drag and thereby can have relatively more efficient low-load operation.

High-Power Efficiency

A motor with a high RPM/volt can be used to replace a motor that turns relatively slowly. The higher RPM/volt for a given motor design, the fewer turns it will use, and these will be of a thicker wire, therefore they will have less resistance. A high gear ratio is used to keep the same propeller RPM for a given throttle setting. The available gearbox ratios can be a limiting factor, though.

Typical brush motors won't take very high RPMs, so you are forced to choose motors with low RPM/volt and therefore relatively higher resistance (more turns of thinner wire), which limits their efficiency.

Brushless motors can be made reliable at relatively higher RPMs, and allows selection of the therefore relatively more efficient high RPM/volt configurations. A well designed brushless motor can also provide an additional margin of lower resistance for a given RPM/volt at a given motor weight and size. For our applications, it also allows a high short-term load without causing increased wear, because the only limiting factor is the temperature of the windings. This rises relatively slowly because the windings of the brushless motors are directly embedded in the outer portion of the motor, which is relatively massive compared to a brush motor armature, and therefore takes time to heat. This means you can have an extremely wide range of relatively efficient power output.

Purchase Price

Mail Order prices in US dollars shown for comparison purposes:

Item	MaxCim	Aveox	Brush
Controller - Sport	$135 (micro, BEC)	$199 analog	$80 FX-350 micro, BEC
Motor (continuous/peak) Watts Output	$175 (350/750)	$190 (360/600)	$130 Astro 25 Sport (350/450 10 sec)
Gearbox	$40	$40 other co.	$40 Astro
Wires, Connectors	included	included	$10
350W S tern	$340 package deal	$360 package deal	$260
System Weight	12.5 oz	13.6oz	15.8oz

Purchase Price

Brushless power systems cost about US$135 (MaxCim) up to US$240 (Aveox) for the controller and US$170 for the motor to US$550 for the Aveox F5B motor. Brush motors range from $10 to $400, controllers from $50 to $200.

Life Span

Sooner or later, all brush motors need maintenance, or are worn out:

- the cheapest ones are thrown away, but meanwhile deliver less performance
- the better ones last a long time, unless pushed hard, but deteriorate as they wear
- the best ones are designed for particular jobs, and can cost more than brushless motors! They also can wear rather quickly when pushed hard
- brushless motors generally have the life of their ball bearings, and can be pushed hard without accelerated wear

Limiting Factors

Brush bounce, winding strength, brush friction, brush wear, and commutator deterioration all conspire to limit the power output and efficiency for a given size brush motor. Brushless are RPM limited by the strength of the method used to retain the magnets to the rotor. Motors of both types are limited by the power dissipated in the copper windings.

Conclusion

Brushless power systems are available right now.

- They make sense if you are serious about electrics.
- They generally deliver the best all-round performance for a given motor size and weight.
- They last long enough to make them a good investment.
- The breadth of the performance envelope means a single motor can be appropriate for a wide range of applications. (*This is extremely important to note! - km*)
- Fewer compromises must be made, and it can be easier to achieve high power at the same time as efficiency.

I would be glad to assist any of you in deciding whether a brushless system makes sense for you. I have done a great deal of numerical analysis of both brushless and brush power systems to best be able to apply each of them. I may follow this article with a more technical one if there is enough interest.

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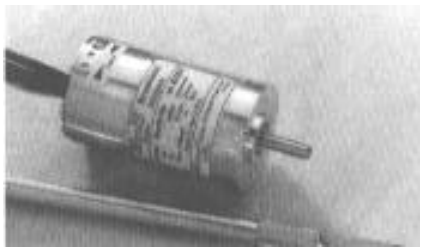
MaxCim Info

This info was taken from the product release info of the Aug. 1995 Model Aviation

It is presented here for your information and reference

Max15 Series brushless DC cobalt motors from MaxCim Motors, 57 Hawthorne Dr., Orchard Park,

NV 14127-1958 (tel. or fax 1-716-662-5651).



"More Power per Dimension" are the bywords of this company about its new Max15 series of high-performance motors. This gives the modeler great power in a compact, lightweight unit, which features "Plug-n-Play" technology for the serious flier of electric-powered models. These motors have more efficiency than others of equal size, as they don't have the friction and resistive losses associated with brushes and commutators. This gives longer flight time per watt of input power. An aluminum housing for the coil windings provides direct heat dissipation to the outside air for higher peak and continuous power capability. Motor cooling is easily accomplished by airflow over the motor exterior. The Max15 Series uses the best, temperature stable, samarium cobalt magnets currently available. These motors are lubricated with synthetic grease and have double-shielded ball bearings. Since a brushless motor has no mechanical commutator, the motor life is essentially equal to the bearing life, which can approach 50,000 hours in average "sport" service. The user selects the "Fixed Optimum Timing" for the chosen rotation direction. No adjustment is necessary; just set it, and forget it. The Max15 "anti-cog" magnetic design provides a unique combination of low audible noise and minimal mechanical vibration, contributing to long life of the airframe, R/C system, and gearbox. Max15 motors require no maintenance, no break-in, no brush dust to clean up, and no capacitors or diodes to jury-rig in the wiring (meaning higher reliability and ease of use). These motors are American-made and were developed from over 10 years of aerospace and industrial applications of brushless motor technology. Direct only.

ElectroSpeak

by Rob Campbell

USING CURRENT MEASUREMENTS FOR TIMING BRUSH DC MOTORS

from the "**Electric Model Flyer**"

(see previous article for rest of credit)

It took a long time for me to find out how to set the timing on the type of motors we most commonly use to power our electric aircraft. I'm not sure why this is. Maybe I just missed the articles on the subject when they appeared in periodicals. Or maybe I didn't ask the right questions, or the persons I talked to didn't know how or didn't feel it was necessary.

I have read up a bit on DC motors but the actual reason why timing must be advanced with higher armature currents does not jump out at me. I think what is going on here is basically a distortion of the normal stator permanent magnet field by the strong, rotationally oftset, magnetic field being generated by the rotor windings.

When faced with making a reversal in the direction of rotation, I used to find neutral timing and just change the timing so that it was advanced the same amount in the other direction. I suppose this wasn't a bad approach, but there are better ways. If you don't know how to adjust timing or when such adjustments are required, here are some tips.

The best source of information on setting timing, that I am aware of, is Bob Boucher's Electric Motor Handbook.

If you can afford it (*You can't really NOT AFFORD IT! - km*), go to your local hobby shop and BUY THE BOOK. The book contains a lot of good information that I could not possibly pass on here. The method outlined here is not the only method, but it is a universal method of setting electric motor timing for brush motors requiring only a few tools that should keep most of us out of trouble!

The truth is, depending on the circumstances, you may never have a situation where the timing on one of your motors MUST be adjusted. For example, AstroFlight claims their motors are timed at the factory. The most common reason the timing MUST be re-set on a motor is undoubtedly to handle a reversal of rotation - such as is required by installing or removing a standard gear and pinion gearbox. This highlights an advantage of belt and internal-tooth gear drives - it is not necessary to re-time the motor when these are installed or removed because the direction of rotation of the motor does not change.

If you are using an inexpensive can motor it probably does not facilitate brush timing adjustments. You may still be able to adjust the timing with some ingenuity on your part. At the lower currents that these motors operate, timing adjustment is less critical.

To properly time a motor a starting point for the adjustment must be established. This starting point is NEUTRAL TIMING. Adjusting the brush holders so that commutation switching occurs earlier in rotation relative to the permanent magnet field is called