

Design Project: DC motor

This worksheet and all related files are licensed under the Creative Commons Attribution License, version 1.0. To view a copy of this license, visit <http://creativecommons.org/licenses/by/1.0/>, or send a letter to Creative Commons, 559 Nathan Abbott Way, Stanford, California 94305, USA. The terms and conditions of this license allow for free copying, distribution, and/or modification of all licensed works by the general public.

Your project is to design and build a permanent magnet DC electric motor from commonly available hardware (no motor kits). There are many motor designs available on the internet, and in hobby books, so I will not give a sample design here.

Deadlines (set by instructor):

- Project design completed:
- Components purchased:
- Working prototype:
- Finished system:
- Full documentation:

Questions

Question 1

The armature windings of your DC motor will have very low resistance. Too low, in fact, to accurately measure with an ohmmeter connected directly to the commutator terminals, because the contact resistance between the meter probes and terminals will be a large percentage of the resistance read by the meter.

One way to avoid this contact resistance problem and measure very low resistances using normal meters is to employ what is known as the *Kelvin resistance measurement technique*: measuring the voltage dropped by the low-resistance element when a substantial DC current is passed through it.

Draw a diagram showing how this measurement technique works, and explain *why* it works.

[file 01502](#)

Question 2

If we apply Ohm's Law to the calculation of armature current, based on the applied voltage and the known armature winding resistance, we obtain a value for current that *far* exceeds the value of current measured when the motor is running at speed. Explain why this is.

[file 01503](#)

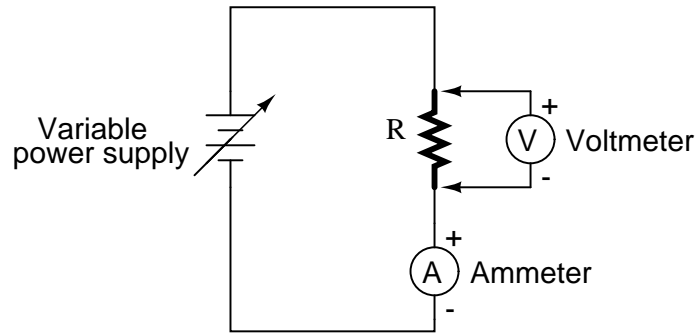
Question 3

You will notice that a very important factor in your motor's performance is the *brush angle*: the points of contact that the brushes make with the commutator bars, as compared to the axis of the field magnets. What brush angle results in maximum unloaded motor speed? Why can't we just have the brushes contact the commutator bars at any arbitrary angle?

[file 01504](#)

Answers

Answer 1



R is calculated by way of Ohm's Law.

Answer 2

I won't directly answer the question here, but I will tell you that the calculated armature current will be the same as the actual motor running current *if* the armature is forcibly stalled (held so that it cannot move). It is only when the armature gains rotational speed that the operating current dramatically decreases: this is your hint.

Answer 3

There are certain brush angles for which the motor simply will not run at all. This relates back to basic DC motor theory, and the interaction between the armature's magnetic field and the permanent magnets.

I cannot provide an "optimum" brush angle as an answer here, because that will vary with the specific design of your motor.

Notes

Notes 1

Kelvin resistance measurement is a very common technique used in electrical metrology, because it neatly sidesteps the problem of contact resistance in the path of high current. It is a technique well worth learning for the serious student of electronics.

Notes 2

Once students understand this phenomenon, they will comprehend why electric motors of all kinds draw massive amounts of current when first started ("*inrush* current"), but do not when running at full speed. Being able to see this first-hand is a great educational experience for most students.

Notes 3

Students are often fascinated with the effect that different brush contact angles have on motor performance, often spending hours of time experimenting to find the "sweet spot" for their particular motors.