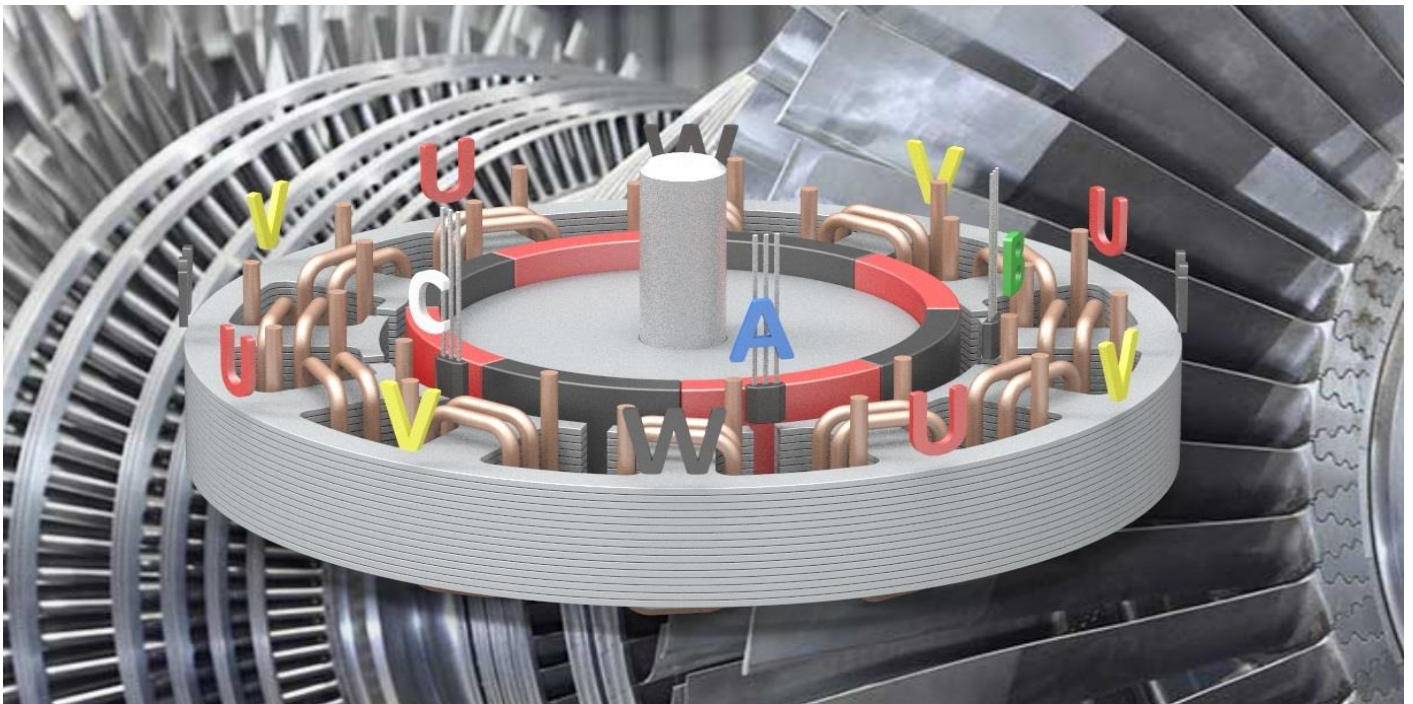


# BRUSHLESS DC MOTORS





A brushless DC motor (BLDC) is constructed as shown in the above image. Coils are wound on a number of poles on a laminated stator. The rotor has alternate North and South poles around its circumference.

The motor illustrated has an 8-pole construction. There are 4 pairs (a pair comprises a North and a South pole) of poles on the rotor, and each of the stator windings has 4 poles. This is a three phase motor with three windings designated U, V, and W.

There are three hall-effect sensors designated A, B, and C which are oriented at  $60^\circ$  intervals and detect the position of the rotor.

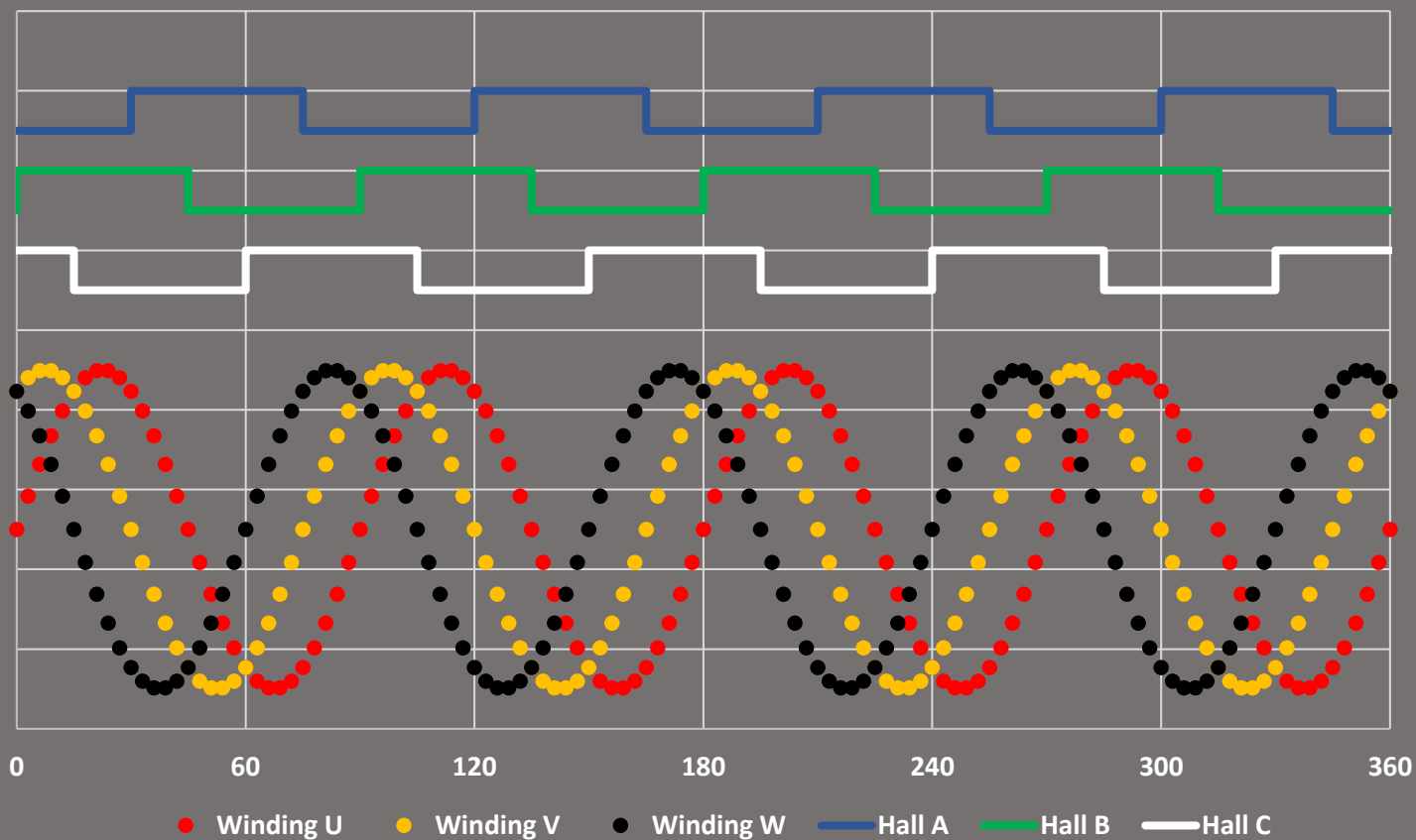
The windings are shown separately, but in practice all of the U windings would be connected in series, similarly the V and W windings.

The motor controller switches (or varies in a sinusoidal manner) the current applied to the three windings, each winding is energised with a waveform  $60^\circ$  out of phase with the others, this causes a magnetic field to be generated by the stator which rotates, and which causes the rotor to rotate. The phase of the excitation waveforms is controlled by the position signals derived from the hall sensors.

This control of the excitation currents is effected electronically, without the use of brushes, hence the term brushless - elimination of the brushes enables a great improvement in reliability compared to brushed motors.



Hall Sensor Signals and Winding Excitation for 8-Pole Motor





# Brushless DC Motors - Customisation



There are a number of ways in which the BLDC motors can be customised to optimise for a customer application. These possibilities include (but are not limited to) the following:

**Custom Flange** – the end housings of the motors are cast and machined in tolerance critical areas. If a custom mounting is advantageous (eg to fit the motor with screws inserted from the rear of the motor), then custom housings are possible. Tooling cost for straightforward modifications of this kind are typically <\$5000USD.

Once tooling is made the impact on unit cost is small.

**Shaft Modification** – flats, keyways, splines, leadscrew form, pinion or rear shaft extension are common modifications. The shaft is a machined component so tooling is not normally required, although some setup charges or MOQ may apply. The impact on unit cost depends on the complexity of modifications, and on tolerances required.

**Encoders** – Encoders can be added to provide position feedback. Encoders can provide relative or absolute position information. Mounting encoders typically requires shaft and housing modifications.

**Lead-wire Modification** – longer or shorter lead-wires, cable (with outer sheath), or addition of connectors are common modifications. Different lead-wire material is possible to conform to standards in different countries / applications. Impact on unit cost depends on material and labour costs. Tooling may be required for some such modifications.

**Insulation System** – higher temperature class (may also require magnet and bearing changes), or higher isolation class are usually straightforward. Impregnation or over-moulding of motor windings can improve heat transfer from coil windings to stator, enhance isolation, and improve resistance to vibration, and to hostile environments / corrosion. Changes which require modification of moulded insulation components can require tooling charges.

**Bearing Changes** – Bearings can be changed to withstand higher radial or axial loading, to accommodate a custom shaft, to use corrosion resistant material, to withstand higher or lower temperatures, or to incorporate seals for better sealing.

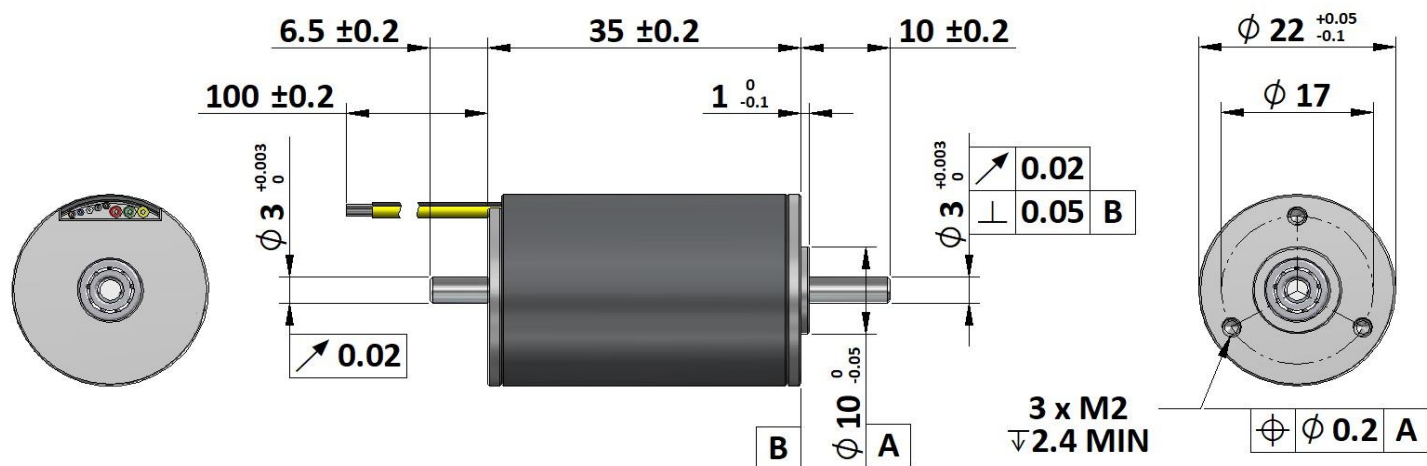
**Winding Change** – Motor windings can be changed to modify the motor speed and torque characteristics, and / or to optimise for best compatibility with a chosen drive.

**Temperature Range** – Metal parts of the motor will normally withstand a fairly wide temperature range.

Insulation materials, magnets, bearings, and lubricating grease or oil may need to be changed to withstand wide temperature variations.

**Sealing** – modified housings, seals, sealing coatings are possible to improve resistance of the motor to aggressive environmental conditions.





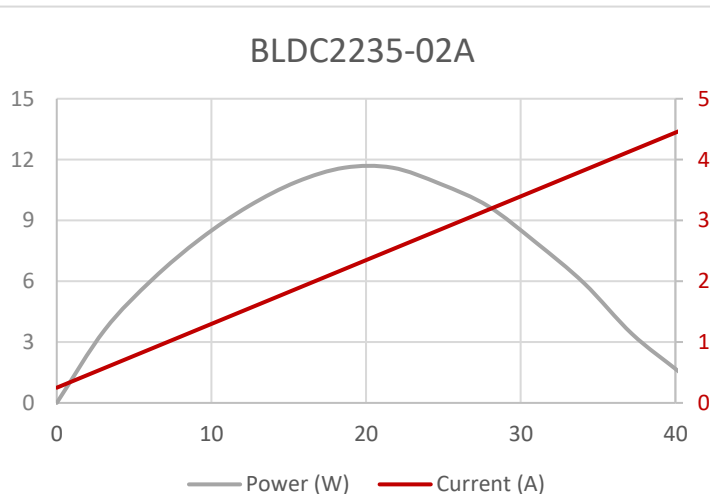
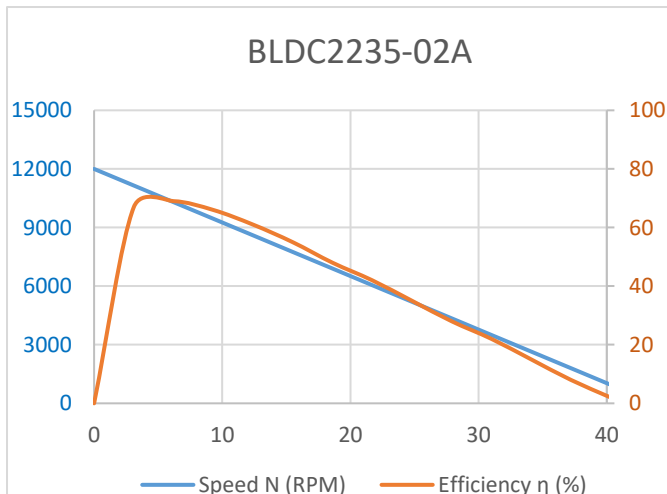
## Phase Leads, TBDmm<sup>2</sup>, PE

Hall Sensor Leads, 0.15mm<sup>2</sup>, PTFE

U	V	W	5V	GND	A	B	C
Red	Green	Yellow	Brown	Black	Blue	White	Grey

Motor Winding Option	02A	02B	02C	
Motor Poles	2	2	2	
Voltage (VDC)	12VDC	24VDC	36VDC	
No-Load Speed (RPM)	12000	24000	36000	
Rated Torque (mNm)	13.4	10.8	5.8	
Rated Speed (RPM)	8228	21060	34436	
Rated Current (A)	1.62	1.33	0.81	
Rated Input Power (W)	19.4	31.8	29.1	
Rated Output Power (W)	11.6	23.8	20.9	
Rated Efficiency (%)	59.5	74.9	71.9	
Max Efficiency (%)	66.8	75.2	78.3	
Stall Current (A)	5	10	14	
Stall Torque (mNm)	44	90	136	
Speed Constant (RPM/V)	1000	1000	1000	
Torque Constant (mNm/A)	9.23	9.38	9.42	
Resistance (Phase to Phase) Ω	2.5	2.5	2.5	
Mechanical Time Constant (ms)	5.1	4.9	4.9	
Rotor Inertia (g-cm²)	1.5	1.5	1.5	

Ambient Temperature -40°C to +125°C

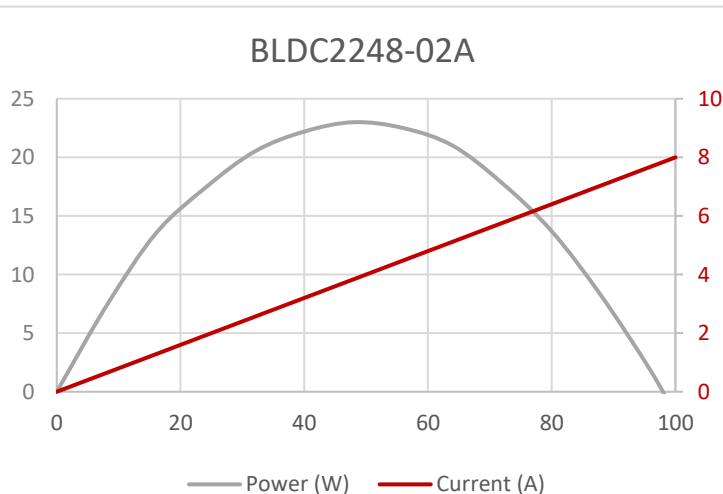


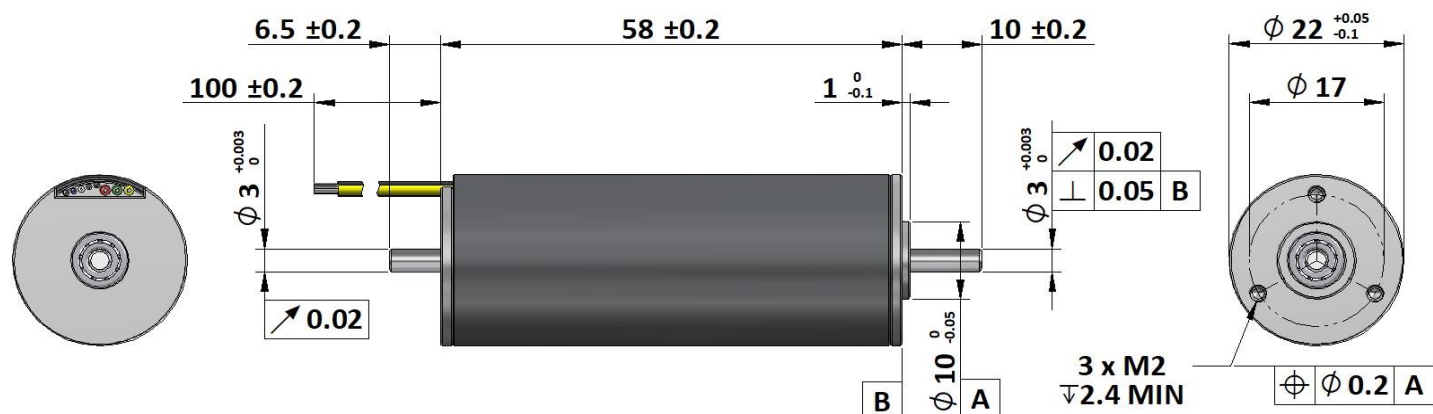


Hall Sensor Leads, 0.15mm<sup>2</sup>, PTFE

U	V	W	5V	GND	A	B	C
Red	Green	Yellow	Brown	Black	Blue	White	Grey

Ambient Temperature -40°C to +125°C





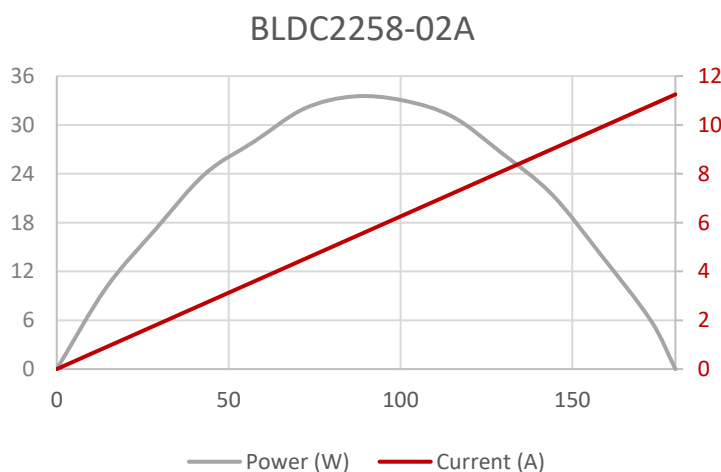
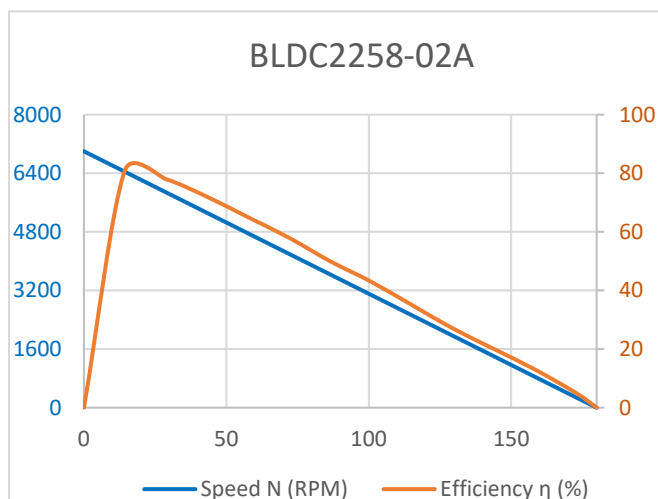
## Phase Leads, TBDmm<sup>2</sup>, PE

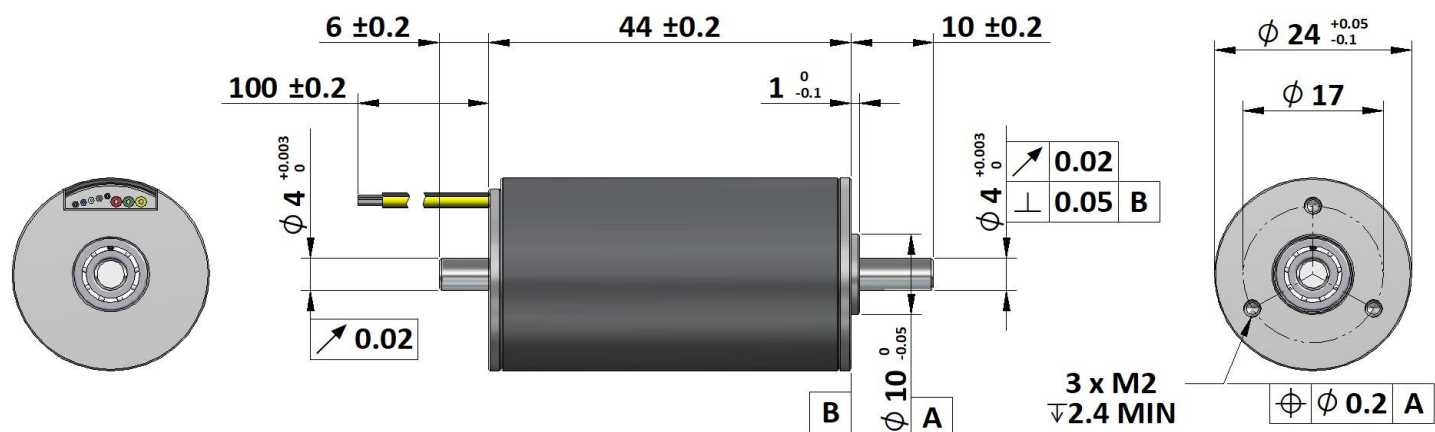
Hall Sensor Leads, 0.15mm<sup>2</sup>, PTFE

U	V	W	5V	GND	A	B	C
Red	Green	Yellow	Brown	Black	Blue	White	Grey

Motor Winding Option	02A	02B	02C	02D
Motor Poles	2	2	2	3
Voltage (VDC)	12VDC	24VDC	36VDC	48VDC
No-Load Speed (RPM)	7000	14000	21000	28000
Rated Torque (mNm)	53.2	48	39.5	30.2
Rated Speed (RPM)	4960	12177	19505	26859
Rated Current (A)	3.43	3.12	2.62	2.06
Rated Input Power (W)	41.2	74.8	94.2	98.7
Rated Output Power (W)	27.6	61.3	80.7	85
Rated Efficiency (%)	67.1	81.9	84.6	86.2
Max Efficiency (%)	79.1	84	85.7	87.2
Stall Current (A)	11	23	34	46
Stall Torque (mNm)	185	372	558	745
Speed Constant (RPM/V)	583	583	583	583
Torque Constant (mNm/A)	16.17	16.26	16.28	16.3
Resistance (Phase to Phase) Ω	1.05	1.05	1.05	1.05
Mechanical Time Constant (ms)	1.5	1.5	1.5	1.5
Rotor Inertia (g-cm²)	3.3	3.3	3.3	3.3

Ambient Temperature -40°C to +125°C





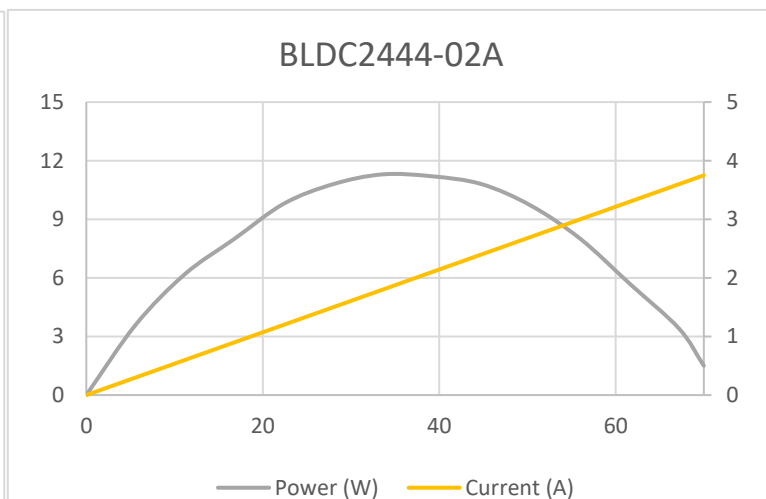
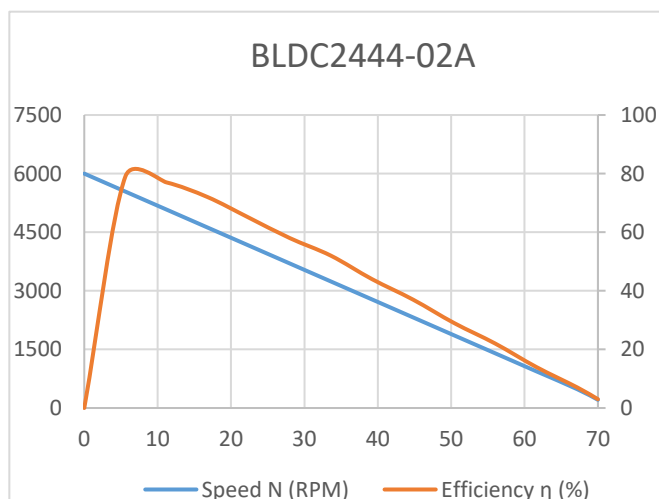
## Phase Leads, TBDmm<sup>2</sup>, PE

Hall Sensor Leads, 0.15mm<sup>2</sup>, PTFE

U	V	W	5V	GND	A	B	C
Red	Green	Yellow	Brown	Black	Blue	White	Grey

Motor Winding Option	02A	02B	02C	02D
Motor Poles	2	2	2	3
Voltage (VDC)	12VDC	24VDC	36VDC	48VDC
No-Load Speed (RPM)	6000	12000	18000	24000
Rated Torque (mNm)	33.7	30.5	25.3	17
Rated Speed (RPM)	3238	9537	15965	22630
Rated Current (A)	1.88	1.73	1.48	1.07
Rated Input Power (W)	22.6	41.5	53.3	51.5
Rated Output Power (W)	11.4	30.4	42.3	40.4
Rated Efficiency (%)	50.6	73.3	79.3	78.4
Max Efficiency (%)	73.7	77.9	79.6	80.4
Stall Current (A)	4	8	12	16
Stall Torque (mNm)	75	151	227	302
Speed Constant (RPM/V)	500	500	500	500
Torque Constant (mNm/A)	18.72	18.84	18.88	18.9
Resistance (Phase to Phase) $\Omega$	3	3	3	3
Mechanical Time Constant (ms)	6.1	6	6	5.9
Rotor Inertia (g-cm <sup>2</sup> )	6.2	6.2	6.2	6.2

Ambient Temperature -40°C to +125°C

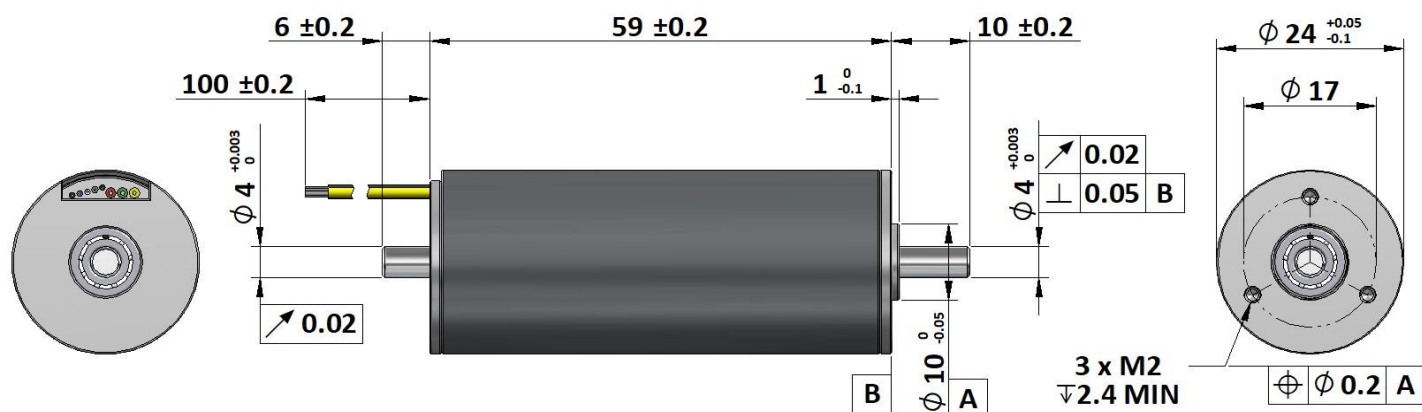






GEEPLUS

BLDC2459



Phase Leads, TBDmm<sup>2</sup>, PE

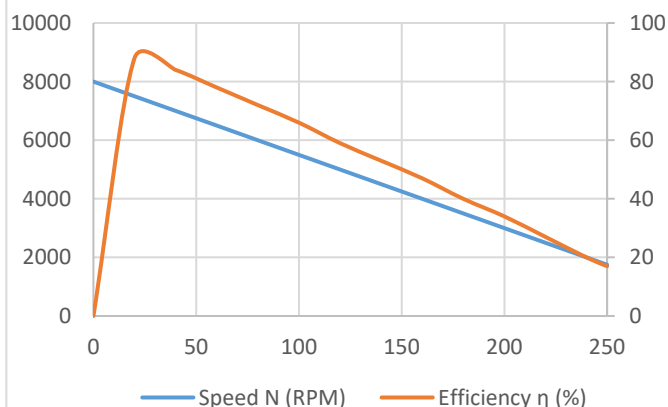
Hall Sensor Leads, 0.15mm<sup>2</sup>, PTFE

U	V	W	5V	GND	A	B	C
Red	Green	Yellow	Brown	Black	Blue	White	Grey

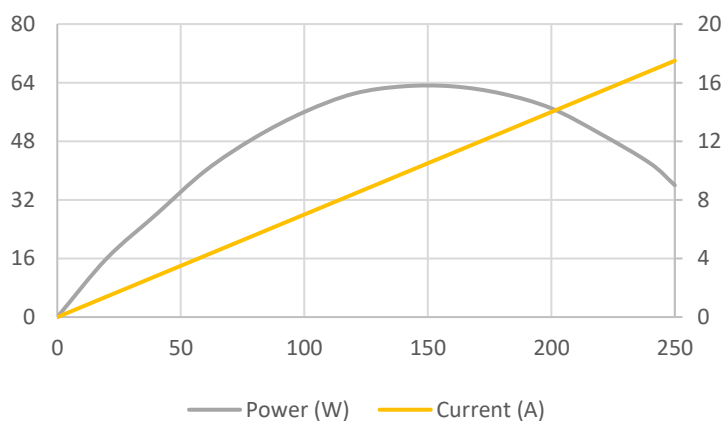
Motor Winding Option	02A	02B		02D
Motor Poles	2	2		3
Voltage (VDC)	12VDC	24VDC		48VDC
No-Load Speed (RPM)	8000	12000		24000
Rated Torque (mNm)	70.8	63.7		42.7
Rated Speed (RPM)	6137	10313		22873
Rated Current (A)	5.07	3.5		2.44
Rated Input Power (W)	60.8	83.9		117.3
Rated Output Power (W)	45.5	68.8		102.2
Rated Efficiency (%)	74.8	82		87.1
Max Efficiency (%)	86.8	85.3		87.5
Stall Current (A)	12	24		48
Stall Torque (mNm)	306	456		913
Speed Constant (RPM/V)	667	500		500
Torque Constant (mNm/A)	14.26	18.99		19.02
Resistance (Phase to Phase) Ω	0.56	1		1
Mechanical Time Constant (ms)	3.2	3.2		3.2
Rotor Inertia (g-cm <sup>2</sup> )	10	10		10

Ambient Temperature -40°C to +125°C

BLDC2459-02A

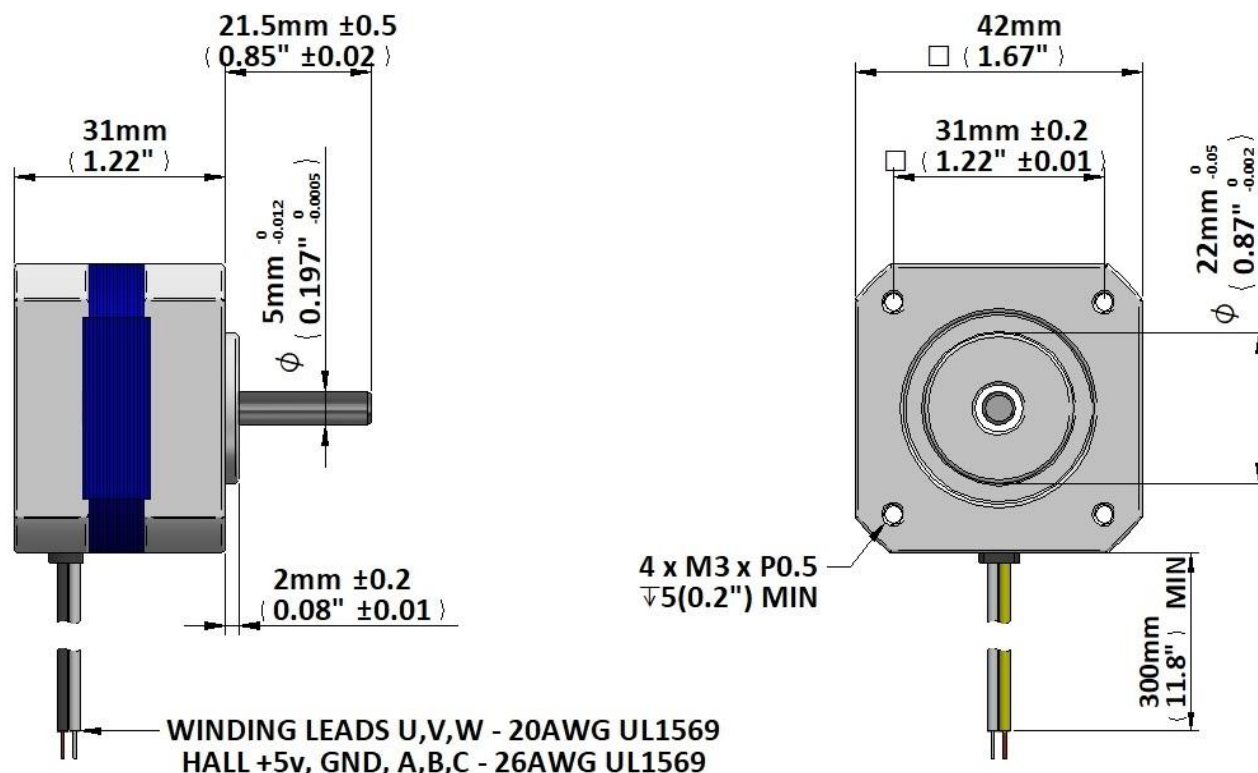


BLDC2459-02A



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**GEEPLUS****BLDC4231**

Phase Leads, 20AWG, UL1569

Hall Sensor Leads, 28AWG, UL1569

**U****V****W****5v****GND****A****B****C**

Red

Yellow

Black

Red

Black

Blue

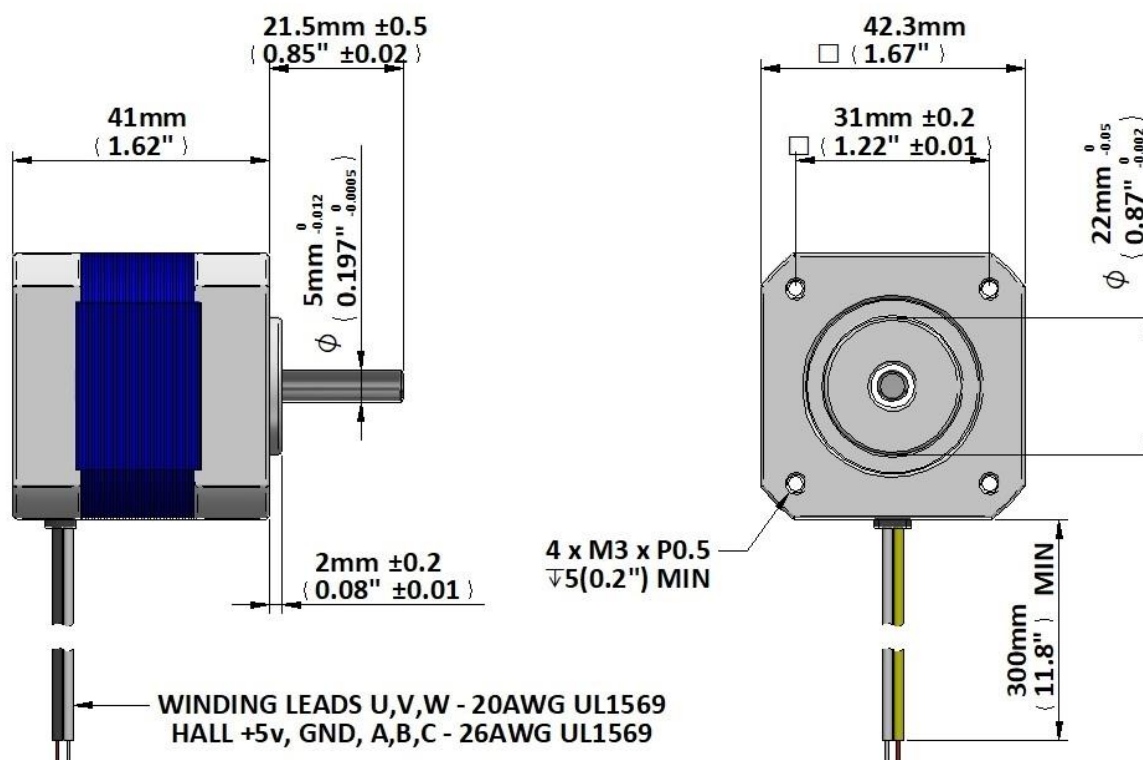
Green

White

Motor Winding Option	01A		
Motor Poles	8		
Voltage (VDC)	24VDC		
No-Load Speed (RPM)	5000 ±10%		
Rated Torque (Nm)	0.02		
Rated Speed (RPM)	4000 ±10%		
Rated Current (A)	<1		
Rated Power (W)	10		
Max (Stall) Torque (Nm)			
Back-EMF Constant (V/kRPM)			
Torque Constant (Nm/A)			
Resistance (Ω)			
Mass (kg)	0.25		
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -10°C to +40°C			

Geeplus reserves the right to change specifications without notice

[www.geeplus.com](http://www.geeplus.com)

**GEEPLUS****BLDC4241**

Phase Leads, 20AWG, UL1569

Hall Sensor Leads, 28AWG, UL1569

**U****V****W****5v****GND****A****B****C**

Red

Yellow

Black

Red

Black

Blue

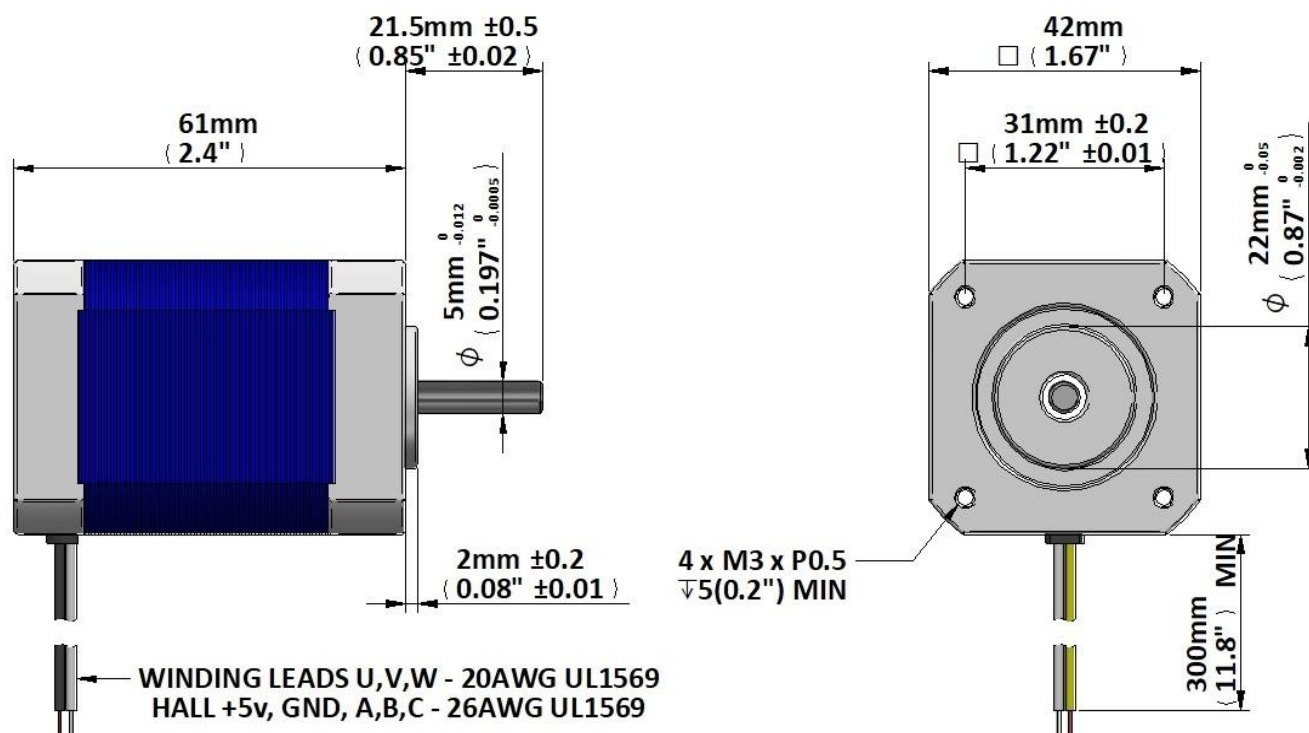
Green

White

Motor Winding Option	01A		
Motor Poles	8		
Voltage (VDC)	24VDC		
No-Load Speed (RPM)	5000 $\pm 10\%$		
Rated Torque (Nm)	0.063		
Rated Speed (RPM)	4000 $\pm 10\%$		
Rated Current (A)	<2		
Rated Power (W)	25		
Max (Stall) Torque (Nm)	0.19		
Back-EMF Constant (V/kRPM)	3.13		
Torque Constant (Nm/A)	0.039		
Resistance ( $\Omega$ )	1.5		
Mass (kg)	0.3		
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -10°C to +40°C			

Geeplus reserves the right to change specifications without notice

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Phase Leads, 20AWG, UL1569

Hall Sensor Leads, 28AWG, UL1569

**U**

**V**

**W**

**5v**

**GND**

**A**

**B**

**C**

Red

Yellow

Black

Red

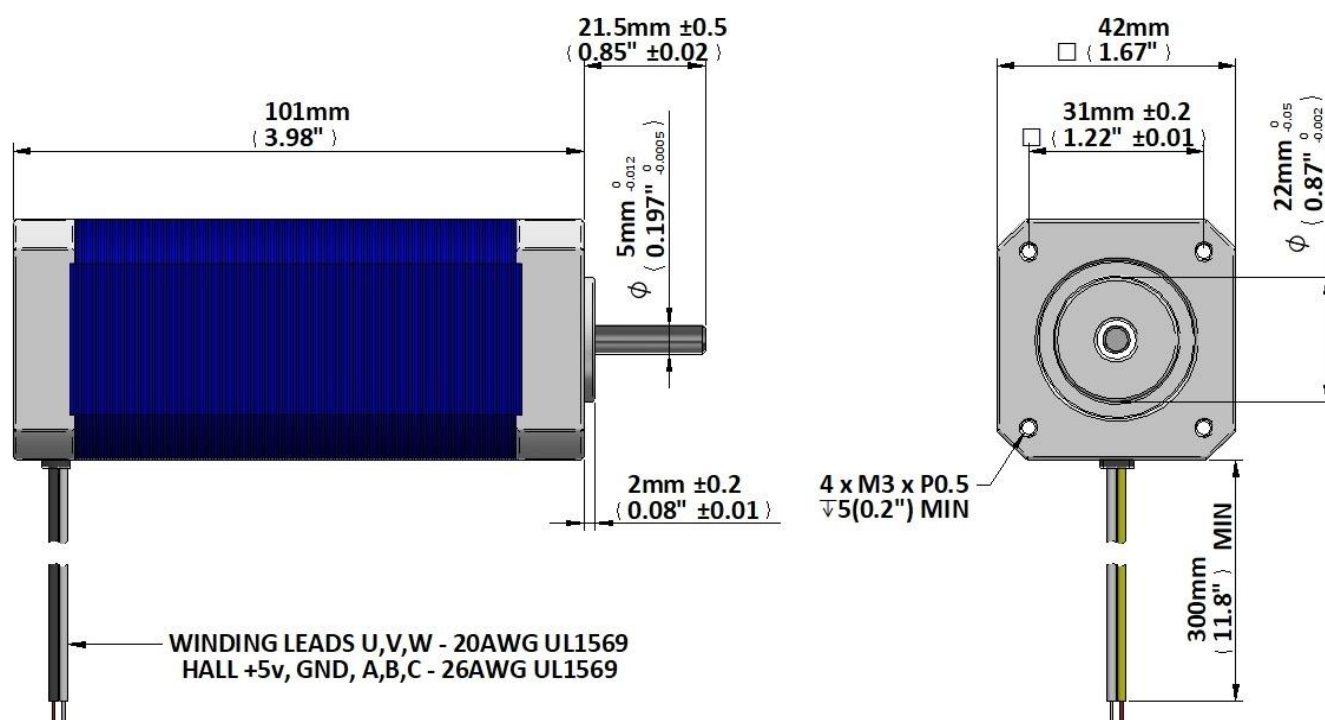
Black

Blue

Green

White

Motor Winding Option	01A		
Motor Poles	8		
Voltage (VDC)	24VDC		
No-Load Speed (RPM)	5000 ±10%		
Rated Torque (Nm)	0.125		
Rated Speed (RPM)	4000 ±10%		
Rated Current (A)	<3.5		
Rated Power (W)	50		
Max (Stall) Torque (Nm)	0.38		
Back-EMF Constant (V/kRPM)	3.15		
Torque Constant (Nm/A)	0.04		
Resistance (Ω)	0.74		
Mass (kg)	0.5		
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -10°C to +40°C			



Phase Leads, 20AWG, UL1569

Hall Sensor Leads, 28AWG, UL1569

**U**

**V**

**W**

**5v**

**GND**

**A**

**B**

**C**

Red

Yellow

Black

Red

Black

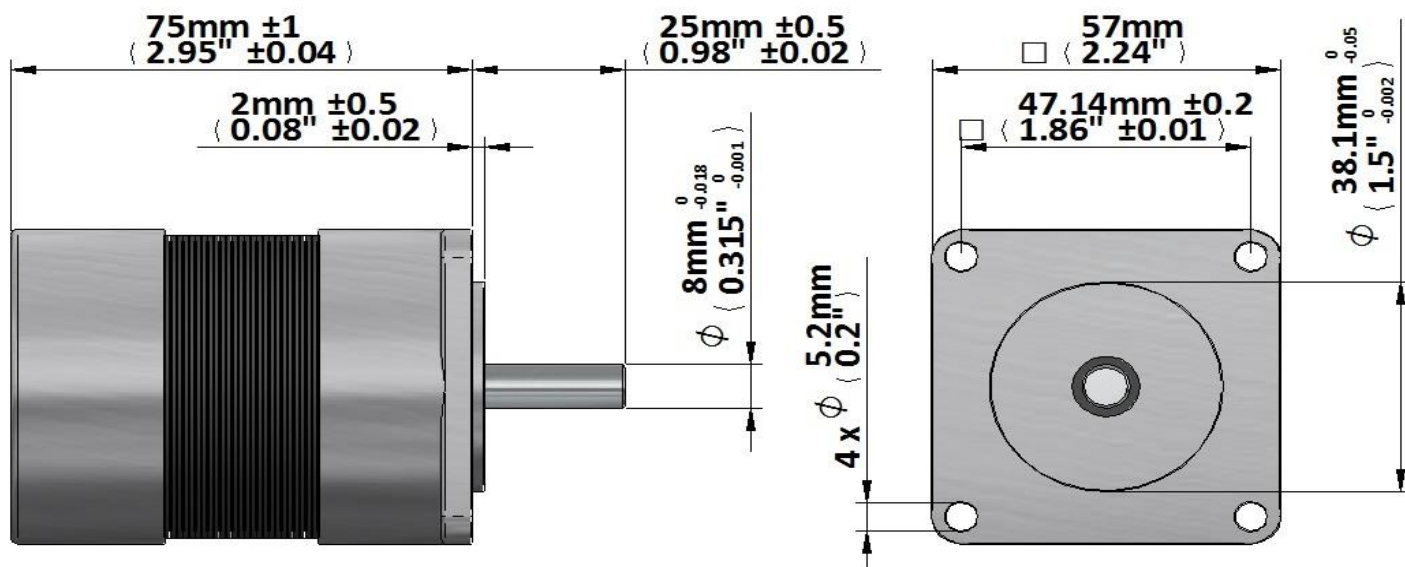
Blue

Green

White

Motor Winding Option	01A		
Motor Poles	8		
Voltage (VDC)	24VDC		
No-Load Speed (RPM)	5000 $\pm 10\%$		
Rated Torque (Nm)	0.25		
Rated Speed (RPM)	4000 $\pm 10\%$		
Rated Current (A)	<7		
Rated Power (W)	100		
Max (Stall) Torque (Nm)			
Back-EMF Constant (V/kRPM)			
Torque Constant (Nm/A)			
Resistance ( $\Omega$ )			
Mass (kg)	0.9		
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -10°C to +40°C			





Phase Leads, 18AWG, UL1569

Hall Sensor Leads, 26AWG, UL1569

**U**

**V**

**W**

**5v**

**GND**

**A**

**B**

**C**

Red

Yellow

Black

Red

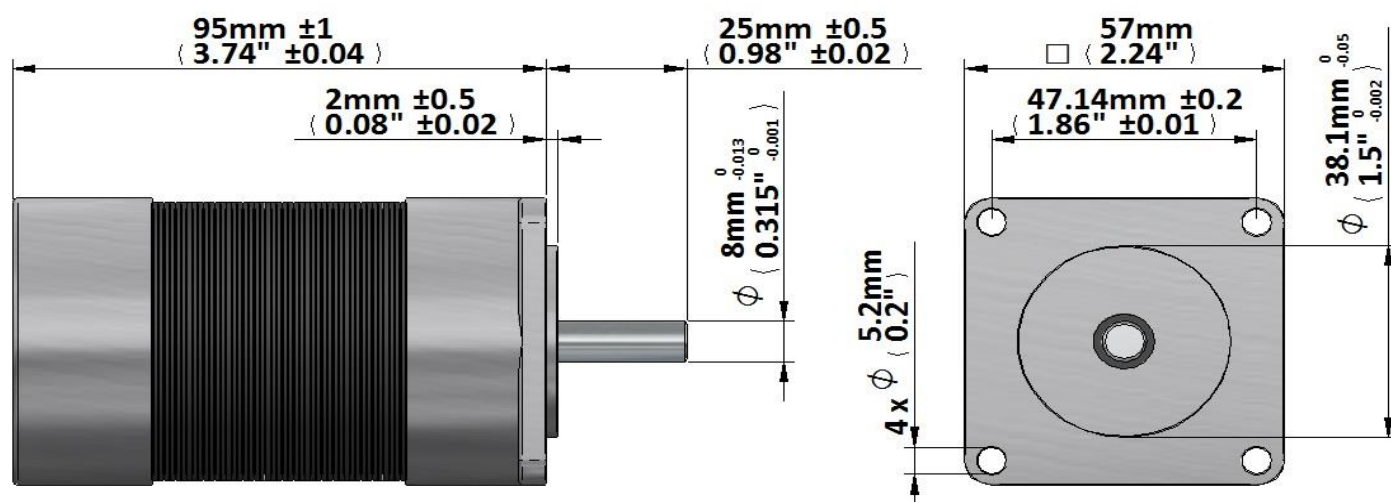
Black

Blue

Green

White

Motor Winding Option	01A		
Motor Poles	4		
Voltage (VDC)	24VDC		
No-Load Speed (RPM)	4900 $\pm 10\%$		
Rated Torque (Nm)	0.22		
Rated Speed (RPM)	4000 $\pm 10\%$		
Rated Current (A)	5.2		
Rated Power (W)	90		
Max (Stall) Torque (Nm)	0.8		
Back-EMF Constant (V/kRPM)	3.15		
Torque Constant (Nm/A)	0.045		
Resistance ( $\Omega$ )	1.22		
Mass (kg)	0.9		
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -20°C to +40°C			



Phase Leads, 18AWG, UL1569

Hall Sensor Leads, 26AWG, UL1569

**U**

**V**

**W**

**5v**

**GND**

**A**

**B**

**C**

Red

Yellow

Black

Red

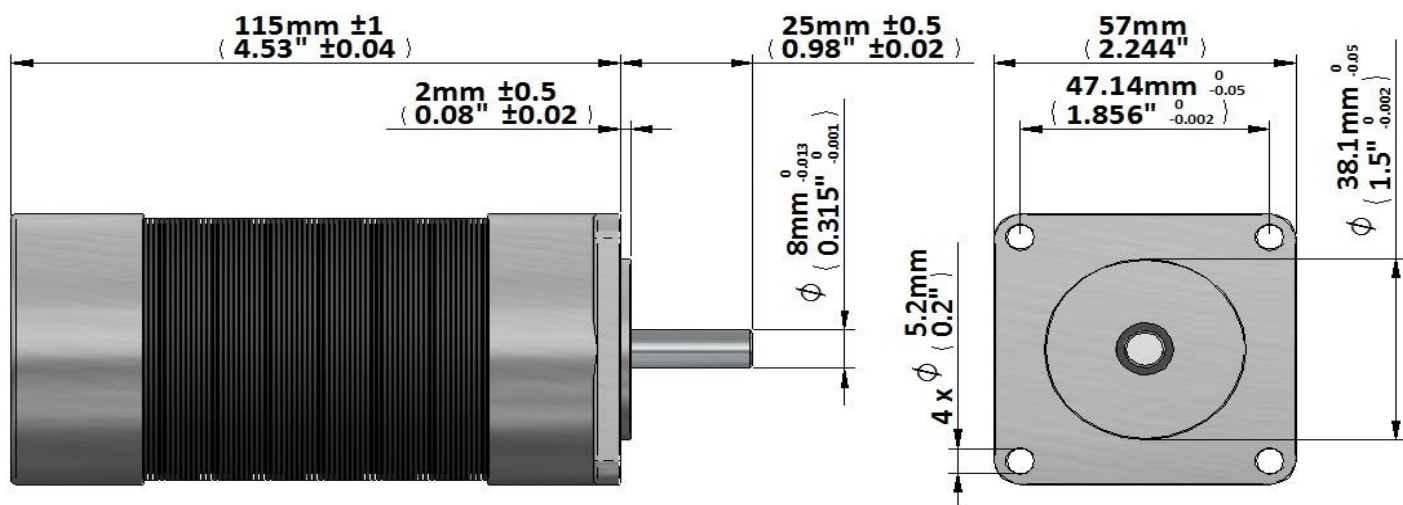
Black

Blue

Green

White

Motor Winding Option	01A		
Motor Poles	4		
Voltage (VDC)	24VDC		
No-Load Speed (RPM)	5200 $\pm 10\%$		
Rated Torque (Nm)	0.32		
Rated Speed (RPM)	4000 $\pm 10\%$		
Rated Current (A)	7.4		
Rated Power (W)	130		
Max (Stall) Torque (Nm)	1.2		
Back-EMF Constant (V/kRPM)	3.13		
Torque Constant (Nm/A)	0.044		
Resistance ( $\Omega$ )			
Mass (kg)			
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -20°C to +40°C			



Phase Leads, 18AWG, UL1569

Hall Sensor Leads, 26AWG, UL1569

**U**

**V**

**W**

**5v**

**GND**

**A**

**B**

**C**

Red

Yellow

Black

Red

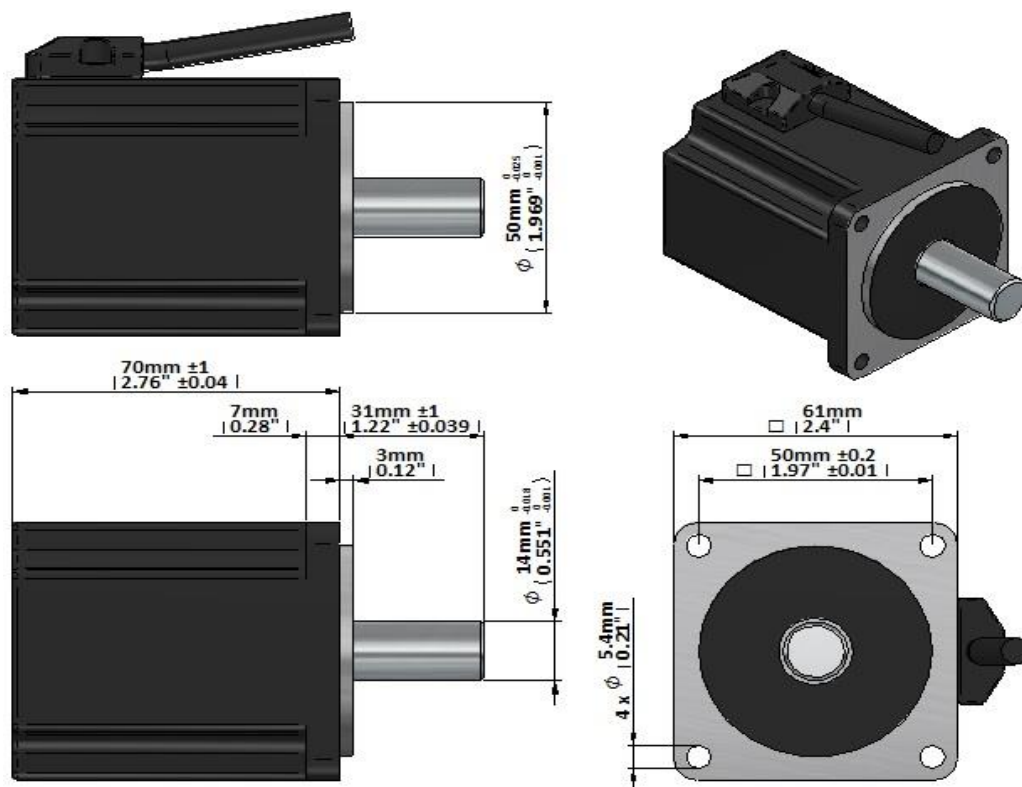
Black

Blue

Green

White

Motor Winding Option	01A		
Motor Poles	4		
Voltage (VDC)	24VDC		
No-Load Speed (RPM)	5350 $\pm 10\%$		
Rated Torque (Nm)	0.42		
Rated Speed (RPM)	4000 $\pm 10\%$		
Rated Current (A)	9.7		
Rated Power (W)	170		
Max (Stall) Torque (Nm)	1.7		
Back-EMF Constant (V/kRPM)	3.08		
Torque Constant (Nm/A)	0.043		
Resistance ( $\Omega$ )			
Mass (kg)			
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -20°C to +40°C			

**GEEPLUS****BLDC6070**

Phase Leads, 18AWG, UL1569

Hall Sensor Leads, 26AWG, UL1569

**U**

Red

**V**

Yellow

**W**

Black

**5v**

Red

**GND**

Black

**A**

Blue

**B**

Green

**C**

White

Motor Winding Option	01A		
Motor Poles	8		
Voltage (VDC)	36VDC		
No-Load Speed (RPM)	5100 ±10%		
Rated Torque (Nm)	0.3		
Rated Speed (RPM)	4000 ±10%		
Rated Current (A)	5		
Rated Power (W)	80		
Max (Stall) Torque (Nm)	1		
Back-EMF Constant (V/kRPM)	4.35		
Torque Constant (Nm/A)	0.06		
Resistance (Ω)	???		
Mass (kg)	0.9		
Shaft Runout (mm MAX)	0.025		
Insulation Class B			
Dielectric Strength 500VDC for 1min			
Ambient Temperature -20°C to +40°C			

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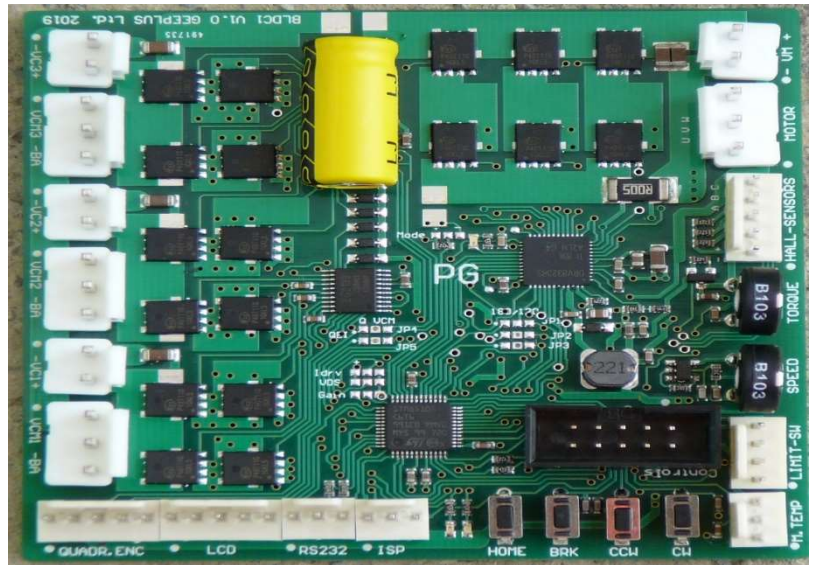
[www.geeplus.com](http://www.geeplus.com)



# BLDC1 – Motor Controller

The Brushless DC Motor Controller BLDC1 provides basic control functions for motors with power up to approximately 1kW.

In addition, the controller can provide PWM current control for up to 3 bipolar devices (VCM or Bistable Solenoid) with source voltage 8-36 VDC and current output up to 40 Amps (12 Amps is maximum without heatsinking).



- Provides 3-phase drive for motors with hall-sensor 60° from poles, 120° trapezoidal commutation
- V supply 8-60V
- Motor Current 40 Amps max (12 Amps is maximum without heatsink)
- Over-current and under-voltage protection
- Controls – Turn CW, Turn CCW, Brake, Go Home
- LCD interface (SPI)
- Quadrature Encoder Input for VCM control (3<sup>rd</sup> VCM output is not available if this is used)
- Speed Control by on-board trimmer or 0-5v control signal
- Torque Control by on-board trimmer or 0-5v control signal
- RS232 interface for PC