Antennas, not so difficult after all

Yep, antennas are not simple at first glance but not complicated if you know the basics.
With some imagination you could compare them with a light-bulb. You can mount it on a metal plate, the ground and connect one line from your power supply to the center contact of the light bulb and the other to the plate. Current will flow through the bulb and groundplane and the light will burn. Nothing magical about that. The current will cause the lamp to radiate energy in the form of light.

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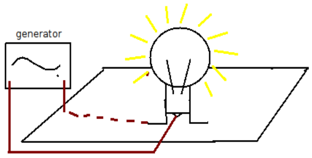
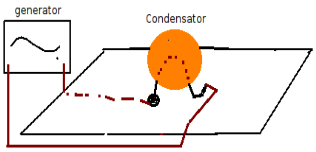
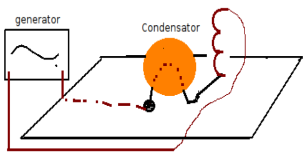


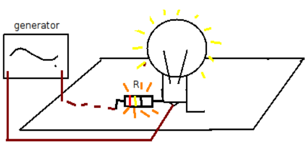
If you use an AC signal this
will follow the same route as a DC signal. Now change the lightbulb by a capacitor and use a piece of coax from your ac signal source to the lamp. The center conductor to the capacitor, the braiding to the ground. Current will still flow. Inside the capacitor there will be an electric field. One leg of the capacitor is at ground level so there is an electrical field between the coax center and ground.



We now have one part of a radio wave. The electric field. Lets place a little coil between the capacitor and the coax center conductor. Current can flow as before but around this coil will be a magnetic field. So there we have the second part of a radio wave. The magnetic field.



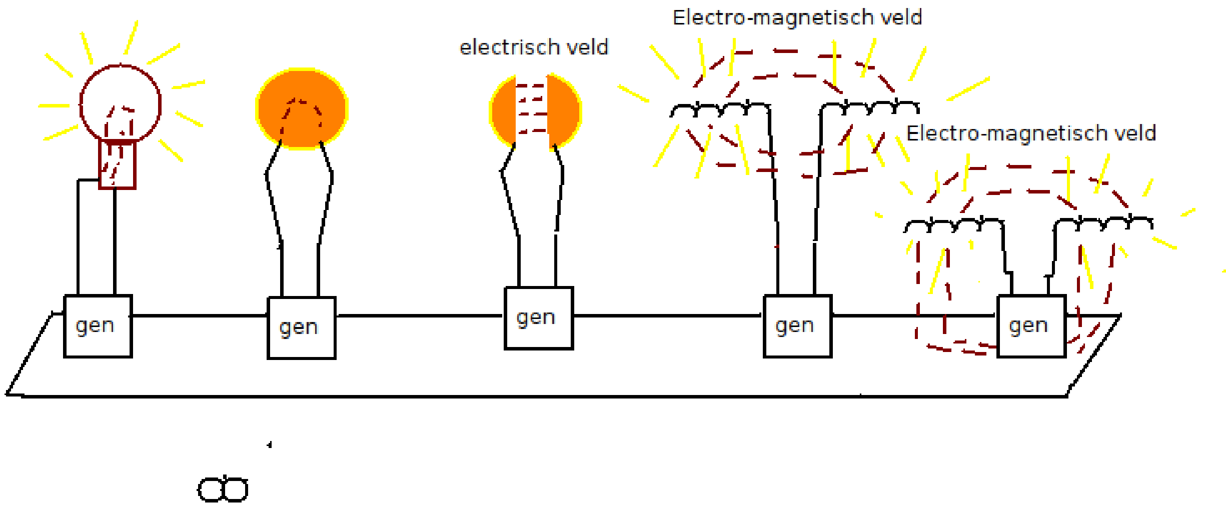
A straight piece of wire also has some inductance, but any conductor that has current flowing makes a magnetic field. If we mount this at a certain distance about the groundplane this wire has a capacitance towards ground. So if we connect the centre of the coax to the wire and the braiding to ground we have an antenna. It will always radiate. But to be clear. A capacitor and a coil will radiate but you can hardly call it an effective antenna. But this is to show an antenna is made out of parts with inductive and capacitive parameters.



The only problem is the ground. This is not always a perfect conductor. If we go back to our lamp we could see the earth path as having a resistor. The lamp will radiate but not as bright. We lose energy in the resistance of the ground. In real live this resistance can be real big compared to the total resistance of your system.

Now look at a dipole. If we look again at our first example we now connect the lamp hanging very high above the groundplane. We use two wires to connect it. The lamp will burn like before but there is no ground resistance eating up a part of the energy. Now we exchange the lightbulb for the capacitor. Nothing changes, current still flows. The amount of current in both conductors is the same and symetrical.

Now we take the next step. We break open the capacitor amnd remove the dielectrium. We have an air capacitor made of two plates. We use some magic tool and stretch the plates until they transform in two wires. We just learned a piece of wire has inductance. They are still opposite so they have capacitance too. Now we move the ends of the wires outward until we have a dipole. The more the wires move outward the smaller capacitance will be, the longer the wire will be stretched the more inductance they get (and capacitance goes up to). But we have to hang it high so the capacitance toward earth will be as small as possible otherwise current will flow through that too with all its losses.



So here we have an antenna. The different versions and forms all have to do with impedance matching, direction of radiation, gain and polarisation . This is why it then get so complicated, but remember all those antennas still have the same basics.

Lets take the next step. A transmitter is something like a wall contact you use to feed your refrigerator. It will deliver as much power as the refrigerator asks. The same with a transmitter and an antenna. The transmitter will deliver the power the antenna asks for. That can be more then he likes or can do. That is why transmitters are made to be connected to a 50 ohm load. With 50 ohm they deliver an amount of power that keeps them happy. But you are told only maximum power transfer is possible if the Resistance of the source and load are equal. So a transmitter must be 50 ohms. This is a wide spread misconception. A maximum powertransfer would be the end of your transmitter. It will fry itself if it was not protected. If the brochure tells you the transmitter is 100W in 50 ohm this tells you it will it is not allowed to do more not that it is 50 ohm. Without protection it will be able to do more but that means voltage and current will rise and components will be not rated for that. 50 ohms is also a value chosen because we have coax that is 50 ohms, not because a transmitter likes to have 50 ohm or an antenna in resonance is 50 ohm. We could easy make a transmission line and antenna that is 400 ohm and then make a transmitter that likes to see 400 ohm.

So now you know an antenna is a thing that has inductor and capacitor like behavior with some added resistance. This is the cause the antenna has a certain impedance at a certain frequency. This impedance is formed by the joined reactance of all parts. If that is 50 ohms the transmitter is happy. So every body is happy. If the antenna is mounted in such a way that the resistive losses are as small as possible, radiowaves are free to go and in the right direction you have a decent antenna. Everything will radiate. A non radiating antenna is the most difficult thing to make, but not everything radiates effective.

We still have a little problem. We like the antenna to be 50 ohms resonant because our transmitter likes that. But there are many factors unknown and hard to measure but that have a big influence at your antenna. That is why you never should copy an antenna design 1:1. Most times this ends with a disappointment. This will not always be caused by the design or you making a mistake. It are the circumstances you are not aware of and you often can not influence or measure them but the antenna needs to be adapted to them too.

So now we want a 50 ohm resonant antenna. Resonance will say the inductive reactance is as big as the capacitive part. This is not 50 ohms. This can be everything. But by using calculated sizes, materials, high, the surrounding ect, you can make a 50 ohm resonant antenna. But resonant will not be a guarantee for a good antenna. A good antenna doe not have to be resonant. As long as the whole system is resonant because your transmitter likes that.

There is a second problem. It has to be 50 ohms and if that is a problem because of some factors like size or you want it multiband you have to make something that makes your system as a whole resonant and 50 ohms. Between transmitter and antenna is a so called transmission line. That could be an open line, or coax or even a single feeder.

The open line is symmetrical. If the antenna is symmetrical too everything is perfect. This is almost free of losses (you have to believe me there because that is a story as long as this one). The transmitter has a coax connection and is asymmetrical or unbalanced. A small pin in the middle and a big groundplane, cabinet ect on the other side. So we have to put something in between. A balun. But you can use coax and connect it to a unbalanced antenna like a vertical groundplane. But for a dipole there must be some transformation from balanced towards unbalanced in between. The balun. (Balanced to Unbalanced)

Now the biggest problem. We know we want a 50 ohm antenna because the transmitter likes that so we can do two things. Adapt the antenna or the transmitter. The latter will be a bit difficult so most times we do the first. We can add a impedance adjustment between antenna and transmitter. This is called a tuner. You can make a fixed one for one frequency or a variable one. This can be with capacitors and inductors, or an other form of matching like stubs, RF transformers ect.
So every one is happy, Now, not really. A tuner is sometimes able to adjust a broad way of impedances. So it can make a realy bad antenna look good. This really bad antenna will still not radiate proper, the tuners does its best and sparks are jumping around, coils get hot. Conclusion: a tuners sucks. NO, the antenna sucks, this is not the fault of the tuner. Thanks to the tuner you can use this excuse for an antenna. A tuner is an adapter/transformer not a last try to transform a dummy load into an antenna.

There are symmetrical and unsymmetrical tuners. If you use a dipole, feed it with open line and a symmetrical tuner. Place the balun between transmitter and tuner. There it will see 50 ohms and has little trouble of performing its task. It has to be a reactance about 4x the highest impedance of the load and at this place that will be always 50 ohms. But you have to decide yourself between wishes, possibilities and abilities.

If you use coax you need a asymmetrical antenna. Coax is rather ideal stuff, in theory, it does not radiate (in theory), it is about 50 ohms, easy to route through your shack, to be short, it is handy. The bad part is it can radiate as hell is there is unbalance, you always need some common mode choke or balun if you go towards symmetrical. The other downside is, it has losses. So if the antenna is not 50 ohm there will be reflections in the coax in the direction of your tuner. Suppose I send 100W towards the antenna. I lose 10 W on the way to the antenna. The SWR is bad so 9W from the 90W will be reflected back to the tuner. The tuner receives about 8W from this 9W and sends it back so 7W enters the antenna again. About half a Watt goes back to the tuner ect
This is not really a problem for our radio signals. We do not hear that. But for analogue TV this gives strange effects. But you loose power in coax, few in aircom+, a lot in bat quality RG58. 100 meter RG58 for 70cm gives you a perfect SWR, even without an antenna.......

Now is this just the principle and also very compact. In real live there are a number of other factors but the basics stay the same. Most books are about how EM fields are made and travel, complicated calculations, velocityfactors, radiation diagrams, gain ect but you need to know the basics to understand that.

To bring bad news first, there are no compact magic multiband antennas and everything is realtive. If I tell you antenna X is great and there are some people who think that too this will still not say it is true. Most magic antennes are build by people who have some space problem and their only reference at that location are other magical antennas and not with a real good antenna for HF. Because this always somewhere between big and gigantic. If you have such an antenna you do not build a magic antenna and if you do you are not thrilled so you do not bother to write a website story about it. But also think there is a purpose for magical antennas without them a lot of HAMs could not be QRV at all.

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