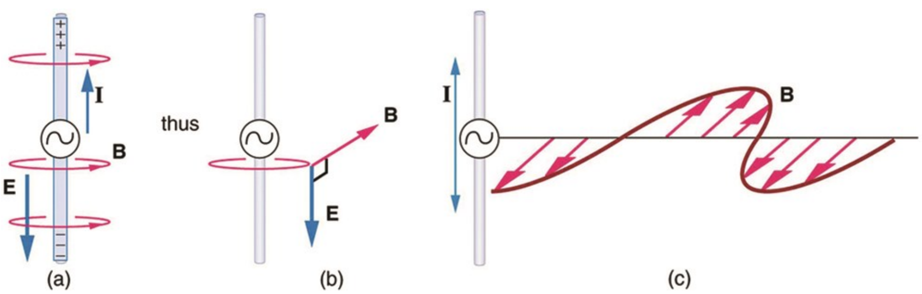
Brass Tacks

An in-depth look at a radio-related topic

The physics of radio communication

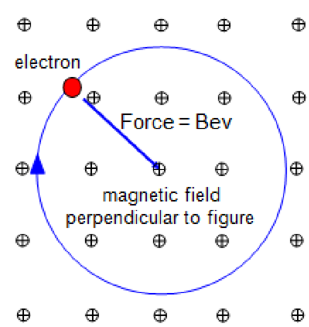
So, exactly how does radio communication work? As innocent as this question might sound, it's actually a very complex topic. On one hand, you turn on your HT (handheld transceiver), press the PTT (push-to-talk) button, speak into the microphone, and your friend listening on another HT tuned to the same frequency, but across the room, can hear your voice, assuming his volume is adjusted appropriately. On the other hand, two major processes are taking place, and to even begin understanding the interaction between the two HTs, we need to consider each separately, to appreciate the mystery behind what we call *radio communication*.

Your radio combines your voice with a *carrier signal* in one way or another (modulation), and prepares (filters, shifts, amplifies) your *modulated signal* for transmission into the space surrounding your antenna. The transmitter portion of your radio, no matter how large or small, old or new, produces an electrical signal of *alternating voltage and current*, and presents that signal by two conductors at its output. A two-conductor transmission line, such as your coaxial cable or tiny traces in your HT, then delivers the signal from your transmitter output to your antenna.



Simple or complicated, your antenna is a network of electrical conductors arranged to present an *impedance* ideally matching that of your transmitter. This impedance completes the electrical path of the modulated electrical signal, allowing the current from one conductor of your transmitter output to flow through one conductor of your transmission line, through your antenna, back through the other transmission line conductor, and eventually to the other transmitter output conductor. Then 1/(2f) seconds later (**f** is your transmitter frequency) the entire electrical process reverses itself.

Transmitting



What happens at the antenna is the focus of this discussion. As current flows in one direction, then the opposite direction, through the antenna conductors (elements), the charges (electrons) in the elements move in a circular pattern, their revolution time equal to the signal frequency. Each charge presents an electric field around it, and because it's moving, its field intensity fluctuates with the same periodicity (frequency) at any given point near the charge.

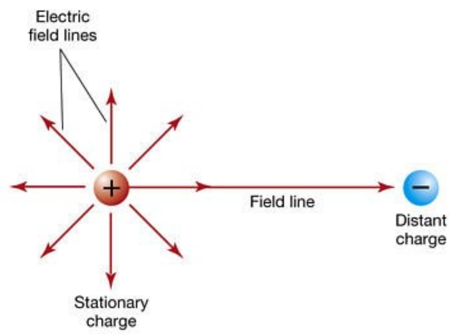
Brass Tacks

continued

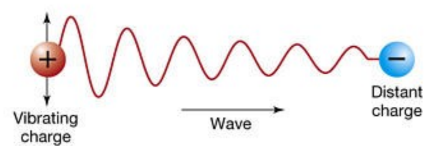
The changing electric field, in turn, produces an accompanying magnetic field with the same frequency. Both of these fields leave the location of the moving charge (source) in all directions, and at the speed of light, their peak intensities decreasing as the inverse square of their distance from the source. And because these outwardly moving fields vary in intensity from zero to peak and back to zero at a constant frequency, they resemble a wave-like pattern as they travel.

Receiving

When this field pair reaches another piece of electrically conductive material, such as your friend's antenna (or anything metal, for that matter), the electric component of the field pair will start affecting the charges in his antenna elements, causing them to move in a circular pattern with a periodicity equal to the frequency of the electrical wave.



The movement of the charges results in a current that's *induced* in the conductive material of your friend's antenna elements, which current is conducted by a transmission line to his radio. His receiver circuitry then processes (amplifies, filters, shifts) the electrical signal, removes the carrier signal (demodulation), and presents the remainder to his audio system, where he's then able to hear your voice through his speaker.



Summary and addendum

Seemingly simple to the casual observer, radio communication involves some foundational laws of physics, described by some very complex mathematics underlying electrical and electromagnetic behavior. This is true at both the transmitting end and the receiving end of the communication journey, the two processes roughly mirroring each other. At the heart of this magic is the embodiment of *Gauss's Law* (an electric field results from an electric charge), *Ampere's Law* (interaction between an electric field and a magnetic field), and *Faraday's Law* (a magnetic field can produce a voltage).

In short, the magic of radio occurs because of the interactions between voltage, current, impedance, the electric field, the magnetic field, and flux. This is not the appropriate place to explain all these terms, but suffice it to say that they all arise from the fundamental property of charge, connected by the laws of physics known collectively as *Maxwell's Equations*.

Essentially, charge produces a flux, which presents a potential (voltage), which, if it moves another charged particle, produces current, which, if it changes (*alternating* if it changes periodically), generates an electromagnetic wave, which is propagated outward. At another location the same wave is picked up, and the process works in reverse, to produce the desired output. All that, from a pair of cheap handheld transceivers. Now you know the depth of that magic.

— Noji Ratzlaff, KNØJI (kn0ji@arrl.net)