Datasheet



Description: F86-12BL8520-42S
Fan diameter: ϕ405mm
Rated voltage: 13.6V DC

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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
℃	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 table

Key Word	Descriptions
CCU	Custom Control Unit
Drive	Motor with axially integrated electronics
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

Fan diameter：ϕ405mm

Nominal voltage ： 12V

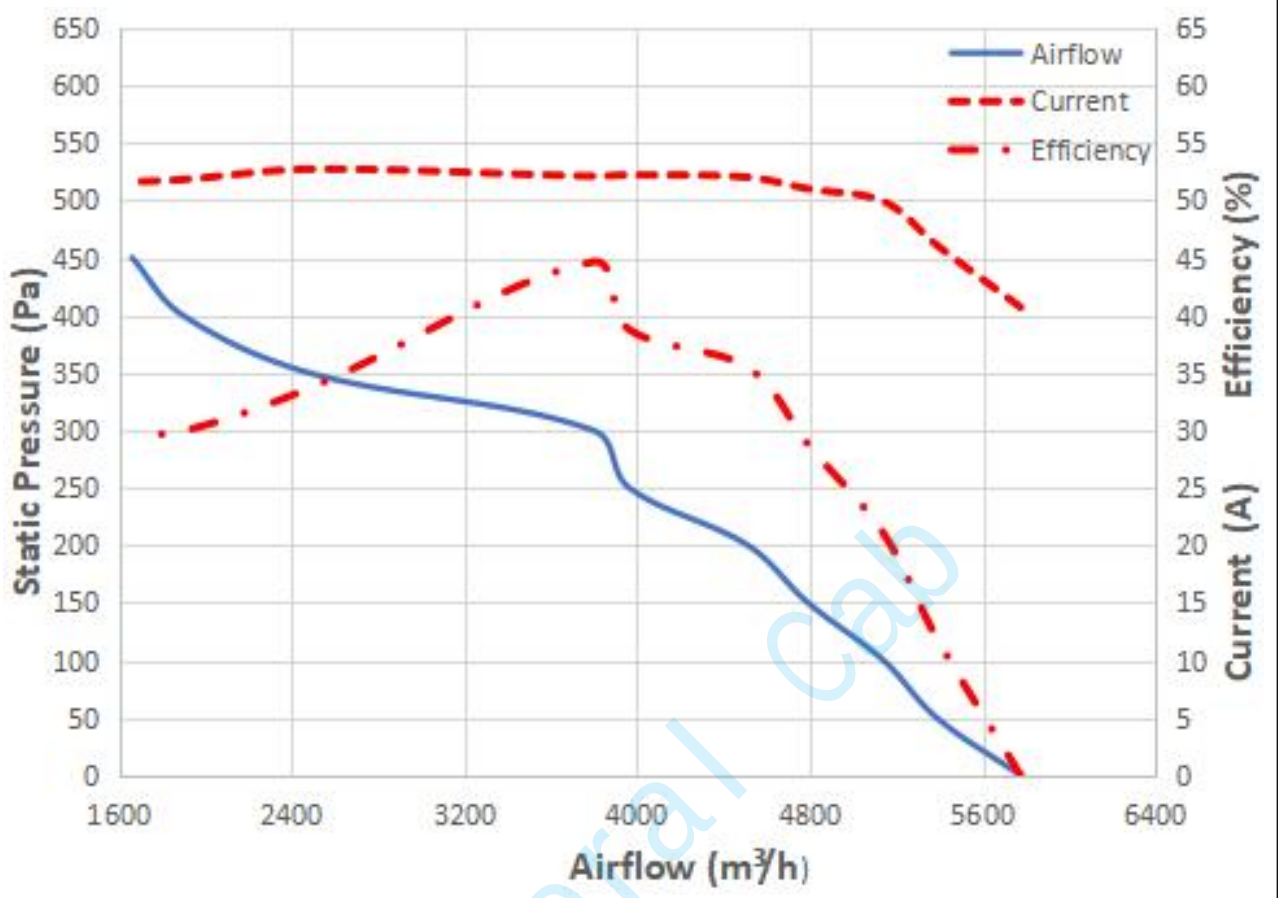
4.Features

Max fan speed	rpm	2800
Min fan speed	rpm	800
Sound pressure level at max speed	dBA	80- at 1 m from the fan module - lateral side (2)
Weight	kg	3.45
Operating supply voltage range	V	9.0 ~ 16.0 at the Drive connector
Supply voltage to reach max speed	V	13.6 ~ 16.0 at the Drive connector
Operating ambient temperature range	°C	-40 ~ +120
Speed derating threshold	°C	+85 (1)
Storage temperature range	°C	-40 ~ +125
Lifetime	h	Up to 40000H (depending on mission profile)
Time from 0 rpm to max speed	s	16 (20°C)
Load dump protection (Pulse 5b)	V	35 (Pulse peak value 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) Due to the thermal inertia of the system, rapid temperature changes will not cause the fan to derate. Overload may cause the fan to derate prematurely. (2) The noise value in the free-air intake state is for reference only and does not represent the actual noise of the fan in application, because the noise of the fan in application will be affected by the water tank, air guide cover, etc.		

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5.Air Performance

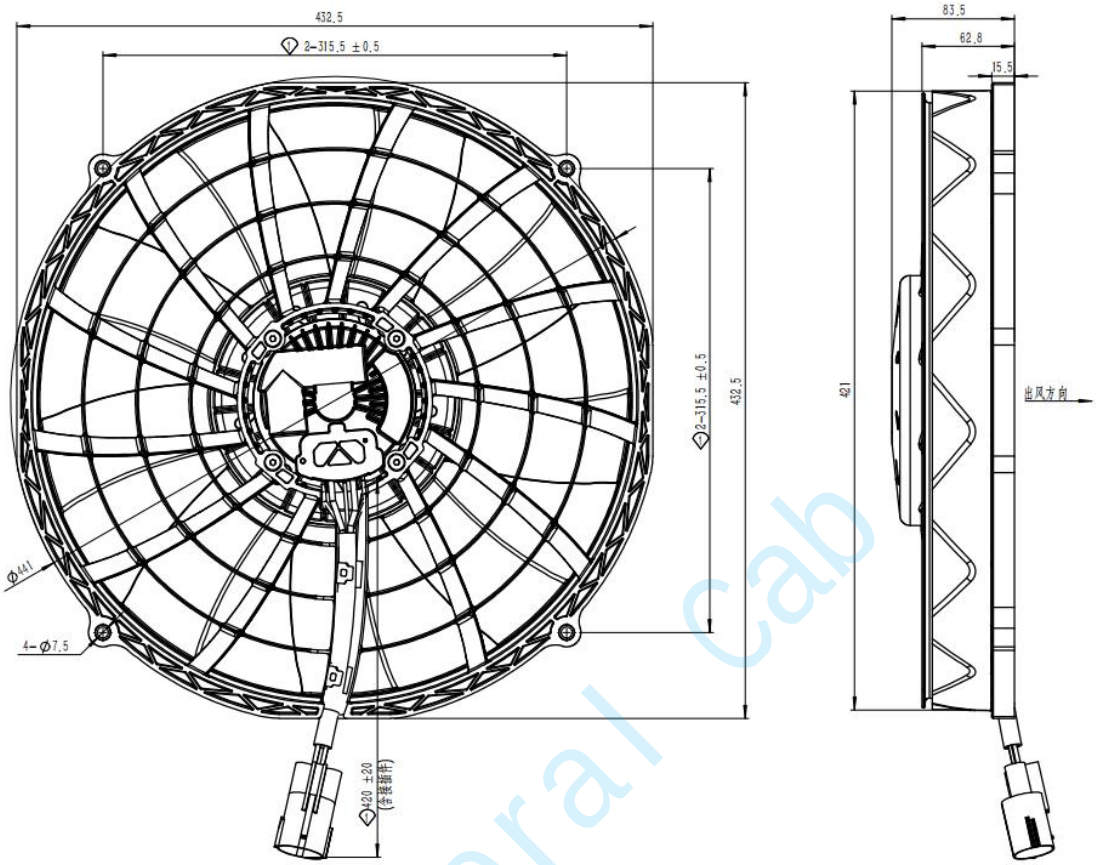


Power Supply Voltage	13.6V (at the connection)	Test Number	-	Test equipment setup in accordance with ANSI AMCA 210
Air Density	1.16 kg/m³	Ambient Temperature	20°C ± 5°C	

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6.Mechanical Data

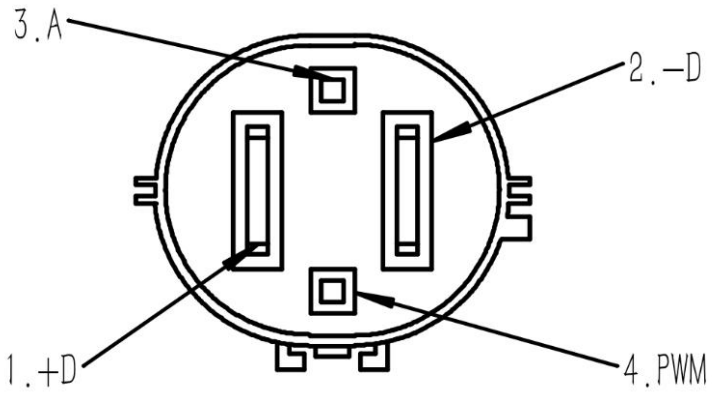


All the dimensional units in the above figures are in millimeters (mm). M6 bolts are used to fix the fan, and the nominal maximum tightening torque is 3(+1/0) Nm. The definition of the nominal tightening torque is applicable to new, clean, and lubricated-free bolts.

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7.Connector and Wires



Connector： YAZAKI				
Connector Part Number ：7282-8497-90				
Identification(*)	+D	-D	A	PWM/E
Pin Number	1	2	3	4
Wire Color	Red	Black	White	Blue
Sealing p/n	7158-3036-70	7158-3036-70	7158-3030-50	7158-3030-50
Pin p/n	7114-3273-02	7114-3273-02	7114-4102-02	7114-4102-02
Section [mm^2]	10.0	10.0	0.75	0.75

* For abbreviations, please refer to the chapter on drive pin functions.

Remarks: It is prohibited to pick up the fan directly by the wire harness.

8.Further Features

Compliance		ECE Reg.10-07 and its updated content-Unified Provisions on the Approval of Vehicles in Respect of Electromagnetic Compatibility
		2002/95/EC RoHS - Directive on the Restriction of the Use of Hazardous Substances
		2000/53/EC and its updated content-End-of-Life Vehicles (ELV) Directive

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Ingress Protection		IP68 and IP6K9K
Allowed power supply max ripple	rms	1%
Fuse protection		According to the requirements of ISO8820 - 3, the specified fuses must be used in the circuit. Each fan should be equipped with a separate fuse.

9.Measurement Conditions

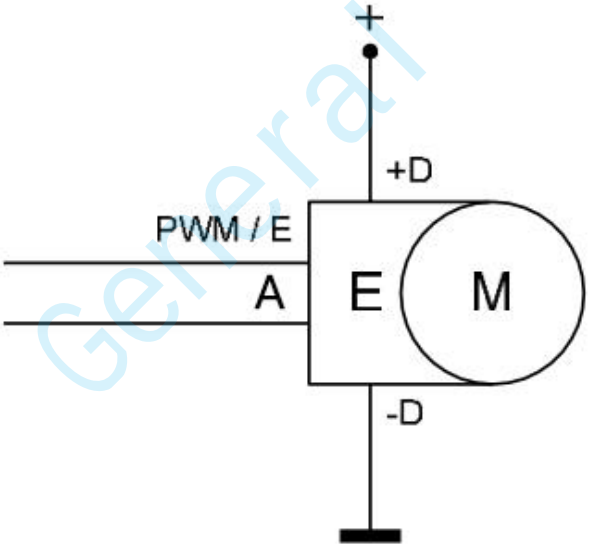
Unless otherwise specified, the below conditions are assumed:

- T_{AMB} = 20℃±5℃ and
- U_B = 13.6V±0.2V (at the Drive connector)

10.Hardware Function

10.1.Fan Drive

The drive diagram is as follows:



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

10.2.Drive pin Functions

The electrical Drive interface consists of 4 pins:

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

10.3 Interface Hardware for Digital Control: pin PWM/E

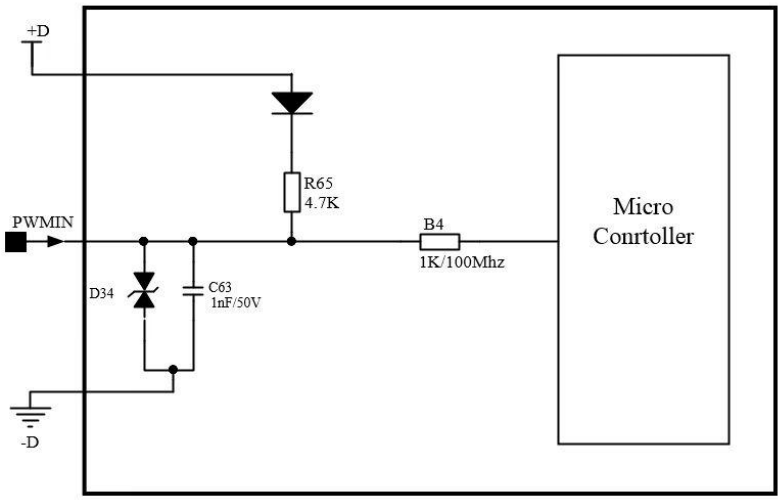
10.3.1. Digital PWM Input / Active Low: PWM/E

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.

Parameter	Min	Typical	Max	Unit	Denomination
PWM/E Frequency Range	50	100	1000	Hz	f_{PWM}
PWM/E Duty Cycle Range	0		100	%	Dc_{min} ..Dc_{max}
PWM High Level Voltage	UB * 0.65			V	U_{PWMH} 1)
PWM Low Level Voltage			UB * 0.40	V	U_{PWML} 1)
PWM/E Resolution		1		%	Dc_{resol}
PWM/E Accuracy		1		%	Dc_{accu}
PWM/E Current			5	mA	I_{PWM}
PWM/E Wake-up Voltage	UB – 2			V	U_{PWMWU}
PWM/E Wake - up Pulse	150			μs	T_{wakeup}
PWM* pull up resistor		4.7		KΩ	

The schematic diagram of the digital PWM input / active low is shown as follows:

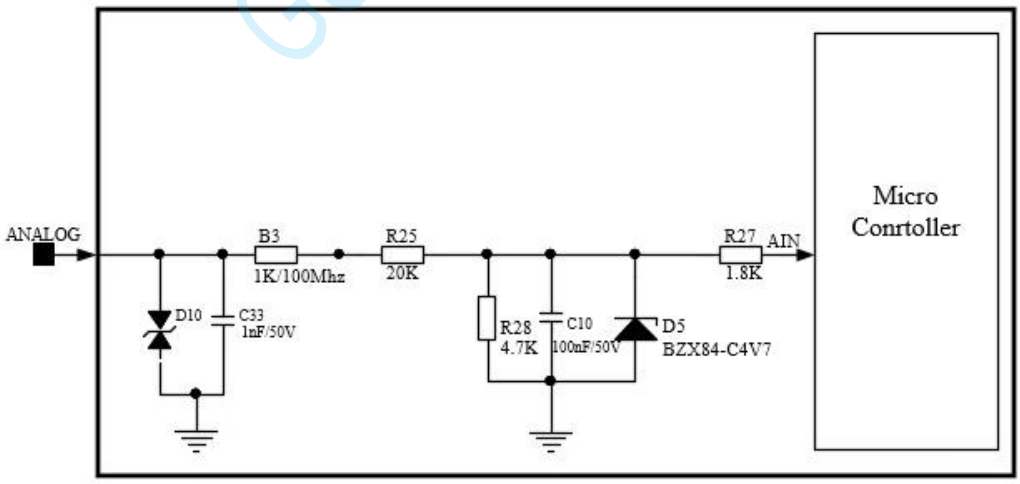
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10.4. Interface Hardware for Analog Control: pin A

Parameter	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			5	mA	I_{Amax}

The schematic diagram of the analog input: A is shown as follows:



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11.Software Functions

11.1.Drive Modes

The Drive has three working modes, and the main difference lies in the different Drive current consumption:

1. Quiescent current mode
2. Electronics active mode
3. Run 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	< 50 mA	0
3	Run mode	Depends on the required speed and on the load	Depends on the duty cycle of the PWM signal

When the PWM*/E* receives a 100% duty cycle signal, the Drive enters the Quiescent current mode. The time for the Drive to enter the Quiescent current mode depends on the actual PWM fundamental frequency and the number of samples for authenticity checking. After detecting that the PWM signal is a 0% Drive signal, the Drive will enter the Quiescent current mode after waiting for another 2 - 10 seconds.

When the PWM duty cycle is at any value between 0 and 100%(excluding 100%) and meets the conditions in Chapter 10.3, the Drive will enter the Electronics active mode.

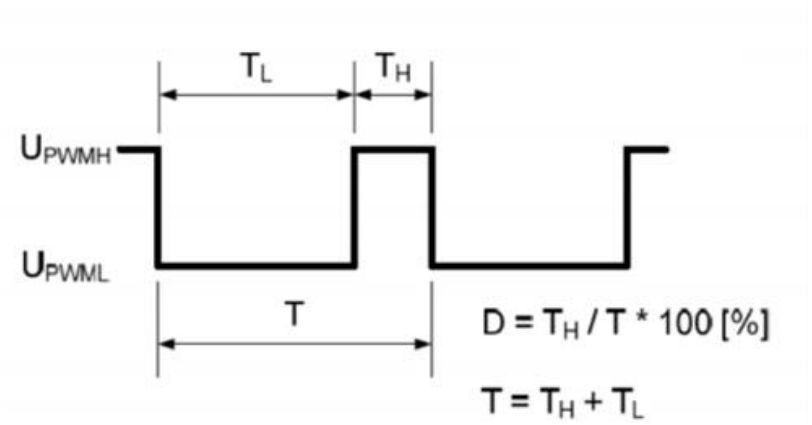
The condition of the Drive enter the Run mode:
If the duty cycle of the PWM signal reaches the proportion required for the Drive to run, and the PWM duty cycle value is valid according to the chapter 11.2.

If the analog signal on pin analog input A has a value where the Drive is asked to run, (refer to 11.3).

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11.2.Digital Control: Transfer Function PWM Input

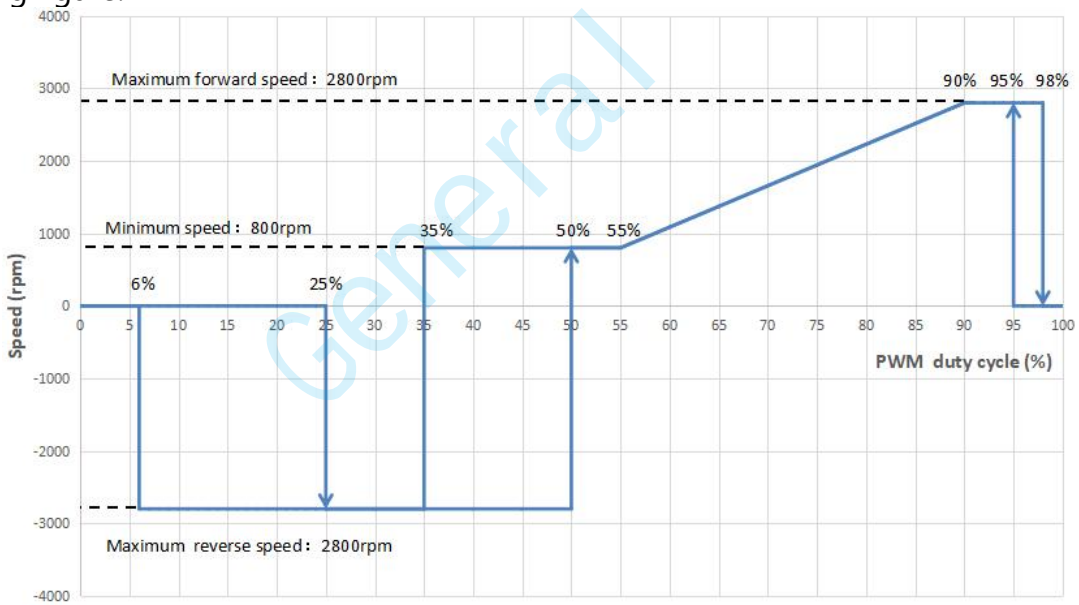
The transfer function PWM input refers to the relationship between the Drive speed and the duty cycle of the pin digital PWM input/active low:



The definition of the duty cycle in the above figure is also called the positive logic duty cycle. Refer to the following definitions:

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

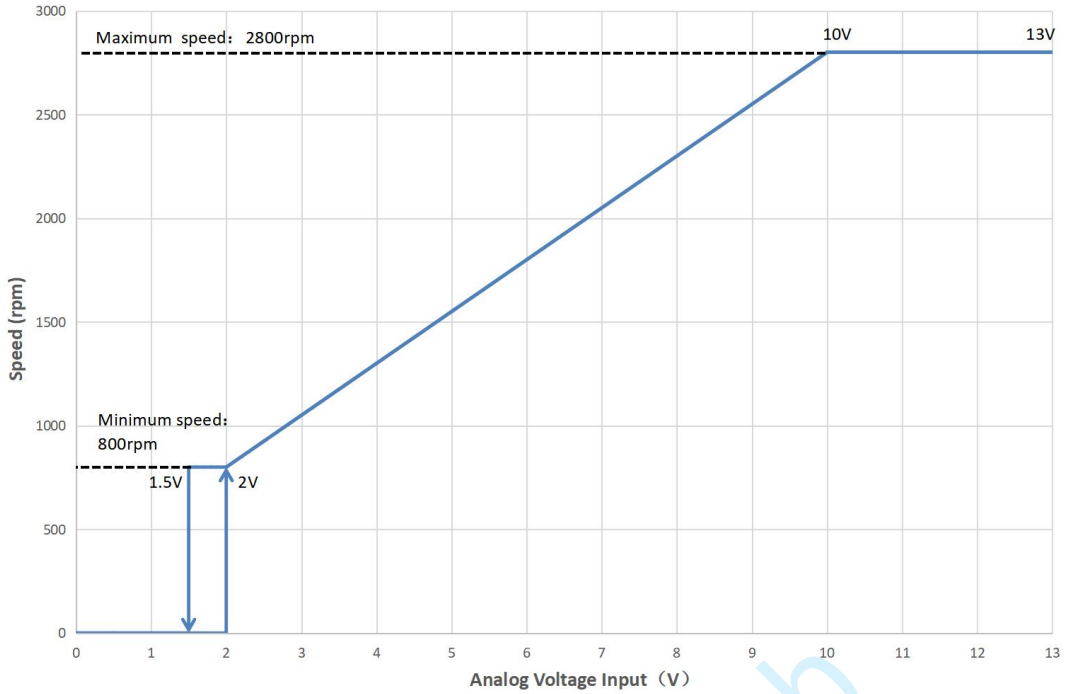
Based on the definition of the duty cycle, the transfer function PWM input is shown in the following figure.



11.3. 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.

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11.4.Drive Protection Modes

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

Protection Mode	**Fault Handling**
Drive Blocked	Once the fan stall is detected, the following strategy will be executed: The controller tries to automatically start 10 times (restart without power - off), with an interval of 10 seconds each time. If it still doesn't recover after 10 attempts, the fan will not stop, and it will keep trying to start at 10s intervals.
Over-current	Once the fan over-current is detected, the following strategy will be executed: The controller stops outputting, and then tries to automatically start 10 times (restart without power-off), with an interval of 10s each time. If it still doesn't recover after 10 attempts, the fan will automatically stop. To resume operation, it needs to be manually powered off and restarted.
Drive Overloaded	When drive overload is detected, the fan will operate at a reduced speed while maintaining a constant power, and it will not stop.
Drive Overheated	When drive overheating (derating temperature point) is detected, the fan will operate at a reduced speed; when the maximum operating temperature point is exceeded, the controller stops outputting. When the temperature returns to normal, the fan resumes operation.
Over/Under voltage	If the power supply voltage exceeds the operating voltage range, the controller stops outputting. When the voltage returns to normal, the fan resumes operation.

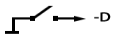
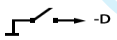
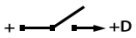
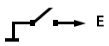
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In any case, when the Drive receives a valid PWM signal requiring it to run, the drive will try to recover from failures.

12.Application Instructions

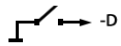
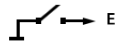
12.1.Drive Interface

Based on the usage of PWM/E and the signal pin A inputs, there are 8 ways to configure the drive interface (connection between the drive and the user system) (see the table below):

Mode Description	Mode	+D	-D	PWM/E	A	Pin	
On/Off to Negative Pole	1	+		–	+		4
On/Off to Positive Pole	2		–	–	+		4
On/Off to Enable Terminal at Low Level	3	+	–		+		4
Analog Control 1	4	+		–	analog		4
Analog Control 2	5		–	–	analog		4
Active-Low Analog Control	6	+	–		analog		4
Digital Control	7	+	–	PWM	n.c.	3	
Analog/Digital Mixed Control	8	+	–	PWM	analog		4

- **+D** : Drive Positive Power Supply
- **–D** : Drive Negative Power Supply
- **PWM/E** : Active-Low PWM Input
- **A** : Analog Input
- **+** : Connected to Positive Pole
- **–** : Connected to Negative Pole
- **analog** : Analog Voltage Signal
- **PWM** : PWM Signal

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- **n.c.** : Not Connected
-  : Switch between Drive Positive Power Supply and Positive Pole
-  : Switch between the Drive Power Supply and the Negative Pole/Ground
-  : Switch between the active-low enable terminal input and the Negative Pole/Ground

12.2 Interface Mode 1: On/Off to the Negative Pole

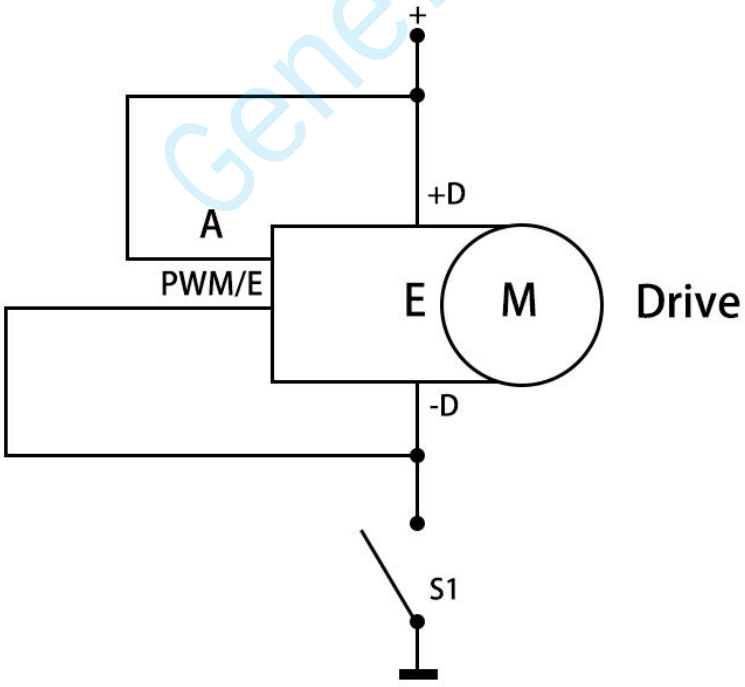
For this product, to implement On/Off to the Negative Pole at the drive interface, the following is required:

- Connect A to +D
- Connect PWM/E to –D

See the diagram below. When S1 is closed, the drive enters the max speed operation state after circuit initialization.

This mode is used when the CCU driving the controller has limited capability or when such a CCU does not exist. The drive is only turned on or off by a power switch, such as a relay, MOSFET, or a mechanical switch.

The rated current value of this switch is determined by the current consumed by the drive.



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12.3 Interface Mode 2: On/Off to Positive Pole

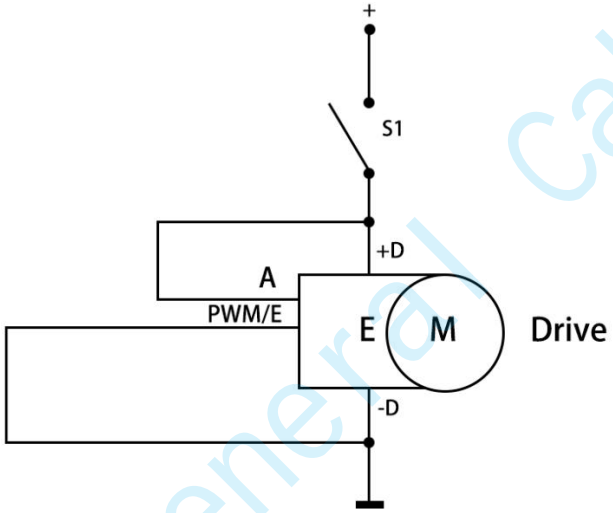
To implement On/Off to Positive Pole at the drive interface for this product, the following is required:

- Connect A to +D
- Connect PWM/E to –D

See the diagram below. When S1 is closed, the drive enters the max-speed operation state after circuit initialization.

This mode is used when the CCU driving the controller has limited capabilities or does not exist. The drive is only turned on or off by a power switch, such as a relay, MOSFET, or mechanical switch.

The rated current value of this switch is determined by the current consumed by the drive.



12.4 Interface Mode 3: On/Off with Enable Low

To implement the low-active On/Off mode at the drive interface for this product, the following is required:

- Connect A to +D
- Use PWM/E as a low-active enable terminal

See the diagram below. In Mode 3, the drive can remain under supply voltage at all times, controlled by a low-current enable input driven by a low-cost, low-side signal driver in the CCU.
When the enable input PWM/E is at a dominant level, the drive enters the quiescent current mode after a short delay.

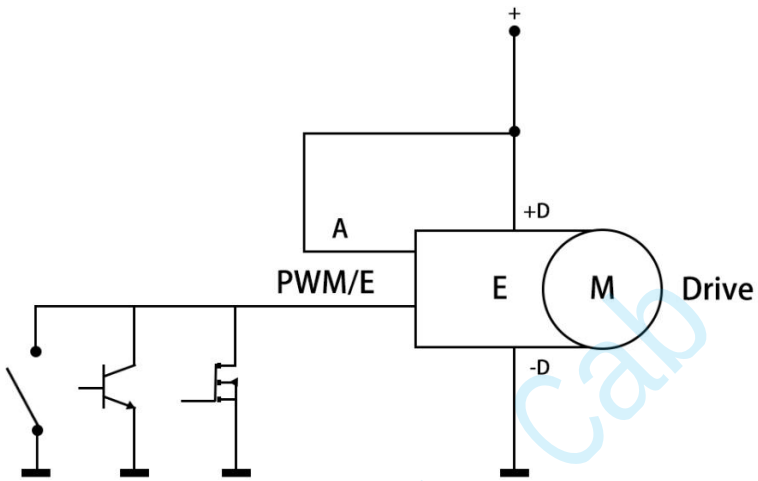
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When the enable input PWM/E is at a recessive level, the drive enters the max-speed operation state after circuit initialization.

This mode is used when the CCU for controlling the drive has limited capabilities or when such a CCU does not exist.

The rated sink current value of the PWM/E enable input of the driver is determined by the current value consumed at the PWM/E terminal.

The circuit structure of the drive PWM/E is a typical active-low "open collector" configuration, as shown in the diagram below.



12.5. Interface Mode 4: Analog Control 1

For this product, to implement the Analog Control 1 mode in the drive interface, the following are required:

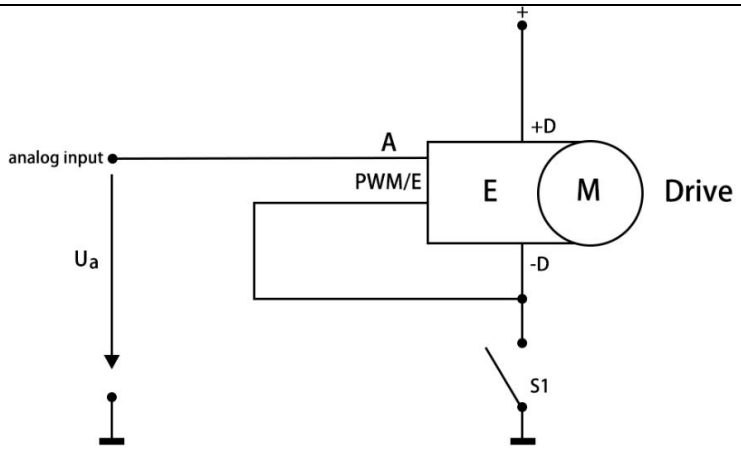
- Connect A to the analog input.
- Connect PWM/E to -D.

See the diagram below. When S1 is turned on, after the drive initializes the circuit, it will operate at the speed required by the analog input signal at terminal A.

The rated current value of this switch is determined by the current value consumed by the drive.

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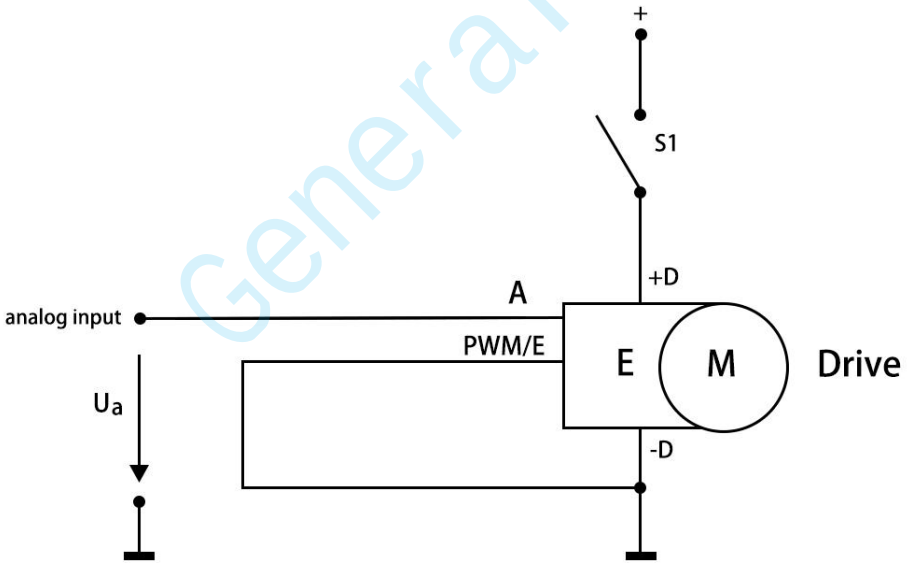
12.6. Interface Mode 5: Analog Control 2

For this product, to implement the Analog Control 2 mode via the drive interface, the following is required:

- Connect A to the analog input.
- Connect PWM/E to -D.

Refer to the diagram below. When S1 is turned on, after the drive initializes the circuit, it will operate at the speed specified by the analog input signal at terminal A.

The rated current value of this switch is determined by the current consumed by the drive.



12.7. Interface Mode 6: Active-Low Analog Control

For this product, to implement the active-low analog control mode via the drive interface, the following is required:

- Connect A to the analog input.

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- Configure PWM/E as an active-low enable terminal.

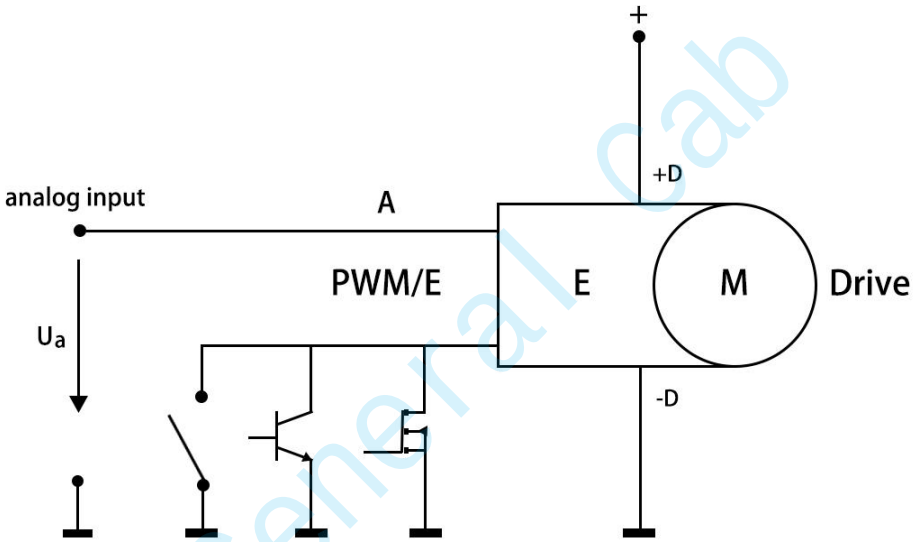
Refer to the diagram below. In Mode 6, the drive can remain at the power supply voltage level continuously and is controlled by the active-low current enable input. This recessive level is driven by the low-cost Low-side signal driver in the CCD.

When the PWM/E enable input is at a dominant level, the drive enters static mode after a short delay.

When the PWM/E enable input is at a recessive level, after the drive initializes the circuit, it will operate at the speed specified by the input signal at the analog input terminal A.

The rated sink current value of the PWM/E enable input of the driver is determined by the current value consumed at the PWM/E terminal.

The circuit structure of the drive PWM/E is a typical active-low "open collector" configuration, as shown in the diagram below.



In this operating mode, the positive pole of the power supply voltage is usually permanently connected. When the drive is operated for the first time, the PWM/E terminal must be connected to the negative pole of the power supply voltage. After that, the drive speed is controlled by the analog voltage at the pin A.

12.8. Interface Mode 7: Digital Control

For this product, to implement the digital control mode in the drive interface, the following is required:

- Input the PWM signal to PWM/E

See the diagram below. In Mode 7, the drive can maintain at the power supply voltage level and is controlled by the low-current PWM and the PWM/E input enable terminal. The

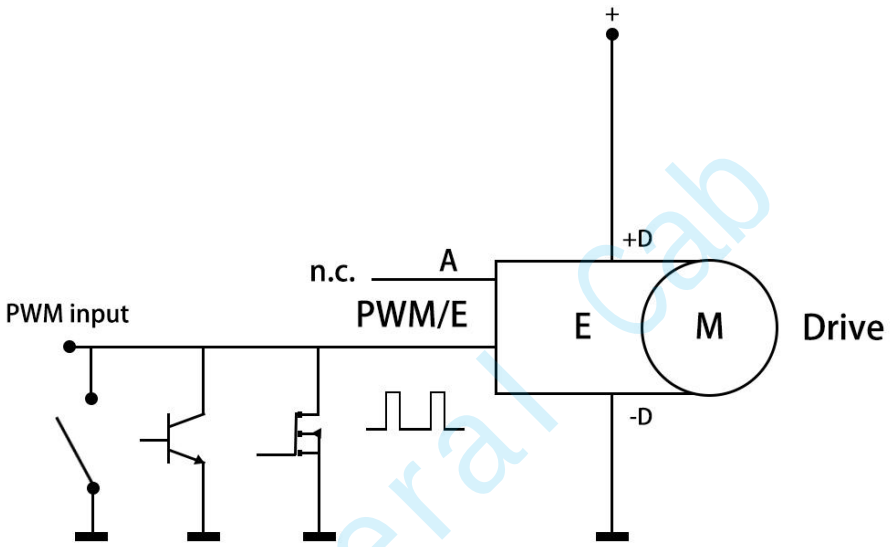
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PWM/E enable input signal is controlled by the low-cost Low-side signal driver within the CCU.

When the PWM/E enable input is at a dominant level, the drive enters the static mode after a short period of time. When the enable terminal PWM/E is driven by PWM, after the circuit initialization, the drive operates at the speed required by the duty cycle.

The rated sink current value of the driver's enable input terminal PWM/E is determined by the current value consumed at the PWM/E terminal.

The circuit structure of the drive PWM/E is a typical active-low "open collector" configuration, as shown in the diagram below.



In this operating mode, the positive pole of the power supply voltage is usually permanently connected. When operating the drive, the PWM signal must be input to the PWM/E terminal, and then the drive speed is controlled by the duty cycle of the PWM signal.

12.9. Interface Mode 8: Analog/Digital Hybrid Control

For this product, to implement the analog/digital hybrid control mode in the drive interface, the following are required:

- A is the analog input terminal.
- Input the PWM signal to PWM/E.

See the following figure. In Mode 8, the drive can maintain at the power supply voltage level and is controlled by the low-current PWM and the PWM/E input enable terminal. The

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PWM/E enable input signal is controlled by the low-cost Low-side signal driver within the CCU.

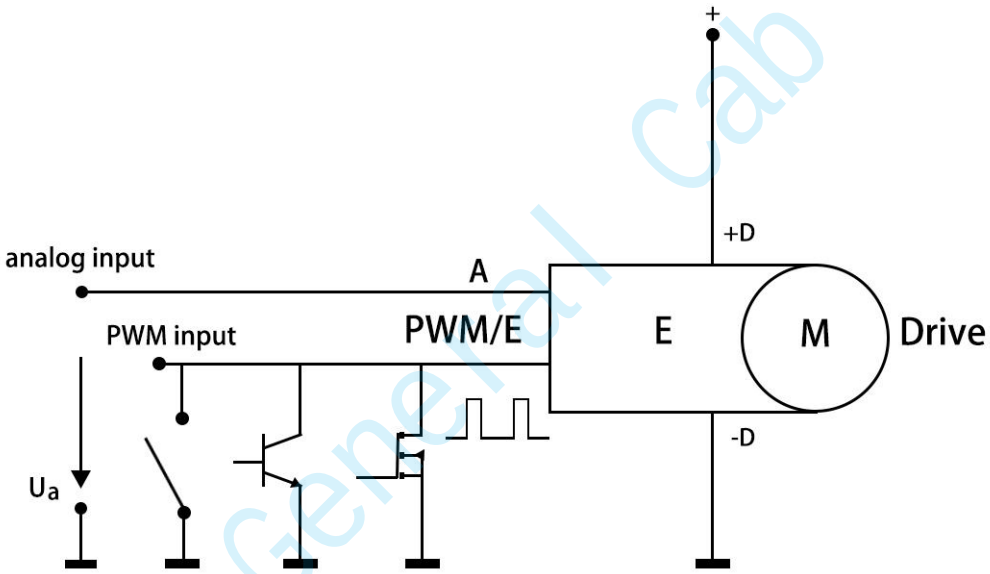
When the PWM/E enable input is at a dominant level, the drive enters the static mode after a short period of time.

When the PWM/E enable input is at a recessive level (switched to the negative pole of the power supply voltage), after the circuit is initialized (if the circuit is not activated), the drive operates at the speed required by the analog input signal at A.

When the enable input terminal PWM/E is driven by PWM, after the circuit is initialized (if the circuit is not activated), the drive operates at the speed required by the duty cycle.

The rated sink current value of the driver's enable input terminal PWM/E is determined by the current value consumed at the PWM/E terminal.

The circuit structure of the drive PWM/E is a typical active-low "open collector" configuration, as shown in the diagram below.



In this operating mode, the positive pole of the power supply voltage is usually permanently connected. When operating the drive, the PWM signal must be input to the PWM/E terminal. After that, the drive speed is controlled by the duty cycle of the PWM signal.

If PWM/E is switched to the negative pole of the power supply voltage, the drive speed is controlled by the analog voltage of pin A. Therefore, both digital input and analog input are feasible in hybrid control, and the digital PWM signal has priority.

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13.Document Change Records

Original document author: Simon
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Simon Sun	20260708	V1	Initial release
Simon Sun	20261015	V2	PWM updated

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General Cab

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