Miniature Rotating Magnetic Field Generator

PC fan analysed

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These days most PCs contain several fans that help cool the CPU, graphics processor, motherboard chipset and the rest of the electronics. At first sight such a fan may appear to have a simple construction, but there is a lot of control electronics working behind the scenes as well.

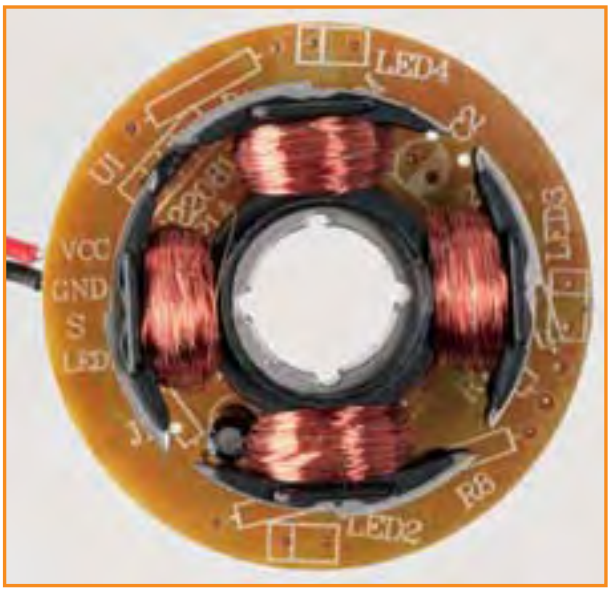


Figure 1. **The PCB inside the fan has four poles with coils that are driven by a rotating magnetic field generator.**

The modern-day fan is a low-key part in a case that contains super-fast processors, memory and other high-tech chips. Even so, the manufacturers of these fans have incorporated a lot of electronics to provide them with several fail-safe mechanisms and a longer lifespan. Motors using a commutator and brushes (lots of wear!) haven't been used for this purpose for a long time!
We have dismantled several PC fans in the Elektor Electronics labs to give you an insight of their construction. The inside of such a modern fan (called a DC brushless motor) consists of a number of stacked metal sheets, which make up four poles, each of which has a coil wound round it (**Figure 1**). On the rotor (the rotating part with the blades) is a circular magnet that has four north/south poles divided evenly around its circumference. If we now generate a rotating magnetic field in the four coils using an electronic circuit powered by the PC's DC supply, the rotor will turn with a specific number of revs. To detect the instantaneous position of the north/south poles of the rotor-magnet a Hall sensor, which reacts to the changing magnetic field, is mounted close to the magnet. This signal is used to drive the coils in pairs at just the right time to make the fan turn at the required speed. Thanks to the high level of integration these days it is possible to put all the driver electronics including the hall sensor into a single four-pin package, as you can see in **Figure 2**. Several years ago you still needed a handful of components for this, as shown in the photo of an older model in **Figure 3**.

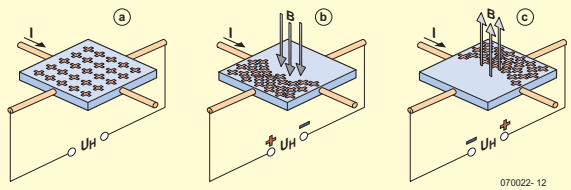
ALL IN A SINGLE IC

In **Figure 4** you can see the internal block diagram of the 4-pin IC used in this fan. In this case it is an ATS276 made by Anachip, but there are many other similar ICs available from other manufacturers. Inside the IC is a voltage regulator (Reg.), which provides the internal circuit with a stable supply voltage. The Hall sensor's output is fed to a differential amplifier (Amp) with a hysteresis circuit, which drives the two transistors for the coils.
This is a fairly basic IC. There are also more intelligent versions that can detect when the rotor stalls, provide

Figure 2. Calling it a rotating magnetic field generator seems to be an overstatement: all the electronics and the Hall sensor are in a 4-pin IC. Apart from an electrolytic capacitor no other components are required.

Hall-sensor

A Hall sensor operates using the so-called Hall effect. This was discovered in 1879 by the American physicist Edwin Hall.
When a current flows through a magnetic field, a potential difference is created at right angles to the magnetic field. The strength of the magnetic field can be determined by measuring this potential difference. A Hall element consists of a thin sheet of semiconductor material, which has a current forced through it. When there is a magnetic field at right angles to the sheet it causes a change in direction of the driving current. This creates a change in concentration of the charge carriers, which is perpendicular to the current flow. This potential difference is called the Hall voltage. In the production of Hall elements use is made of materials such as indium antimonide (InSb) and indium arsenide (InAs).



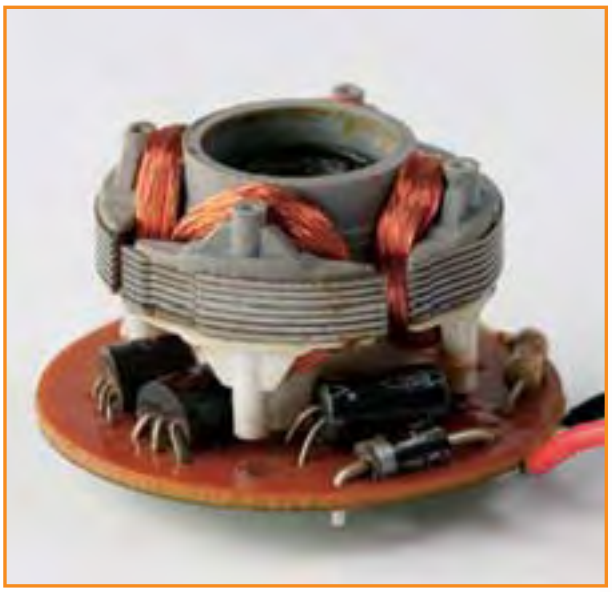


Figure 3. For a comparison we opened up an older fan. The drive electronics and sensor are all discrete components.

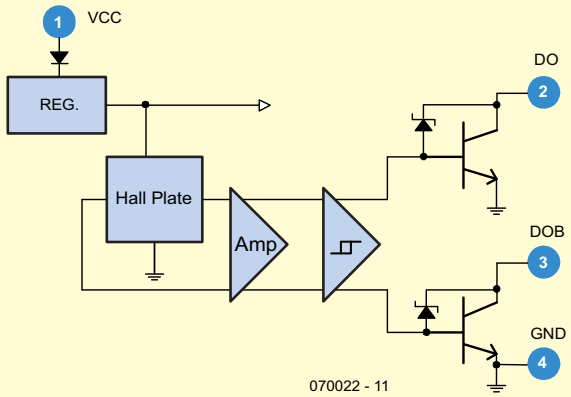


Figure 4. Internal block diagram of the IC used in our fan. The coils are driven directly by the IC, with currents up to 0.4 A.

an output signal of the revs (usually found on CPU and motherboard chipset fans) and which also have thermal protection.
The weakest point of a PC fan is often not the control electronics but the bearing. Cheaper fans usually have a simple sleeve bearing that can wear out fairly quickly and introduce some play to the rotor. More expensive (and better) fans make use of ball bearings. In the last few years special lubricants and techniques have been introduced to make the fans run almost noiselessly and give them a longer lifespan.

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