Commutation electrical meaning

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I wanted to add a note on how this all comes together when we deal with power electronics. Note that the field of power electronics is typically more interested in i.e. efficient voltage regulation (this effects i.e. how long your phone battery lasts) but in machines land we are typically interested in turning motors around.

So, commutation is how we do that. In brief, this is how we manipulate currents in inductors to build magnetic fields in motors to "pull" the motor-rotor around. Properly "commutating" a motor means properly aligning this magnetic field to produce maximal torque.

The beauty of the brushed motor is that we don''t have to commutate it: the brushes do this for us: they are arranged so that power is switched in alternating directions through the motor as it spins.

The output of these systems is AKA "space vector pwm" - PWM signals that put a "vector" of magnetic field in space. However, our "voltage vector" does not equal our "current vector" (or actual field vector) - and so Field Oriented Control adds the additional step of closed-loop current control into the mix.

This uses some space transforms that can seem perplexing at first. They are in place to effectively reduce the required bandwidth of our current controllers... This is a whole adventure, I''m just providing pointers here, so I apologize for the brevity. Enter the rabbit hole at your own risk.

This has the advantage of being simple: we connect one of the half-bridges to ground, and another to voltage. This drives current through two of the coils simultaneously (so it is, also, slightly less power dense). We can do this easily in hardware with hall switches, something which I am not going to go into at length: basically, hall sensors measure the rotor position by measuring the position of the rotor''s magnetic field.

Recall that each of these sinusoids is actually composed of many smaller switching cycles: our duty cycle into each coil is rarely 100% on. So, we can sense "free" coil voltage during PWM off times.

Sound difficult? Correct. It requires very low-level manipulation of microcontroller peripherals (to i.e. only sample voltage sensing ADCs when voltage driving PWMs are low) and really good input filtering / state estimation.

However, it''s complicated by the stepper motor''s internal geometric complexity. The most common type we find is the "hybrid stepper" which is part variable reluctance, part permanent magnet motor.

I doubt that I have time for it here, but suffice it to say that a stepper can be treated like a BLDC, and driven with fully sinusoidal (and closed loop) field oriented control. This is what I have developed for my stepper driver: the controller senses rotor position, and (given a calibration table) can quickly calculate outputs that generate a magnetic field which is 90 degrees offset from the rotor"s static field.

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