



Electric Flight

The power system basics



Electric vs. Nitro, Equivalents

| OS Max, nitro engine | HP | Weight | Nitro Propeller | Watts (746w/hp) |
|---------------------------------|---------------|---------------|----------------------------|------------------------|
| OS Max .10LA | .27HP @ 17000 | 3.95oz | 7x4 - 7x5 | 200 watt (.27HPx 746) |
| OS Max .15LA | .41HP @ 17000 | 4.87oz | 7x5 - 8x5 | 300 watt (.41HPx 746) |
| OS Max .25LA | .6HP @ 15000 | 6.9oz | 9x5 - 10x5 | 450 watt (.6HPx 746) |
| OS Max .40LA | 1.0HP @ 16000 | 9.5oz | 10x6.5, 10.5x6 11x5 | 750 watt (1HPx 746) |
| OS Max .46LA | 1.2HP @ 16000 | 9.6oz | 11x6 - 11x7 | 900 watt (1.2HPx 746) |
| OS Max .65LA | 1.7HP @ 16000 | 18oz | 12x7 - 13x8 | 1275 watt (1.7HPx 746) |
| | | | | |
| OS Max .25FX | .84HP @ 18000 | 8.8oz | 9x5 - 10x5 | 630 watt (.84HPx 746) |
| OS Max .61FX | 1.9HP @ 16000 | 19.4oz | 12x6 - 13x7 | 1425 watt (1.9HPx 746) |
| OS Max .91FX | 2.8HP @ 15000 | 19.3oz | 13x8 - 13x9 | 2100 watt (2.8HPx 746) |
| OS Max 1.60FX | 3.7HP @ 9000 | 32.6oz | 16x10-14, 18x10-12 | 2775 watt (3.7HPx 746) |

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Terminology (or what's that mean?)

Watts = volts * current

Examples

- n $7.4\text{v} * 10\text{amps} = 74\text{watts}$
- n $11.1\text{v} * 25\text{amps} = 277\text{watts}$
- n $22\text{v} * 50\text{amps} = 1110\text{watts}$

1 horse power = 746watts



Terminology (or what's that mean?)

Kv = The number of rpm's a motor will spin for every volt applied to motor.

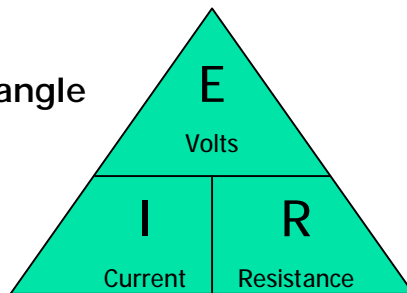
Examples

- n 980Kv motor connected to a 3 cell (11.1v) battery will spin 10878rpm (unloaded)
- n $1400Kv \times 11.1v = 15540rpm$ (unloaded)
- n $1400Kv \times 7.4v = 10360rpm$ (unloaded)

Basic electronics - formulas

Ohm's law Triangle

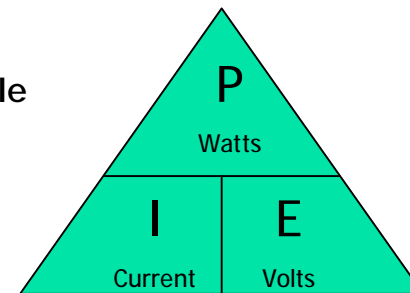
$$E = I * R$$
$$I = E / R$$
$$R = E / I$$



Place thumb over the element you wish to solve. (i.e. cover "I" = E / R)

Power Triangle

$$P = I * E$$
$$I = P / E$$
$$E = P / I$$



E = Voltage (sometimes "V" is used instead of "E", and measured in "volts")

I = Current (measured in "amperes")

R = Resistance (measured in "ohms")

P = Power (measured in "watts")

Example 1

25amp motor on 3-cells

$$(I)25A * (E)11.1v = (P)277w$$

motor

Example 2

60watt light bulb draws .5A or
500mA

$$(P)60w / (E)120v = (I).5amp$$
 draw

Example 3

60watt light bulb has 240 ohms
of resistance.

$$(E)120v / (I).5A = (R)240$$
 ohms

Inrunner vs. Outrunner

Inrunner and Outrunner are the two types of brushless RC motors.

Outrunner - brushless motor has the permanent magnets on the **outside** of the electromagnets. You can see in the picture that the outer hub holding the permanent magnets has the output shaft attached in the center.

Inrunner - The permanent magnets of inrunner brushless motors are positioned on the **inside** of the electromagnets. Inrunner brushless motors are setup very similar to old school canned motors, except the permanent magnets and electromagnets are in opposite positions.

Outrunner Brushless Model Aircraft Motors

Outrunner RC motors spin much slower and provide much more torque than inrunner motors. The greatest benefit of an outrunner motor is the fact that a gearbox is not needed. This makes the airplane literally silent! Outrunner motors are much easier to mount. Outrunner brushless RC motors are slightly less efficient than inrunner motors. This shouldn't be a huge factor when making your decision between the two.

Inrunner Brushless Model Aircraft Motors

The faster a motor spins, the more efficient it is. Inrunner motors turn very fast and are more efficient than outrunner motors. Inrunner brushless RC motors require a reducing gearbox between the motor and propeller. For this reason, the output speed and torque of the propeller can easily be "*tweaked*" to facilitate different flying characteristics by using different size gears. The downside is added parts that can and do fail. The gears get stripped, and the gearbox shafts are easily bent. It can also be an obstacle when mounting the gearbox motor combination neatly, especially under a cowling.

Outrunner type motor



The outside spins
i.e. outrunner

Inrunner motor



Only the shaft
spins



Basic Electric Motor Selection

Motor watts required per pound of airplane weight.

- n 100w/lbs = trainer\sport (minimum)
- n 150w/lbs = 3D aerobatics
- n 250+w/lbs = extreme

n Examples

- n 16oz Sport airplane = 100w
- n 24oz Pylon Racer = 300w
- n 4lb Trainer = 400w
- n 8lb Sport plane = 800 – 1200w



Battery Selection

"C" discharge rating

- n Battery "C" rating = The max amount of current a battery can deliver. (1C is 1 times the batteries rated current.)
 - n Examples
 - n 1300ma (1.3A) 12C battery can deliver (1.3A x 12) 15.6A
 - n 2100ma (2.1A) 15C battery can deliver (2.1A x 15) 31.5A
 - n 2100ma (2.1A) 20C battery can deliver (2.1A x 20) 42A

Balancer

- n LiPo-Balancers eliminate the problem of cell imbalance, allowing your LiPo packs to reach their maximum life span.
- n Traditional LiPo chargers simply terminate the charge when one cell goes above 4.25 Volts. This gradually reduces pack capacity because the imbalance slowly increases with each cycle.
- n LiPo Balancers allow the charging process to continue until ALL cells have reached 4.20V while still protecting each cell from overvoltage.



Propeller Selection

Propellers can be selected two ways:

- n Use the factory recommended propeller for your motor.
 - n Incorrectly sized propellers can draw too many amps and burnout your motor.

- n Use amp meter to determine current and rpm's for your motor.
 - n Do not exceed recommended current.

Pitch Speed = (RPM x Pitch)/1056

Example:

- n AXI 2208-26, 3cell battery, 7x4 prop
(15762rpm x 4")/1056 = 59mph*
*losses will reduce this number

Typical Naming Scheme

n Typical motor numbering scheme's

n AXI 2208/26, 1420Kv

22mm diameter

8mm thick

RPM's per volt

26 turns of wire

n Scorpion S-2208-30, 1293Kv

22mm diameter

8mm thick

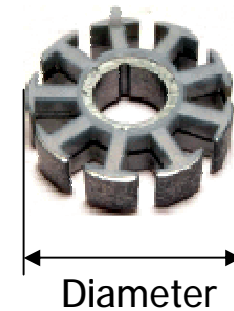
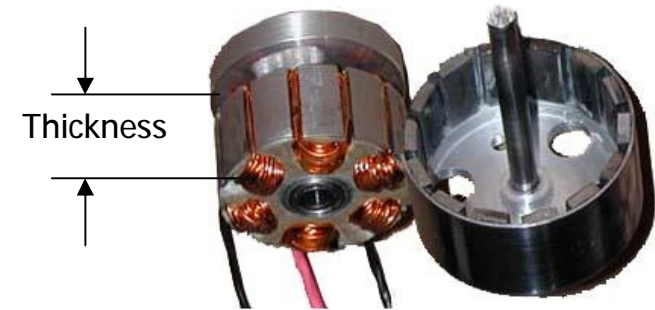
RPM's per volt

30 turns of wire

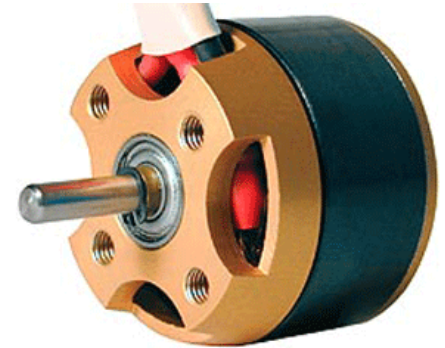
n E-Flight Power 15, 950Kv

Equivalent to a .15cc

RPM's per volt



AXI 2208-26



Tiny, but BIG power for SPEED 300 to 400 class airplanes

Small and very robust but light weight (45g, 1.6 oz with 14cm long heavy-duty silicone cabling) brushless motor with rotating case suitable for all models of 300-400 size which will surprise you with very high power it can deliver. Hardened steel shaft is 3.2mm and is supported by two large ball bearings which ensures great mechanical stability. Thanks to Model Motors for using the newest materials these motors achieve in their weight category extremely high efficiency and high load possibility. A new future in AXI design is a provision for radial mounting.

n 2208-26 Factory Specifications:

n Voltage Range 2-3xLi-Poly

n Max. Efficiency Current 5-9A

n RPM per volt 1420Kv Max.

n Efficiency 82%

n Max. loading 11A / 60 s

n No load Current / 8V 6 A

n Internal resistance 155mohm

n Dimensions 27.7x26 mm

n Shaft Diameter 3.17 mm

n Motor weight 45g

n Recommended model weight - 7 to 17.8 oz

n Propeller range:

n 2xLi-Poly prop 8"x4.5"

n 3xLi-Poly prop 7"x4"

n 10 cells prop 8,5"x5"

$$7.4V \times 9A = 67w$$
$$11.1v \times 9A = 100w$$

$$11.1v \times 1420Kv = 15762rpm$$

100w / lbs
PerfectJ

$$7"x4" \text{ pitch speed}$$
$$(15762rpm \times 4")/1056 = 59mph^*$$

*losses will reduce this number

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E-Flight Power 15



Key Features

- Equivalent to a 15-size glow engine for sport and scale airplanes weighing 36- to 56-ounces (2.5 to 3.5lbs)
- Ideal for size 3D airplanes 32- to 40-ounces (2 – 2.5lbs)
- Ideal for models requiring up to 425 watts of power High torque, direct drive alternative to inrunner brushless motors
- External rotor design, 5mm shaft can easily be reversed for alternative motor installations
- High quality construction with ball bearings and hardened steel shaft
- Slotted 12-pole outrunner design

Overview

The Power 15 is designed to deliver clean and quiet power for 15-size sport and scale airplanes weighing 36- to 56-ounces (2.5 – 3.5lbs), 3D airplanes 32- to 40-ounces (2 – 2.5lbs), or models requiring up to 425 watts of power.

Specification

Type: Brushless Outrunner Motor
 Size: 15-size
 Bearings or Bushings: Ball Bearings
 Wire Gauge: 16
 Recommended Prop Range: 10x6–13x6.5
 RPM/Volt (Kv): 950
 Voltage: 7.4 - 14.4V
 Resistance (Ri): .03 ohms
 Idle Current (I_o): 2.00A @10V
 Continuous Current: 34A
 Maximum Burst Current: 42A (15 sec)
 Cells: 8–12 Ni-MH/Ni-Cd or 3-4S Li-Po
 Speed Control: 40-45A Brushless
 Weight: 152g (5.4 oz)
 Overall Diameter: 35mm (1.4 in)
 Shaft Diameter: 5mm (.20 in)
 Overall Length: 50mm (1.9 in)
 Electric Prop 10x6 to 13x6.5

**Sport @100watts / lb
250-350 watts**

**3D @150watts / lb
300-375 watts**

950Kv x 7.4v = 7030 rpm
 950Kv x 11.1v = 10545 rpm
 950Kv x 14.4 = 13680 rpm

34A x 7.4v = 250W
 34A x 11.1v = 377W
 34A x 14.4v = 489W



Advanced Motor Formulas

Efficiency: Motor Efficiency = P_{out}/P_{in} , $P_{out} = (V_{in} - I_{in} * R_m) * (I_{in} - I_o)$

Motor Kv: $K_v = RPM / (V_{in} - V_{loss})$, $V_{loss} = I_{in} * R_m$

Motor RPM: $RPM = K_v * (V - V_{loss})$, $V_{loss} = I_{in} * R_m$

Watts: $Watts = V * I_{in}$, Alternately $P=I^2R$ ($P = I * I * R_m$)

Stalled Motor: $I_{stall} = V_{in} / R_m$

Torque constant: Torque constant: $K_t=K_b * 1.345$, $K_b = Voltage\ constant\ (Volt/1000\ RPM)$

Torque Loss: $Torque = K_t * (I_{in} - I_o)$

Termination: $Wye = the\ number\ of\ winds\ you\ have\ performed$, $Delta = divide\ the\ number\ of\ turns\ by\ 1.73$

Watts per Horsepower: 1 horsepower = 746 watts

Kv-Rpm constant: $K_v * turns = motor\ constant$, (ex. $K_v=1090 * 32T \sim = 35000$ so, $35000/28T \sim = 1250K_v$)

Adv. Motor Formulas - Acronyms

Acronyms:

Rm = Resistance value of the motor, derived from the guage of wire used.

Pout = Power Out of the Motor expressed in Watts

Pin = Power In of the Motor expressed in Watts

Vin = Voltage Into the Motor

Iin = Current Into the Motor

Io = Noload Current of the Motor, derived from running a motor WOT without a prop at varying voltages. Io can be expressed with an associated Voltage and should be.

Kv = K value or voltage constant, the expressed value where the rpm can be surmised by a given voltage. For a 2000 Kv motor an input voltage of 10V would net 20000RPM.

Istall = The load current of a motor which is purposely stalled, hence not turning.

Kt = Torque constant (oz-In/A)

Kb = Voltage constant (Volt/1000 RPM)



Resources:

www.rcgroups.com

- n Excellent source of information.

www.innov8tivedesigns.com

- n Scorpion motors / kits
- n Scorpion Calc – free motor calculation software

www.motocalc.com

- n *MotoCalc* will tell you everything you need to know: Amps, Volts, Watts, RPM, Thrust, Rate of Climb, and much more!
- n \$39.00