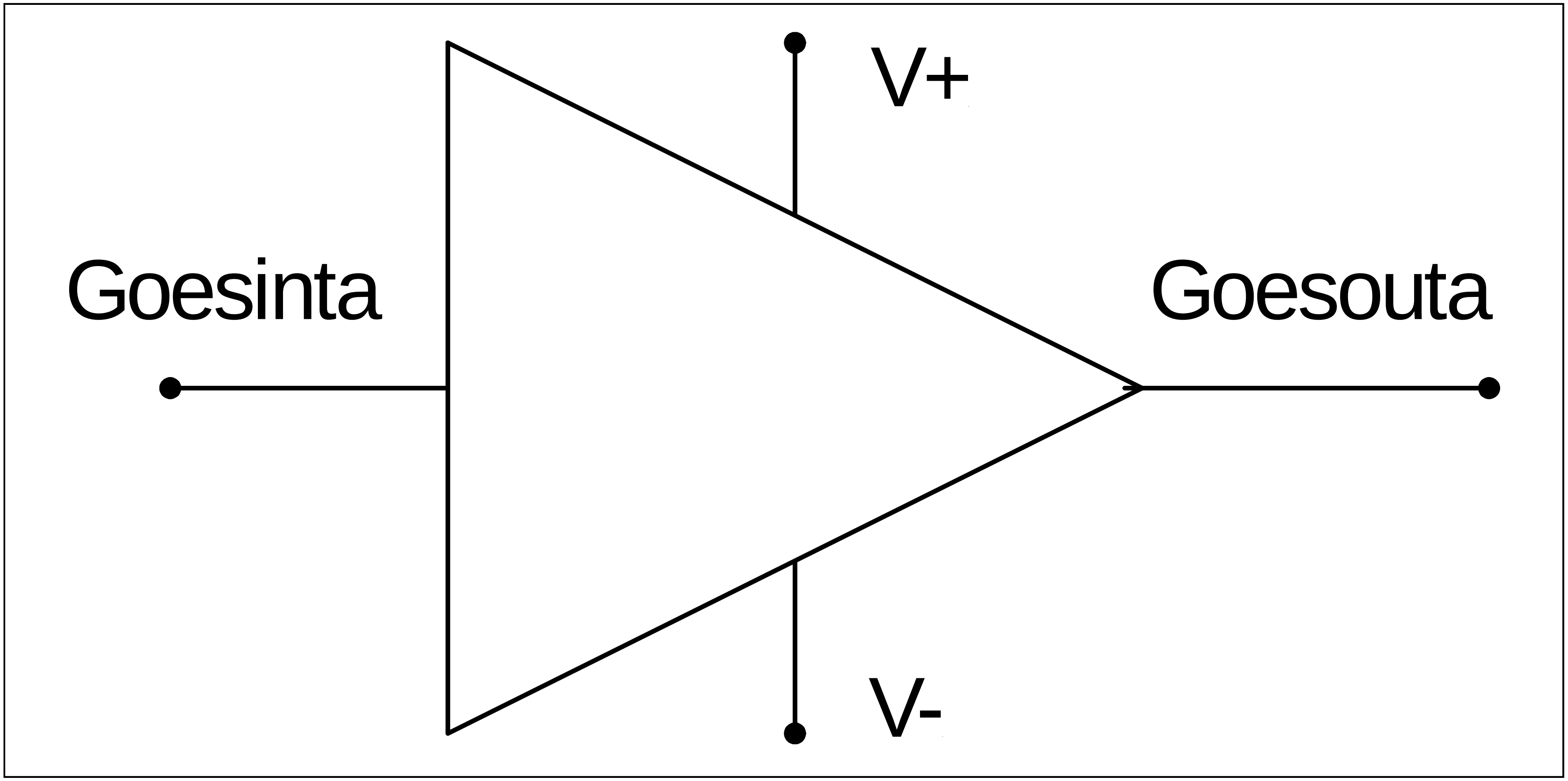
Sierra College **MECH-1**
Jim Weir **530.272.2203**
jweir43@gmail.com
www.rstengineering.com/sierra

Lesson 09

Amplifiers & RF Transmission/Reception

Amplifiers. When we take a small signal and make it **LARGER**, we use an electronic circuit called an AMPLIFIER.

Amplifiers may be further broken down into several TYPES. The three types are VOLTAGE amplifier, CURRENT amplifier, and POWER amplifier. A transistor (bipolar or field effect) may be configured as any one of these three by circuit design.



For example, in a standard broadcast band radio, the signal at the antenna goesinta (antenna connector) is generally measured in microvolts and the output (goesouta) to the speaker is measured in watts (power). Somehow in between we've got to get a voltage gain of a million or so with a power gain of a billion or so. How to do this?

If we presume (terrible word) that each transistor can have a voltage gain approximately equal to its current gain (beta = 100 or so), then 3 transistors in series (100 * 100 *100) will give us a gain of a million. Since transistors are about 3¢ apiece, we can run them a little below their rated gain and use four of them with each one "choked down" to an individual voltage gain of 32 to give us our voltage gain of a million. Similarly, taking this one volt that we just generated from our voltage amplifier and simultaneously making a voltage/current (power) amplifier using three or four transistors gives us a total transistor count of 7 or 8 transistors. Take the back off of any cheap transistor radio and count the "three legged fuses" and you will come up with seven or eight transistors.

Ah, you say, you want both AM and FM capability? Not a problem. A couple of more transistors and some clever design will give you an AM/FM radio.

Ah, you say, you want shortwave? Not a problem …

RF TRANSMISSION & RECEPTION.

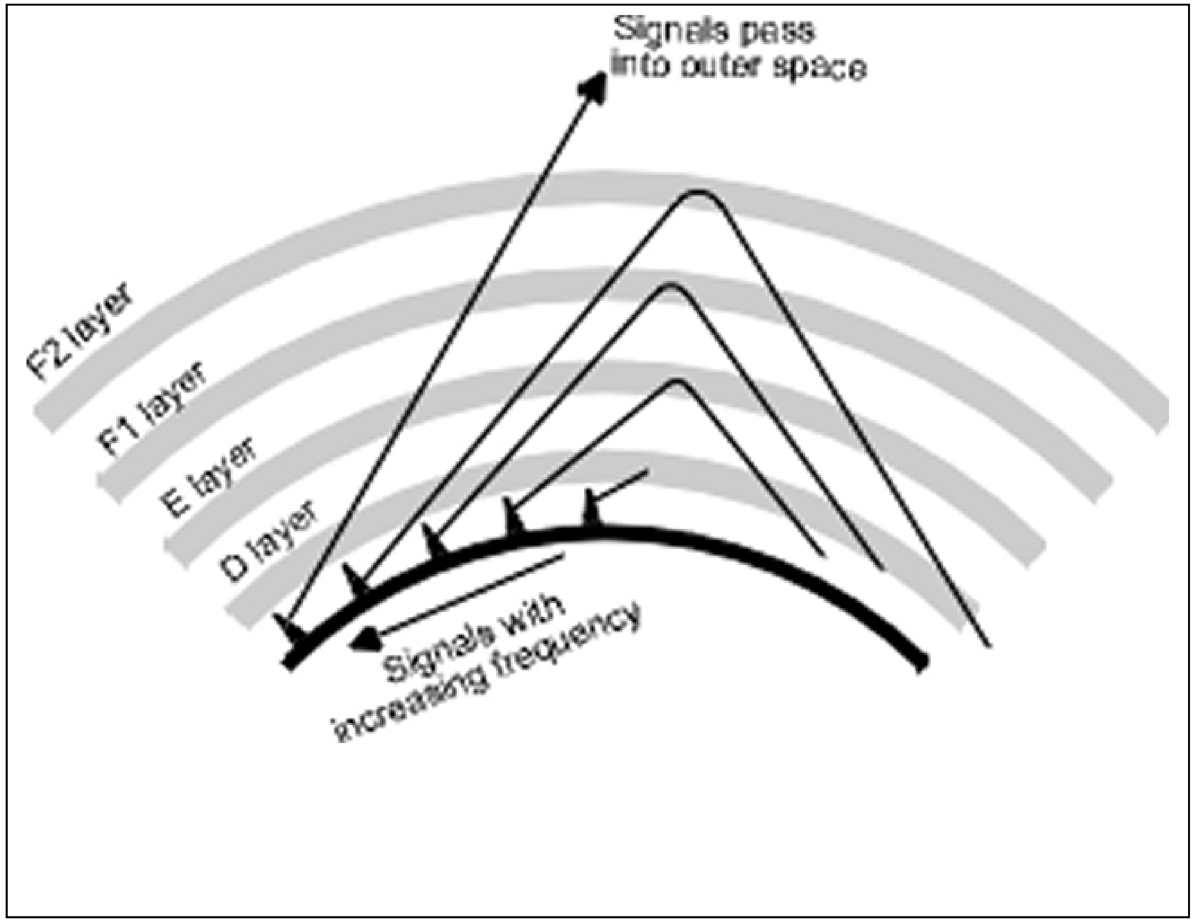
" click … click … click" At 12:30 p.m. Newfoundand time on the 12th of December 1901, those three clicks revolutionized human communications.

The letter S in Morse code (dot…dot…dot) was transmitted from Cornwall, England to St. Johns, Newfoundland, Canada. The person at the receiving end? Guglielmo Marconi. The person at the transmitting end? John Fleming … the same John Fleming that was to invent the "edison diode" vacuum tube a few years later.

The exact location of the receiver? Signal Hill, St. Johns, Newfoundland, the last landmark that Charles Lindbergh saw on his solo crossing of the Atlantic Ocean. Lindbergh's European landfall was over the Irish coast, just a few dozen miles away from the Fleming transmitter site in Cornwall.

As we shall soon see, what Marconi THOUGHT he heard on a particular frequency could not possibly have happened, but by serendipity, what he heard was not on the frequency that he expected.

High above the earth's surface, the sun is constantly bombarding the IONOSPHERE with cosmic rays and UV radiation. Some of this radiation strikes the earth's surface but the vast majority are absorbed by 3 "layers" of atoms. And, an atom struck by radiation absorbs the energy given by the ray but loses an electron or two, thus becoming ionized. Hence the "ionosphere".



The lowest of the layers, the "D" layer is where most of the radiation is captured, where the atmosphere is the thickest. Low frequency signals, up to about 3 MHz. are completely absorbed by the D layer. Thus a standard AM broadcast band signal must use the "ground wave" (the radio space between the ground and the D layer, about 50 miles above the earth's surface) to propagate the signal. Once the signal hits the D layer, it is totally absorbed. However, immediately at sundown, the D layer totally disappears.

So, at noon of December of 1901, could Marconi have heard "dit … dit … dit" on 800 kHz. from a station a thousand miles away? Not likely. What is more likely is that Marconi was using an untuned receiver and the HARMONICS of his 800 kHz. transmitter (say, the fifth harmonic at 4000 kHz. or 4 MHz.) were being reflected by the E layer and heard in Newfoundland. The antenna? 500 feet of wire supported by balloons and kites.

The next layer, the "E" layer (70 miles up) is continuous, but it is far stronger immediately after sundown and slowly loses its reflective powers towards sunrise. Signals between 3 and 30 MHz. are continuously reflected by the E layer and at night even broadcast band signals down as low as 530 kHz. are also reflected.

During the day, the F layer combines into a single layer about 120 miles up and at night it splits into two layers, one at 120 miles and one at 200 miles. Signals that bounce off of the F layer can travel tremendous distances in a "single hop" (one bounce) and completely around the world on multiple hops.

Signals above 30 MHz. generally do not bounce off of any layer, but instead just keep on going out into space. However, during periods of extremely active solar flares (the "sunspot" cycle) signals up to 150 MHz. can be reflected from the F layers. The next sunspot cycle peak is due to occur in late 2023 or early 2024 and is supposed to be the strongest series of flares since the monster year of 1985.