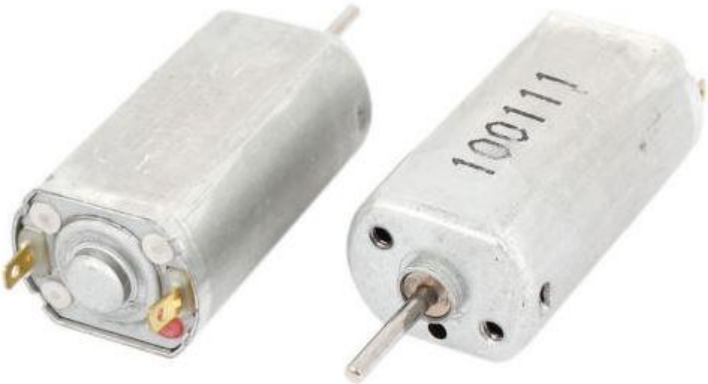
Tech Article – Motors Part 1

I see so much discussion about the power or performance of various motors, I decided it is time to bring some light to an often murky subject.

Most of us have cars with at least four different shapes of motor.

There's the slimline FF-050 found in many F1 cars – because it fits, and now in some Scalextric Saloons.



Then there is the common FC-130 such as the Slot.it short cans and NSR Shark series.

Slot.it make the only slot motor designed from scratch for use in slot cars – their Flat-6 series.

And finally the "Boxer" motor, technically referenced as the FK-180 shape. A larger and usually more powerful motor.

There is only so far we can go in comparing electric motors to our beloved internal combustion engine, but I'll use analogy where practical.

The ff-050 is a bit like a turbocharged motorcycle engine. Often developing buckets of revs, but it wouldn't drag a large family saloon up hills too well.

The FC-130 "S-can" is more like the motor in a small saloon car.

The Flat-6 is a bit like a turbocharged 6 cylinder, and at the top of the pile for "power" is the 5 litre V8 in your favourite Ford/Holden/insert brand here.

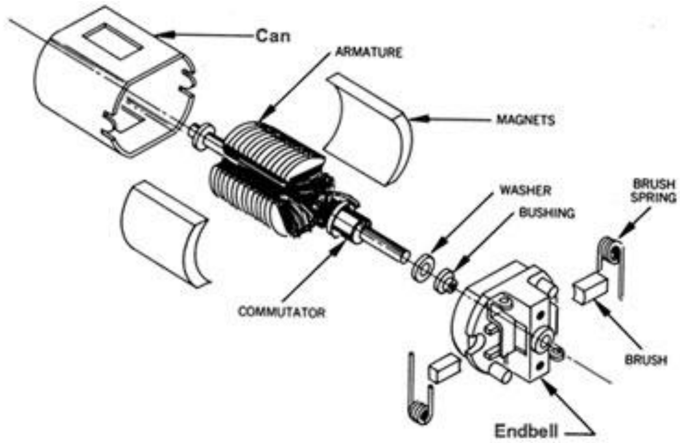
However all people usually think about is the RPM of the motor – and even these aren't always stated on the same basis. We need first to check with RPM that we are comparing apples with apples and that the RPM is quoted at the most common 12 volts.

Some motors have RPM quoted at the voltage output of the home-sets which their manufacturer produces (typically 14.8 to 16). If you need to convert back to 12 volts, just multiply the stated RPM of the motor by 12, then divide it by the voltage stated by the maker in their specification. That levels one part of the playing field.

This brings us to why a boxer motor is an utter beast even though it typically develops less rpm than the ff-050 motor in the Scalextic or Policar F1

The answer is also best compared to the old American analogy. "There *ain't no substitute for cubic inches.* "

The reality is, the length of the motor can determines how long you can make the magnets around the armature, and the diameter of the can determines how large and thick you can make them. The larger the magnets, the more magnetic field they generally have as a start point, and the more effect they will have on a motor armature when we create a magnetic field by feeding electrons (voltage) through the armature windings. Then of course the same goes for those armature windings. The bigger that armature, the more windings, and/or the heavier gauge of wire we can use to ram those electrons down the channel via the motor brushes and commutator as the armature begins to spin.



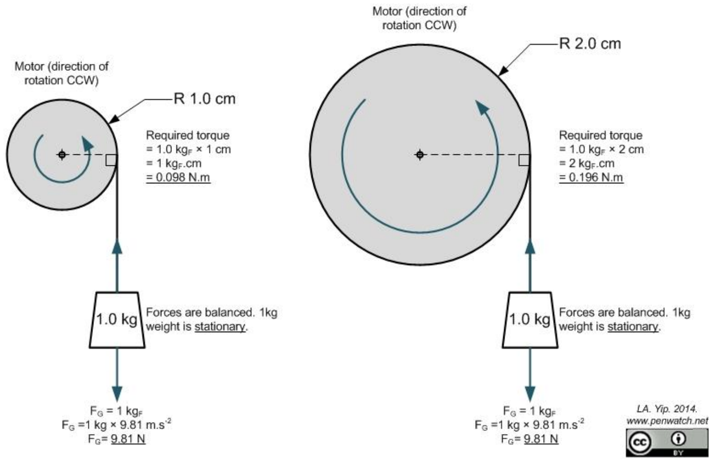
The fixed magnets cause the armature to rotate as the electro-magnet created by the armature tries to escape them – just like trying to force the same poles of two fixed magnets together.

The bigger the fixed magnets and the bigger the electro magnets of the energized armature, the more power you get. From this description you can easily figure out that simply looking at the stated RPM output of a motor is not going to tell you how powerful it is.

So how DO we measure the power of a motor ?
Well with petrol engines we look at the maximum horsepower it develops, but for electric motors – especially small ones, we use “watts”

Just for your interest before we leave the analogy. There is a direct conversion between the two – 1 horsepower = 746 watts. It is just more convenient to talk a few watts of power than a fraction of a horsepower.

While petrol motor force is usually measured as newton-metres, or pound feet in the old speak, those units would be too large a unit for our wee motors.



The usual unit of measurement is -: get ready for it g-cm or g/cm “**A gram centimetre**” In lay speak.

It is the amount of force it takes to lift a one gram weight one centimetre. Most serious makers of motors for slot cars give you a g/cm measurement as well as an RPM measurement. The chart above is in **KILO**gram centimeters, for larger motors like those used in industry, as I couldn’t find one related to our small motors.

They do this so that you can get a rough idea of how powerful that motor is just from those two numbers.
But if you want to know how powerful that motor is, you need to convert those numbers to horsepower – OOOPS, I mean watts . . . we measure in watts.

Okay you say, how the hang would we know what watts …… and are you talking about the power used?

Nope, let’s just ignore the power used, except to say that if we could measure the power used, and somehow subtract the power lost in mechanical friction, moving air inside the motor, waste heat, etc. we would be left with the power the motor develops to “do work” – drive things.
We cannot easily measure all the losses, but we can measure the output power – how much work that motor can do spinning our wheels for us.

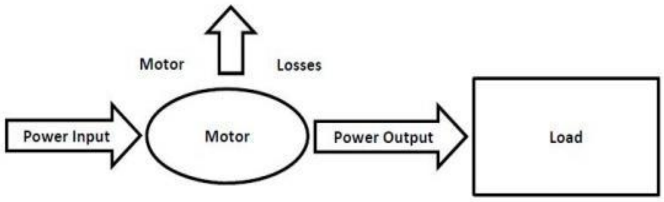
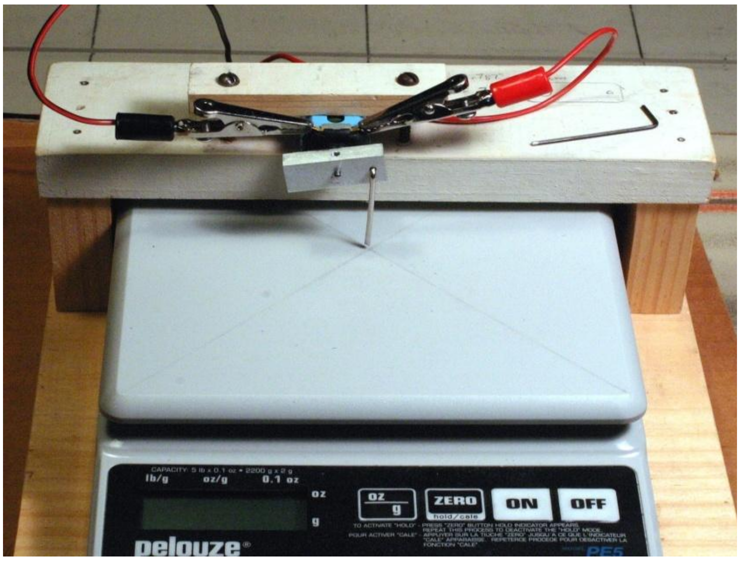


Figure 5: Depiction of Motor Losses

The power output – for us in watts "wattage output"

With a petrol motor we can put it on a dyno, and with small motors for slot cars and other uses we can do something very similar.
A dyno for automobiles measures the torque the motor develops from which we can calculate horsepower – Very useful if you are building race cars to go fast. Torque is your force to twist and move things.

Electric motor makers will measure the RPM the motor develops; by using a tachometer to check how many times the motor rotates in a given time frame.
And just like the dyno that measures the torque of a petrol motor, we measure the torque (force) of electric motors. with a torque dynamometer – similar to in automotive, but more sensitive – it measures rotational force when you hook up a motor to it.
The picture below is nicked from [SlotCars News Blogspot](), which for years tested every slot car motor they could lay their hands on.



When I get around to it, I have a nice instrument which just needs mounting, so I can run my own torque tests… I just need that Round TUIT.
Before everyone scuttles off to grab a slot car and look at the motor, "here's one I prepared earlier"

There you go . . . 20,500rpm and 200 g-cm
All very good you say, but you promised us that we could measure electric motors in watts, just like petrol motors in horsepower. Well fortunately, there is a simple formula we can apply to those two figures to get a horsepower . . . oops again WATTAGE power output for any motor.
Here it is :- **((RPM/2)*(Torque as g/cm/2))/100000**

Before you utter an Irish curse on me, you don't need to do all that calculation yourself, because I have a spreadsheet. You can enter as many sets of numbers as it takes to bore you, and compare up to eight motors at a time to compare their power.
Right here for download. I already inserted some examples, but play around to your heart's content.

Most motors I sell in Slotraceshop have that data in their description, as provided by the manufacturer. Others I don't normally stock; say from NSR or Thunderslot, will generally have that data on the paper sleeve for your use.
As example, I remember when we thought the ScaleAuto red can 26k motors were brutish, "too high revving" etc. It took a while to figure out that these were an S-can motor with torque characteristics very different to the milder S-can motors with which we were more familiar. – They were simply a motor that looked to us like a family saloon 4 cylinder, but were in fact a supercharged diesel, with torque characteristics more like a V8 – as diesels have.

Tech Article – Motors Part 2

Just to recap where I ended last month – Myth Number One

The first myth I often hear and like to bust is "*those motors are smoother than those other motors*"

People think of electric motors are like they do petrol motors with efficiency bands where they run better, or power bands during which they accelerate more. – It really is a myth. The reality is; electric performance is pretty much straight line from lowest volts able to rotate the armature, through to maximum applied voltage.

What sometimes confuses people is how their CAR performs with one motor versus another. - Selecting the right gearing for the combination of car weight and slot track, alongside the technical characteristics of any given motor will make the right combo appear superior – and the motor always gets the credit – or blame!

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Having outlined in September how we can measure the power of a motor by reading the RPM at say 12 volts alongside the torque at 12 volts, and apply a simple (-ish) formula.

Here it is again :- **((RPM/2)*(Torque as g/cm/2))/100000**

We can therefore take the listed figures for any two or more motors and easily figure out output power in watts

We can also look at how those numbers compare for two motors, and compare their performance characteristics.

One may be a high revving bumble bee, boy racer motor with that annoying pop-off valve, that only has as much power as a family saloon, versus a lower revving 10 cylinder diesel motor in an Audi Q7 or VW Tourag, that might look slow on the rpm scale, but could drag that family saloon or boy racer backwards at finable speeds.

In the chart below, the slimline Policar ff-050 motor is the highest revving, yet lowest powered of the bunch.

Insert RPM and torque at 12V to calculate the motor power in watts

Motor Power Calculator		
RPM	Torque G/CM	Wattage
Policar ff-050 slimline motor		
24,500	95	5.82

Motor Power Calculator		
RPM	Torque G/CM	Wattage
Slot.it MX15 as in the DTM cars		
21,000	150	7.88

Motor Power Calculator		
RPM	Torque G/CM	Wattage
Slot.it Flat-6 (Yellow can standard)		
20,500	200	10.25

Motor Power Calculator		
RPM	Torque G/CM	Wattage
Sideways Raptor Boxer motor FK-180		
21,400	350	18.73

Among these motors it comes down to the difference in the shape of the motors which dictates the size of the magnets and armature. If you would like this motor mower calculator as a spreadsheet you can use yourself, just email me for a copy. I have it set up so you can compare up to eight motors at a time, and a spreadsheet database of a wide range of motors from various makers.

There is a place for all these motors. The slimline motor or an S-Can may be the only motors which fit a small car.

TYPES

The FF-050 – a slimline motor used in narrow chassis, and classic cars, lots of rpm, very little torque

The common FC-130 “S-can”motor. Variants are used in most Scalextric cars, the Group C, DTM and Classic Slot.it models, sidewinder NSR, Carrera and so on.

The low profile Flat 6 may be the best option when you need to sneak a motor underneath an interior.

The FK-180 boxer motors are in general the largest and most powerful.

In Europe where much racing is done on plastic tracks with steel rails, the flat-6 and boxer in angle-winder are often chosen because they provide the largest magnetic down-force.

We often retain the podded chassis cars in the standard configuration to keep racing costs down. Where the motor class and power are open, we have the choice of switching pod configuration. – I run most of my own GT cars in sidewinder configuration rather than with the flat-6 or boxer angle-winder with which most came standard. I just like the feel of sidewinder driven cars, - how they drive.

Within a given motor class there are also wide variances of the relationship between RPM and torque.

The ScaleAuto Red S-can I mentioned last earlier was quite high revving at 28,000 rpm. What I didn’t understand 10 years back, was that it was also developing very high torque for the time, – in excess of the stated 180 g/cm, and often more rpm than specified. It was about 13 watts.

It belonged in different cars than we were running at the time, we weren’t so knowledgeable about tuning RTR cars; and combined with incorrect gear ratio, made cars powered by it somewhat difficult to drive.

Whatever you do, you need to consider the torque characteristics of the motor you are using, alongside the car it is going into, and what gear ratios might suit it.

So there you have it, some food for thought when choosing and replacing motors; or simply when you need to consider how you gear an existing motor the best for your racing situation.

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