6mm Pager Motors

(Or, how I came to love the 4.5 ohm Didel "super pager")

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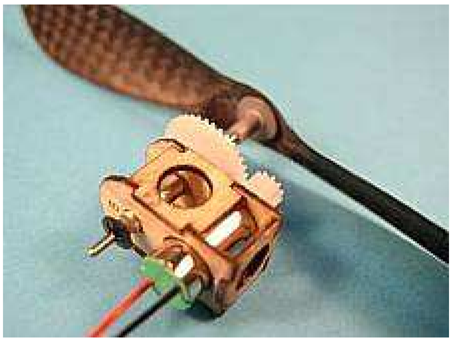
For some time now there has been a lot of interest in pager-motor powered micro planes. There is also a lot of confusion about how to best put these motors to use and what the differences between motors are. In this article I take a look at many of the commonly available 6mm pager and Bit Car motors. I also examine the Didel 4.5 ohm pager in some detail as well as gears, props, and gearboxes for pager motors.



As usual several friends provided useful technical help and advice as I proceeded with the tests for this article. Roger Carignan did parallel tests of the 4.5 ohm Didel pager when we first got it and were trying to figure out exactly what it was capable of. He and Matt Keennon were also very useful sounding boards for preliminary results and sources of advice. Carl Martin made gearboxes that allowed motors to be easily swapped and thus many different motors to be tested. He also made gearboxes that allowed testing pager motors at seven different gear ratios. Hopefully the result of all this is to bring some clarity to the confusion surrounding pager and Bit Car motors.

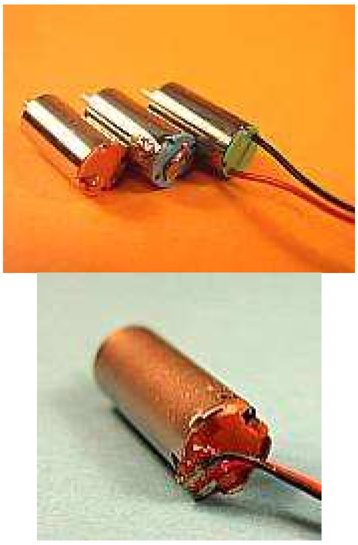
6mm Motor Overview

Pager motors are a class of inexpensive motors originally used to power a vibrating alert in pagers and cell phones. They are often coreless, but can also use traditional cored technology. One question we might have about a particular motor is how to determine exactly which motor it is. The easiest way is to measure the resistance in ohms across the two terminals or leads. To measure the resistance first connect the motor leads to a multimeter. Put a pinion on the motor shaft and then insert it into a short balsa stick with a hole in the middle that can be pressed over the pinion. The stick makes it easier to precisely position the motor shaft. Measure the resistance, then rotate the shaft slightly and measure again. Repeat this several times. The motor shaft must be completely at rest each time or the reading will not be valid. Use the highest measure because lower readings may occur if the motor shaft is positioned such that the brushes are straddling the commutator for two sets of windings rather than one. Finally, the resistance readings can differ by as much as +/- 1 ohms for identical motors from the same source. With the resistance of the motor in hand and pictures of the motors in this article or knowing the motor's source you should be able to determine approximately which motor you have and how to use it.

Not all pager or Bit Car motors are created equal. There are a number of different manufacturers making Bit Car motors. It is not feasible to attempt to catalog them all here. Motors from cars purchased at the same time may last for the same amount of time or perform differently. And, motors from different manufacturers may not perform or last the same. The Bit Car manufacturers may source their motors from more than one manufacturer or switch from time to time. Thus it's difficult to know for certain exactly what you are getting. The

Didel motors are to some extent the exception as they come from one motor manufacturer which does not change. However, even within Didel motors there can be some moderate variation just due to the manufacturing process. Remember, these motors cost only a few dollars at retail and are being cranked out in volume in Asia. Some variation is bound to occur in this high-volume low-cost manufacturing process.

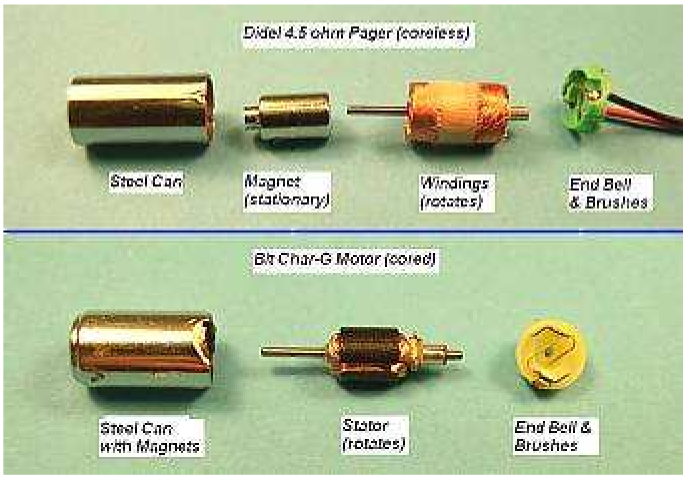
Connection methods fall into three main categories. Pager motors generally come with wire leads exiting the back bell, but occasionally on the side near the front bell. Bit Car motors generally make their ground connection through the motor case and their positive connection through a small terminal on one side of the back bell, or through a diamond shaped connection in the center of the back bell. This makes it more difficult to solder up the Bit Car motors. The Didel pager motors with resistances less than 10 ohms are essentially Bit Car motors with wire terminals exiting the back bell. This makes them easier to use.



Connection methods left to right: side-bell contact, center-bell contact, wire connections. The picture on the right shows the distinctive connections for the surplus 6.1mm brown bell pager.

Most of the 6mm motors available are coreless. The top panel in the picture below shows the Didel 4.5 ohm pager motor after it has been taken apart. There is a steel can that has the stationary magnet permanently attached to the inside of the front bell. Normally this magnet does not come out but was drilled out and removed for this illustration. A set of coreless windings fits over this magnet and has a back plate where the windings attach to the commutator. A shaft passes through the commutator, through the stationary magnet, and out the front bell. Essentially the windings are a drum that rotates around the stationary magnet.

The bottom panel in the picture below shows a Bit Char-G motor after it has been taken apart. The steel can has curved ferrite magnets inside it. The stator is simply a very small version of a traditional cored stator. In fact, this one measures just 4.2mm in diameter. And, finally there is a plastic end bell with the brushes. The Mabuchi 6mm motor that Toytronics sells looks very similar inside to the Bit Char-G motor.



In a coreless pager motor the windings rotate around a stationary magnet. In a traditional cored motor the cored stator rotates inside a set of magnets.

The motors in these tests include most of the 6mm Didel motors, several of the Bit Char-G motors, several of the Bit Clone motors, and a few of what I am calling surplus pager motors. I do not have all the Bit Char-G or Bit Clone motors so present results for those I do have. The Snow Globe Bit Clone motors were provided by Billy Stiltner. The ZipZap Bit Clone motors I purchased at Radio Shack in a hop-up kit. The Bit Char-G motors I obtained nearly two years ago, early on in the Bit Car craze, from a hobby shop in Hong Kong in genuine Bit Char-G packaging. I don't know if Bit Char-G cars still come with these cored type motors. The Didel pagers I obtained directly from Didel. But, most of them are also available from various other vendors who carry Didel products. I've also included the 7mm Didel pager for comparison as people have often been curious how this larger pager motor performs.

Focus of Tests & Methodology

In this set of tests I simplified the problem of evaluating different motors by using just one gear ratio and prop. I chose a 5-inch prop as much larger and the prop would either look funny or would hit the ground for typical scale or stick planes sized about right for pager motors. I chose the 6.7:1 gearing as the higher ratio from the Didel 81t spur gear is more difficult to fit inside a scale cowl, unless the plane had a radial engine, and would also require a larger prop. I've also focused on single stage gearing. Thus, this set of tests is really an exercise in finding the best motor for a given prop and gearing. It is possible that for a different prop and gearing a different motor might do better. However, if one motor outperforms another motor by a sufficient margin, then it is likely to also do so for other props and gear ratios.

Test Results

Table 1 presents results from tests of all motors with 6.7:1 gearing and GWS 5x3 prop. Within the Didel pager motors group we can see that the lower ohm motors generate more thrust, and also have a higher amp draw. The 3.2 ohm motor has an amp draw of 0.58, which would be too high for the E-Tec 90mAh cell's 0.5 amp max discharge rate. More importantly this motor runs hot and its static thrust quickly declines. This prop and gearing is clearly too much for this motor. The 4.5 ohm motor, however, has a substantially lower amp draw of

0.33, well under the E-Tec 90's max amp draw. Moreover it does not run hot and generates virtually the same 14.7g thrust as the hotter wind 3.2 ohm motor. Moving to the 6.0 ohm motor the amp draw is almost the same as the 4.5 ohm motor, but its thrust is substantially lower at 10.5g. The higher 8 and 10 ohm motors have substantially lower amp draws of 0.21 and 0.18 amps respectively. But, their thrust is substantially lower at about 7.7g and 7.5g. Clearly within the Didel pagers the 4.5 ohm motor is in the sweet spot in terms of maximum thrust without overheating or exceeding the E-Tec 90's amp limit. The 10 ohm motor is also clearly best where lower thrust is required but low amp draw is important. Finally, the 7mm pager develops roughly the same thrust as the 10 ohm motor, but pulls the same amps and weighs nearly twice as much. It just doesn't measure up compared to its smaller siblings.

Overall the Bit Clone motors do not perform as well as the Didel motors. The white bell Snow Globe motor has the same 4.5 ohm resistance as Didel 4.5 ohm motor. However, it pulls 0.44 amps compared to the Didel's 0.33 amps. And, it develops a gram less thrust and runs hot. Although I've tested several of the Didel 4.5 ohm pagers with equivalent results, this is the only Bit Clone motor I have with this resistance. However, other people seem to be finding similar results for the Didel motor outperforming the Bit Clone motors. The hotter wind 3.7, 3.3, and 2.6 ohm Bit Clone motors ran very hot and burned out within a minute. The similar resistance Didel 3.5 ohm motor runs warm and does not immediately burn out. Again, the Bit Clone motors do not seem to perform as well as the Didel motors. However, if the Bit Clone motors are equipped with smaller props they might last longer, although developing less thrust. Overall, the 3-motor ZipZap hop-up package does not seem that useful to me. Two of the motors have too hot of winds and quickly burn out and the third doesn't have a hot enough wind and develops less thrust than the Didel 4.5 ohm pager.

The Bit Char-G and Mabuchi motors are not coreless. The Mabuchi pulls slightly more amps and develops less thrust than the equivalent 10 ohm Didel. The higher resistance Bit 2.2 motor pulls more amps and develops less thrust than the Didel 4.5 ohm motor. Clearly the coreless motors have the advantage here.

Within the general surplus motors the Namiki shines and develops equivalent thrust to the 10 ohm Didel. This motor has been known for a while to be a good pager motor and this confirms it. Still, it does not develop the thrust that the 4.5 ohm Didel does. The brown bell surplus motors are the ones often available from general electronics surplus houses. In addition to being heavy, and having a non-standard 6.1mm case, they don't perform well either. They have relatively higher amp draws for their resistance and develop only typical thrust.

6mm Motor Static Tests
(6.7:1 Gearing, GWS 5x3 Prop, 3.6 Volts)

	Motor Characteristics				Static Measurements				Figures of Merit		
	Description	Length (mm)	Weight (g)	Resistance (ohms)	Amps	Watts	Thrust (g)	Prop Rpm	Thrust/ Wt	(T/Wt)/A	Notes
DIDEL											
Didel MK06-30	Black, blue dot	12	1.32	32.9	0.06	0.19	3.2	2,010	2.4	40.4	
Didel MK06L-10	Black open back	15	1.63	10.5	0.12	0.92	7.7	2,970	4.7	39.4	
Didel MK06-10	Black	12	1.32	10.4	0.18	1.35	7.5	2,940	5.7	31.6	
Didel MK06-8.5	Green, blue dot	12	1.32	8.5	0.21	0.76	8.6	3,150	6.5	31.0	
MK06-6.0	Brown	12	1.32	6.0	0.32	1.15	10.5	3,480	8.0	24.9	
MK06-4.5	Green	12	1.32	4.5	0.34	1.22	14.7	3,960	11.1	32.8	
MK06-3	Pink	12	1.32	3.5	0.50	1.80	15.7	4,170	11.9	23.8	(1)
Didel Mk07-10	7mm motor	17	2.70	10.0	0.12	0.43	7.4	2,900	2.7	22.8	
BIT CLONE											
Snow Globe	White	12	1.32	4.5	0.44	1.58	13.7	3,720	10.4	23.6	(2)
Snow Globe	Green	12	1.32	3.7	0.57	2.05	14.7	3,930	11.1	19.5	(3)
ZipZap	Green	12	1.32	8.1	0.25	0.90	7.7	3,030	5.8	23.3	
ZipZap	Yellow	12	1.32	3.3	0.58	2.09	14.9	4,080	11.3	19.5	(3)
ZipZap	Orange	12	1.32	2.6	0.64	2.30	14.5	4,050	11.0	17.2	(3)
BIT CHAR-G											
2.2 Yellow	cored	12	1.32	5.6	0.52	1.87	12.2	4,020	9.2	17.8	(4)
2.6 Orange	cored	12	1.32	6.0	0.77	2.77	15.2	4,300?	11.5	15.0	
3.0 Red	cored	12	1.32	1.7							
OTHER											
Namiki	white bell	15	1.63	9.5	0.14	0.50	8.0	2,970	4.9	35.1	
Surplus	Brown bell 6.1mm	16	1.94	7.9	0.18	0.65	8.2	3,180	4.2	23.5	
Surplus	Brown bell 6.1mm	16	1.94	10.7	0.18	0.65	6.8	2,880	3.5	19.5	
Toyts/Mabuchi	RF-J20WA, cored	12	1.23	10.7	0.19	0.68	5.6	2,580	4.6	24.0	

Notes: (1) runs warm; (2) runs slightly warm; (3) runs very hot and quickly fried (4) runs moderately warm

One last way to characterize all these motors is by some simple figures of merit. What we see is that the Didel 4.5 ohm pager has a very high thrust/weight ratio and also a high (thrust/weight)/amps ratio. The other motors with higher values on this measure, which considers both weight and amp draw, have substantially lower levels of thrust. Since the E-Tec 90mAh cell can easily handle the amp draw of the 4.5 ohm Didel this motor overall looks like the best choice for a 6.7:1 gear ratio and 5x3 prop.

Exploring the 4.5 Ohm Didel 6mm Motor

Since I first flew my Quick Junior with the 4.5 ohm pager motor in August of 2003 it is quickly becoming "the" pager motor to use. Properly geared and propped, it generates good power without getting hot. And it is a very good match for the discharge capabilities of the E-Tec 90mah LiPoly cell. Consequently it is worth exploring this motor in more detail.

Let's start with a quick review of the this motor's characteristics. Early on in my use of this motor, before it was widely available, I sent one to my friend Roger Carignan. He was interested in using it direct drive in a super micro 10g version of his pusher configuration Pinky, while I was more interested in using it geared in my Quick Junior. Roger enhanced Joachim Bergmeyer's formulae for finding motor constants for a given motor (see the February 2003 Inside Story article). Roger's version improves the calculation of rotational power loss based on two measurements of no load conditions, rather than one. I don't want to go into more detail here. It's enough to say that Roger measured motor constants for this motor and then I did the same with my equipment and got virtually the same results.

The graph below shows motor efficiency and power, in Watts of output, for the 4.5 ohm pager at various RPM's. The dotted red line shows power output which peaks at 0.64W and 25,519 RPM. The solid blue line shows efficiency which peaks at 52% and 33,818 RPM.

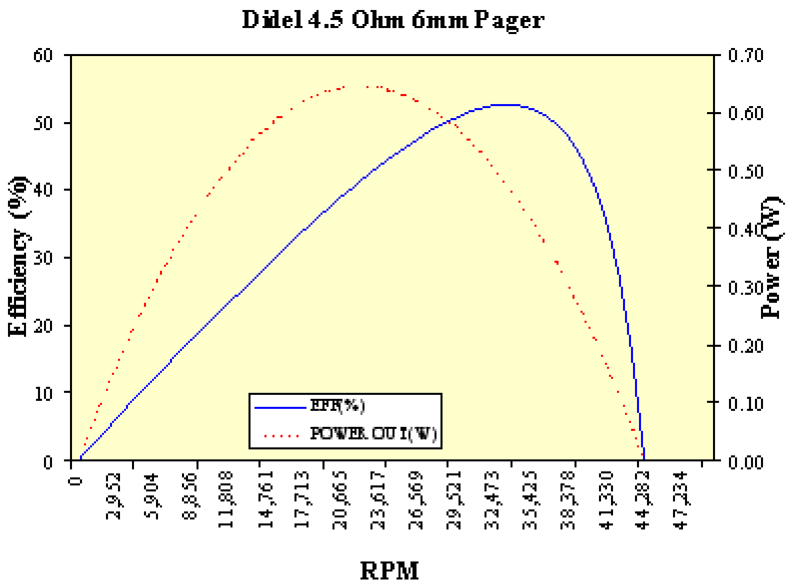


Table 2 below shows a variety of static tests for the 4.5 ohm pager. The first two rows give the **predicted** measures for max efficiency and max power and the corresponding motor RPM. These are useful for interpreting the results of the various static tests. In general we will want to choose prop and gear combinations that have a motor RPM that lies between the max power and max efficiency RPMs. If the ET-90 LiPoly cell is used we have plenty of capacity, so efficiency will not really be an issue, and we should try to find prop and gearing choices where the motor RPM is closer to the max power RPM.

For each test the amps, watts, thrust, and prop and motor RPM are given under the static measurements heading. For each test the predicted amps, efficiency and power are also given under the predicted motor measures heading. And, for the efficiency and power the percentage of the max efficiency and max power at the top of the table are also given.

The Falcon PU04 propulsion set now comes with the Didel 4.5 ohm motor. It has a gear ratio of 6.5:1, and will soon come with a folding KP00 69mm prop. So a limited set of tests for this gearing are included. However, since the 6.5:1 and 6.7:1 ratios are so close, I present more tests for the 6.7:1 gearing, but they really apply to the PU04 with its 6.5:1 gearing as well.

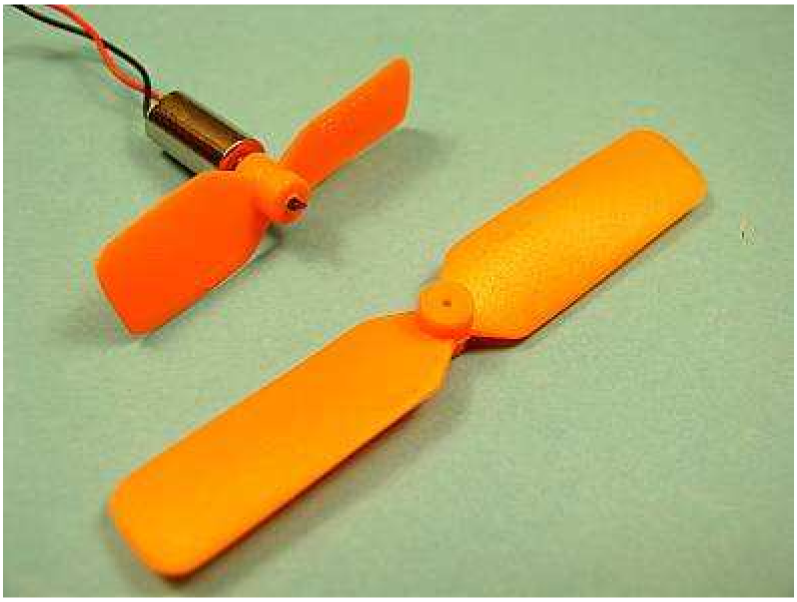
Table 2: Didel 4.5 Ohm 6mm Pager at 3.6 Volts

	Prop & Gearing			Static Measurements					Predicted Motor Measures				
										Efficiency		Power	
	Prop	P/D	Gearing	Amps	Watts	Thrust (g)	Prop Rpm	Motor Rpm	Amps	(%)	%Max	(W)	%Max
	MAX EFFICIENCY							**32,818**	**0.23**	**52.4**		**0.50**	
	MAX POWER							**23,519**	**0.41**	**43.4**		**0.64**	
	GWS 2.5x0.8, 37mm	0.55	DD	0.39	1.40	3.9	24,030	24,030	0.40	44.1	84	0.64	100
*	GWS 2.5x0.8, 41mm	0.49	DD	0.43	1.55	5.8	21,150	21,150	0.45	39.8	76	0.64	100
	GWS 2.5x0.8, 49mm	0.41	DD	0.48	1.73	5.8	17,200	17,200	0.51	33.1	63	0.61	95
	GWS 2.5x0.8	0.32	DD	0.55	1.98	6.8	13,140	13,140	0.58	25.8	49	0.54	84
	CF 3.0x2.5	0.83	3:1	0.40	1.44	7.5	6,660	19,980	0.47	37.9	72	0.64	99
	U80, 70mm trimmed	0.73	3:1	0.38	1.37	8.2	7,770	23,310	0.42	43.1	82	0.64	100
*	U80 3.2x2.0	0.63	3:1	0.40	1.44	8.9	6,870	20,610	0.46	38.9	74	0.64	100
	CF 3.5x3.5	1.00	4:1	0.47	1.69	8.5	4,230	16,920	0.52	32.7	62	0.61	95
*	U80 3.2x2.0	0.63	4:1	0.34	1.22	9.3	6,960	27,840	0.34	48.9	93	0.60	94
	CF 3.5x2.7	0.77	4:1	0.40	1.44	11.0	5,550	22,200	0.43	41.4	79	0.65	100
	U80 3.2x2.0	0.63	5:1	0.26	0.94	8.5	6,630	33,150	0.26	52.5	100	0.49	76
*	CF 3.5x2.7	0.77	5:1	0.33	1.19	10.3	6,120	30,600	0.30	51.4	98	0.55	86
	CF 3.5x3.5	1.00	5:1	0.39	1.40	9.2	4,380	21,900	0.44	40.9	78	0.65	100
	GWS 4.0x4.0	1.00	5:1	0.41	1.48	9.6	4,020	20,100	0.47	38.1	73	0.64	99
	GWS 4.5x4.0	0.89	5:1	0.40	1.44	9.4	4,140	20,700	0.46	39.0	74	0.64	100
	CF 4.8x3.1	0.65	5:1	0.44	1.58	12.5	3,360	16,800	0.52	32.5	62	0.61	94
	KP00 96mm, 3.7x2.8	1.32	6.5:1	0.34	1.22	8.9	3,960	25,740	0.38	46.4	89	0.63	98
	GWS 5.0x4.3	0.86	6.5:1	0.43	1.55	10.5	3,030	19,695	0.47	37.4	71	0.64	99
*	GWS 5.0x3.0	0.60	6.5:1	0.36	1.30	14.0	3,960	25,740	0.38	46.4	89	0.63	98
	GWS 4.0x4.0	1.00	6.7:1	0.32	1.15	9.5	4,170	27,939	0.34	49.0	94	0.60	94
	GWS 4.5x4.0	0.89	6.7:1	0.36	1.30	12.3	3,720	24,924	0.39	45.4	87	0.64	99
	GWS 5.0x4.3	0.86	6.7:1	0.41	1.48	14.1	3,210	21,507	0.44	40.3	77	0.65	100
*	GWS 5.0x3.0	0.60	6.7:1	0.34	1.22	14.7	3,960	26,532	0.36	47.4	90	0.62	96
	Blue 10cm, 4x4	1.00	6.7:1	0.42	1.51	9.7	3,360	22,512	0.43	42.0	80	0.65	100
	GWS 5.0x4.3	0.86	7.4:1	0.38	1.37	12.3	3,060	22,644	0.34	49.3	94	0.60	93
*	GWS 5.0x3.0	0.60	7.4:1	0.32	1.15	12.8	3,810	28,194	0.35	48.5	92	0.61	95
	GWS 6.0x3.0	0.50	9:1	0.32	1.15	13.5	3,360	30,240	0.30	51.1	98	0.56	87

Let's work through an example for the 6.7:1 gearing with a 5x3 prop. This combination has a motor RPM about midway between the max efficiency and max power RPM's. Its 0.34 amp draw is well within the 0.50 amp max discharge capability of the ET-90 LiPoly cell. The predicted motor measures columns show a predicted amp draw of 0.36 amps, which is very close to the actual 0.34 measured amp draw. Predicted efficiency is 47%, which is 90% of the 52% max efficiency for this motor. Predicted power is 0.61 Watts, which is 96% of the max power of 0.64 Watts for this motor. Overall, this is a very good combination for this motor. In fact it is probably the best combination if prop diameter is not a constraint. The higher pitch 5x4.3 prop has a higher amp draw with the 6.7:1 gear ratio but develops less thrust. Although the motor RPM is closer to the max power RPM, it is below that RPM. So, it would seem to be moderately over propped. Overall we find that just about the best combination for this motor is either the 6.5:1 or 6.7:1 gearing and a 5x3 prop.

If you are building a semi-scale plane with a 10 to 12 inch or so wing span and would like the prop to not hit the ground, the 5-inch prop is probably not an option. A prop the size of the U80 or maybe a slightly larger 3.5-inch prop is probably a better choice. From the table we can see that the U80 is a good match with 4:1 gearing. It develops about 9g thrust with high percentages of max efficiency and max power. If a bit more thrust is needed the larger diameter and higher pitch 3.5x2.7 prop delivers 11g thrust, but efficiency drops.

One way to save weight on the lightest models might be to eliminate the gearbox, which typically weigh about 0.7g, and run the motor direct drive. To explore this possibility I tested the motor DD with a GWS 2.5x0.8 prop. Then, I trimmed the prop to a smaller diameter, tested it, trimmed it again, tested, and so on. The results are shown near the top of Table 2 along with the prop diameter in millimeters after trimming. The first thing worth noting is that the untrimmed prop is clearly overloading the motor, and also pulls more amps than the ET-90 cell can provide. The motor RPM is far below the max power RPM. Only the 37mm trimmed prop has an RPM close to the max power RPM. The picture below shows the untrimmed and the 37mm trimmed prop, which can best be described as a "nub." The best prop is probably the 41mm version. The amp draw is on the high side for this motor, and I don't know how long it will last at a 0.43 amp draw. It ran only slightly warm so motor life might be ok. The other thing to note is these were very crudely trimmed props where the ends were simply chopped off and then sanded thin. It may be possible to get better thrust by trimming this prop to have a slightly larger diameter than 41mm, but with thin tapered blades. If this is attempted the goal should be to get a much nicer trimmed prop that pulls about 0.43 amps, and hopefully with higher thrust.



For direct drive static tests a GWS 2.5x0.8 prop was cut down in stages and tested at each diameter. Shown here is the original prop next to one cut down to 37mm (0.94 inches).

How to use Table 2

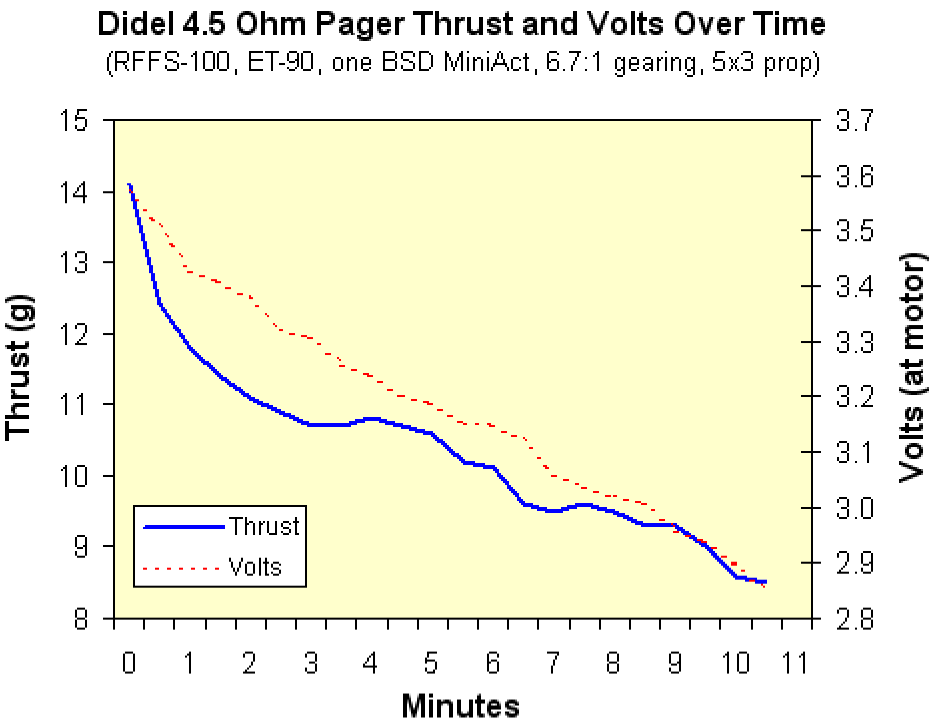
Here's how to use Table 2. Spec out your plane to figure out the maximum size prop you are willing to have on it. If you don't care about taking off from the ground you may be willing to accept a prop that is longer than the landing gear. Once you have your prop size, find something close in the table that has a motor RPM close to the max power RPM and has a good thrust compared to other similar sized props. I've highlighted one prop in each gearing category that is a good choice, although others may be acceptable too. Next compare the static thrust with some of the rules of thumb about how much thrust to weight you need and compare this to your estimated plane weight. A good one for indoor models is that if your static thrust is at least equal to 1/4 your model weight it will be able to fly, and equal to 1 your model weight it will fly well, and equal to 3 it will be aerobatic. So, if you have a plane that is not excessively draggy, like a biplane, and it weighs 15g and you choose a prop and gear combination that yields 10g static thrust you will have a great performing plane. Alternately some people prefer a watts/ounce rule that at 1.5 watts/ounce the model will have average performance, 2.0 is about right for a typical sports model, and 2.5 will give aerobatic performance. In this case a 3.5x2.7 prop geared 4:1 would be a good choice. These rules of thumb are thanks to John Worth, Bob Aberle, and Don Srull.

Rules of Thumb for Indoor Power & Thrust			
	Watts per Ounce	Watts per Gram	Thrust per Gram
Level Flight	1.5	0.035	0.25
Sport Flyer	2.0	0.071	0.50
Aerobatic	2.5	0.088	0.75

Thrust Over Time

I can almost hear someone reading this thinking "I wonder if I can make a pager plane with this motor that will hover?" The graph below shows the results from a test designed to simulate full throttle over time. All the previous tests were powered by a laboratory power supply straight to the motor, with volts measured at the motor terminals. This test powered the motor via an RFFS-100 receiver, with a single BSD MiniAct hooked up, and powered by a freshly charged ET-90 cell. During the test I operated the actuator back and forth to put an additional load on the cell due to actuator use. I measured volts under load at the battery and also at the motor terminals. Volts at the motor terminals were about 0.15 volts lower than at the battery throughout the test. The test was terminated when volts at the battery dropped below 3.0 volts.

This test represents an extreme test of the propulsion system and the ET-90 cell. Thrust drops steadily during the test from about 14g to 8.5g. Volts under load at the motor also drops steadily from 3.6 to 2.9 volts. During the first three minutes of discharge the average thrust is 11.8g and the average volts is 3.4. Over the remaining 7.5 minutes of discharge the average thrust is 9.8g and average volts is 3.1. These are very encouraging results. Since most of us don't fly our micro planes at full throttle for the entire flight we will have power for the occasional loop if the plane is relatively light. If we choose to cruise around at partial throttle the flight time will be considerably longer than 10 minutes. Now about that hovering. If someone builds a plane light enough to hover, these results show that the hovering will have to be done in the first couple of minutes of the discharge.



Gears and Gearing

The table below shows the single stage gearing possibilities using Didel or Falcon gears. The Didel gears are 0.3 mod (except for one pair of 0.2 mod gears) and the Falcons are 0.25 mod.. The Didel spur gears have lightening holes and a 12t gear on the front. The also offer a wide variety of gear sizes. The lightest gear set by far at 0.078g is the 5:1 gearing using the Didel 0.2 mod gears. Gear sets that were used in tests for this article are noted with a check mark.

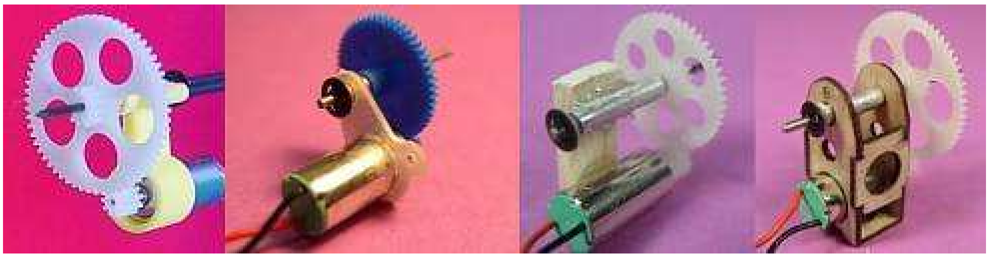
Single-Stage Pager Motor Gearing Summary

	Used in	Gearing				Weight (g)		
	Tests	Ratio	Mod	Pinion	Spur	pinion	spur	both
Didel	✔	3:1	0.30	12	36	0.043	0.12	0.163
Didel	✔	4:1	0.30	12	48	0.043	0.14	0.183
Didel		5:1	**0.20**	12	60	0.011	0.07	0.078
Didel	✔	5:1	0.30	12	60	0.043	0.19	0.233
Falcon		5.3:1	0.25	8	42	0.008	0.14	0.148
Didel		5.3:1	0.30	9	48	0.021	0.14	0.161
Falcon		6:1	0.25	7	42	0.008	0.14	0.148
Falcon	✔	6.5:1	0.25	8	52	0.008	0.21	0.218
Didel	✔	6.7:1	0.30	9	60	0.021	0.19	0.211
Didel		6.7:1	0.30	12	81	0.043	0.34	0.383
Falcon	✔	7.4:1	0.25	7	52	0.008	0.21	0.218
Didel	✔	9:1	0.30	9	81	0.021	0.34	0.361

Pinions	Mod	bore (mm)
Didel 9t	0.3	0.6, 0.7, 0.8, 1.0
Didel 12t	0.3	0.78, 0.97
Didel 12t	**0.2**	0.63
Falcon 7t	0.25	0.6
Falcon 8t	0.25	0.7, 0.8, 1.0

* Didel 4.5 ohm motor shaft is 0.8mm

The picture below shows a range of possible gearboxes for pagers. Didel Makes a 6.7:1 gearbox for the 6mm motor that allows the motor to be inserted or removed easily. More recently Falcon has introduced a 6.5:1 (PU04) gearbox which comes with the Didel 4.5 ohm motor glued in place. Falcon also sells their 5.25:1 (PU03) gearbox which comes with the 6x15mm Namiki motor. Also shown is a simple stick gearbox which takes very little time to construct and is simply the motor and an aluminum/nylon bearing tube glued to a stick. It is light and works well. At the far right is one of the laser cut gearboxes my friend Carl Martin made me which allowed easy swapping of motors. Carl also made gearboxes for both Didel and Falcon gears in a wide range of gear ratios not available in gearbox form from either manufacturer. Thanks again Carl!

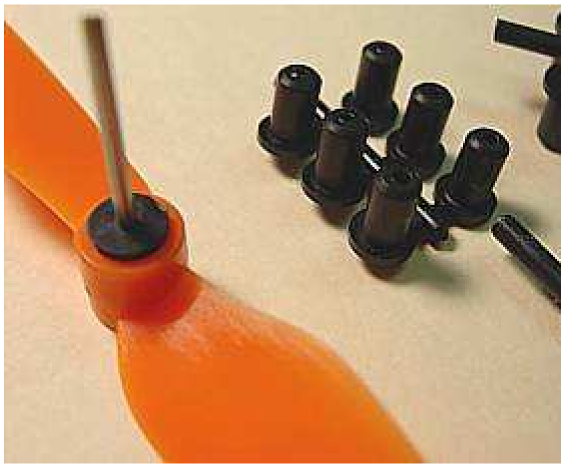


Single stage gearbox possibilities in 6.7:1 and 6.5:1 gearing include, left to right: Didel, Falcon, simple stick, and Carl Martin laser cut.

Props

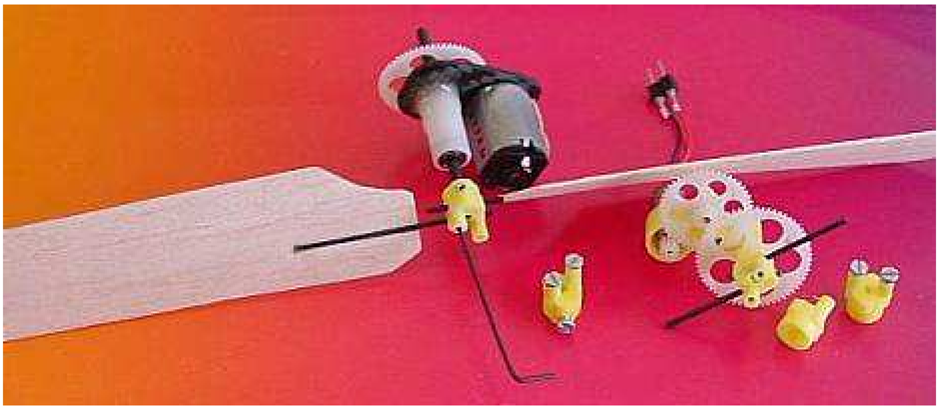
Now a word about props. It would be nice if we had available an assortment of very light props perfect for pager motor gearboxes. But, we don't. Both the Didel and Falcon gearboxes use 1mm shafts for weight reasons. The U80 prop will press fit on this size shaft. And recently Falcon has added a special version of the folding KP00 96mm folding prop that is also a press fit on a 1mm shaft. But, other than the GWS 2.5x1.0 and 2.5x0.8 props none of the GWS props are a press fit on a 1mm shaft. Bob Selman Designs has just introduced a set of six molded prop adapters that will convert the 4mm bore GWS props to a press fit on a 1mm shaft. These adapters are a micro necessity as they allow a wide range of GWS props to now easily be used. The 3mm bore GWS props can be used with these adapters if the hole in the prop is carefully reamed or drilled out to 4mm. The famous blue 10cm and 12cm rubber props have about a 1.5mm bore and won't work with a 1mm shaft. However, I've found that by cutting a short length of aluminum tube that is a snug fit (use CA) over a 1mm shaft, I can sleeve the shaft up to a larger size and then I ream out the blue props to fit over this sleeved shaft. All the Didel gearboxes come with a similar sleeve to adapt the shaft to 2mm bore props such as the Westechnik CF props.

These are some of the props that can be used with pager motors.



The new Bob Selman Designs prop adapt
allow the popular GWS 4mm bore props to
used with a 1mm shaft.

Weight in any pager powered plane is always a concern. Weights for these props (without adapters) is given in the table. If you truly want to save weight, molding a CF copy of the GWS 5x3 prop will result in a prop that weighs between 0.55 and 0.65g. That's nearly a gram of weight savings, which is quite substantial on a plane weighing between 13 and 18 grams. See the June 2003 Inside Story for more information on how to mold your own CF props. And, of course there are other light weight props that can be made. There are the popular yogurt container thin plastic props. Didel also sells a variety of hubs that press on the 12t gear on the front of their spur gears. These allow balsa or plastic prop blades to be glued to CF rod which is then inserted into the hub from each side. These allow easy adjustment of the pitch of the blades.



Didel prop hubs allow constructing your own props with adjustable pitch blades in any size or pitch desired. They are available in configurations to press on the front of Didel spur gears or for use with a 2mm shaft.

Prop Weights and Bores

	Size (in)	Bore (mm)	Wt (g)
GWS	2.5x0.8	1.0	0.45
U80	3.2x2.0	1.0	0.68
KP00 96mm	3.7x2.8	1.0	1.21
Blue 10cm	4.0x4.0	1.5	1.06
GWS	4.0x4.0	4.0	1.07
GWS	4.5x4.0	4.0	1.35
Blue 12cm	4.7x4.7	1.5	1.55
GWS	5.0x3.0	4.0	1.44
GWS	5.0x4.3	4.0	1.56
GWS	6.0x3.0	3.0	2.19
GWS	70x3.5	3.0	2.85

Conclusion

It couldn't be a better time to build pager powered micro planes. We now have the 4.5 ohm Didel "super pager" that is at a sweet spot in terms of what we need from a pager motor. It really is the pager motor of choice. Accept no substitutes. We have the new E-Tec 90 mAh LiPoly cell which is perfectly matched for this motor. It is light and compact and has good discharge capabilities. We have a variety of sources for gears and gearboxes for pager motors, as well as prop adapters that allow a wide variety of props to be used with them.

I have presented data that will allow matching the 4.5 ohm pager with a good gearing and prop combination for the intended application. If you want to get your feet wet in pager powered planes, the Quick Junior plans in the December 2003 Inside Story column is a good plane to get started with. After that an appropriately sized and light semi-scale plane is a possibility. The gym ceiling is now the only limit to what can be done with pager powered planes.