low (switched to supply voltage minus), the Drive goes to the speed requested by the analog input A after the initialization of the electronics (if the electronics is not already activated).
When the enable pin PWM* / E* is driven with PWM, the Drive goes to the speed requested by the duty cycle after the initialization of the electronics (if the electronics is not already activated).
The appropriate sink current rating of the driver for the enable pin PWM* / E* has to be dimensioned according to the current consumption of the pin PWM* / E*.
The circuit structure to drive the pin PWM* / E* can be any active low “open collector”.
In this operating mode the supply voltage plus is usually connected permanently. To run the Drive on the pin PWM* / E* a PWM signal has to be applied and with the duty cycle of the PWM signal the Drive speed can be then controlled. If the pin PWM* / E* is switched to supply voltage minus the Drive speed can be then controlled with an analog voltage on the pin A.
So a mixed control with either digital or analog input is possible. The priority has the digital PWM signal.



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14 Interface parallel configuration

The Drives can be used in a parallel configuration in the PWM driven modes as well as in analog driven modes and also in the combines analog / PWM mode in such a way that the control lines are connected in parallel as shown in below for the example of two Drives.



There is no limitation from the Drive‘s point of view in paralleling them. Nevertheless from the CCU’s point of view it has to be considered that all of the Drives needs a certain current each on the signal lines PWM* / E* and A. This has to be taken into account for dimensioning the driver stage which controls digitally via the PWM* / E* inputs of the Drives or which controls analog via the A inputs of the Drives. The output driver stage of the CCU needs to be capable of driving minimum the input currents of PWM* / E* and / or A times the number of the Drives.

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15 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			
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

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

16 Document change history

Initial document author: SPAL TEAM
Latest revision: 000

Document author	Date	Revision	Comment
SPAL TEAM	17.03.2014	000	Initial Version. The Hardware and Software functions are copied from the document: P:\(S)BL generale\(S)BL interfaces

Table 2: Document change history

Document status: released

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