

Ampere*turn versus mT and Gauss

What is the relationship between AT (Ampere*turn) and Tesla or Gauss? What magnet strength will activate a 15 AT reed switch at 5 mm? There is not an answer that is both simple and accurate. Because the reed switch is made of ferrous material, it affects the magnetic field into which it is placed. That is, the magnetic field is different with and without a reed switch present. The relationship between magnet strength, reed switch sensitivity, and activation distance is dependent on both the size and shape of the magnet and the position and shape of the reed switch, including its leads.

The magnetic coupling of the magnet to the reed switch is very important. For example, the length of the magnet and the length of the reed switch leads will affect the result. This is illustrated in the chart on the next page. As reed switch lead material is removed, the reduced magnetic coupling will decrease the sensitivity and decrease the activation distance. However, depending on the magnet length and orientation to the reed switch, removing reed switch lead material may also increase the magnetic coupling and activation distance.

A simple but not very useful answer to the Tesla or Gauss versus AT question is the classic formula for a long solenoid (copper coil): $B = \mu NI/L$ where B is flux density in Tesla, $\mu = 4\pi 10^{-7}$, N = number of turns, I = current [A], and L = coil length [m]. In Gauss and inch units, this is $B = NI/(2.02L)$ where B is in Gauss and L = coil length [inch]. This is not very useful because it applies to a coil rather than a magnet, and it applies to a long or infinite coil. It is a good approximation only when the length to diameter ratio of the coil is greater than five.

Similarly, measuring a reed switch of known AT in a Helmholtz Coil will relate AT to mT, but again this uses a coil rather than a magnet. Again, this has limited applicability in relating AT to mT for a typical reed switch / magnet application.

There are methods for answering the magnet strength versus switch sensitivity question, but they are not simple. One method is to use computer modeling, but this has the disadvantages of requiring expensive software, accurate models and a good understanding of the magnetic components involved. Another method is to solve a specific problem experimentally using a range of reed switch sensitivities and magnet sizes. Like the first method, this has disadvantages as well as advantages.

As a starting point, a rule-of-thumb can be used that is simple but not very accurate. The rule is that about 0.1 mT (1 Gauss) per reed switch Ampere*turn will activate the reed switch when both magnet poles are near the two ends of the switch. For example, about 2 mT (20 Gauss) is needed at a point in space near both poles of a magnet to activate a 20 AT reed switch at that same point. Activating from one end using only one magnet pole will require about twice as much magnetic field compared to activating using both poles. This rule is an order-of-magnitude approximation. A specific case could vary from this by a factor of 2 or more. See page 2 for a graph showing specific relationships for specific magnets and switches.

One might wonder why reed switches are specified using units of Ampere*turn instead of mT or Gauss. The reasons are practicality and convention. The most practical way to generate the magnetic field for testing reed switch sensitivity is to use a test coil. The only way to specify reed switch sensitivity without also having to specify the test coil used is to generate a large uniform magnetic field using a large solenoid, Helmholtz coil, or similar coil geometry. This is possible to do, but the coil sizes and currents needed become unwieldy, and the benefit is negligible because it does not solve any of the above-mentioned issues relating the sensitivity measurement to real-world problems.

MAGNETIC FLUX DENSITY VS. PULL-IN FOR FULL LENGTH HAMLIN MDCG-4 REED SWITCHES AND THREE HAMLIN MAGNETS

Magnet parallel to and centered on switch. Measured at center of switch after removing it.

