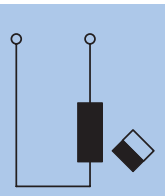
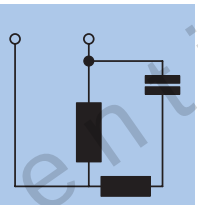
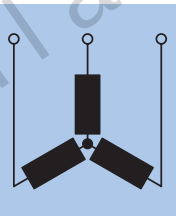
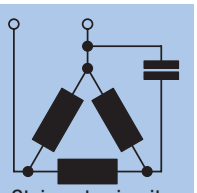
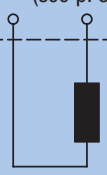
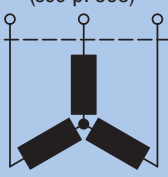
Motors

Motors made by ebm-papst

In AC and EC technology, ebm-papst relies on the proven external-rotor motor principle, with the rotor turning around the stator within. Advantages of the ebm-papst external-rotor principle are:

- *Space saving design due to integrated bearings and direct installation inside the impeller*
- *lower load and more precise balancing of the bearing due to the fixed connection of all rotating elements*
- *Prolonged service life due to the motor-impeller unit placed right within the air flow*

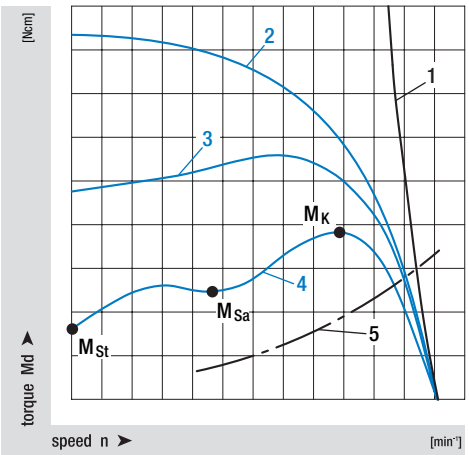
The ebm-papst motors achieve very good results in efficiency and acoustic behaviour when used in EC technology.

Features	AC motors			EC motors	
	Shaded-pole motor	Single-phase capacitor motor	3-phase motor	Single-core motor	3-core motor
1~ AC voltage connector	Yes	Yes	Limited use (Steinmetz circuit)	Yes	Yes
3~ AC voltage connector	No	No	Yes	No	Yes
DC voltage connector	No	No	No	Yes	Yes
Design of circuit diagram - Stator -			  Steinmetz circuit	Electronics (see p. 598) 	Electronics (see p. 598) 
Rotor principle	Squirrel cage	Squirrel cage	Squirrel cage	Magnetic rotor	Magnetic rotor
Efficiency	Low	Medium	Good	Excellent	Excellent
Continuous speed setting integrated	No	No	No	Yes	Yes
Noise behaviour	Medium	Good	Excellent	Medium	Excellent

AC motors

AC motors (induction motors) are based in their function on the principle of the asynchronous rotation of the stator rotating field and rotor.

Torque curves of the motor types



Key:

1	– EC motor	5	– System characteristic
2	– 3-phase motor	M_{St}	– Starting torque
3	– Single-phase motor	M_{Sa}	– Saddle torque
4	– Shaded-pole motor	M_K	– Breakdown torque

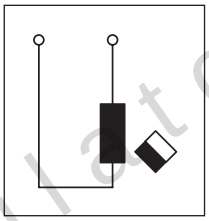
Start-up current

The start-up current of our AC motors is maximally 4x higher than the nominal current given.

Shaded-pole motor

Each pole of the motor is divided electro-magnetically into a main and auxiliary pole (split) via a cage winding in order to generate a starting torque.

At ebm-papst, shaded-pole motors are available as 2 or 4-pole symmetrical external or internal rotor designs.

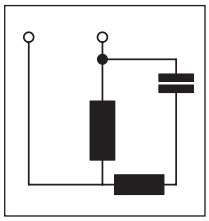


Advantages:

- Extremely robust motor design due to cast squirrel cage rotor and stable bearing system
- Cost-efficient motor
- Extremely easy to connect
- Long service life

Single-phase capacitor motor

Two cores (main winding MW and auxiliary winding AW) generate the rotating field of the single-phase capacitor motor via a capacitor connected in series to form an auxiliary winding.

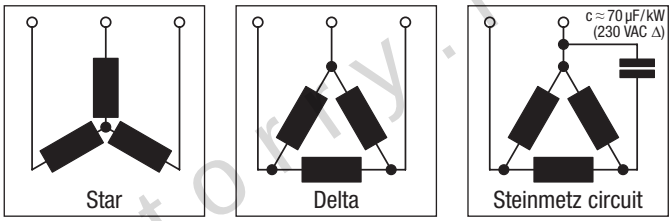


Advantages:

- Extremely robust motor design due to cast squirrel cage rotor and stable bearing system
- Diverse options for setting speed
- Efficiency between 30 % and 75 % (depending on motor size)
- Long service life
- Good vibration and noise behaviour

3-phase motor

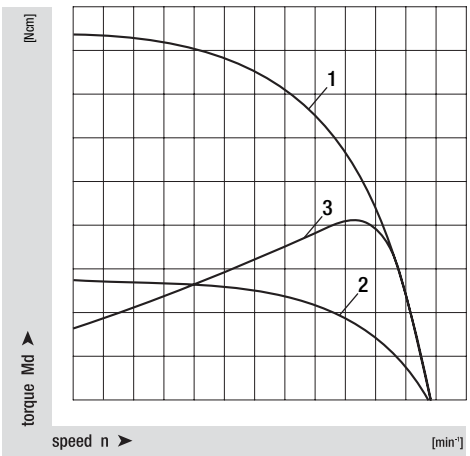
The three motor cores are offset by 120° and generate a circular rotating field when connected to the 3-phase mains.



Advantages:

- Extremely robust motor design due to cast squirrel cage rotor and stable bearing system
- Very good vibration and noise behaviour
- Efficiency between 40 % and 80 % (depending on the motor size)
- Long service life

Torque curves of 3-phase motors



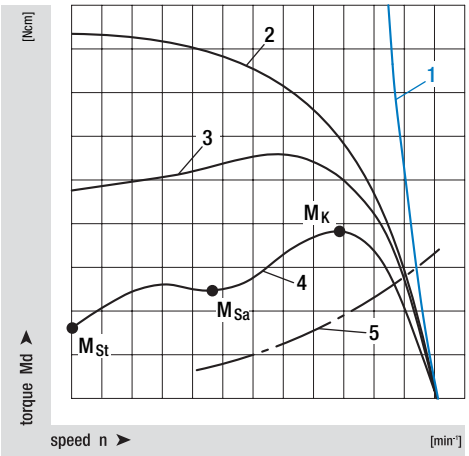
Key:

1 – Delta
2 – Star
3 – Steinmetz circuit

EC motors

EC motors are based in their function on the principle of the synchronous rotation of stator rotating field and rotor.

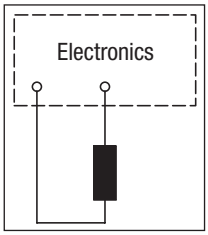
Torque curves of the motor types



Key:

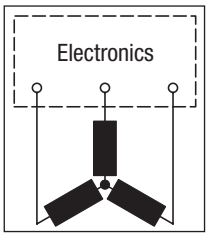
1	– EC motor	5	– System characteristic
2	– 3-phase motor	M_{St}	– Starting torque
3	– Single-phase motor	M_{Sa}	– Saddle torque
4	– Shaded-pole motor	M_K	– Breakdown torque

Single-core motor



Advantages:
- Integrated speed setting
- Efficiency between 50 % and 80 % (depending on the motor size)
- Long service life

3-core motor



Advantages:
- Integrated speed setting
- Good efficiency between 60 % and 90 % (depending on the motor size)
- Long service life
- Very good vibration and noise behaviour even in controlled operation
- Can be used as drive motor

Control technology

Open and closed loop control using ebm-papst technology

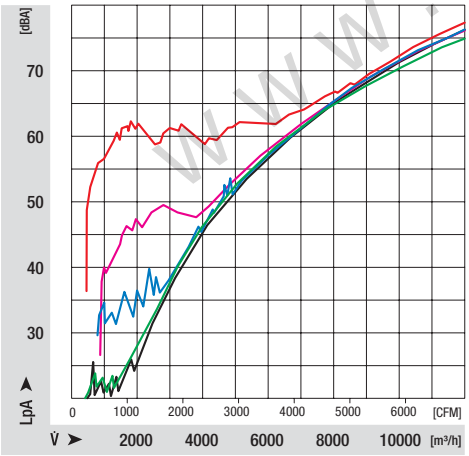
Depending on the field of application, fan speed has to be adjusted. In AC technology, the speed setting option can result in an increase in installation expenditure and, typically, a less favourable noise performance and an increase in power input.

Here, ebm-papst EC technology is a more eco-friendly and cost-efficient alternative. The EC motor with integrated commutation electronics offers high efficiency across the entire speed range and optimal acoustic performance at minimal installation expenditure.

Features	AC							EC commutating electronics		
	Series resistance	Transformer	Speed stepping	Phase-angle control	Phase-angle control with sine filter	Frequency inverter	Frequency inverter with sine filter	integrated	integrated with switch power supply	external
Installation	+	–	+	–	–	–	–	++	–	–
Noise behaviour	+	++	–	––	–	–	+	++	+	+
Power input	––	–	–	–	–	+	+	++	+	+
Service life	+	+	–	–	+	–	+	+	+	+

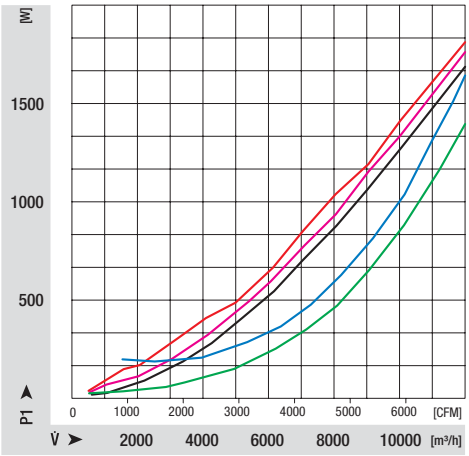
+ = positive ++ = very positive – = negative –– = very negative

Acoustic performance of controlled motors



Key:
- ebm-papst EC controls
- Frequency inverter with sine filter
- Phase-angle control without sine filter
- Phase-angle control with sine filter
- Transformer

Power input of controlled motors

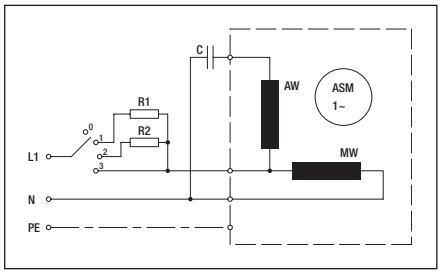


Key:
- ebm-papst EC controls
- Frequency inverter with sine filter
- Phase-angle control without sine filter
- Phase-angle control with sine filter
- Transformer

Speed setting with AC motors

Speed setting helps to optimise power input and the flow noise as requested.

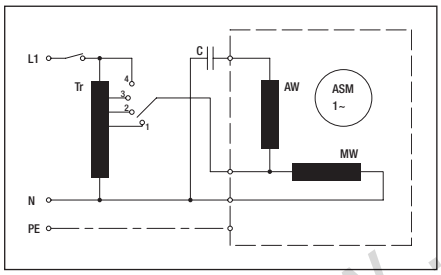
When selecting a voltage controller, note that the nominal current in the partial load range can be up to 20 % (depending on the controller) above the specified maximum current.



Series resistance

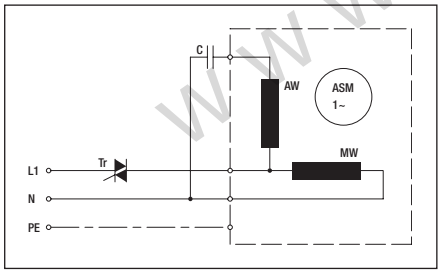
- Fixed speed steps
- Speed setting via change in motor voltage
- Cost-efficient
- Small capacities

Note: Capacitors or chokes reduce the loss capacity.



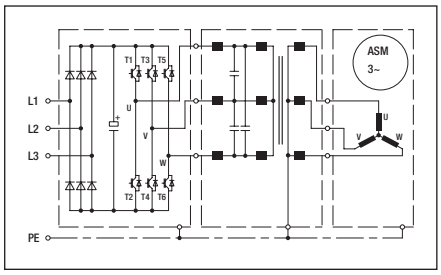
Transformer

- Fixed speed steps
- Speed setting via change in motor voltage



Phase-angle control

- Continuous speed setting
- Speed setting via change in motor voltage
- Cost-efficient
- Acoustic performance and warming has to be reviewed in the application



Frequency inverter with sine filter

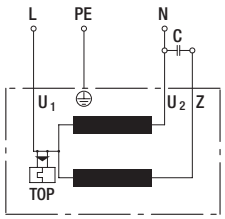
- Continuous speed setting
- Speed setting via change in frequency of rotating field
- High efficiency

Note: An all-pole sine filter (phase-phase and phase-earth) has to be used.

Electrical connections AC

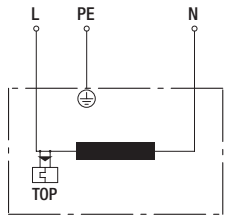
Fans (1~ 230 VAC power line)

A1) Single-phase capacitor motor
with TOP wired internally



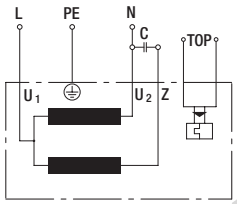
U_1 = blue
U_2 = black
Z = brown
⏚ = green/yellow

B) Shaded pole motor
with TOP wired internally



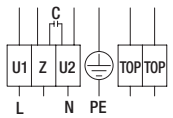
L = blue
N = brown
⏚ = green/yellow

A2a) Single-phase capacitor motor
with connection for external TOP



U_1 = blue
U_2 = black
Z = brown
⏚ = green/yellow

A2b) Single-phase capacitor motor
with connection for external TOP

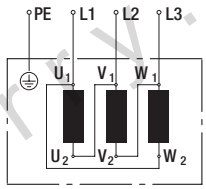


U_1 = blue
U_2 = black
Z = brown
⏚ = green/yellow

Fans
with terminal box

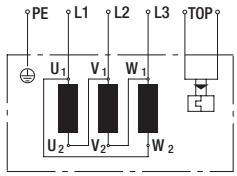
Fans, 1 speed (3~ 230 VAC power line)

C1) Delta connection (3~ 230 VAC power system)
without TOP



U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

D1) Delta connection (3~ 230 VAC power line)
with TOP

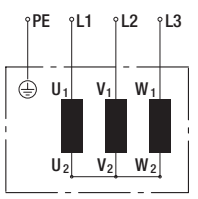


U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

Direction of rotation is reversed by swapping two line phases.

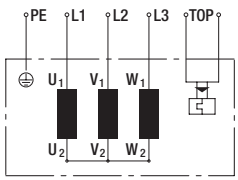
Fans, 1 speed (3~ 400 VAC power line)

C2) Star connection (3~ 400 VAC power system) without TOP



U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

D2) Star connection (3~ 400 VAC power line) with TOP

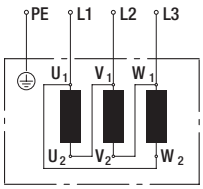


U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

Direction of rotation is reversed by swapping two line phases.

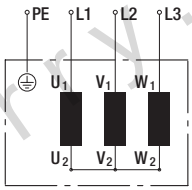
Fans, 2 speeds via Δ/Y-switch (3~ 400 VAC power line)

E1) Delta connection (high speed) without TOP



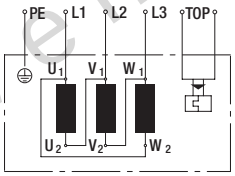
U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

E2) Star connection (low speed) without TOP



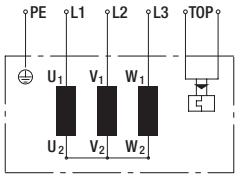
U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

F1a) Delta connection (high speed) with TOP



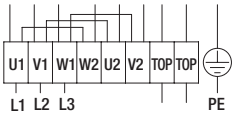
U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

F2a) Star connection (low speed) with TOP



U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

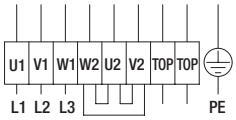
F1b) Delta connection (high speed) with TOP



Fans with terminal box

U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

F2b) Star connection (low speed) with TOP



Fans with terminal box

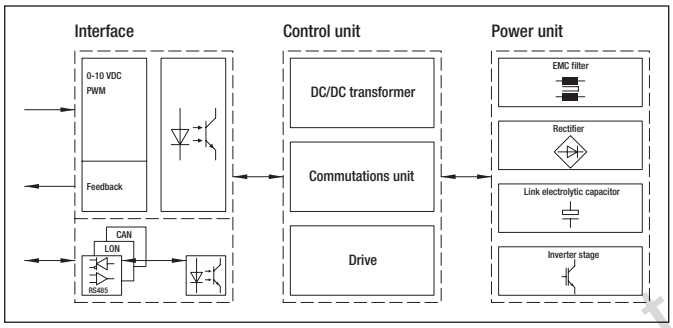
U_1 = black
U_2 = green
V_1 = blue
V_2 = white
W_1 = brown
W_2 = yellow
⏚ = green/yellow

Direction of rotation is reversed by swapping two line phases.

Speed setting with EC motors

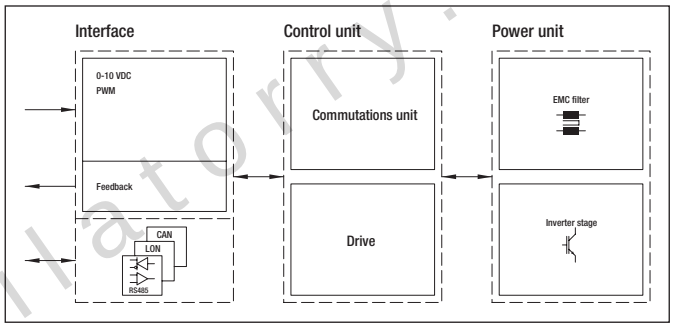
The speed of EC motors is set via commutation electronics. Via electronic circuits and depending on the rotor position, this commutation switches the motor currents on and off.

Principle of AC-fed commutation electronics



(with electrically isolated interface)

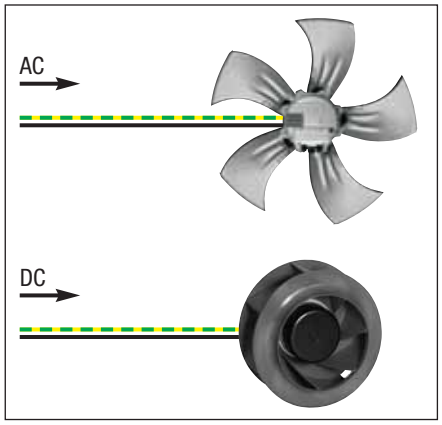
Principle of DC-fed commutation electronics



Integrated commutation electronics

- Compact unit
- Easy to install
- Low installation expenditure
- Can be operated all over the world

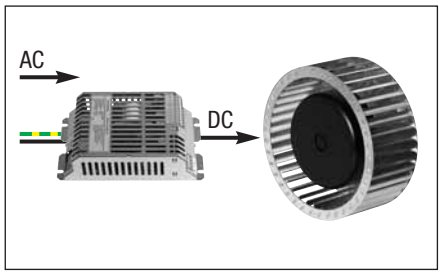
Note: Motors with 12-72 VDC supply voltage have to be fed via electrically isolated supply unit.



Integrated commutation electronics with switch power supply

- Protective extra-low voltage 24 / 48 VDC

Note: Switch power supply is not included but has to be ordered as accessory.



Typical features of the ebm-papst commutation electronics:

- Input for analogue and digital signals
- Open and closed loop control as well as monitoring of the motor
- Integrated EMC filter
- High efficiency throughout the entire speed range
- Speed setting via linear set value (0-10 VDC) or PWM signal
- Low-noise operation across the entire speed range
- minimal extra costs for additional functions (open / closed loop control)
- Optional BUS interface

Types of alarms and reactions with EC motors

With DC-fed EC motors, certain faults in modes of operation are recognised by the electronics, and the motor is automatically restarted.
With AC-fed EC motors, certain faults in modes of operation are recognised by the electronics, and the motor is switched off.
The motor restarts automatically after the following failures have been diagnosed:

- Line failure
- Phase failure
- Line under-voltage
- DC link voltage too high or too low
- Locked rotor

With the following types of failures, there is no automatic restart.
Here, hardware or software reset is required:

- Motor temperature too high
- Temperature of cooling element or ambient temperature of electronics too high
- Hall failure

Hardware reset

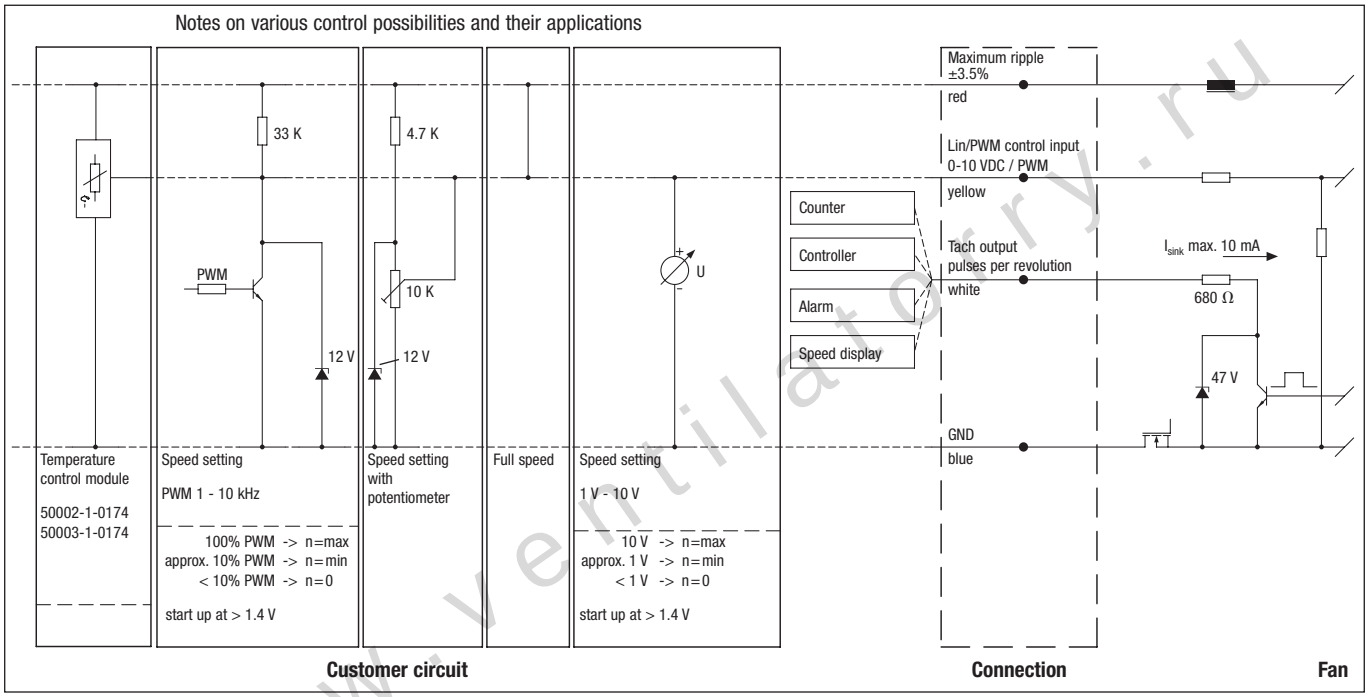
Switching off the fan and restarting it after one minute results in hardware reset.

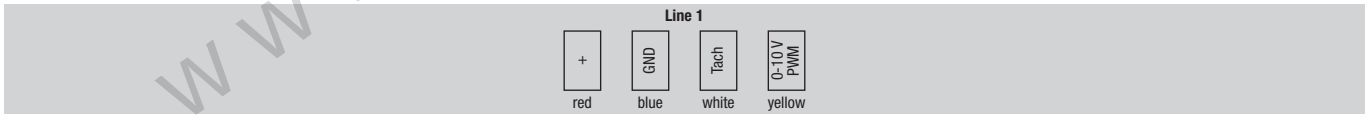
Software reset

Software reset is via ebmBUS and LISA software, hand-held control terminal, or PDA with Fan Control Software.

Electrical connections EC

G) EC motors (nominal voltage 24 / 48 VDC)

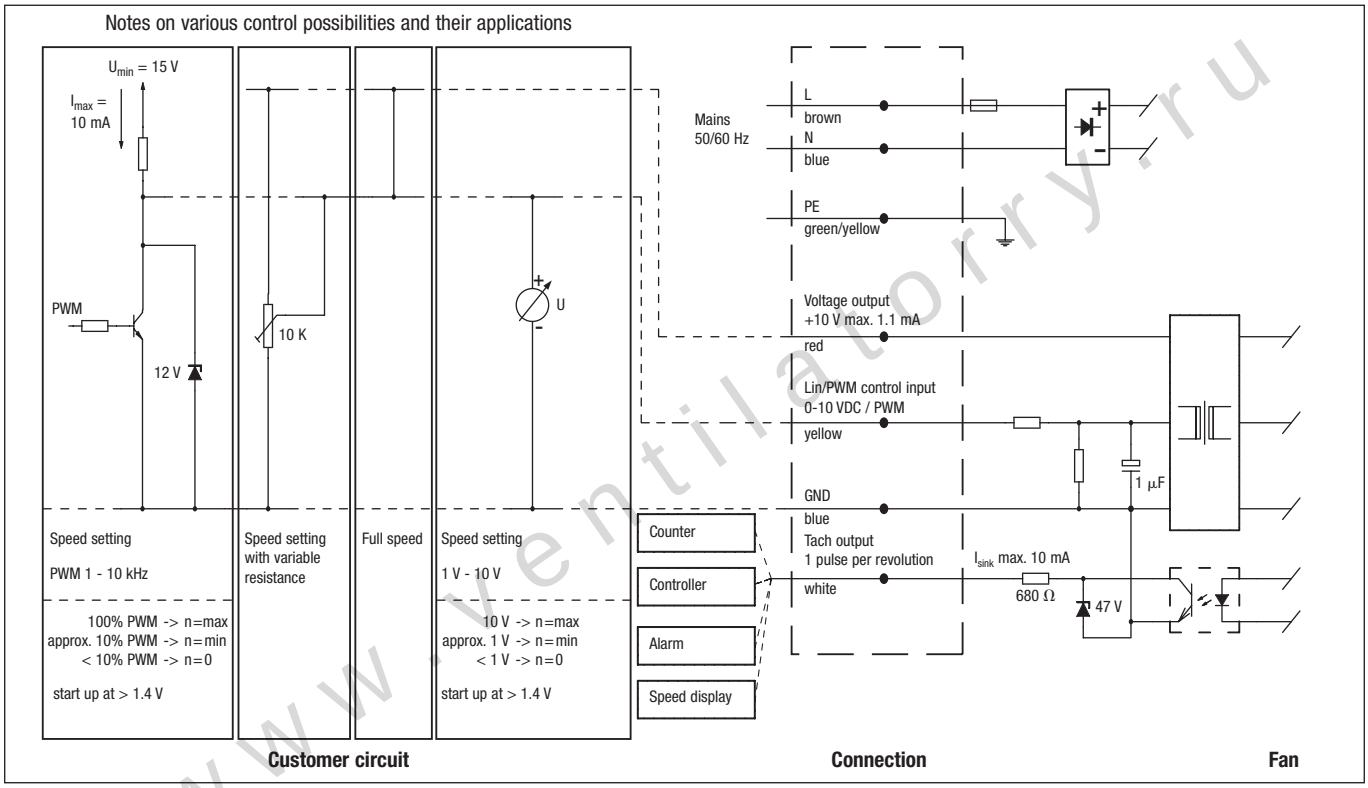


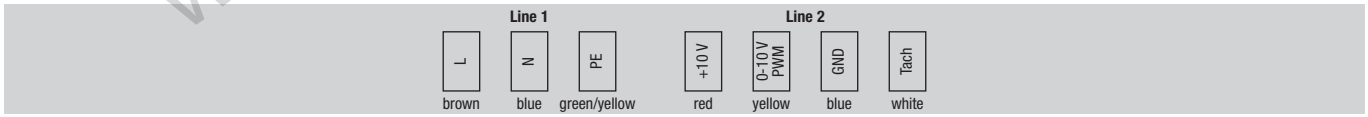


Line	Connection	Colour	Assignment / function
1	+	red	Maximum ripple ± 3.5 %
	GND	blue	GND

Line	Connection	Colour	Assignment / function
1	Tach	white	Tach output:
			2 pulses / revolution (M1G045/M1G055)
			3 pulses / revolution (M1G074/M3G084)
	0-10 V / PWM	yellow	Control input (Impedance 100 kΩ)

H1) EC motors (size 055, line-fed)

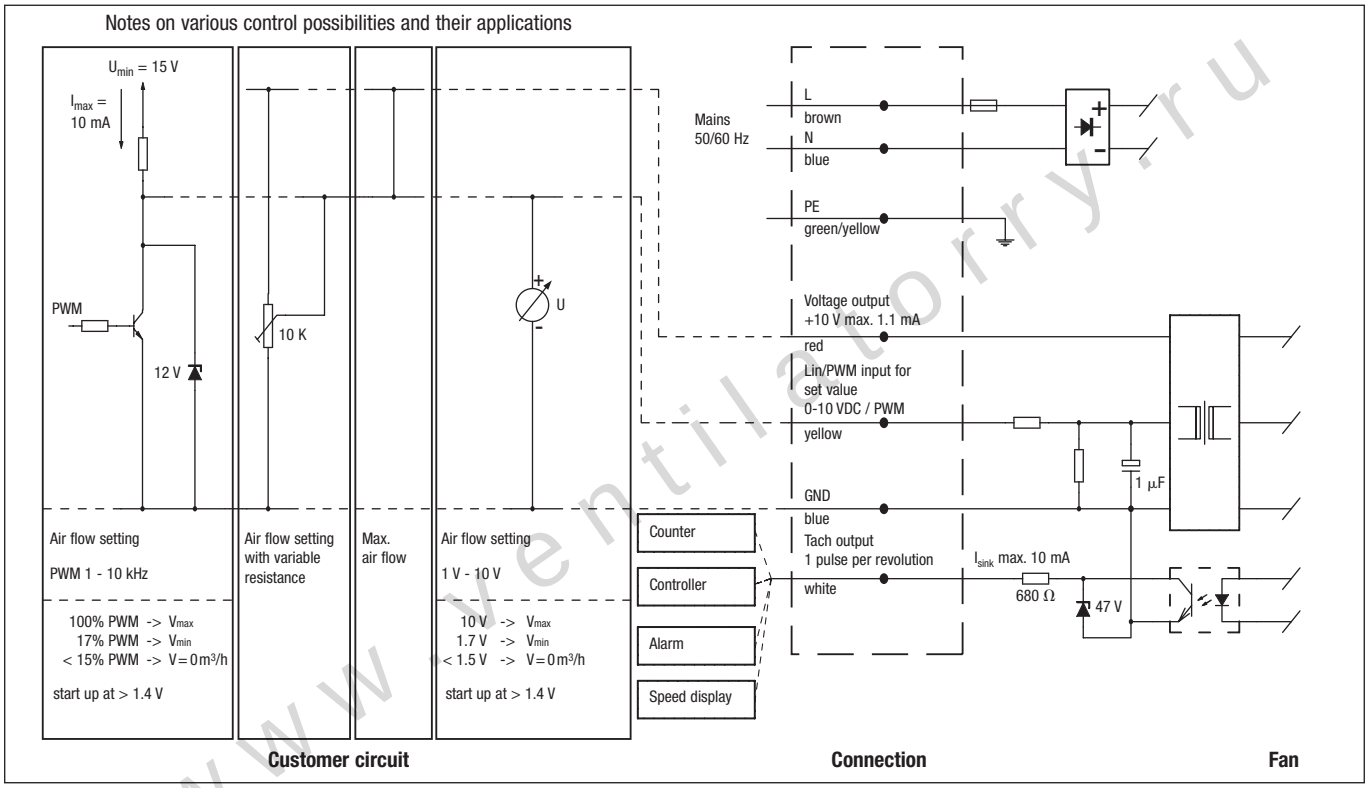


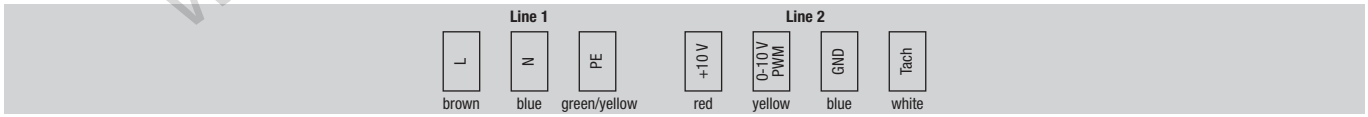


Line	Connection	Colour	Assignment / function
1	L	brown	Mains 50/60 Hz, phase
	N	blue	Mains 50/60 Hz, neutral
	PE	green/yel	Protective earth

Line	Connection	Colour	Assignment / function
2	+10 V	red	Voltage output +10 V max. 1.1 mA
	0-10 V / PWM	yellow	Control input (Impedance 100 kΩ)
	GND	blue	GND
	Tach	white	Tach output: 1 pulse per revolution

H2) EC motors (size 055, line-fed and constant air flow)

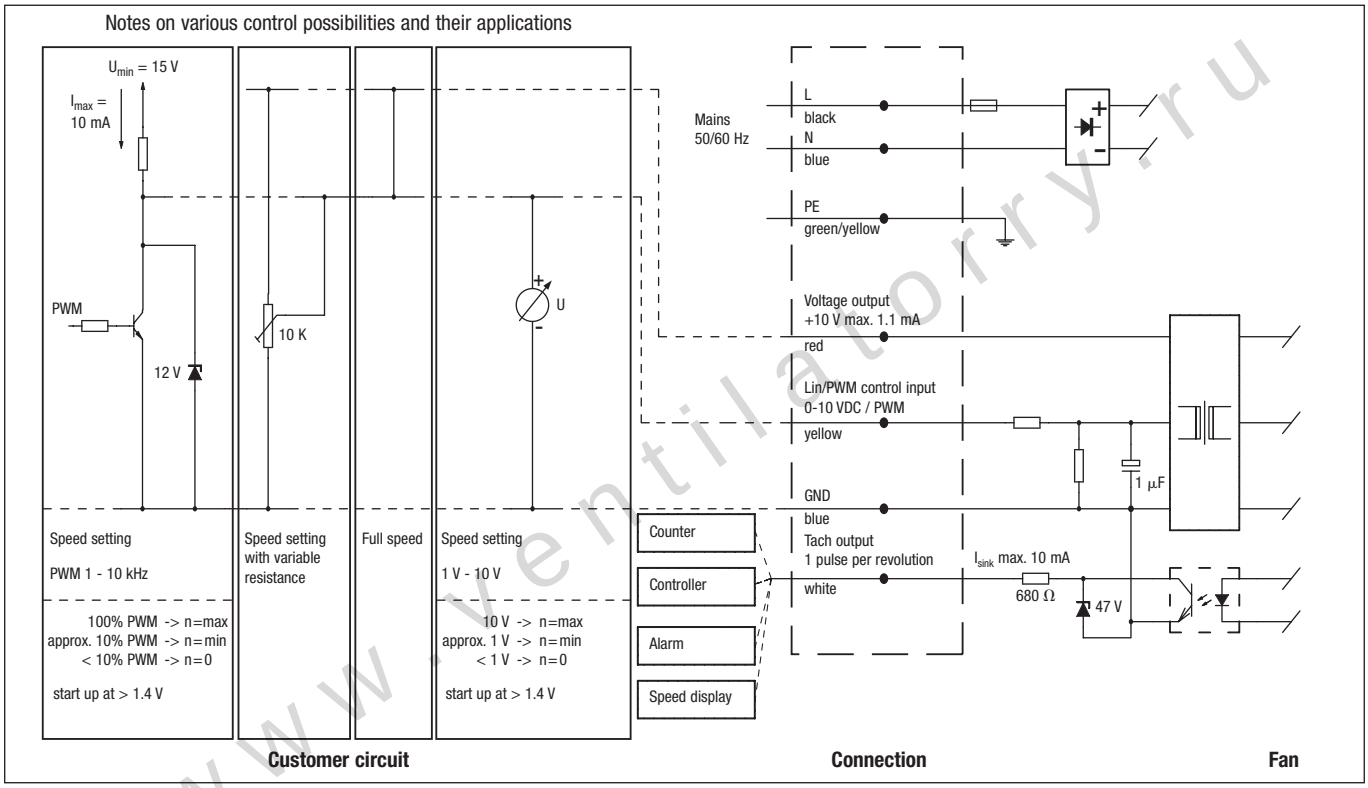


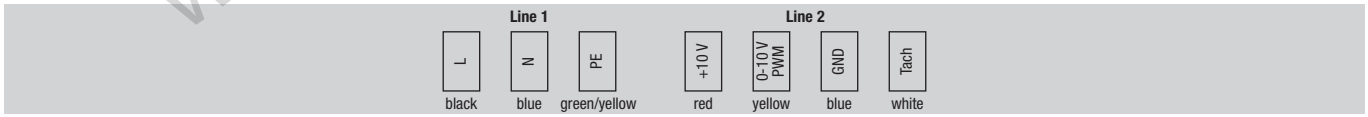


Line	Connection	Colour	Assignment / function
1	L	brown	Mains 50/60 Hz, phase
	N	blue	Mains 50/60 Hz, neutral
	PE	green/yel	Protective earth

Line	Connection	Colour	Assignment / function
2	+10 V	red	Voltage output +10 V max. 1.1 mA
	0-10 V / PWM	yellow	Input for set value (impedance 100 kΩ)
	GND	blue	GND
	Tach	white	Tach output: 1 pulse per revolution

J1) EC motors (size 074, line-fed)

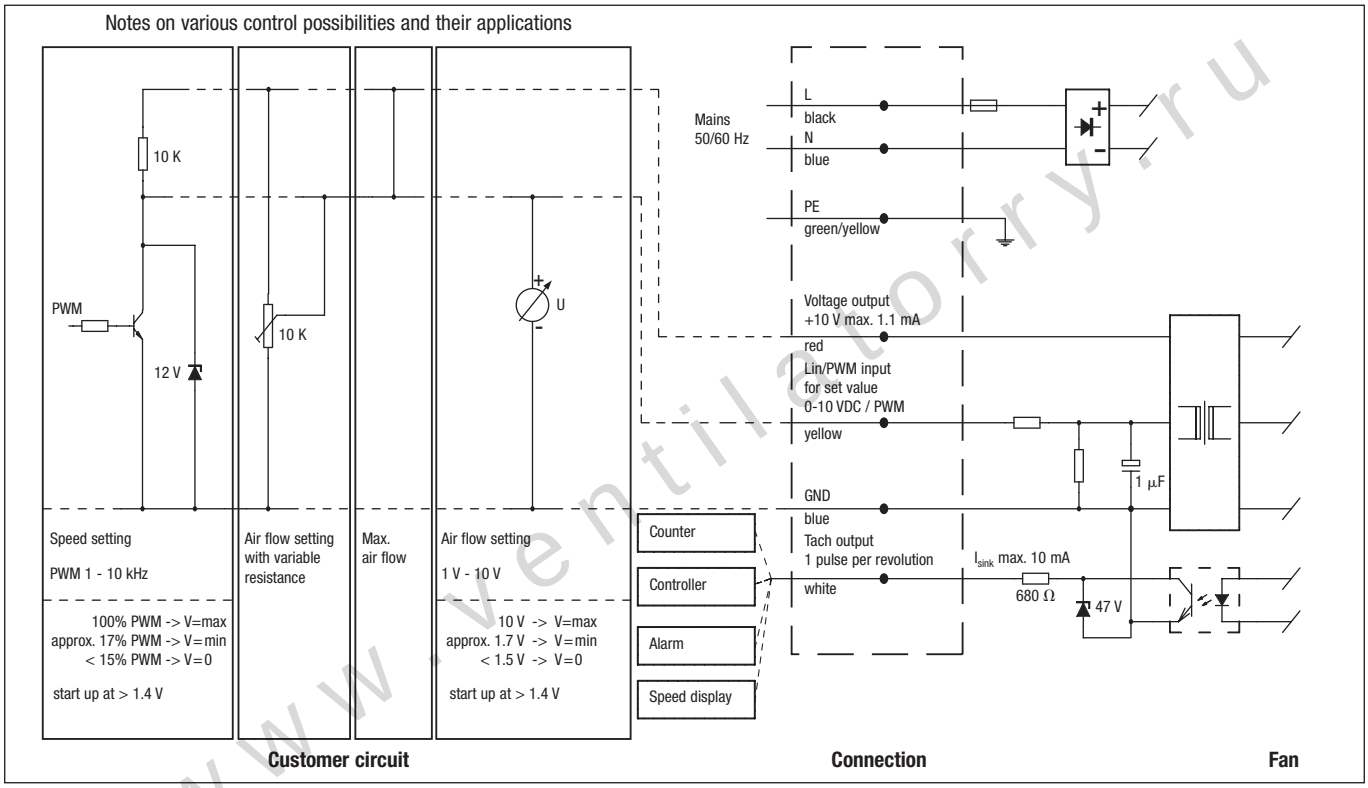


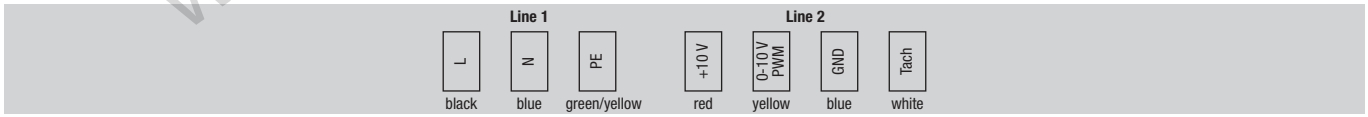


Line	Connection	Colour	Assignment / function
1	L	black	Mains 50/60 Hz, phase
	N	blue	Mains 50/60 Hz, neutral
	PE	green/yel	Protective earth

Line	Connection	Colour	Assignment / function
2	+10 V	red	Voltage output +10 V max. 1.1 mA
	0-10 V / PWM	yellow	Control input (Impedance 100 kΩ)
	GND	blue	GND
	Tach	white	Tach output: 1 pulse per revolution

J2) EC motors (size 074, line-fed and constant air flow)

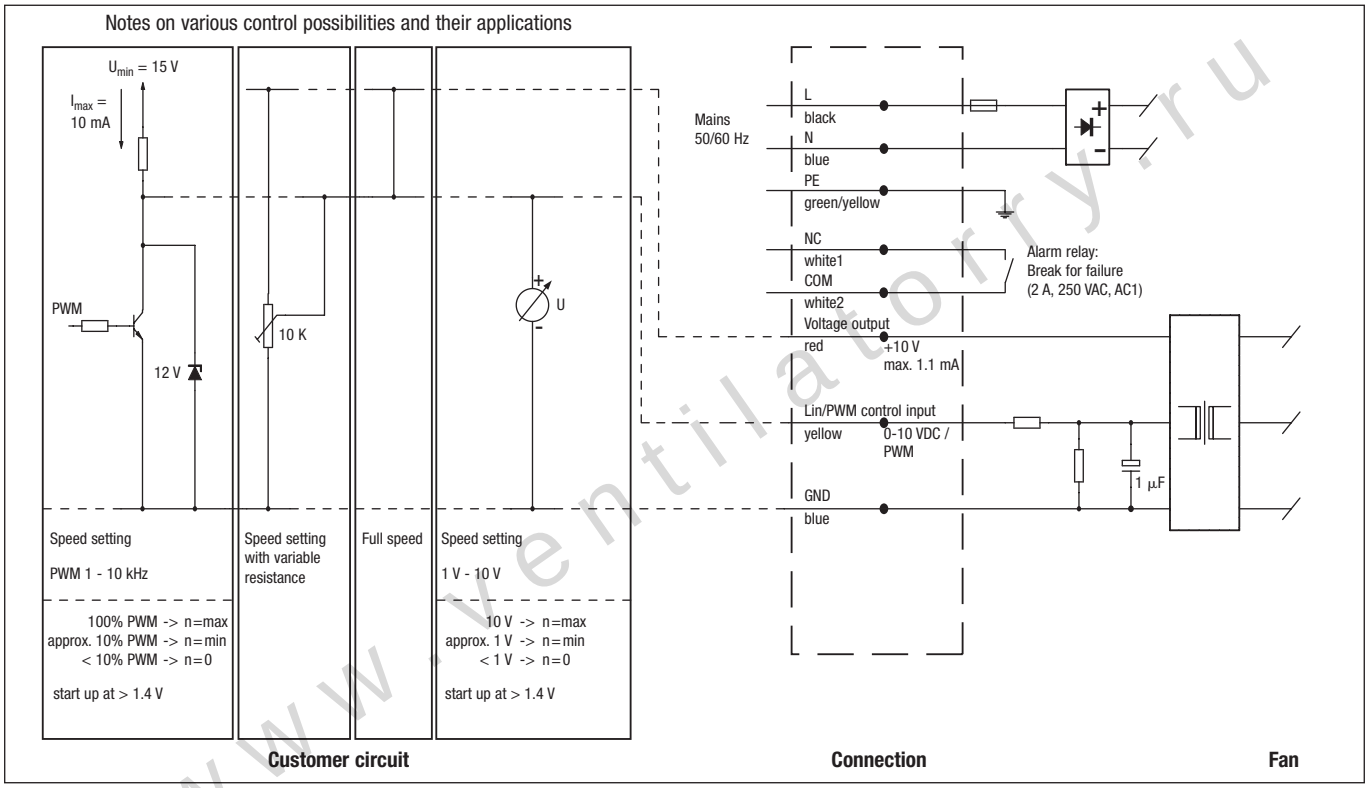


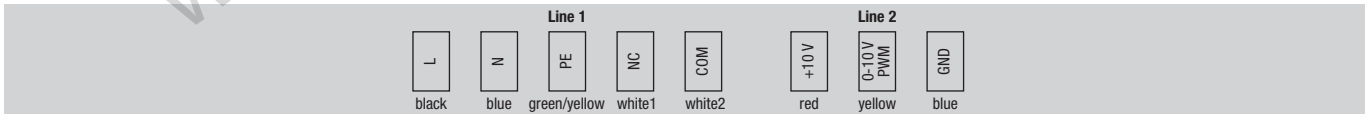


Line	Connection	Colour	Assignment / function
1	L	black	Mains 50/60 Hz, phase
	N	blue	Mains 50/60 Hz, neutral
	PE	green/yel	Protective earth

Line	Connection	Colour	Assignment / function
2	+10 V	red	Voltage output +10 V max. 1.1 mA
	0-10 V / PWM	yellow	Input for set value (impedance 100 kΩ)
	GND	blue	GND
	Tach	white	Tach output: 1 pulse per revolution

K1) EC motors (size 084, line-fed)





Line	Connection	Colour	Assignment / function
1	L	black	Mains 50/60 Hz, phase
	N	blue	Mains 50/60 Hz, neutral
	PE	green/yel	Protective earth
	NC	white1	Alarm relay, break for failure
	COM	white2	Alarm relay, COMMON

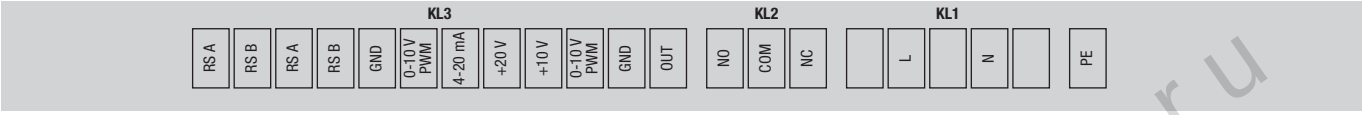
Line	Connection	Colour	Assignment / function
2	+10 V	red	Voltage output +10 V max. 1.1 mA
	0-10 V / PWM	yellow	Control input (Impedance 100 kΩ)
	GND	blue	GND

K2) EC motors (size 084/112 with ebmBUS, mains-powered)

Connector	Connection	Assignment / function
KL1	PE	Protective earth
	N	Mains 50/60 Hz, neutral
	L	Mains 50/60 Hz, phase

Connector	Connection	Assignment / function
KL2	RS B	RS485 interface for ebmBUS; RS B
	RS A	RS485 interface for ebmBUS; RS A
	+15 V	Operation: +15 V (50 mA); Alarm: 0 V
	0 V	Operation: 0 V; Alarm: +15 V (50 mA)

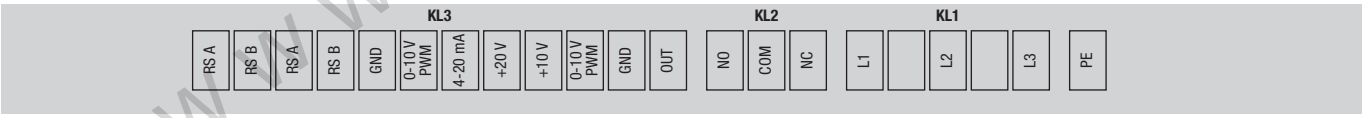
L1) EC motors (size 112, single-phase mains-powered)



Connector	Connection	Assignment / function
PE	PE	Protective earth
KL1	N	Mains 50/60 Hz, neutral
	L	Mains 50/60 Hz, phase
KL2	NC	Alarm relay, break for failure
	COM	Alarm relay, COMMON (2A, 250 VAC, AC1)
	NO	Alarm relay, make for failure

Connector	Connection	Assignment / function
KL3	OUT	Master output 0-10 V max. 3 mA
	GND	GND
	0-10 V / PWM	Control / Actual value input (Impedance 100 kΩ)
	+10 V	Supply for external potentiometer,
		10 VDC (+10 %) @ 10 mA
	+20 V	Supply for external sensor,
		20 VDC (±20 %) @ 50 mA
	4-20 mA	Control / Actual value input
	0-10 V / PWM	Control / Actual value input
	GND	GND
	RSB	RS485 interface for ebmBUS; RS B
	RSA	RS485 interface for ebmBUS; RS A
	RSB	RS485 interface for ebmBUS; RS B
	RSA	RS485 interface for ebmBUS; RS A

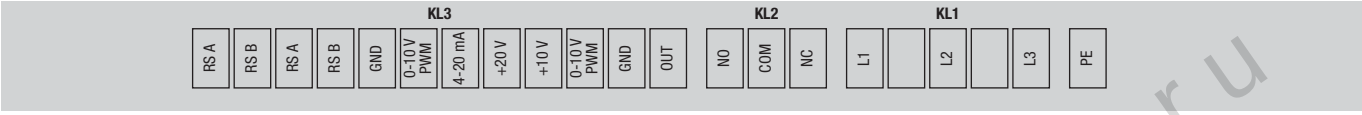
L2) EC motors (size 112, three-phase mains-powered)



Connector	Connection	Assignment / function
PE	PE	Protective earth
KL1	L3	Mains; L3
	L2	Mains; L2
	L1	Mains; L1
KL2	NC	Alarm relay, break for failure
	COM	Alarm relay, COMMON (2A, 250 VAC, AC1)
	NO	Alarm relay, make for failure

Connector	Connection	Assignment / function
KL3	OUT	Master output 0-10 V max. 3 mA
	GND	GND
	0-10 V / PWM	Control / Actual value input (Impedance 100 kΩ)
	+10 V	Supply for external potentiometer,
		10 VDC (+10 %) @ 10 mA
	+20 V	Supply for external sensor,
		20 VDC (±20 %) @ 50 mA
	4-20 mA	Control / Actual value input
	0-10 V / PWM	Control / Actual value input
	GND	GND
	RSB	RS485 interface for ebmBUS; RS B
	RSA	RS485 interface for ebmBUS; RS A
	RSB	RS485 interface for ebmBUS; RS B
	RSA	RS485 interface for ebmBUS; RS A

M) EC motors (size 150, three-phase mains-powered)



Connector	Connection	Assignment / function
PE	PE	Protective earth
KL1	L3	Mains; L3
	L2	Mains; L2
	L1	Mains; L1
KL2	NC	Alarm relay, break for failure
	COM	Alarm relay, COMMON (2A, 250 VAC, AC1)
	NO	Alarm relay, make for failure

Connector	Connection	Assignment / function
KL3	OUT	Master output 0-10 V max. 3 mA
	GND	GND
	0-10 V / PWM	Control / Actual value input (Impedance 100 kΩ)
	+10 V	Supply for external potentiometer,
		10 VDC (+10 %) @ 10 mA
	+20 V	Supply for external sensor,
		20 VDC (±20 %) @ 50 mA
	4-20 mA	Control / Actual value input
	0-10 V / PWM	Control / Actual value input
	GND	GND
	RSB	RS485 interface for ebmBUS; RS B
	RSA	RS485 interface for ebmBUS; RS A
	RSB	RS485 interface for ebmBUS; RS B
	RSA	RS485 interface for ebmBUS; RS A

Connection diagram: Condensing pressure control with master-slave fans