

Model Airplane Flight School

Topic 3 – Electric Motors

Electric Motors

- **Electric motors are not just for toys**
- Electric motors come in different designs
- Electronic Speed Controls
- Choosing a motor
- Batteries
- Connecting the Motor to the Battery
- Safety Considerations with Electric Motors



Electric motors come in a wide range of sizes.



An electric motor does not present a model size limitation.

Electric Motors

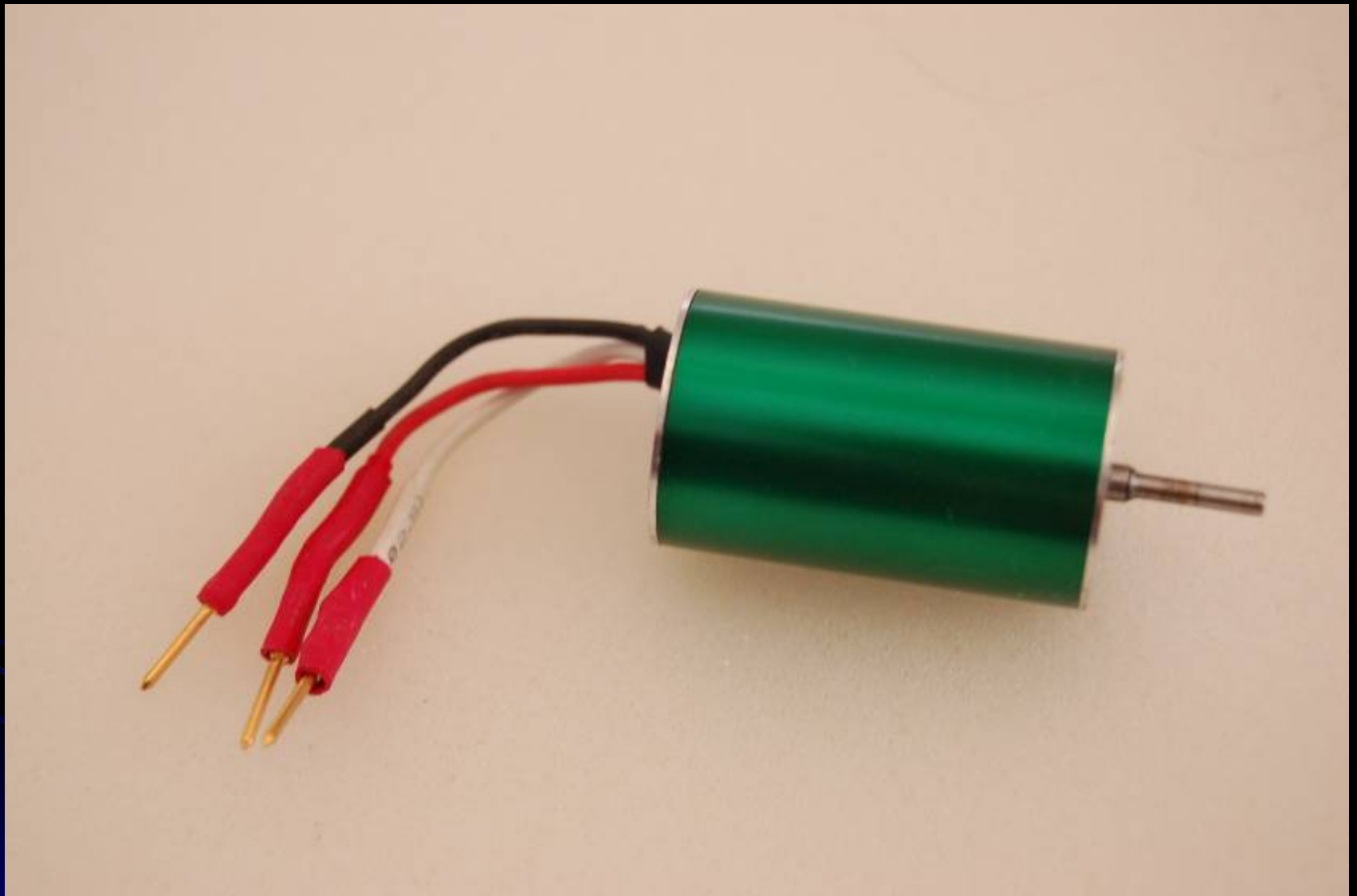
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A brushed motor is most conventional.



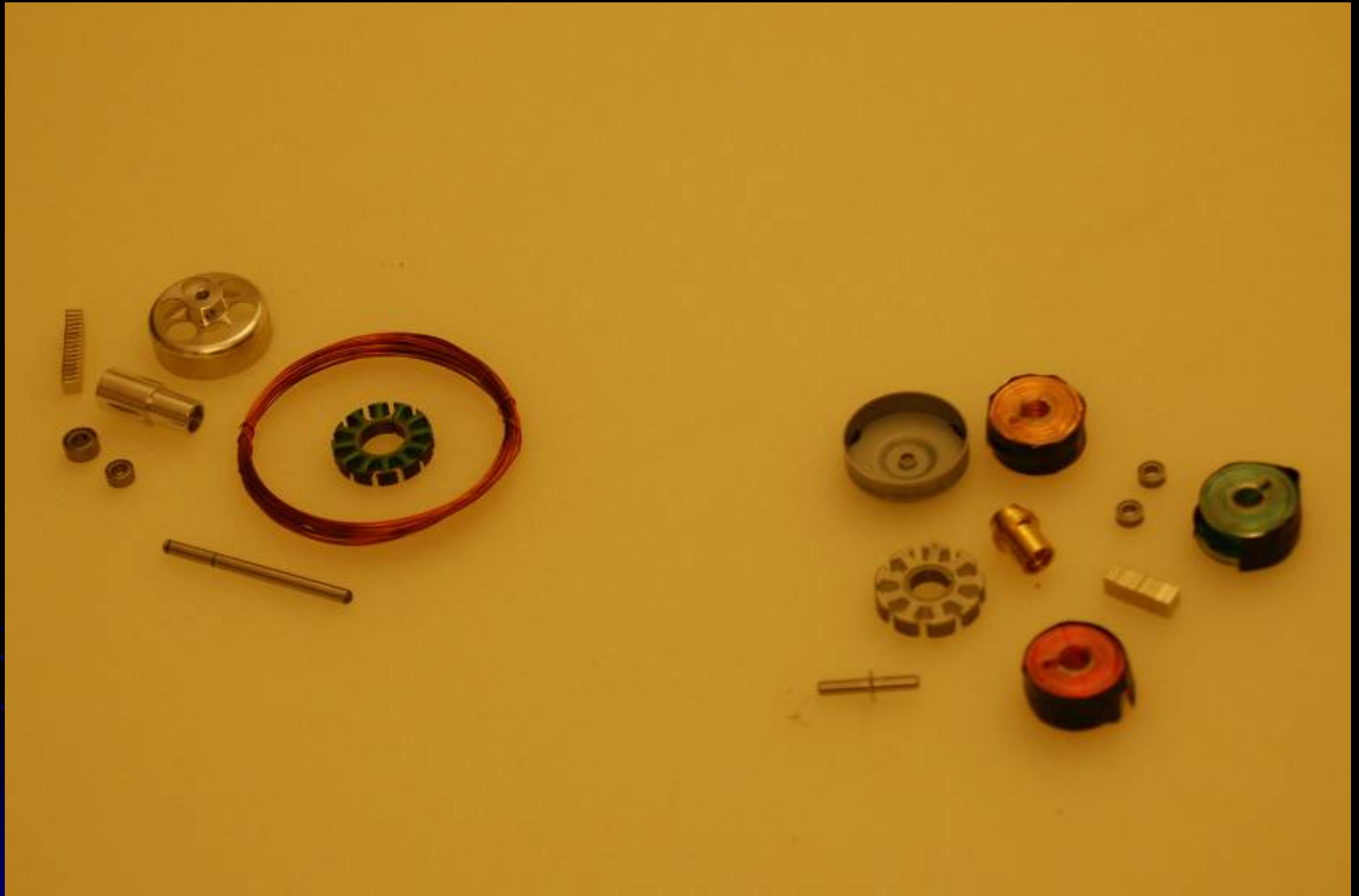
A brushless motor has three wires and no mechanical switching circuit.



An in-runner is a conventional electric motor with the stator coils on the outside.



The case of an out-runner rotates around the stator coils.



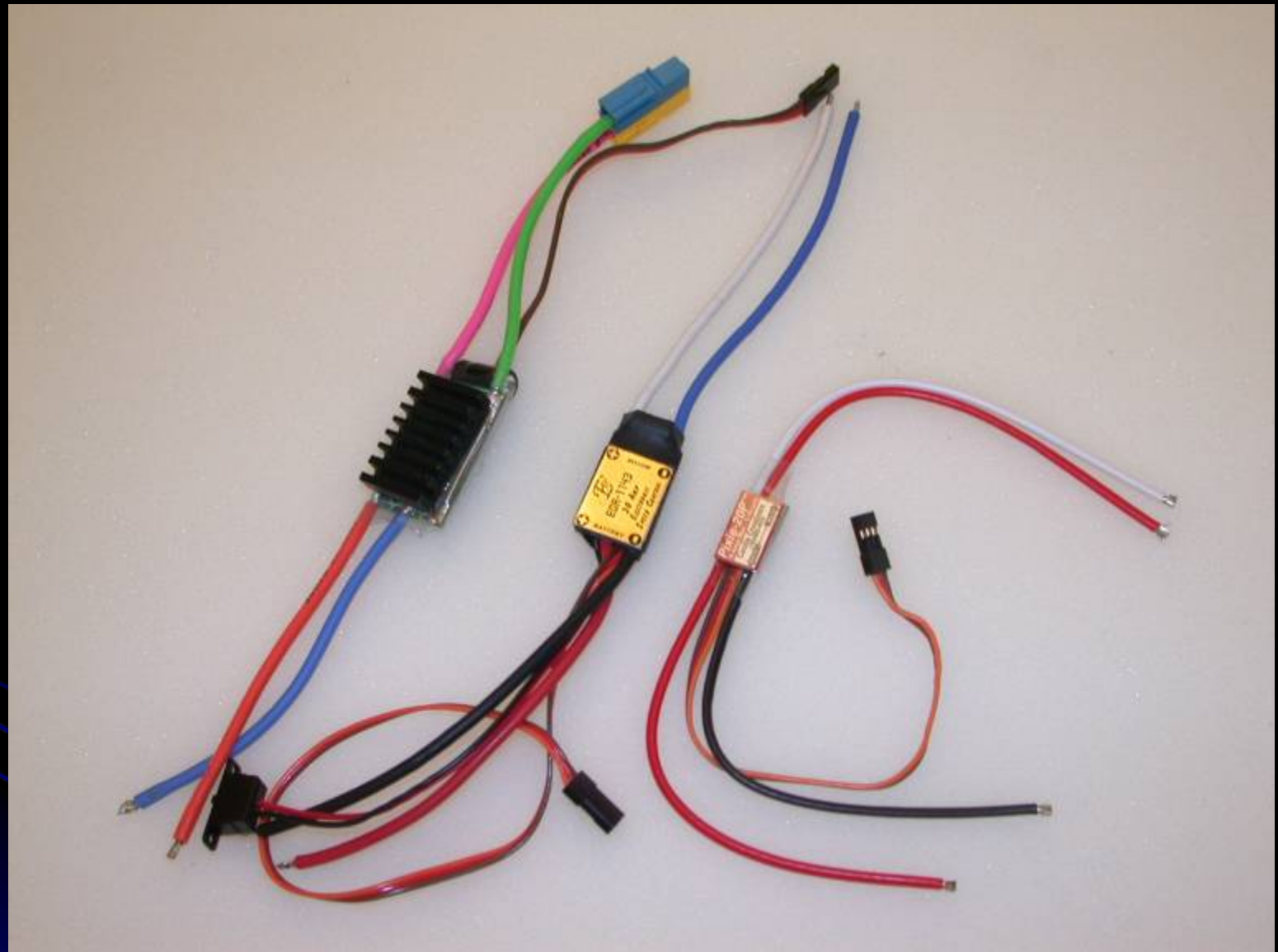
Complete kits for two brushless out-runner motors.



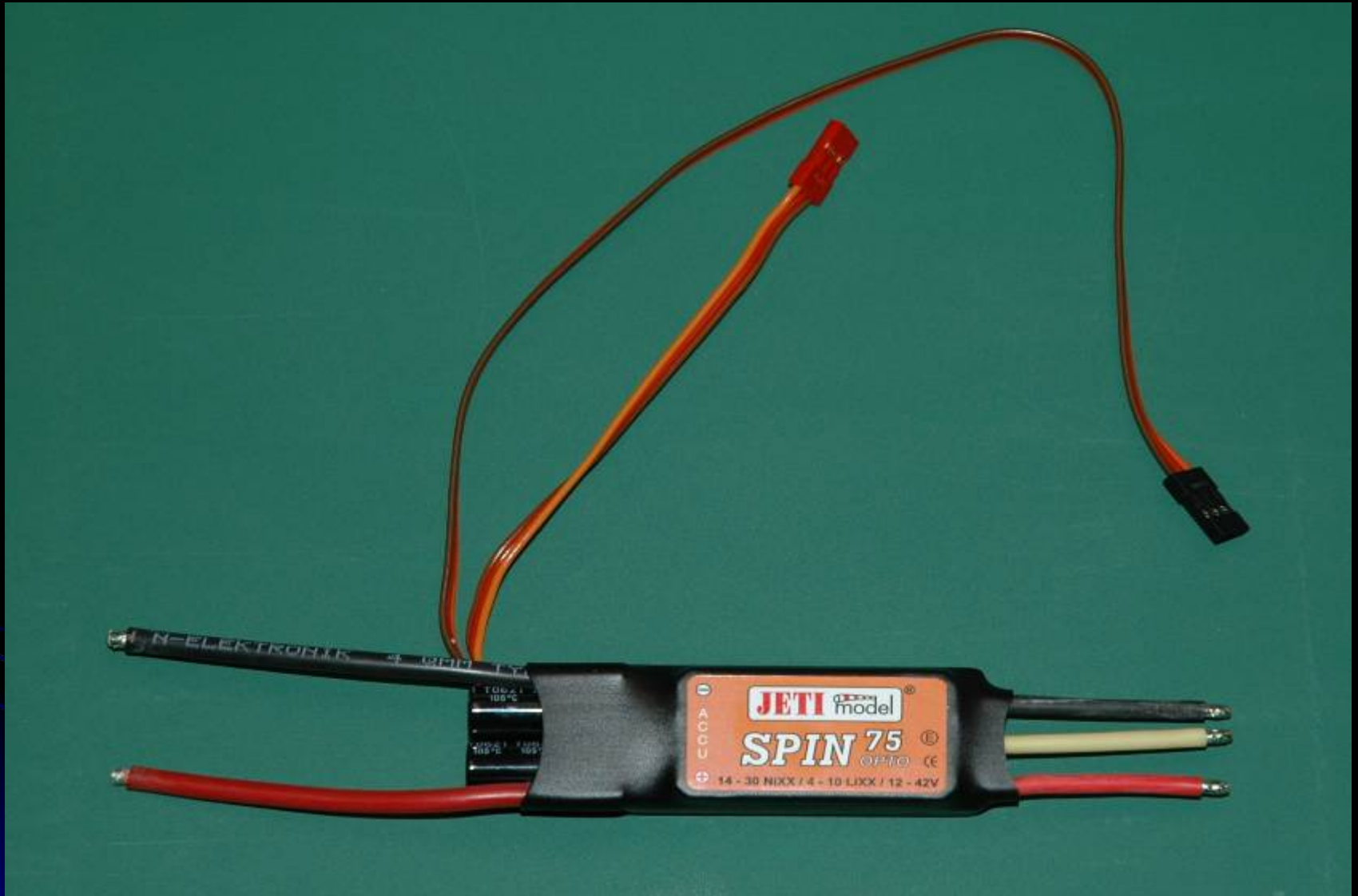
Out-runner parts: Everything but the wire.

Electric Motors

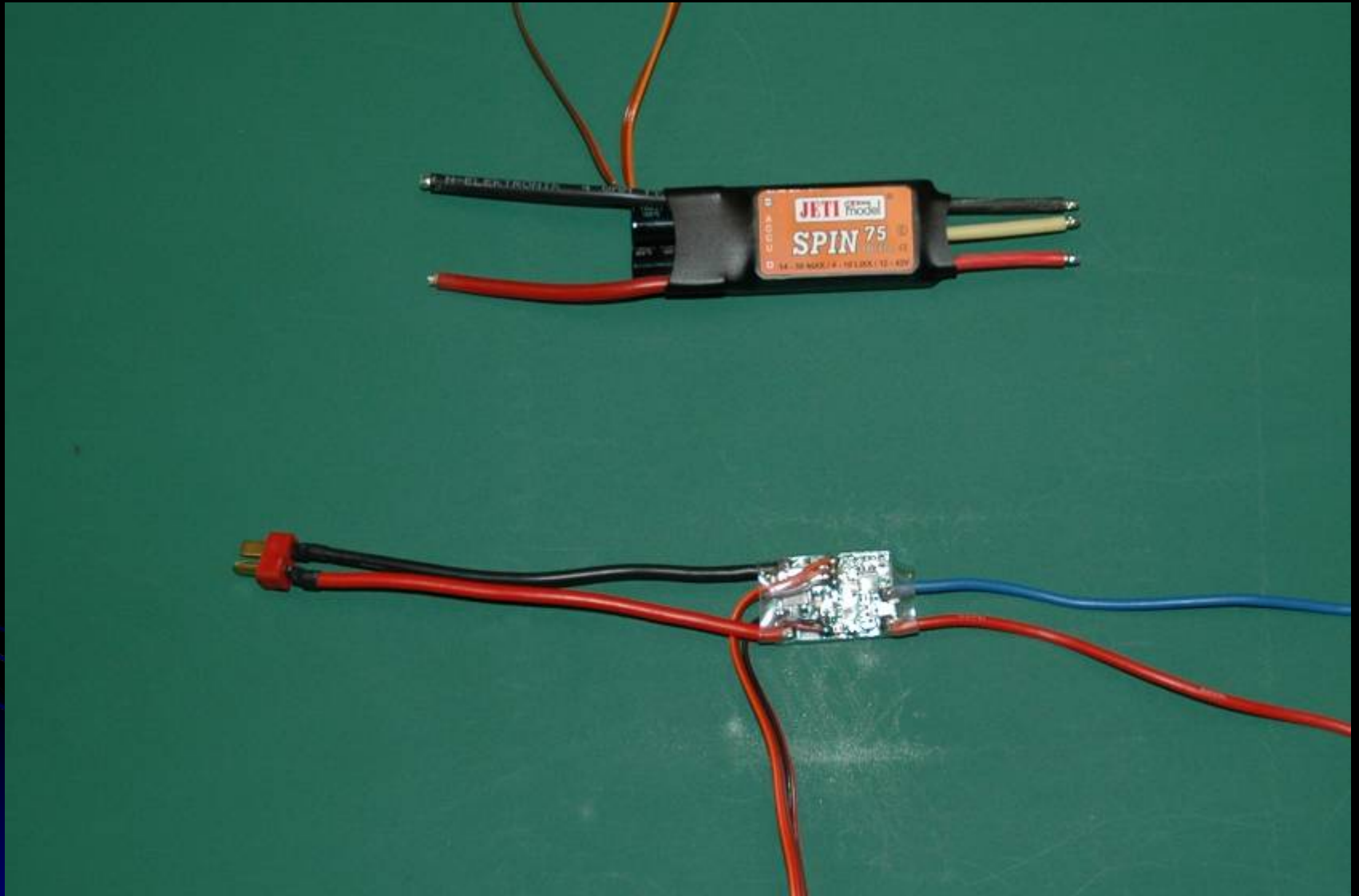
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Brushed speed controls: Two wires in, two wires out.



A brushless speed control: Two wires in, three wires out.



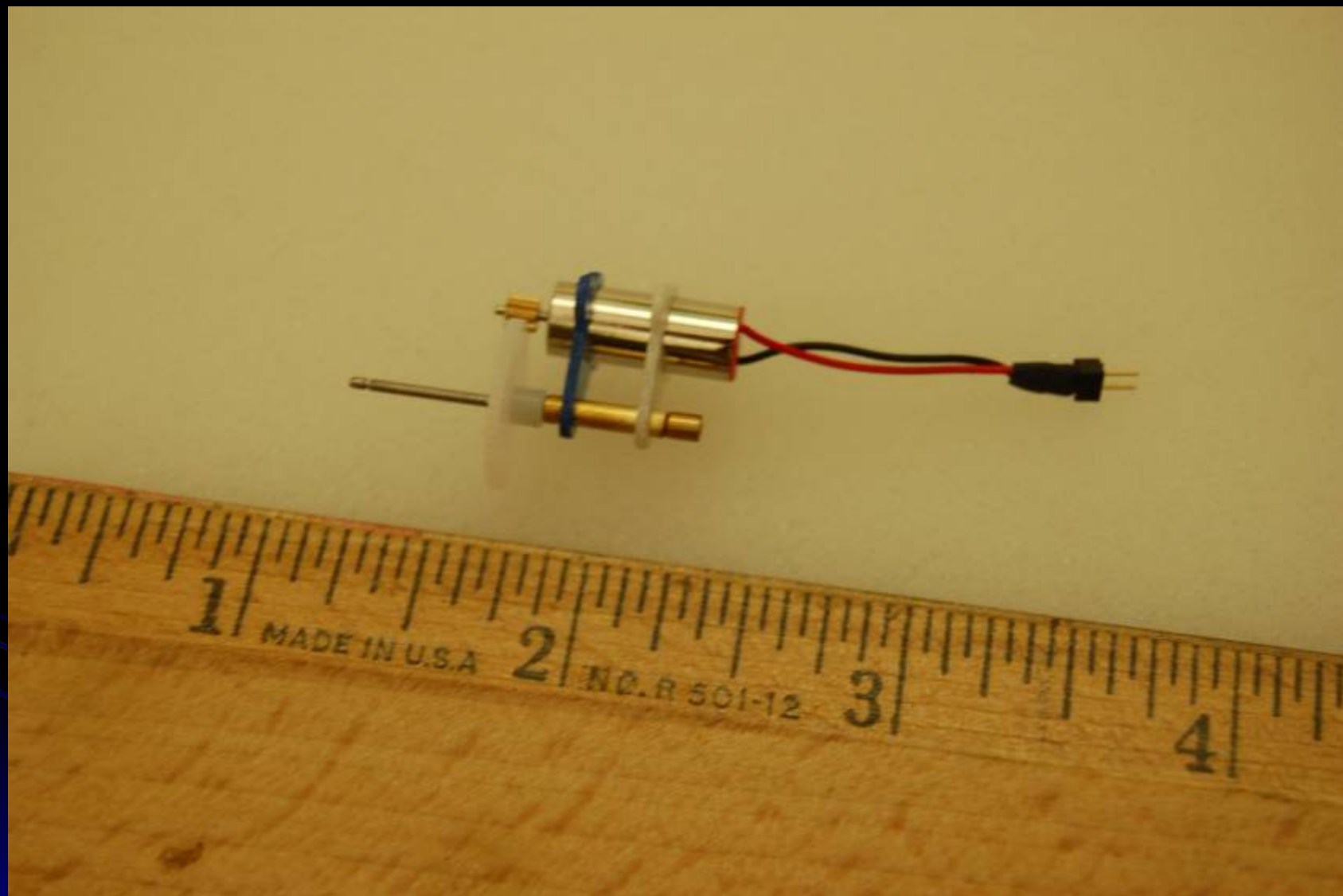
Pop quiz: Which is which?

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A large motor capable of 3500 watts.



A small motor that once made a pager vibrate.

MotoCalc 8.00 MotoWizard - Desired Performance



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[Performance](#)

[Model](#)

[Airfoil](#)

[Thickness](#)

[Field](#)

[Motor](#)

[Gear & Prop](#)

[Battery](#)

[Results](#)

What is the minimum full-throttle performance that you expect from this plane?

Sedate

Trainer

Sport

Race

Aerobatic

3D Aerobatic

Sailplane

Hotliner

Approximately what minimum partial-throttle flying time would you find acceptable?

4 min

6 min

9 min

13 min

20 min


30 min

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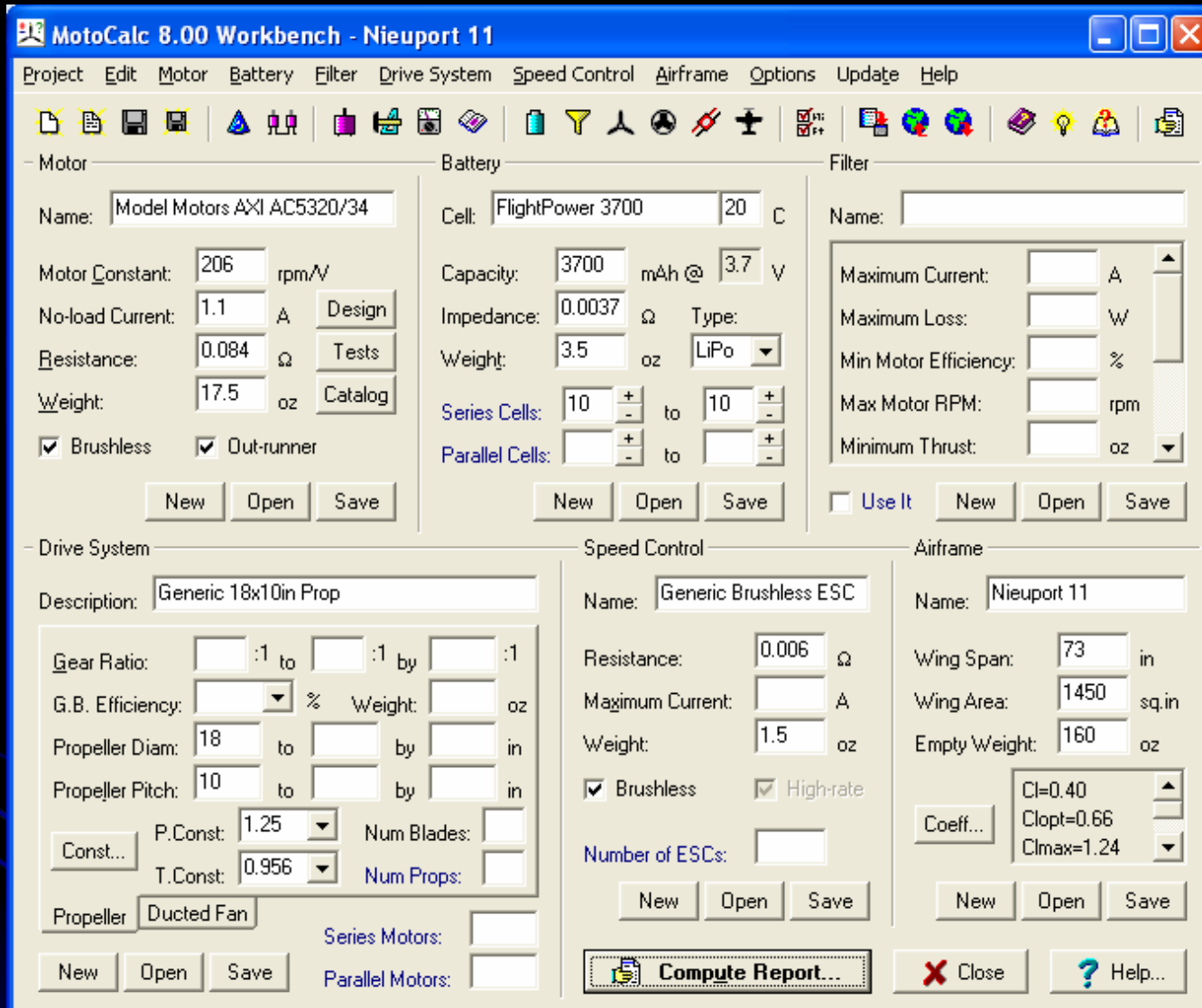
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Describing your needs in MotoCalc.



Specifications resulting from the needs analysis in MotoCalc.

In-flight Analysis - Nieuport 11

Motor: Model Motors AXI AC5320/34; 206rpm/V; 1.1A no-load; 0.084 Ohms.
 Battery: FlightPower 3700 (20C); 10 cells; 3700mAh @ 3.7V; 0.0037 Ohms/cell.
 Speed Control: Generic Brushless ESC; 0.006 Ohms; High rate.

900ft above Sea Level, 29.92inHg, 56°F
 100% Throttle

Drive System: Generic 18x10in Prop; 18x10 (Pconst=1.25; Tconst=0.956) direct drive.
 Airframe: Nieuport 11; 1450sq.in; 214oz RTF; 21.3oz/sq.ft; Cd=0.074; Cl=0.4; Clopt=0.66; Clmax=1.24.
 Stats: 104 W/lb in; 85 W/lb out; 21mph stall; 29mph opt @ 63% (32:39, 89°F); 38mph level @ 77% (23:31, 97°F); 1493ft/min @ 35.2°; -388ft/min @ -8.6°.

AirSpd (mph)	Drag (oz)	Lift (oz)	Batt Amps	Motor Amps	Motor Volts	Input (W)	Loss (W)	MGBOut (W)	MotCb Ef (%)	Shaft Ef (%)	Prop RPM	Thrust (oz)	PSpd (mph)	Prop Ef (%)	Total Ef (%)	Time (m:s)
21.0	12.2	66.2	39.2	39.2	35.3	1385.5	249.5	1136.0	82.0	78.2	6136	173.0	37.1	39.7	31.0	5:39
22.0	13.4	72.6	39.1	39.1	35.3	1380.4	246.6	1133.8	82.1	78.4	6148	170.6	36.2	41.0	32.2	5:41
23.0	14.7	79.4	38.9	38.9	35.3	1374.2	243.1	1131.1	82.3	78.6	6163	168.1	35.4	42.4	33.3	5:42
24.0	16.0	86.4	38.7	38.7	35.3	1367.1	239.3	1127.9	82.5	78.8	6180	165.5	34.5	43.7	34.4	5:44
25.0	17.3	93.8	38.5	38.5	35.3	1359.1	235.0	1124.1	82.7	79.0	6199	162.8	33.7	44.9	35.5	5:46
26.0	18.7	101.4	38.2	38.2	35.4	1350.0	230.3	1119.7	82.9	79.3	6220	160.0	32.9	46.1	36.5	5:49
27.0	20.2	109.4	37.9	37.9	35.4	1340.0	225.3	1114.7	83.2	79.5	6242	157.2	32.1	47.2	37.5	5:52
28.0	21.7	117.6	37.6	37.6	35.4	1328.9	220.0	1108.9	83.4	79.8	6266	154.2	31.3	48.3	38.5	5:55
29.0	23.3	126.2	37.2	37.2	35.4	1316.7	214.4	1102.3	83.7	80.1	6291	151.2	30.6	49.3	39.5	5:58
30.0	24.9	135.0	36.8	36.8	35.4	1303.4	208.5	1094.9	84.0	80.4	6317	148.1	29.8	50.3	40.5	6:02
31.0	26.6	144.2	36.4	36.4	35.4	1288.8	202.3	1086.5	84.3	80.7	6345	144.9	29.1	51.3	41.4	6:06
32.0	28.4	153.6	36.0	36.0	35.4	1275.4	194.9	1080.4	84.7	81.2	6381	142.0	28.4	52.1	42.3	6:10
33.0	30.2	163.4	35.4	35.4	35.5	1256.5	188.0	1068.5	85.0	81.5	6413	138.4	27.7	53.0	43.2	6:16
34.0	32.0	173.4	34.8	34.8	35.5	1235.5	180.7	1054.8	85.4	81.9	6447	134.6	27.1	53.8	44.1	6:23
35.0	33.9	183.8	34.1	34.1	35.5	1212.6	173.1	1039.5	85.7	82.3	6483	130.8	26.4	54.6	44.9	6:30
36.0	35.9	194.4	33.4	33.4	35.6	1187.6	165.3	1022.3	86.1	82.7	6521	126.7	25.8	55.3	45.8	6:39
37.0	37.9	205.4	32.6	32.6	35.6	1160.5	157.3	1003.2	86.4	83.2	6560	122.5	25.1	56.0	46.6	6:49
38.0	40.0	216.6	31.7	31.7	35.6	1131.2	149.2	981.9	86.8	83.6	6600	118.1	24.5	56.7	47.4	7:00
39.0	42.1	228.2	30.8	30.8	35.7	1099.7	141.1	958.6	87.2	84.0	6642	113.6	23.9	57.3	48.2	7:12

Motor performance calculations take ambient temperature and heating effects into account.

Color Key: Propeller Stalled Stall Speed @ Clmax=1.24 Level Flight @ Clopt=0.66 Level Flight @ Cl=0.4

MotoCalc analyses of the proposed system.

MotOpinion - Nieuport 11

900ft above Sea Level, 29.92inHg, 56°F

Motor: Model Motors AXI AC5320/34; 206rpm/V; 1.1A no-load; 0.084 Ohms.

Battery: FlightPower 3700 (20C); 10 cells; 3700mAh @ 3.7V; 0.0037 Ohms/cell.

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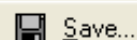
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Power System Notes:

- The full-throttle motor current at the best lift-to-drag ratio airspeed (36.8A) falls approximately between the motor's maximum efficiency current (21.5A) and its current at theoretical maximum output (211.3A), thus making effective use of the motor.
- The voltage (35.3V) exceeds 12V. Be sure the speed control is rated for at least the number of cells specified above.

Aerodynamic Notes:

- The static pitch speed (58mph) is within the range of approximately 2.5 to 3 times the model's stall speed (21mph), which is considered ideal for good performance.
- With a wing loading of 21.3oz/sq.ft, a model of this size will have very sedate flying characteristics. It will be suitable for relaxed flying, in calm or very light wind conditions.
- The static thrust (212.1 oz) to weight (214oz) ratio is 0.99:1, which will result in very short take-off runs, no difficulty taking off from grass surfaces (assuming sufficiently large wheels), and steep climb-outs.
- At the best lift-to-drag ratio airspeed, the excess-thrust (123.2oz) to weight (214oz) ratio is 0.58:1, which will give steep climbs and excellent acceleration. This model should be able to do consecutive loops, and has sufficient in-flight thrust for almost any aerobatic maneuver.



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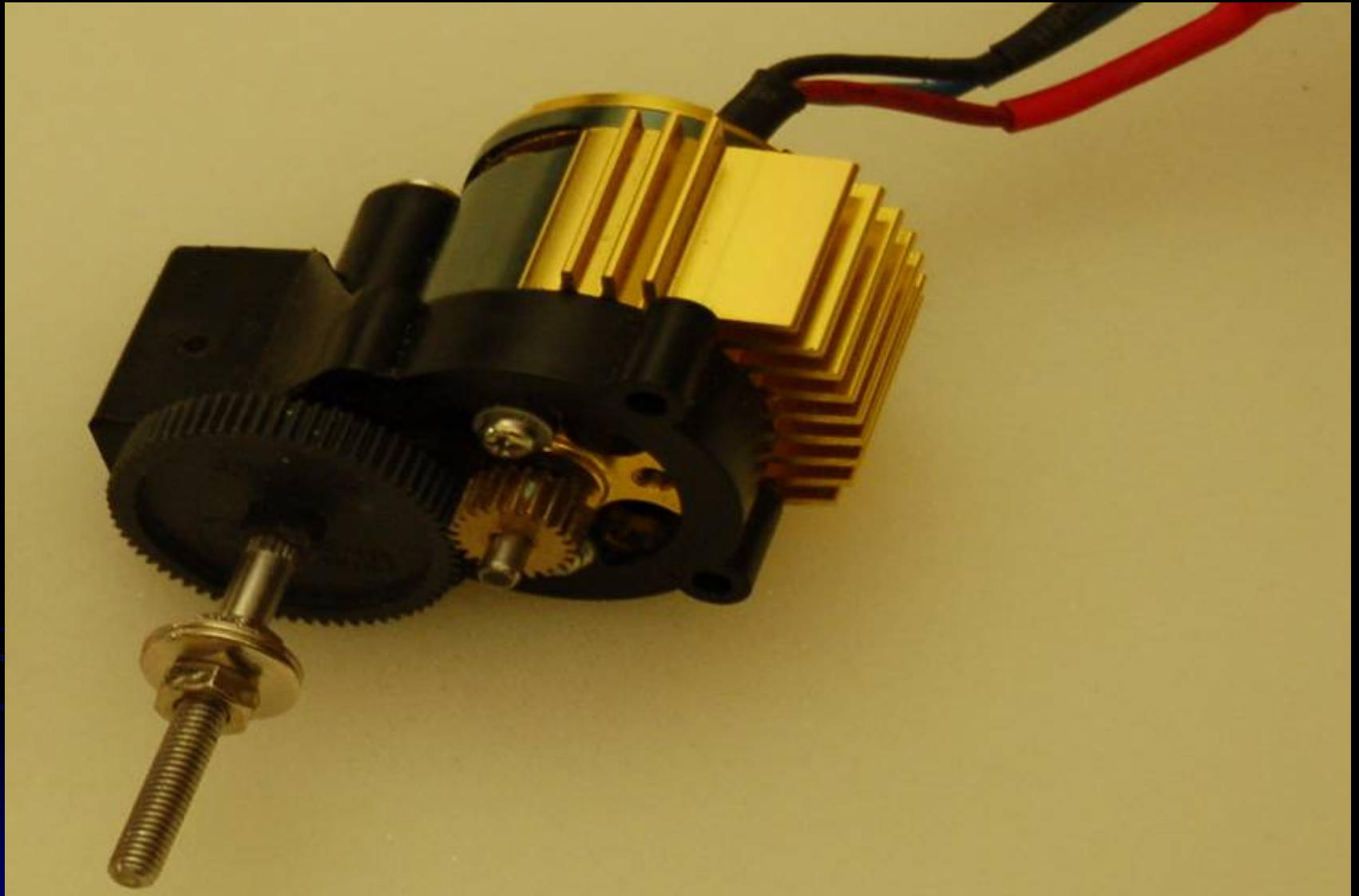


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Help

MotoCalc's opinion regarding how it will fly.



Motors can be geared for more torque.

Electric Motors

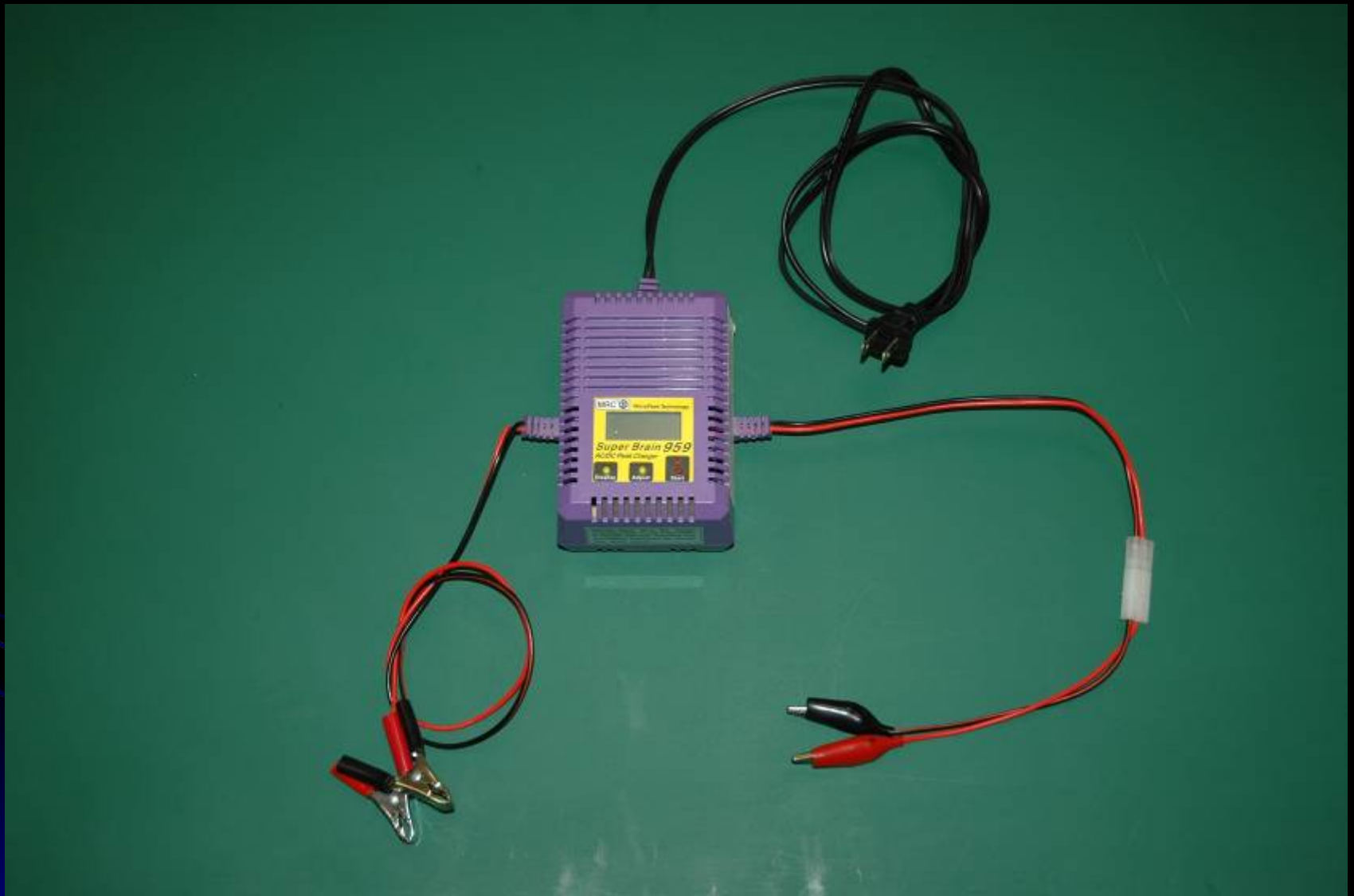
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Batteries come in many shapes and sizes.



Lithium vs. NiCad: 5 oz. vs. 20.



A battery charger should be matched to your batteries and your needs.

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An electric model's wiring harness.

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Safety locks help prevent unanticipated motor starts.