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TECHNIC CHECK

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LEGO® will stop manufacturing and selling Power Functions™ components in 2020. However, this also means that motors, servos and battery boxes will be sold at a premium on the third-party market.

SBricks, PFx Bricks or BuWizz bricks already in use that are equipped with Power Functions connectors can no longer be replenished.

However, the Chinese market has been offering compatible imitation products here for some time, but these must be investigated in terms of their compatibility. Other third-party suppliers are also coming onto the market with interesting motor solutions that are compatible with Power Functions.

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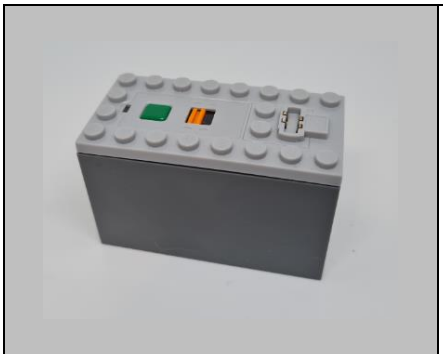
To get you started, here's a brief overview of the Power FunctionsTM components LEGO® has manufactured in the past (2007 to 2020).

	M-Motor (8883)	Old target price: 9 EUR Idle speed: 405 rpm No-load current: 65mA Blocking torque: 11Ncm Blocking current: 850mA Rated speed (9V): 275 rpm Rated current: 310mA
	XL-Motor (8882)	Old target price: 12 EUR Idle speed: 220 rpm No-load current: 80mA Blocking torque: 40Ncm Blocking current: 1.8A Rated speed (9V): 146 rpm Rated current: 550mA
	L-Motor (88003)	Old target price: 15 EUR Idle speed: 390 rpm No-load current: 120 mA Blocking torque: 18 Ncm Blocking current: 1.3A Rated speed (9V): 272 rpm Rated current: 490mA
	E-Motor (87577c01)	E-Motor aus dem Education Energy Set 9688. Motor und Generator. Idle speed: 780 rpm No-load current: 17,5mA Blocking torque: 3.4 Ncm Blocking current: 410mA Rated speed (9V): 420 rpm Rated current: 180mA

	Train Motor (88002)	Old target price: 14 EUR Idle speed: 1900 rpm No-load current: 90 mA Blocking torque: 3.6 Ncm Blocking current: 1.3A Rated speed (9V): 1458 rpm Rated current: 410mA
	Servo (80004)	Old target price: 25 EUR Rotation range: +90deg to -90deg, increment: 7 (in any direction from 0deg) **Attention:** Do not connect directly to battery box. Requires PWM signal

Table 1: LEGO Power Functions motors (photo of E-Motor by LEGO®)

You can find more technical information and characteristic curves for the original LEGO motors on https://www.philohome.com/tech.htm. Philo Hurbain has spent a lot of time gathering and creating information and characteristic curves for the LEGO motors.

	Battery Box (88000)	Old target price: 14 EUR 6x 1.5V AAA Cells = 9V Max. output current: 750mA
	Battery Box (8881)	Old target price: 8 EUR 6x 1.5V AA Cells = 9V Max. output current: 750mA

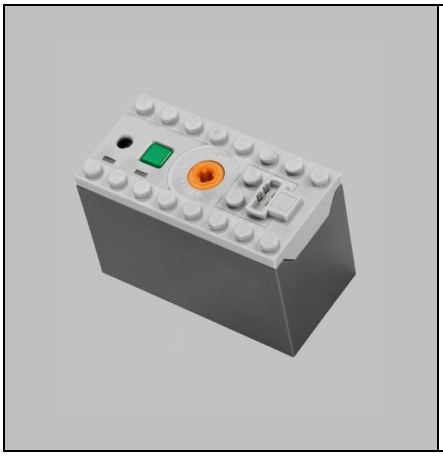
	Rechargeable battery box (8878)	Old target price: 35 EUR Lithium polymer: 7.4V Capacity: 1100mAh Max. output current: 1A

Table 2: LEGO Power Functions battery and rechargeable boxes

Alternative manufacturer

Starting from products with a battery box that uses 6x 1.5V AAA cells or AA cells, we definitely have a 9V system and corresponding motors, servos or LED elements. Switches as well as extension cables are not critical here and can be used by any manufacturer. We ignore infrared controllers and receivers at this point, but there might be deviations from the standard here as well. In addition, many Chinese manufacturers only use 2.4GHz RC controllers instead of infrared.

If the motors use a battery or accumulator box with a lower voltage, the motors are most likely designed for this. Especially for rechargeable batteries, the voltage is often 7.4V. If no data is given by the manufacturer, you should not operate the motor above this voltage either. This begs the question, "What actually happens when you run a motor at a higher voltage?" First, the speed of the motor increases and efficiency deteriorates. In addition, more heat is generated and power consumption increases, which reduces service life. The inrush current also increases accordingly, which must also be taken into account for the power supply. Continuous operation should therefore not take place above the rated voltage or the rated voltage range. In the worst case, an excessive voltage causes a short circuit or interruption in the motor winding, as shown by the experiment of the "Brick Experimental on YouTube" (https://www.youtube.com/watch?v=6byrPRQihMQ).

It is also important to note that some of the control modules from China do not realize speed control. There is only 100% or 0% speed. If there is a control, the motor only starts from a certain value, i.e. there is a jerk.

Also relevant are electronic components present in the motor, which can have an influence on the control. In particular, if e.g. capacitors are used for spark interference, these can impair the pulse width modulation signal under certain conditions..

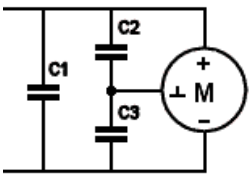


Fig 1: Interference suppression of a DC motor with capacitors

Briefly, let's take a look at pulse width control, which is used by many alternative motor control modules. Here, the signal to the DC load - in our case a motor - is generated digitally in the form of a square-wave signal with varying duty cycle. The duty cycle and the maximum voltage result in an average value, which in turn can assume a value between the supply voltage and 0V. This average value controls the speed of the motor accordingly, where a low duty cycle of e.g. 10% makes the motor turn slower and a high duty cycle of e.g. 80% gives a faster speed. At 100%, the maximum supply voltage is applied to the control output or motor, while at 0% no voltage - i.e. 0V - is output.

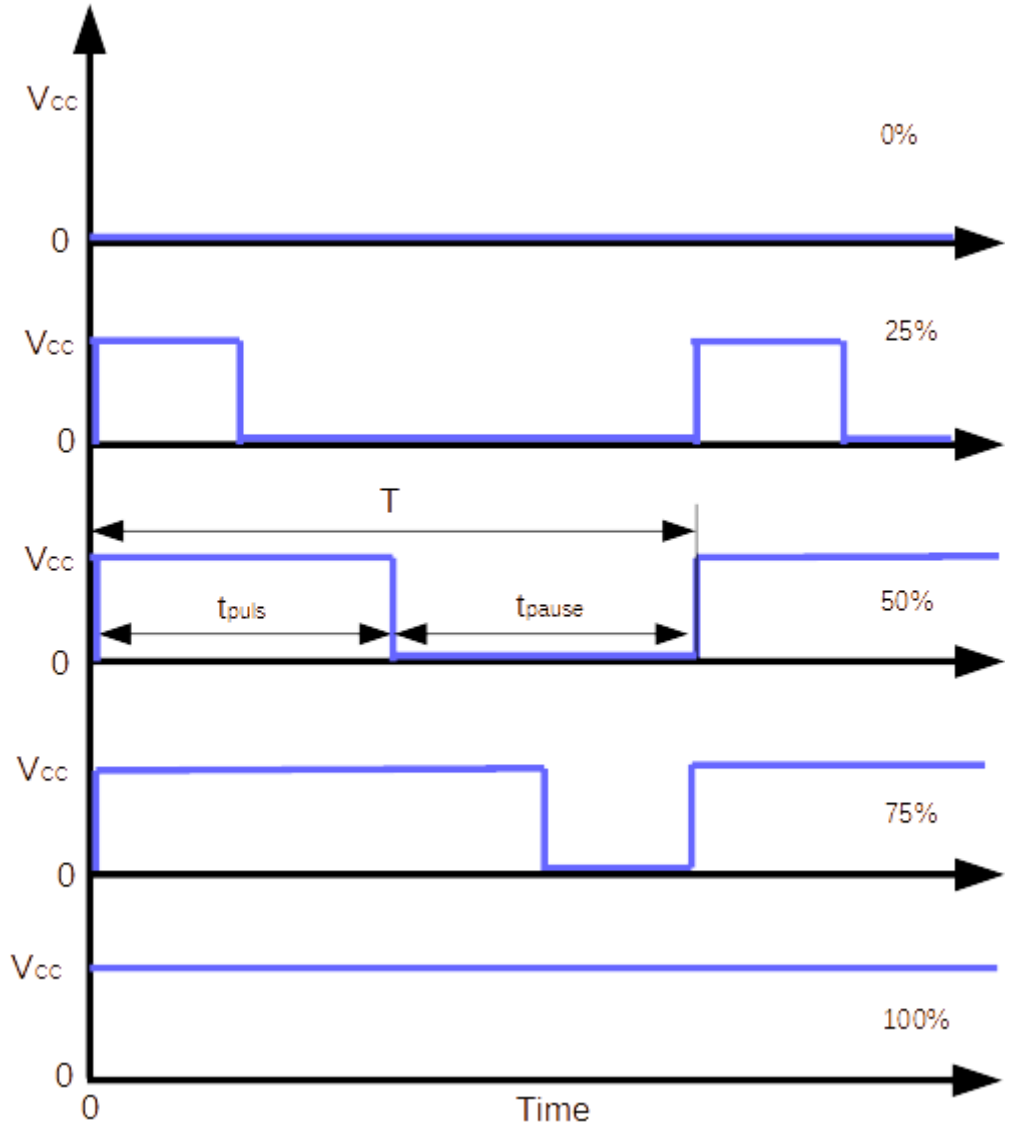


Fig 2: Different duty cycles of a pulse width signal

Some control modules also play with the fundamental frequency of the square wave signal to achieve certain effects. This in turn can lead to side effects depending on the motor, such as high very currents at slow speed and low frequency of the PWM signal.

Since some alternative control bricks like BuWizz, PFxBrick and SBrick exist with Power Functions compatible connectors, the further use of LEGO Power Functions motors is also possible in combination with alternative motors - sometimes with much better functionality. Therefore also at the end of the article an overview of the compatibility to these control bricks.

Blue Brixx

The company Blue Brixx has launched its own series, which are produced by one of the Chinese manufacturers with black ABS. It is important to know that the battery box works with 7.4V output voltage - the typical lithium polymer battery voltage. Based on the information on the website, the motors and servo can also be used for 9V. The construction of the motors is classically simple - a temperature-dependent protective resistor (NTC) is installed next to the electric motor and a gearbox made of plastic is mounted on the front. The motor itself does not have any imprint which may help to determine the origin. Due to the construction, the motors can also be controlled with the IR receiver from LEGO.

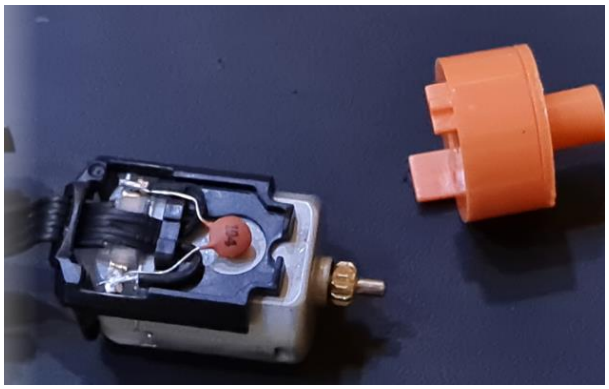


Fig 3: Blue Brixx L-Motor Interior

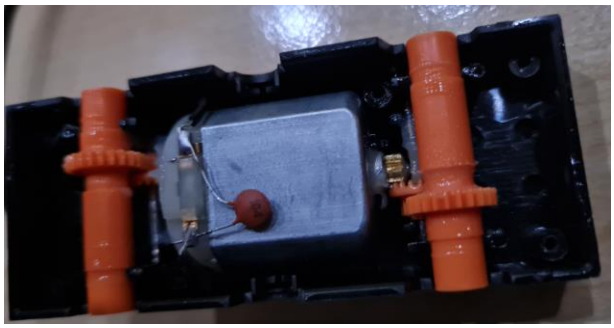


Fig 4: Blue Brixx Railway Engine Interior

The Blue Brixx servo is one of the kind with 90° stop positions without intermediate steps, which is why it cannot be used for soft steering controls. However, we get from Blue Brixx a railroad motor that otherwise can only be obtained from unreliable sources. Here the buyer has a warranty claim and a source of supply in Europe and moreover at a very good price. The engines are overall cheaper than the comparable engines from LEGO when they were still produced. Moderate shipping costs of 4.95 EUR in Germany (from 199 EUR free shipping) and 9.95 to the EU are added.

	M-Motor (401173)	Price: 6.95 EUR Voltage: 9V Idle speed: 1043 rpm No-load current: 185mA Rated speed: appx. 510 rpm Torque: appx. 9.5 Ncm Blocking current: 1.23A
	L-Motor (401174)	Price: 6.95 EUR Voltage: 9V Idle speed: 1130 rpm No-load current: 185 mA Rated speed: appx. 510 rpm Torque: appx. 16.5 Ncm Blocking current: 3A
	XL-Motor (401175)	Price: 6.95 EUR Voltage: 9V Idle speed: 640 rpm No-load current: 175 mA Rated speed: appx. 310 rpm Torque: appx. 32.5 Ncm Blocking current: 2.6A
	Train Motor (401172)	Price: 9.95 EUR Voltage: 9V Idle speed: 3651 1/min No-load current: 85 mA Rated speed: appx. 1700 rpm Torque: appx. 3.2 Ncm Blocking current: 0.85 A

	Servo (401176)	Price: 9.95 EUR Rotation range: +90deg, 0, -90deg No intermediate steps! **Attention:** Do not connect directly to battery box. Requires PWM signal. Not compatible with LEGO IR receiver, but compatible with BuWizz, PFx Brick and SBrick (as motor).

Table 3: Blue Brixx Motors

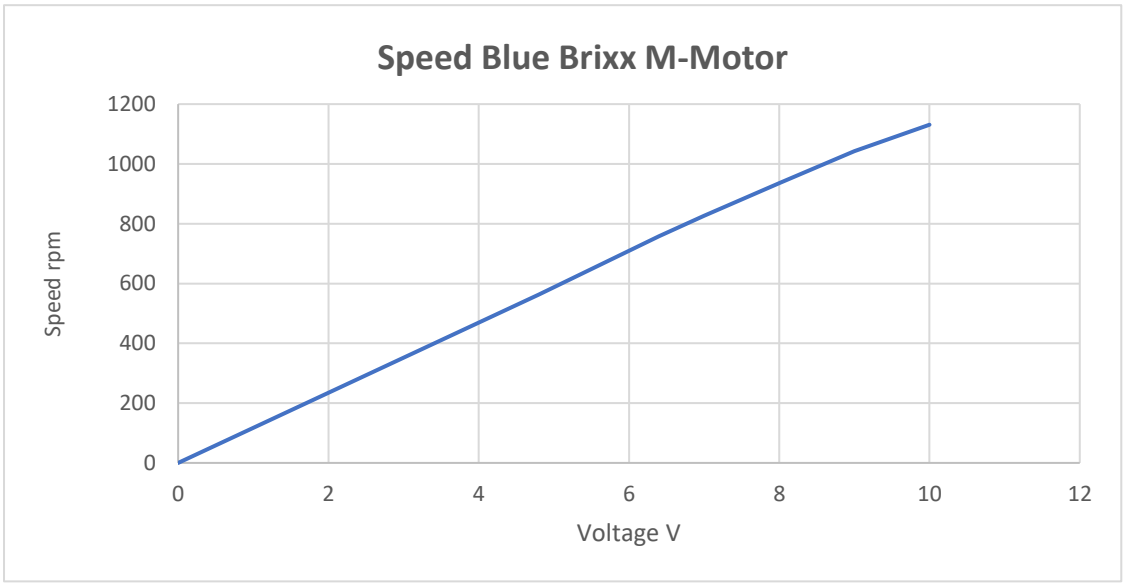


Fig 5: Speed diagram Blue Brixx M-Motor

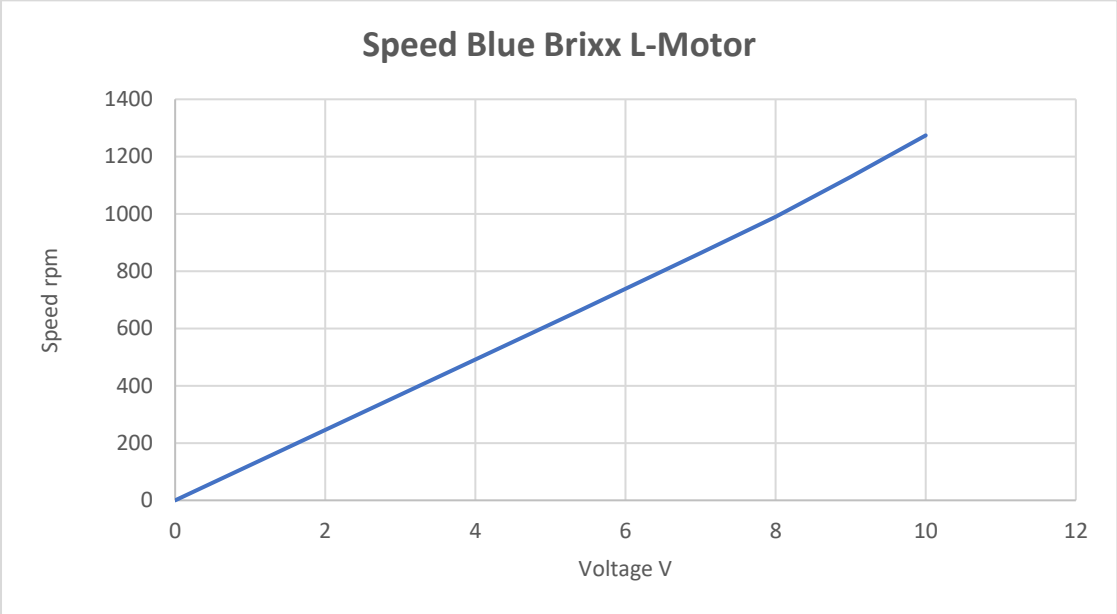


Fig 6: Speed diagram Blue Brixx L-Motor

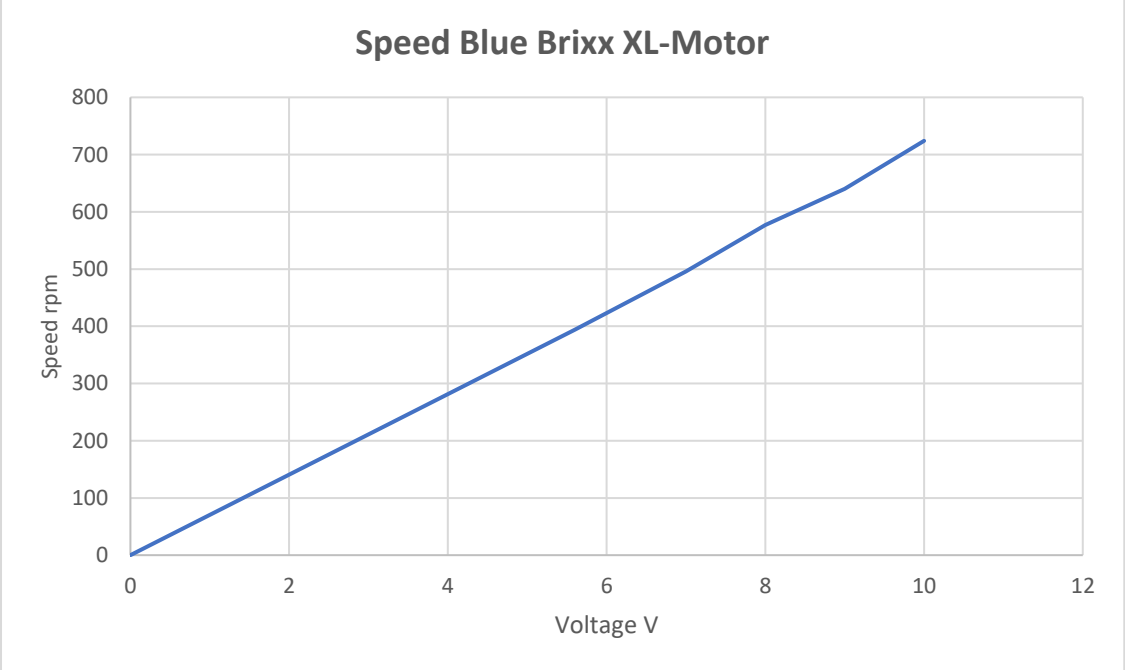


Fig 7: Speed diagram Blue Brixx XL-Motor

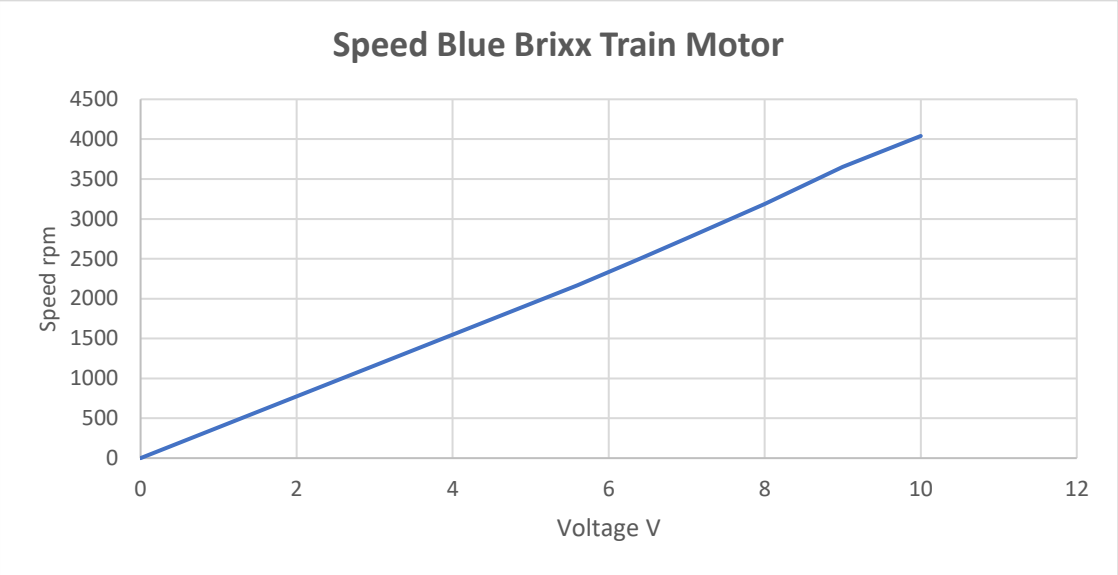


Fig 8: Speed diagram Blue Brixx Train Motor

Manufacturer/Distribution: https://www.bluebrixx.com/

Brickengine

An interesting and independent solution is the motor from Brickengine. Made in Germany and is visually and functionally a proprietary development and not a replica. Equipped with a Power Functions connector, it is an alternative for the M-motor, but 44% smaller (5x2x3 studs). The torque with 5,5N/cm is between the M- and L-motor.

The speed at 9V is 180 1/min - in comparison the M-motor has 272 1/min, so it has 100 revolutions per minute less. But it has more power. But as said, the motor is not an imitation, but a motor with its own performance data and housing construction. The case was manufactured using the 3D DLP (Digital Light Processing) process with 50µm and is very fine for a 3D print and has a pleasant feel.

Fig 9: Brickengine V1 (Photo: Brickengine)

Another special feature is the installed metal gearbox. The well-known motors of LEGO newer generation and the products from Asia usually use plastic gears.

The Technic-hole configuration of the housing is designed for direct connection to Linear Actuators.

Fig 10: Brickengine with Linear Actuator 61927c01

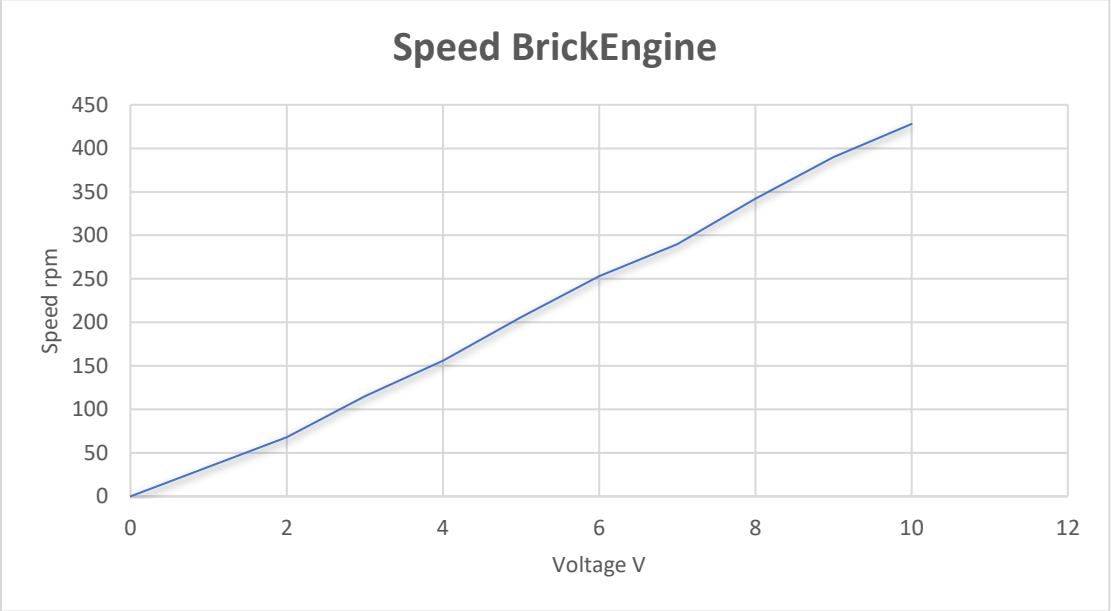


Fig 11: Speed diagram Brickengine V1

The housing design harmonizes with LEGO linear actuators, which can be plugged directly and attached with two pins on the right and left. This makes it interesting for all kinds of construction machines where booms have to be moved.

Depending on the control (voltage level, PWM parameters) the motor starts to rotate with different speed values. With the PFx Brick at 43 min/1, the LEGO IR start the motor at 50 min/1, while with the BuWizz at 90 min/1 and with the SBrick at about 100 min/1 the starting point (idle) is reached. In addition to overcoming the friction in the mechanics, the nominal voltage of 12V of the motor is also decisive, which does not rotate if the voltage is too low. At this nominal voltage, the motor can also be operated without hesitation with the BuWizz in "Ludicrous" mode.

With the BuWizz, the motor gets 460 min/1 in "Ludicrous" mode (11.2 V) and 406 min/1 in "Fast" mode (9.2 V) (all no-load values).

With the PFx Brick, the "Torque Compensation" should be switched off, because here a high current at low drive value triggers the protection circuit of the battery box.

For 19.95 EUR the motor is a bit more expensive than the old L-motor, but for a small series production a fair price.

Hersteller: https://www.brickengine.de/

BuWizz Motor

The company Fortronik, based in Slovenia, which has become known with the BuWizz control module incl. high-performance battery, has also taken on the motor development. In this case, a motor based on the LEGO® RC motor 5292, but with its own performance data, designed for higher speed and torque. In addition, the 5292 was not designed for Power Functions, but with the connectors of the older 9V system - the BuWizz motor has a Power Functions compatible connector. However, the motor only achieves its higher power with the BuWizz and its higher output voltage modes.

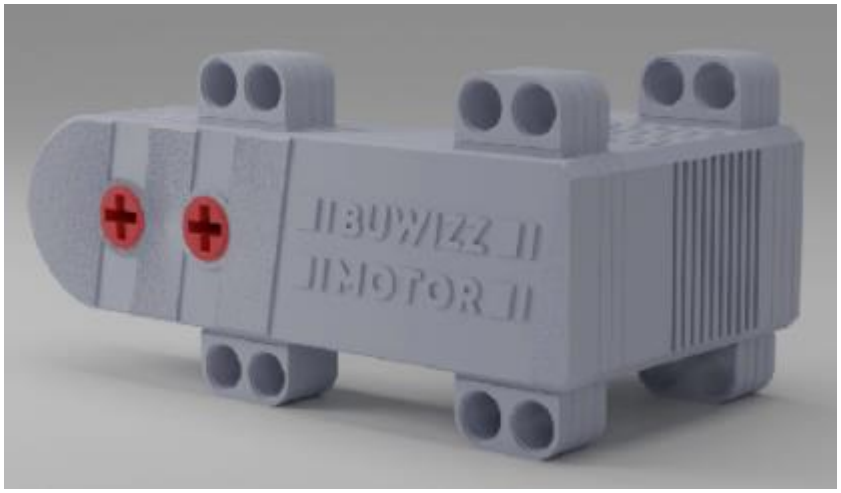


Fig 12: BuWizz Motor (Photo: Fortronik)

According to the manufacturer, an approx. 10% higher speed and a 10% higher torque can be expected compared to the 5292. This has a torque of approx. 14 Ncm, i.e. the BuWizz motor has 15.4 Ncm. With a speed of 1240 1/min on the original, this motor would then be expected to have approx. 1364 1/min. The model is absolutely designed for speed and power to move vehicles as fast as possible. Also the design is made for RC vehicles and not for installation e.g. in locomotives. But for all fans of this division it is the revival of the old 5292 in the Power Functions universe.

Unfortunately, the BuWizz motor was not yet available at the editorial deadline, which is why the characteristic curve and compatibility test are still pending.

<TBD>

Fig. 13: Speed diagram of BuWizz motor

The price for the motor is 28 EUR (including 22% VAT in Slovenia) plus shipping.

Manufacturer: https://buwizz.com/

CaDa

With CaDa, the technology components are operated with 7.4V lithium batteries. The voltage is 1.6V below the Power Functions and the components are therefore not compatible in terms of operating voltage at first glance. However, since CaDa also has a C61011 Cada battery box with 6x AA 1.5V cell capacity in their product line, it can be assumed that the motors are designed for 9V.

In any case, the motors harmonize with LEGO's battery box, as it also provides 7.4V output voltage. However, the motors and the servo do not respond when connected to the LEGO infrared receiver.

Unfortunately, no further technical data on the motors has been or will be published upon request. The components all carry the CADA logo as well as a type number, which definitely prevents confusion with other products or manufacturers.

CaDa has two different product lines for motors, the standard series which follows the size of the motors from LEGO and the Pro series, which provides its own design of the components. Usually you get the motors in sets with a control brick, remote control, LED element and extension cable. However, some retailers also offer the motors and servos individually.

Fig 14: CADA Power System Pack S054-003 and Power System Pack Pro S059-003

The CADA M motor (CJV5014) has a circuit board on the housing, on which there are five capacitors for interference suppression and a resistor connected between the control input (2) and 0V (4), and technically the identification resistor that LEGO also uses in their products. However, the motors are not compatible with the LEGO IR receiver.

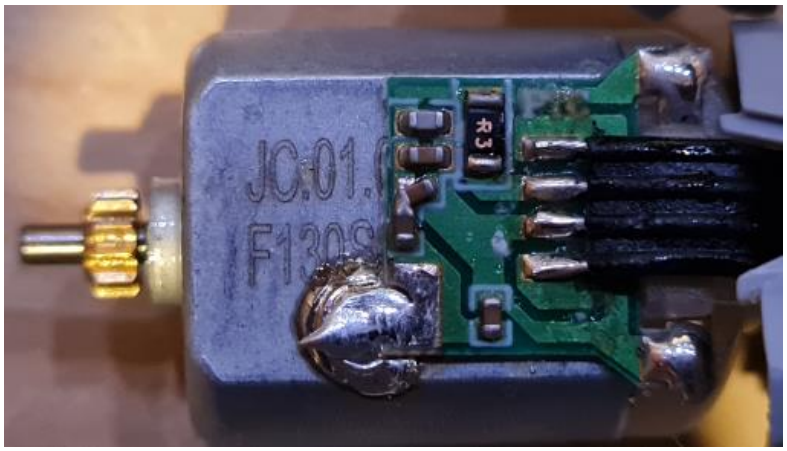


Fig 15: CADA M-Motor Innenleben

The servo from CaDa is definitely special, as it contains a real servo motor and not a simple motor like many other products from Asia, which only positions between +90° and 90° and has difficulties resetting to 0. If you take a look at the inner workings, you will find control electronics and an angle encoder (rotary encoder, rotary encoder) in addition to the DC motor. The gearbox is connected to a spring contact plate, which is guided over the contacts of the front circuit board and thus the position is determined. The circuit board shows that the zero position (top) and seven steps up to the 90° or -90° position can be taken. Unfortunately, it is still not compatible with the LEGO IR receiver, but works with other control modules that can address the positions via the controller.

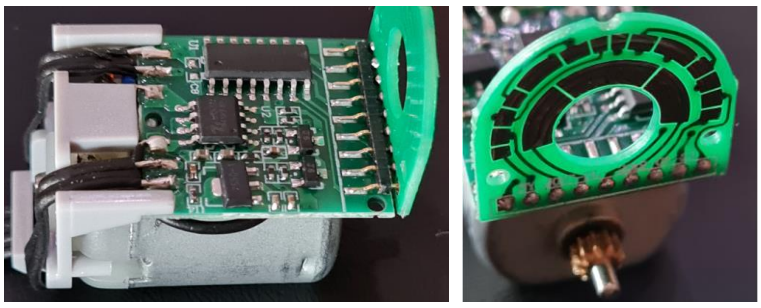


Fig 16: Control electronics (left) and angle encoder (right) of the CaDa servo

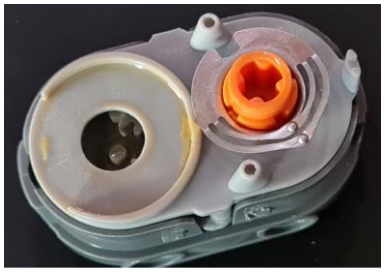


Fig 17: Gear and contact plate of the angle encoder

An interesting new development is the Micro motor in a 2x3 stud housing and a speed of around 342 rpm. The axis connection is external, which results in a 2x4 stud size in the end. The height is 1 brick + 2 plates or 15.9 mm (without stud).

Fig 18: CADA Mico-Motor

The housing is screwed with two very thin screws and allows an easy look inside. The DC motor is connected to a small circuit board on the side, on which a capacitor and a resistor are installed. The two control wires of the Power Functions compatible cable are connected to the PCB and are led out of the case via a slot behind the motor. The strands of the + and - wires still stick out a bit, which can lead to a short circuit if necessary. Something that can be optimized in the manufacturing process.

In the front part of the housing sits the plastic gear with the external axis transducer.

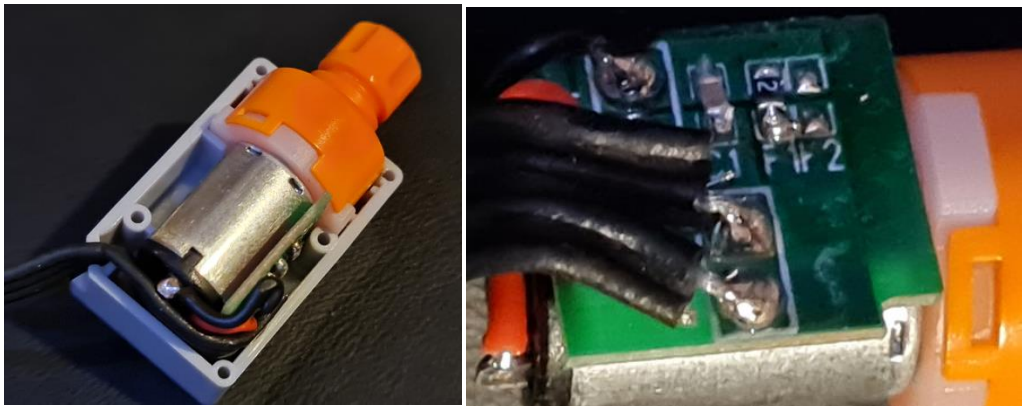


Fig 19: CADA Mico-Motor Interior

	L-Motor (C61012)	Price: appx. 13 EUR Voltage: 9V No-load current: 90mA Idle speed (9V): 755 rpm Blocking current: 1.1A

	M-Motor (CJV5014)	Price: appx. 7.90 EUR Voltage: 9V No-load current: 90mA Idle speed (9V): 755 rpm Blocking current: 0.6A
	Servo (C61013)	Price: appx. 15.90 EUR Rotation range: +90deg, 0, -90deg increment: 7 (in any direction from 0deg) **Attention:** Do not connect directly to battery box. Requires PWM signal. Not compatible with LEGO IR receiver, but compatible with BuWizz, PFx Brick and SBrick (as motor).
	L Pro (JV5028)	Price: appx. 17 EUR Voltage: 9V Idle speed (9V): 1186 rpm No-load current: 150 mA Blocking current: 2A
	M Pro (JV5030)	Price: appx. 12 EUR Voltage: 9V Idle speed (9V): 1340 rpm No-load current: 225 mA Blocking current: 1.8A

	Servo Pro (JV5029)	Price: appx. 19 EUR Rotation range: +90deg, 0, -90deg increment: 7 (in any direction from 0deg) **Attention:** Do not connect directly to battery box. Requires PWM signal. Not compatible with LEGO IR receiver, but compatible with BuWizz, PFx Brick and SBrick (as motor).
	Micro-Motor (??)	Price: From May 2021 component in a new set - individual availability not yet known at editorial deadline Voltage: 9V Idle speed (9V): 370 rpm No-load current: 57 mA Blocking current: 300 mA

Table 4: CaDa Motors

The following diagrams show the speed characteristics as a function of the applied voltage. The tests were measured with a constant voltage applied to the motor and recorded in 1V increments. A digital laser tachometer was used for the measurement.

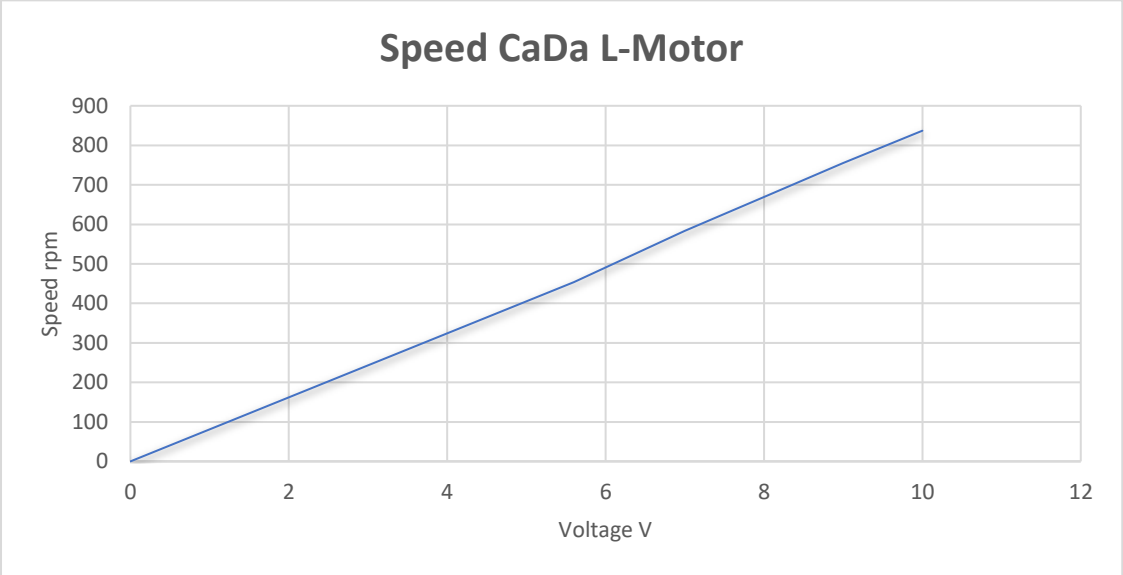


Fig 20: Speed diagram of CADA L-Motor

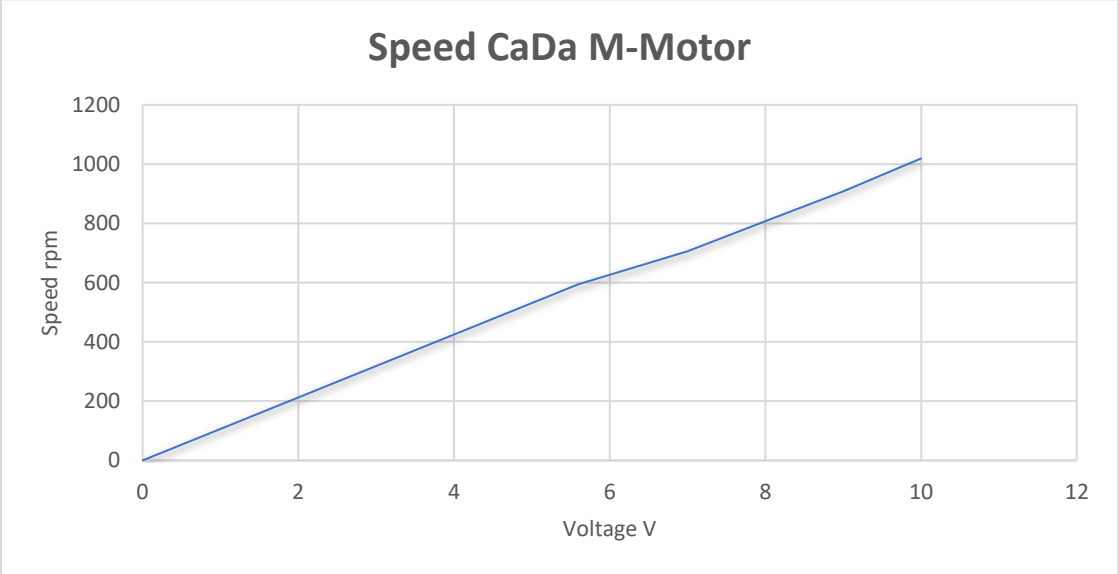


Fig 21: Speed diagram of CADA M-Motor

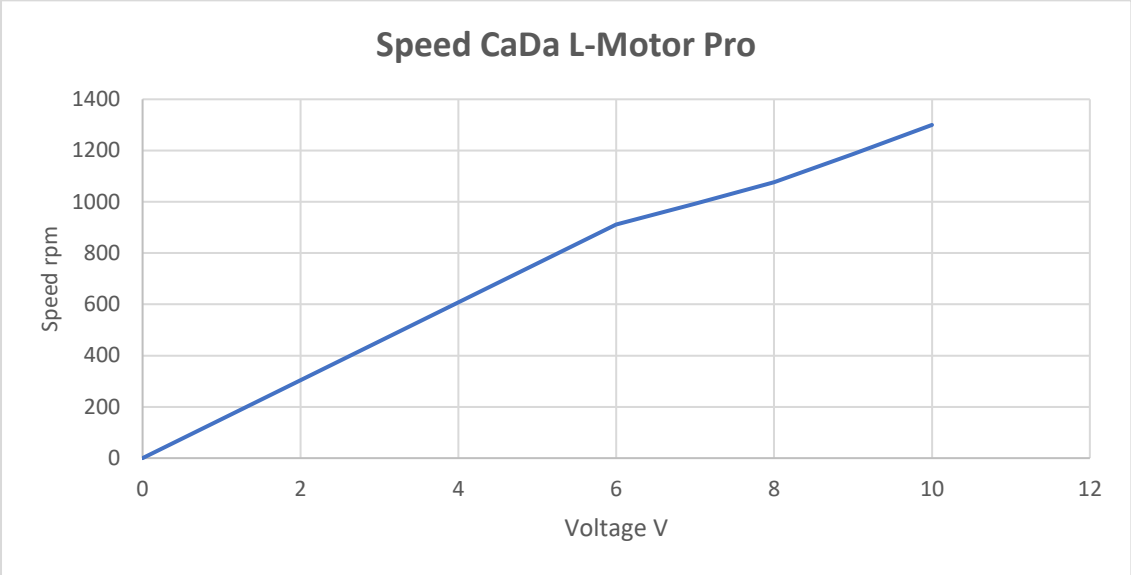


Fig 22: Speed diagram of CADA L-Motor Pro

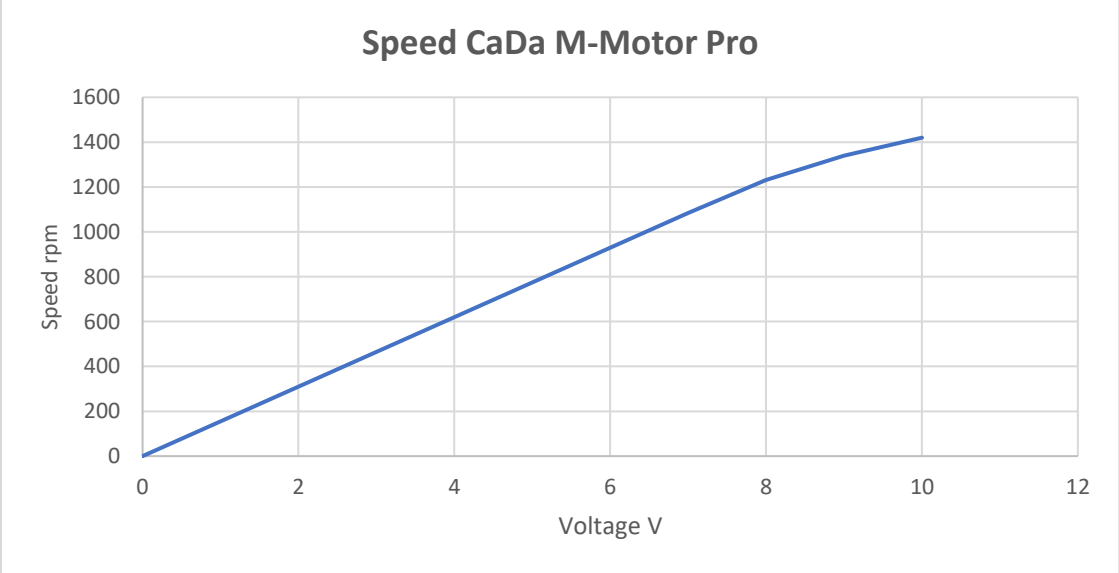


Fig 23: Speed diagram of CADA M-Motor Pro

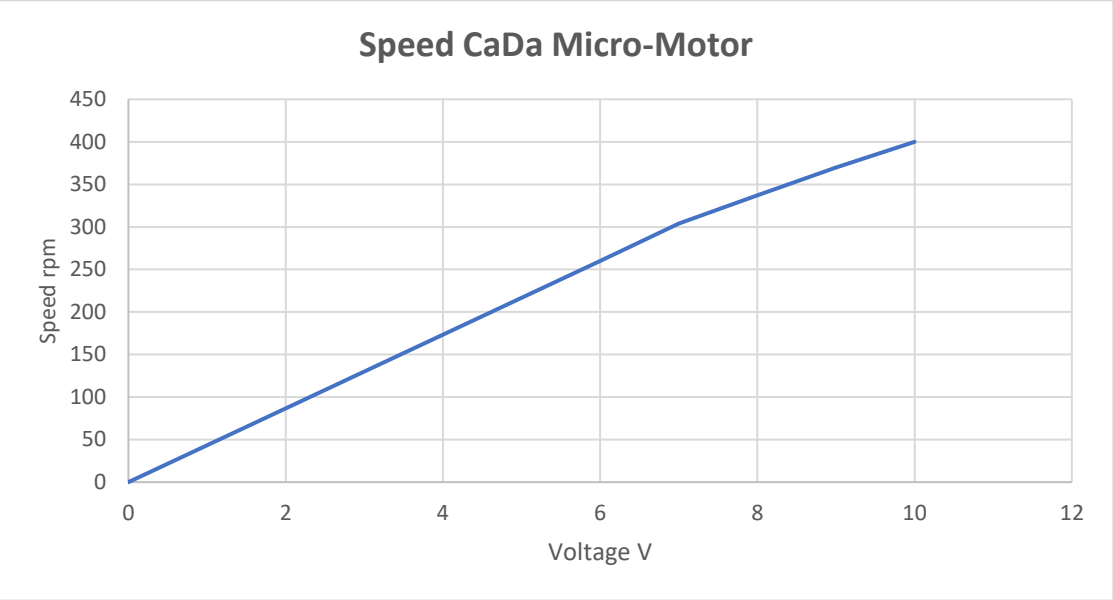


Fig 24: Speed diagram of CADA Micro motor

Manufacturer: Doubleeagle Industry Ltd.
http://en.doubleeagle-group.com/
https://decadastore.com/

WANGE (DUBIE)

Wange is already since the late 90s on the market and obviously does not play with the illegal copies, but supplies its own model or sets designs. The motors produced work with 9V systems and are therefore compatible with Power Functions technology. However, the motors differ in their speed from the original, whereby these are higher. This has also shown own tests with the Technic set **1501**, which come with an 8881 equivalent battery box, an XL, L, and M motor, as well as two 21cm extension cables and 75 Technic parts. Visually, the components do not differ from the original - except for the missing trademark. Depending on the source of supply, the package costs between 24 EUR and 35 EUR. The sturdy box has snap closures as well as a handle and significantly reduces packaging waste. However, the box is only available if you order the set from a retailer in your own country. For orders in Asia, the box is usually not sent with the shipment. One more reason to purchase the motor set locally.

Fig 25: Wange Motor Set 1501

The M motor from Wange has a motor protection element between the control line and one of the motor connections, which responds in the event of overheating/overload. There is no imprint on the motor itself, which allows the origin or type to be determined. Unlike CaDa, the motors from Wange are compatible with the LEGO IR receiver and can therefore be used with the classic Power Functions technology.

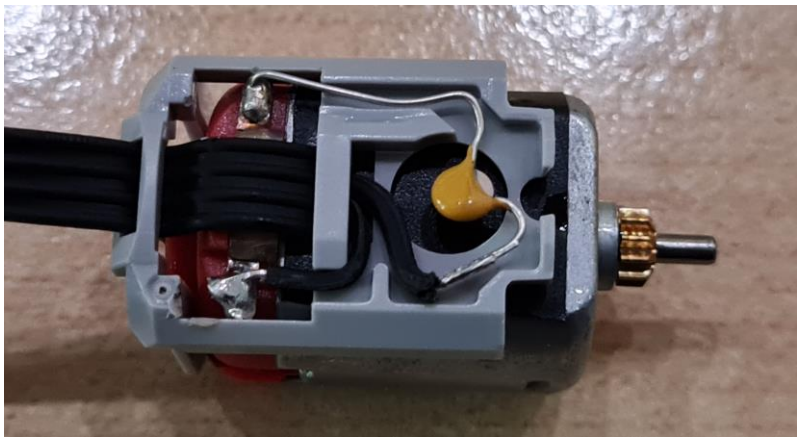


Fig 26: Inner workings of a Wange M motor

	Medium Motor	Only available in set Voltage: 9V No-load current: 90 mA Idle speed (9V): 863 rpm Blocking current: 720 mA
	Large Motor	Only available in set Voltage: 9V No-load current: 90mA Idle speed (9V): 720 1/min Blocking current: 1.1A
	XL Motor	Only available in set Voltage: 9V No-load current: 100mA Idle speed (9V): 450 rpm Blocking current: 1.9A

Table 5: Wange Motors

The following diagrams show the speed characteristics as a function of the applied voltage. The tests were measured with a constant voltage applied to the motor and recorded in 1V increments. A digital laser tachometer was used for the measurement.

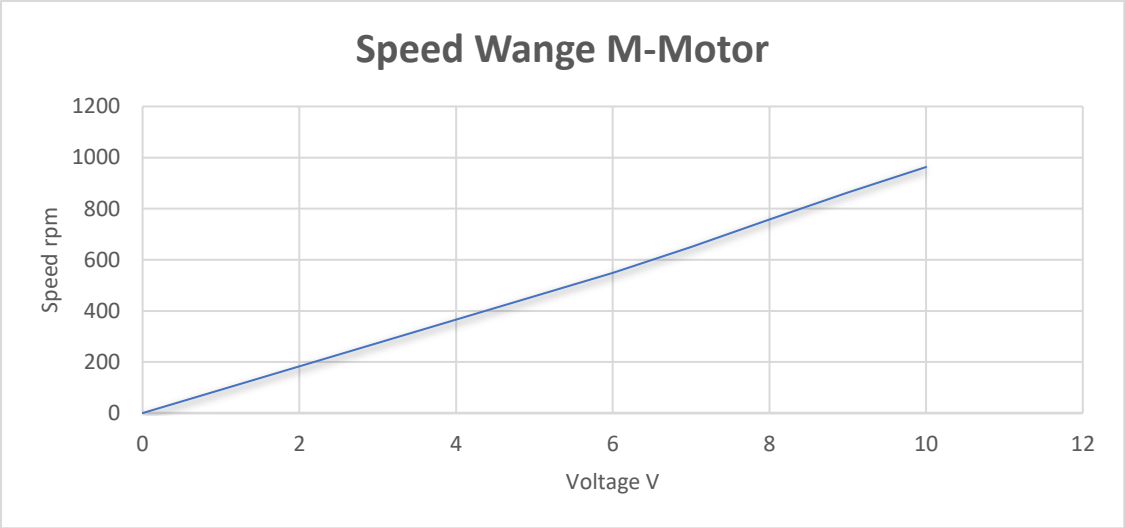


Fig 27: Speed diagram of Wange M-Motor

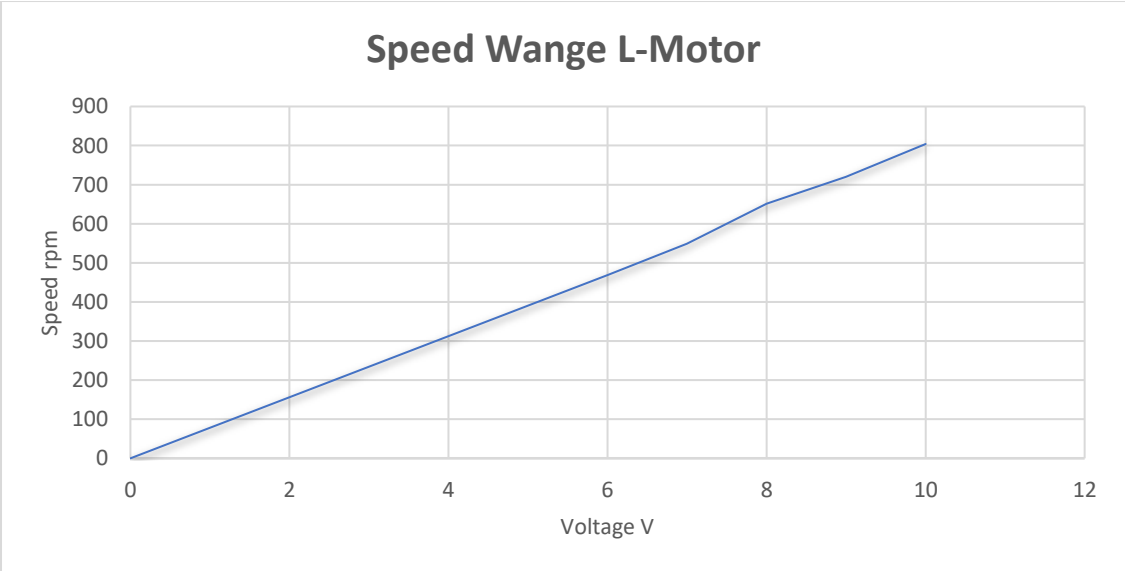


Fig 28: Speed diagram of Wange L-Motor

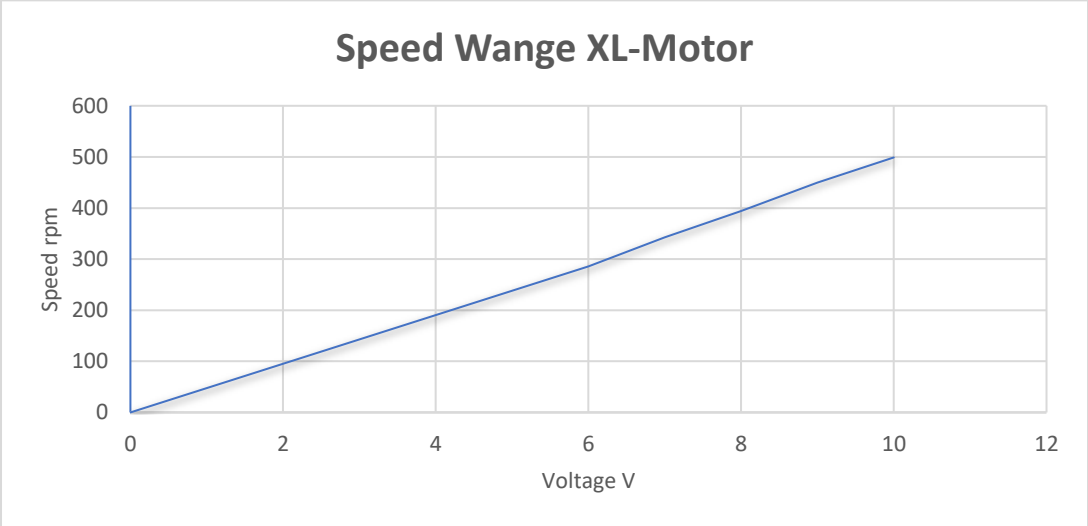


Fig 29: Speed diagram of Wange XL-Motor

Manufacturer: Shantou Wange Educational Material Sci-Tech Co., www.wangetoys.com

Mould King

If you search for Mould King you won't find anything here, because I try not to support manufacturers who clone original LEGO sets and meanwhile also fan models without approval. In addition, it is not clear whether Mould King is the direct manufacturer of the engines or not from a third-party manufacturer engines or produced in the appropriate design. Since allegedly bricks from different manufacturers are purchased, it is obvious that here simply the sets are assembled with purchased material, it is therefore not a real manufacturer.

Third-party control bricks

As mentioned at the beginning, there are three third party manufacturers that develop and offer control bricks for Power Functions (connection system). Vengit with the SBrick, BuWizz from Fortronik and Fx Bricks with the PFx Brick.

The BuWizz V3 will feature two Power Functions connectors and four Powered Up connectors, allowing it to use LEGO's new motors. Since the BuWizz delivers up to 12V output voltage, you have to be careful when using alternative motors, because they might get damaged. Here you should use the "Normal" or "Slow" mode. This also applies to the predecessors BuWizz V2 and BuWizz which are equipped with four Power Functions compatible outputs. With the BuWizz, the clamping force can be different at the connector contacts due to the design. With CaDa, for example, these do not hold so well - the Wange contacts clamp better.

The PFx Brick will get an output voltage limitation via the settings to adapt it for different motors. I.e. also for motors which are designed for the operation of 7.4V or also 3.7V, the connection and the

control is possible. However the PFx Brick has problems with some motors in the low speed range when the torque compensation and/or the Power Functions compatibility mode is active. A reason why even the IR receiver from LEGO can not control the motors - but simply disable these options on the PFx Brick.

With the SBrick, the output behavior can also be adjusted via the new Pro software.

The CaDa control module, which is included in the motor set, copes with all alternative motors, which surprised me at first. However, this is also due to the simple control with 0 or 100%. There are no intermediate steps or speed steps that have to be generated via a PWM signal.

Motor/Servo		**LEGO IR**	**BuWizz 2**	**PFx Brick**	**SBrick**
LEGO M-Motor	8883	Yes	Yes	Yes	Yes
LEGO XL-Motor	8882	Yes	Yes	Yes	Yes
LEGO L-Motor	88003	Yes	Yes	Yes	Yes
LEGO Servo	80004	Yes	Yes	Yes	Yes
LEGO Train Motor	88002	Yes	Yes	Yes	Yes
Blue Brixx M-Motor	401173	Yes	Yes	Yes [3]	Yes
Blue Brixx L-Motor	401174	Yes	Yes	Yes [3]	Yes
Blue Brixx XL-Motor	401175	Yes	Yes	Yes [3]	Yes
Blue Brixx Train Motor	401172	Yes	Yes	Yes [3]	Yes
Blue Brixx Servo	401176	Yes[1]	Yes[1]	Yes [1,3]	Yes[1]
Brickengine Motor	V1	Yes	Yes	Yes[4]	Yes
BuWizz Motor	-	Yes	Yes	?	?
CaDa Pro Servo	JV5029	No	Yes	Yes[3]	Yes
CaDa Pro M-Motor	JV5030	No	Yes	Yes[3]	Yes
CaDa Pro L-Motor	JV5028	No	Yes	Yes[3]	Yes
CaDa Servo	C61013	No	Yes	Yes[3]	Yes
CaDa M-Motor	CJV5014	No	Yes	Yes[3]	Yes
CaDa L-Motor	C61012	No	Yes	Yes[3]	Yes
CaDa Micro Motor	?	No	Yes	Yes	Yes
Wange L-Motor	(88003)	Yes	Yes	Yes	Yes
Wange M-Motor	(8883)	Yes	Yes	Yes	Yes
Wange XL-Motor	(8882)	Yes	Yes	Yes	Yes

Table 6: Compatibility Overview

1 = Only +90°/0/90° via motor +100%/0/-100% speed (not with step control)
2 = Tested with BuWizz V2
3 = Without Torque Compensation and no Power Functions compatibility mode (with Battery Box Current-Limit)
4 = Without Torque Compensation (with Battery Box Current-Limit)

Measurement of the motor data

To determine the motor data, I have built a small box with Power Functions connection. This allows the connection of a laboratory power supply and multimeter to measure the current and voltage. With the switch I can bridge the contacts for the current measurement if necessary.

Fig 30: Measuring box for Power Functions motors

The speed was measured without contact using a laser tachometer. Two reflector strips were applied directly to small rims or directly to axle connections for this purpose, so that the laser can scan them. During the measurement, the button on the measuring device must be pressed for safety reasons - as soon as the button is released, the laser is switched off and the measurement ends.

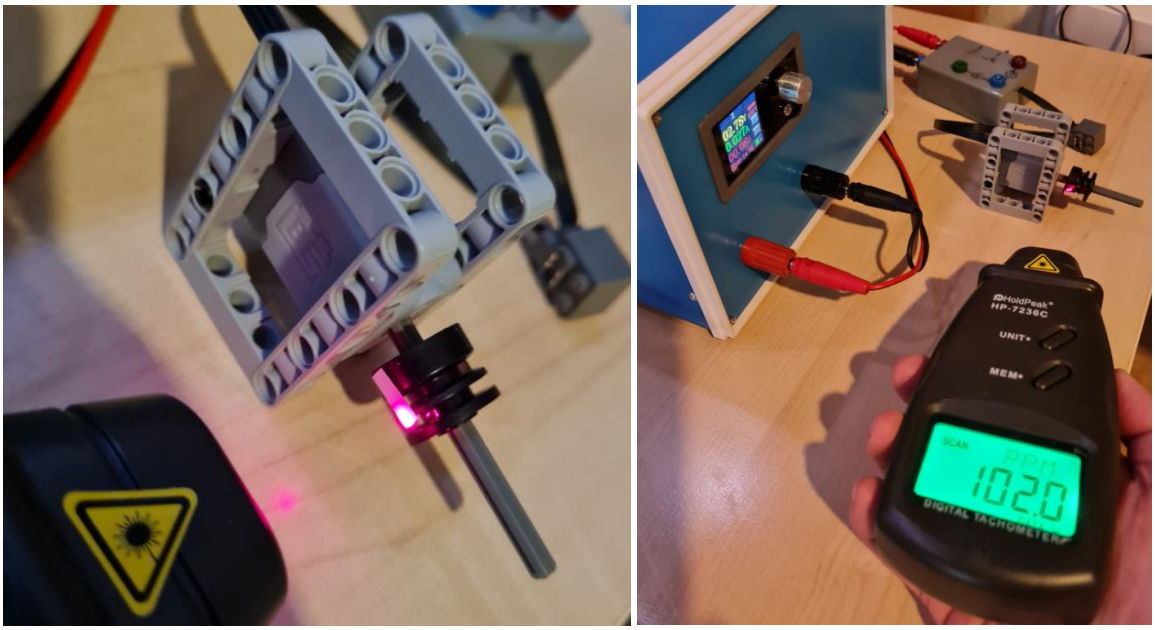


Fig 31: Reflectors on rim and measurement

For torque measurements I have unfortunately no equipment. Where available, information from the manufacturers was used. However, corresponding measurements can be supplied later when the Technic Check is updated.

Conclusion

Only a few motors come from reliable sources, so if possible you should get the products from a dealer in your own country to handle complaints easier. With the servo motors there are probably always problems, because the reset to the 0° position is not done correctly or do not take intermediate positions. These servos are actually motors that drive directly to 90°/-90° stop and cannot assume any positions. If you want to save yourself trouble, avoid goods from unknown manufacturers. Two companies from China stand out when it comes to Power Functions alternatives - CaDa and Wange. These products are also available from local online-stores or from CaDa directly in their web store.

CaDa motors are not compatible with LEGO's IR receiver due to their internal construction (suppression capacitors, resistor), but they are compatible with all alternative control bricks. Wange and Blue Brixx motors are compatible with both the IR receiver and all control bricks.

Alternative manufacturers in Europe such as BuWizz or Brickengine are also taking on the topic of motors. Fx Bricks has announced a train motor for 9V metal tracks, which should please friends of this era in particular, but also newcomers. Only Blue Brixx is currently a reliable source that offers railroad motors with Power Functions connection. In addition, the motors from Blue Brixx are also compatible with the IR receiver from LEGO.

Power Functions is far from dead - if only because fans have accumulated quite a bit of material over 13 years, and alternative control components with Bluetooth have existed for a number of years - long before LEGO took the plunge on the technology, which is now over 20 years old. However, the pricing for the Control+ components has skyrocketed, which is likely to scare off some of the previous buyers. With a 185% increase in the price of a motor (e.g. the XL motor of originally 12 EUR now becomes a whopping 34.99 EUR), this is quite explainable - especially since there are likely to be motors from Chinese production in LEGO products as well (e.g. Mabuchi). In addition, there is no real servo successor for the Control+ generation. The price development for Power Functions components on the third-party market is at least as dramatic. At the time of going to press, a new Power Functions servo was around 70 EUR, which once cost 25 EUR. As a purist, you might give your shirt for it, but there are enough families and fans of bricks for whom you also have to look at the wallet.

Micro motors are also on the rise again - at least among alternative manufacturers like CaDa. These are particularly interesting because they can be used to get things moving in smaller models. In 2x3 and 2x4 format you can also find no-name representatives already on Aliexpress, although here again caution is advised.

Since the topic is dynamic and there will certainly be movements in the market in the future, I will update the Technic Check No. 3 every now and then.

In any case, friends of the Power Functions technology are not faced with a hole and have to forcibly switch to the successor technology. The combination of alternative control bricks and motors in combination with original LEGO goods is still a good solution. Moreover, in this day and age, it is a

question of "sustainability" to continue to use functional material and not to throw it into the (special) trash when there is a generational change.

Sources of supply (Germany/Europe)

https://www.bluebrixx.com/ (CaDa and Wange Motor Sets, own Motor Series)

https://www.freakware.de/ (CaDa Motors individually or as a set)

https://www.klemmshop.de/ (CaDa Motors individually or as a set)

https://www.frankensteins.de/ (CaDa Motors individually)

https://www.custombricks.de/ (CaDa Motors individually)

https://www.steingemachtes.de/ (CaDa Motors individually)

https://www.amazon.de/ and https://www.aliexpress.com/

https://www.bricklink.com/ (Original LEGO motors new/used)

Alternative control bricks for Power Functions

https://buwizz.com/ (and the BuWizz Motor)
https://www.fxbricks.com/
https://www.sbrick.com/

Notes