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| BattleKits **Robot Motors**      High-Performance Electric MotorsOur high-performance A28 motors are designed to give the highest level of performance possible in a brushed DC motor. This is achieved by advanced design and the use of neodymium rare-earth magnet material.  The mid-range F30 motors are designed for the highest performance and efficiency while still using the less expensive ferrite magnets.  The economy E30 motors are designed to give good performance at the lowest possible price.  The A40-300 is our largest motor. It's best for high-power, high duty-cycle applications.  These motors are used in diverse applications including robots, industrial motion control, factory automation, semiconductor manufacturing, motorized scooters, go karts, and electric bicycles.    We stock seven different brushed motors or, with a minimum order of 25 units, we can design custom brushed or brushless motors:   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Type | Large | High-Performance | | Mid-Range | | Economy | | Custom | | Model | **A40-300** | **A28-400** | **A28-150** | **F30-400** | **F30-150** | **E30-400** | **E30-150** | **Custom** | | Peak Horsepower | 3.8 | 4.5 | 3.0 | 3.0 | 2.3 | 2.1 | 1.0 | Varies | | Diameter (inches) | 4.0 | 3.0 | 3.0 | 3.1 | 3.1 | 3.1 | 3.1 | 1.4 to 4 | | Length (inches) | 6.9 | 6.7 | 4.0 | 6.7 | 4.0 | 5.8 | 4.0 | 2 to 9 | | Stall Torque (oz-in) | 3840 | 3720 | 1970 | 2500 | 1370 | 1500 | 710 | Varies | | Efficiency | 84% | 83% | 82% | 84% | 82% | 79% | 76% | Varies | | Voltage\* | 24\* | 24\* | 24\* | 24\* | 24\* | 24\* | 24\* | 6 to 90 | | No-Load RPM | 4000 | 4900 | 6000 | 4800 | 6900 | 5700 | 5600 | Varies | | Pounds | 11.9 | 6.9 | 3.8 | 8.3 | 4.7 | 5.9 | 3.6 | Up to 20 | | Price | $319 | $419 | $309 | $239 | $199 | $109 | $79 | Varies | | Pictures | [A40-300](http://www.battlekits.com/A40_300_N.JPG) | [A28-400](http://www.battlekits.com/A28_400_N.JPG) | [A28-150](http://www.battlekits.com/A28_150_N.JPG) | [F30-400](http://www.battlekits.com/F30_400_N.JPG) | [F30-150](http://www.battlekits.com/F30_150_N.JPG) | [E30-400](http://www.battlekits.com/E30_400_N.JPG) | [E30-150](http://www.battlekits.com/E30-150_N.JPG) | Custom | | Drawings | [A40-300](http://www.battlekits.com/a40-300.GIF) | [A28-400](http://www.battlekits.com/a28-400.GIF) | [A28-150](http://www.battlekits.com/a28-150.GIF) | [F30-400](http://www.battlekits.com/f30-400.GIF) | [F30-150](http://www.battlekits.com/f30-150.GIF) | E30-400 | E30-150 | Custom | | Performance Charts | [A40-300](http://www.battlekits.com/A40-300_Chart.png) | [A28-400](http://www.battlekits.com/A28-400_Chart.png) | [A28-150](http://www.battlekits.com/A28-150_Chart.png) | [F30-400](http://www.battlekits.com/F30-400_Chart.png) | [F30-150](http://www.battlekits.com/F30-150_Chart.png) | [E30-400](http://www.battlekits.com/E30-400_Chart.png) | [E30-150](http://www.battlekits.com/E30-150_Chart.png) | Custom |   \* The above specifications are for 24V. The motors can also be used at 12V or 18V. The RPM is proportional to the voltage so running at 12V will result in half the no-load RPM that is shown above for 24V. The lower voltage also reduces the maximum achievable torque by 50%. The motors have also been tested and used at higher voltages resulting in higher RPM, torque, and power. Shorter duty-cycles are recommended for higher voltages to allow the motors time to cool.    **Horsepower, Torque, and RPM**   |  | | --- | |  | |  | |  |   The horsepower and torque of our high-performance motors are higher than other reversible, permanent magnet motors in this size range. Some *gearmotors* can't even achieve these high torque levels, even after multiplying the torque with a gearbox. (Please note that the above torque figures are the theoretical peak torques when stalled. Operating any high-performance motor while stalled will damage it).  Usually, the higher the voltage and RPM of a motor, the higher its efficiency will be. Some motors have high efficiency, but at a no-load speed of 20,000 RPM or more. Gearing such high RPM down to a usable speed takes several stages of gear reduction. This is heavy and expensive and the efficiency advantage usually disappears. The trick is making a moderate speed motor that is also highly efficient. The relatively low RPM of our motors makes any required speed reduction much easier. The [AmpFlow speed reducer](http://www.battlekits.com/gearheads.htm) is an easy and inexpensive way achieve speed reduction and torque multiplication.  **The A40-300 being tested on a dynamometer** http://www.battlekits.com/Dyno_Test_N.jpg      **Solid Construction - Easy Mounting**   |  | | --- | |  | |  | |  |   These motors are made from two sturdy aluminum castings and a seamless body. The long output shaft makes it easy to mount pulleys, sprockets, and gears in just the position you need them. A second 3/8" diameter shaft extends 1/2" from the rear of most models. This is very handy for mounting encoders, fans, tachometers, brakes, or other devices.  Some motors use an internal fan to reduce overheating. Our motors are efficient enough to operate without a fan. This has three advantages: (1) The motor housing is completely sealed so nothing can enter the motor and damage it; (2) The sealed motor tends to contain radio-frequency noise that would otherwise radiate through the ventilation holes; (3) Increased efficiency because the energy that would normally be used to run the fan generates mechanical power instead.  **A40-300** http://www.battlekits.com/A40_300_Ns.JPG  The armatures in our high-performance and mid-range motors ride in two large high-quality ball bearings and they're dynamically balanced using epoxy rather than by the normal method of drilling the laminations. Drilling can cause eddy currents in the laminations, which increase motor heating.  Each of the four brushes has its own heavy-duty motor lead made from mil-spec 12-gauge flexible stranded wire, (10-gauge for the A40). Each copper strand is coated with pure silver to protect against oxidation and to get the lowest possible resistance in crimped connections. These leads are flexible but not "floppy", so they tend to stay where you put them. The four leads have high-temperature Teflon insulation rated for 200C, (392F).  The E30 economy motors also have two ball bearings, four brushes and two 12-guage motor leads.      **Efficiency**   |  | | --- | |  | |  | |  |   Getting high efficiency from a low-voltage motor is not easy. There are many factors that effect efficiency. We have optimized each of these factors to achieve very high efficiency in these motors.   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | Type | Large | High-Performance | | Mid-Range | | Economy | | | Model | **A40-300** | **A28-400** | **A28-150** | **F30-400** | **F30-150** | **E30-400** | **E30-150** | | Peak Efficiency (PE) | 84% | 83% | 82% | 84% | 82% | 79% | 76% | | RPM at PE | 3700 | 4500 | 5500 | 4500 | 6300 | 5100 | 5000 | | Torque at PE (oz-in) | 300 | 310 | 185 | 170 | 120 | 145 | 85 | | Horsepower at PE | 1.1 HP | 1.4 HP | 1.0 HP | 0.75 HP | 0.75 HP | 0.75 HP | 0.40 HP | | Current at PE | 41 Amps | 51 Amps | 37 Amps | 27 Amps | 28 Amps | 29 Amps | 17 Amps | | HP Range for 75%+ Efficiency | 0.4 to 2.6 | 0.5 to 3.1 | 0.4 to 2.0 | 0.2 to 2.1 | 0.3 to 1.6 | 0.4 to 1.3 | 0.3 to .5 |   As you can see from the above chart, the efficiency of the motors is very high over a broad range of power. The RPM is the same in both directions to within about 3%.  The armatures are wound with heavy gauge wire, and all the space in the armature is used. We left no power-robbing "empty air" in the slots; they are packed with copper! The smaller motors have skewed armature laminations to eliminate the heavy "cogging" that results from using the extremely powerful neodymium magnets. The A40 motor uses straight laminations, but the cogging is kept to a very low level by using a 42-bar commutator. The huge 1.75" diameter of the commutator combined with the four massive brushes and the 42 bars enabled us to get high power and high efficiency from this smooth-running motor, (the A28 and F30 motors have 21 bars). As far as we know, our high-performance and mid-range motors have the highest efficiency of any 24-volt reversible permanent magnet DC brush motors in their size ranges.  http://www.battlekits.com/Armature_N.jpgAnother benefit of the four-brush, 42 and 21-bar designs is the absence of excessive electrical noise. While all motors produce some electrical noise, cheaper motors with fewer commutator bars are more likely to send noisy voltage spikes back to your controller.  Radio-frequency noise is further reduced by the use of internal capacitors. The high-performance and mid-range motors come with four capacitors built right in to the motors. Each of the four brushes has a capacitor wired to its nearest neighbor on each side. This makes the motors ideal for radio-controlled applications.  Using rare earth magnets is normally the only way to get high efficiency from a low-voltage motor. While these magnets are very strong, they are also extremely expensive. We use neodymium rare earth magnets in the A28 motors. To reduce the cost of our other motors, we use a high-energy ferrite magnet known as "T9". The T9 magnet material along with the other design features listed above have enabled us to achieve the same high efficiency of rare-earth in much less expensive motors.      **Motor Control**   |  | | --- | |  | |  | |  |   **A28-400** http://www.battlekits.com/A28_400_Ns.JPG    The high current these motors are capable of drawing requires the use of high quality controllers. Please see our [Motor Controller](http://www.battlekits.com/controllers.htm) page. Optical encoders are available from many sources. [US Digital](http://www.usdigital.com/products/optical-encoders.shtml) offers a wide range of competitively priced products.          **Choosing a motor**   |  | | --- | |  | |  | |  |   The A28s have incredible power-to-weight ratios and for weight-sensitive applications these would be the best choice. The larger A40 weighs more than the A28s, but in some cases this is advantageous. The higher motor mass will decrease the rate of motor heating for a given level of power. If you need high power for several minutes or moderate power for an extended time, the larger A40 is a better choice. Our F30 motors have an excellent balance between cost and performance. And the E30s are solid low-cost alternatives.  Under high loads some of these motors will draw as much current as several arc welders combined. The larger the motor, the longer it will take for the heating to reach temperatures that are potentially damaging. When in doubt, choose the heavier motor.   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | Type | Large | High-Performance | | Mid-Range | | Economy | | | Model | **A40-300\*** | **A28-400** | **A28-150** | **F30-400** | **F30-150** | **E30-400** | **E30-150** | | Lightweight drive (up to 60 lbs) | N/A | N/A | Best | N/A | Better | N/A | Good | | Middleweight drive (up to 120 lbs) | Good | Best | Good | Better | Good | Good | Use Four | | Heavyweight drive (up to 220 lbs) | Good | Best | Use Four | Better | Use Four | Good | Use Four |   \*The A40-300 is not a direct bolt-in for BattleKits. We do not offer it as a drive motor for any robot kits.    **Technical Specifications:**   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | Type | Large | High-Performance | | Mid-Range | | Economy | | | Model | **A40-300** | **A28-400** | **A28-150** | **F30-400** | **F30-150** | **E30-400** | **E30-150** | | Diameter (inches) | 4.0 | 3.0 | 3.0 | 3.1 | 3.1 | 3.1 | 3.1 | | Length (inches) | 6.9 | 6.7 | 4.0 | 6.7 | 4.0 | 5.8 | 4.0 | | Peak HP | 3.8 | 4.5 | 3.0 | 3.0 | 2.3 | 2.1 | 1.0 | | Stall Torque (oz-in\_ | 3840 | 3720 | 1970 | 2500 | 1370 | 1500 | 710 | | Efficiency | 84% | 83% | 82% | 84% | 82% | 79% | 76% | | RPM @ 24V | 4000 | 4900 | 6000 | 4800 | 6900 | 5700 | 5600 | | Shaft Dia. (inches) | 5/8 | 1/2 | 1/2 | 1/2 | 1/2 | 1/2 | 1/2 | | Shaft Length (inches) | 1.75 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | | Keyway (inches) | 3/16 | 1/8 | 1/8 | 1/8 | 1/8 | 1/8 | 1/8 | | Capacitors | Yes | Yes | Yes | Yes | Yes | No | No | | Magnet Type | Ferrite | Neodymium | Neodymium | Ferrite | Ferrite | Ferrite | Ferrite | | No Load Amps | 3.5 | 4.5 | 3.4 | 2.0 | 2.5 | 3.2 | 2.1 | | Resistance (Ohms) | .050 | .042 | .064 | .064 | .081 | .089 | .190 | | Kt (oz-in/Amp) | 8.05 | 6.57 | 5.32 | 6.73 | 4.66 | 5.63 | 5.70 | | Kv (RPM/Volt) | 168 | 206 | 254 | 200 | 287 | 240 | 237 | | Rotor Inertia oz-in-sec^2 | 0.25 | 0.05 | 0.02 | 0.10 | 0.04 | 0.05 | 0.01 | | Thermal Resistance (degC/Watt) | 1.3 | 1.8 | 3.2 | 1.6 | 2.9 | 4.0 | 5.0 | | Weight (pounds) | 11.9 | 6.9 | 3.8 | 8.3 | 4.7 | 5.9 | 3.6 | | Price | $319 | $419 | $309 | $239 | $199 | $109 | $79 | | Pictures | [A40-300](http://www.battlekits.com/A40_300_N.JPG) | [A28-400](http://www.battlekits.com/A28_400_N.JPG) | [A28-150](http://www.battlekits.com/A28_150_N.JPG) | [F30-400](http://www.battlekits.com/F30_400_N.JPG) | [F30-150](http://www.battlekits.com/F30_150_N.JPG) | [E30-400](http://www.battlekits.com/E30_400_N.JPG) | [E30-150](http://www.battlekits.com/E30-150_N.JPG) | | Drawings | [A40-300](http://www.battlekits.com/a40-300.GIF) | [A28-400](http://www.battlekits.com/a28-400.GIF) | [A28-150](http://www.battlekits.com/a28-150.GIF) | [F30-400](http://www.battlekits.com/f30-400.GIF) | [F30-150](http://www.battlekits.com/f30-150.GIF) | E30-400 | E30-150 | | Performance Charts | [A40-300](http://www.battlekits.com/A40-300_Chart.png) | [A28-400](http://www.battlekits.com/A28-400_Chart.png) | [A28-150](http://www.battlekits.com/A28-150_Chart.png) | [F30-400](http://www.battlekits.com/F30-400_Chart.png) | [F30-150](http://www.battlekits.com/F30-150_Chart.png) | [E30-400](http://www.battlekits.com/E30-400_Chart.png) | [E30-150](http://www.battlekits.com/E30-150_Chart.png) |        |  |  | | --- | --- | | **9mm and 1/2" Sprockets and Keys** | **E30-150 Economy Motor** | | http://www.battlekits.com/Sprocket_Ns.JPG The 1/2" bore of our standard sprocket fits all our motors except the A40-300.  The sprocket has 9 teeth and it works with #35 roller chain. It comes with a 1/8" key. | http://www.battlekits.com/E30-150_Ns.JPG |     **Warranty** The motors are warranted to be free from manufacturing defects, and fully operational when you receive them. AmpFlow gives no other warranty, either expressed or implied. Warranties are not transferable. In no event shall AmpFlow's liability exceed the buyer's purchase price, nor shall AmpFlow be liable for any indirect or consequential damages.  **Ordering** Shipments must be to a street address; we can not ship to a PO Box. Please allow 7-10 days for orders shipped by UPS ground, 3-4 days for orders shipped by 2nd day air, and up to 14 days for international orders.    http://www.battlekits.com/visa_logo.gifhttp://www.battlekits.com/mastercard_logo.gifhttp://www.battlekits.com/paypal_logo.gif  We accept Visa, MasterCard, and PayPal.   |  |  |  | | --- | --- | --- | | **A40-300 Motor - $319**      Quantity |  |  |  |  |  |  | | --- | --- | --- | | **A28-400 Motor - $419**      Quantity |  |  |  |  |  |  | | --- | --- | --- | | **A28-150 Motor - $309**      Quantity |  |  |  |  |  |  | | --- | --- | --- | | **F30-400 Motor - $239**      Quantity |  |  |  |  |  |  | | --- | --- | --- | | **F30-150 Motor - $199**      Quantity |  |  |  |  |  |  | | --- | --- | --- | | **E30-400 Motor - $109**      Quantity |  |  |  |  |  |  | | --- | --- | --- | | **E30-150 Motor  -  $79**      Quantity |  |  |  |  |  |  | | --- | --- | --- | | **Nine-Tooth Sprocket and Key for A28, F30 and E30  -  $14**      Quantity |  |  |   [Replacement brushes are available here](http://www.battlekits.com/motor_parts.htm)  Contact us for custom motors and volume pricing. [PowerMail@email.com](mailto:powermail@email.com)    *"That's a beautiful motor! Wow. Good work. Great price. This should become standard equipment for all large robots."*           --Edwin Wise.   Mad Scientist and author of *Applied Robotics*  *"Very powerful. Too fast on 24 Volts even with poor batteries."*           --Mike Schreiber.  Builder of the *Electri-Flyer* electric bicycle.  *"BattleBot participants are constantly trying to make their robots quicker, stronger and faster. With nearly four horsepower and 3840 oz-in torque, the 11.9-pound A40 motor is ideally designed for our larger robots. Since power is often the deciding factor in BattleBot competitions, more and more participants are selecting these motors to power their robots with a lightweight, high-efficiency motor that provides plenty of power on demand."           --*Trey Roski.   CEO of BattleBots.  *"As the first motors designed specifically for robotic combat, these motor perform fabulously! They combines incredible power and some of the best features you could ask for when looking for a high-end motor for a BattleBot. They are the most powerful and finest constructed DC permanent magnet motors that I've ever used. I chose this motor for the weapon motor in* Nightmare *and I am definitely a very satisfied customer!"*           --Jim Smentowski.    BattleBots Champion (Nightmare, Backlash)  *"This motor packs a lot of power into a light-weight package. They give Minion the power it needs and I still have weight to spare!"*           --Christian Carlberg.    BattleBots Champion (Team Cool Robots)  *"Get the best motors you can afford. Good motors are the foundation upon which all else rests. People can win with hokey electronics or even with inoperative weapons, but good motors make good robots."*           --William Gurstelle.    Author of *Building Bots : Designing and Building Warrior Robots*  *"We were extremely pleased with the performance of the motors in our middleweight* Heavy Metal Noise *at BB 4.0. The motor supplied an insane amount of energy to our kinetic disk weapons. Time to spinup was minimal and after combat the motor was never more than mildly warm to the touch."*           --Jay Johnson.    BattleBots Competitor (Big Bang Robotics)  *"I've been building robots as a hobby for about 30 years and this is definitely one of the best motors (power, weight, cost, quality), that I've ever encountered. Since I've never built a 'BattleBot' before, I decided to focus most of my attention on other aspects of the design and having this motor meant that I didn't have to spend many hours 'tweaking' an inferior motor just be competitive."*           --Billy Moon.    BattleBots Competitor  *"I can attest to their super high quality of craftsmanship and design. We tested them with a few different controllers and monitored the results using a Tektronix digital scope and a digital ammeter. Results: This is the largest motor we have tested and amazingly it had the cleanest feedback signal of any motor yet. Generally the higher the quality of motor mechanics, windings, brush and commutator, the cleaner this signal is. This means these motors are less likely to blow a speed controller due to transient voltage spikes.           These motors are VERY well built. We saw no appreciable heat up in the testing we did. We did a lot of stall and near stall testing. These are amazing motors and are ridiculously powerful."           --*Alexander Rose.      BattleBots Champion (Toro, T-minus, Matador) |

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