• *First Steps in Radio*

Getting into Amateur Radio Electronics

Part 1: Ever wonder what you need to know to pass your first amateur exam? This new series will provide the answers — not to the FCC questions themselves, but to the questions most newcomers have about electronics.

By Doug DeMaw,* W1FB

Let's face it: Many potential amateurs feel a bit wary of tackling the electronics involved with earning that first ticket. Whether you're a housewife, a janitor, a factory worker, an English teacher or an advertising executive you may feel inadequate when the time comes to study for an amateur exam. That feeling seems to be shared by most people without a formal background in electronics, no matter where in the world they may live.

After reading the articles in this series, you'll find out for yourself that anyone with the motivation to learn the electronic theory needed for an Amateur Radio license can do so — regardless of their background. I've known children under 10 years of age who passed the Novice exam on the first try, and I've been acquainted with amateurs who were over 80 when they obtained their first license. And then there are persons with disabilities — those without sight or hearing (or both) who have progressed from the first license to the highest class of license (see sidebar on the different types of amateur licenses). Certainly, they have traveled a route that was far more rocky than those of us with no physical impairments.

A great many aspirants seem to give up before they give it a fighting chance. Others attempt to memorize the answers to exam questions. This practice has worked for some people, but it is not to their long-term advantage. Understanding the fundamentals — and that's what it amounts to — of Amateur Radio electronics is very important if you are to feel confident at exam time. This basic knowledge will prove invaluable later in your ham career, too: You'll be able to service your own equipment, you won't be afraid to discuss circuits at club meetings and on the air, and you can enjoy one of the special thrills of ham radio by experimenting and building some of your own equipment.

We shouldn't ignore still another benefit of knowing Amateur Radio theory: It's been the stepping stone to a career in electronics for countless young people. Furthermore, possession of a license puts you in a position to be of service to the federal, state and community governments in time of emergency or disaster. You can be a valuable resource in time of need.

The Fundamentals of Electricity

You may have studied basic electrical theory in high school, but you may have forgotten it because it didn't pertain to your present way of life. That happens to a great many people. So, let's discuss some very fundamental concepts. We'll get into a more detailed treatment in future installments of this series. But for the present, let's talk about ac and dc voltages and currents. These are the basis of all electronics theory, so they are mighty important to us.

Voltage means potential difference. It is called *potential* because the electrical charge is capable of doing some work but

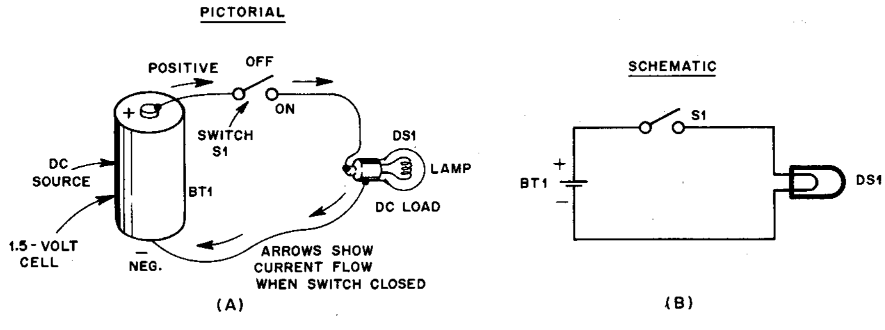

Fig. 1 — The illustration at A shows a simple dc circuit in pictorial form. The arrows indicate the direction of current flow. The drawing at B is the same circuit, but presented in schematic form.

[1]Notes appear on page 25.

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Glossary of Terms

ac — alternating current, or electrical current that flows in one direction, then in another.
ampere — the unit of electrical current, abbreviated A.
ARRL — The American Radio Relay League, Inc., headquarters for U.S. and Canadian ham radio operators and the society of the International Amateur Radio Union.
current — the flow of electrons.
CW — continuous wave, or Morse code.
dc — direct current, or electrical current that flows in only one direction.
Hz — the abbreviation for hertz, one cycle per second.
IEEE — The Institute of Electrical and Electronics Engineers, a professional society.
kHz — the abbreviation for kilohertz, 1000 hertz.
MHz — the abbreviation for megahertz — 1 million hertz.
oscilloscope — a device for giving a visual trace of voltage with respect to time; often called a scope, for short.
QSO — contact with another radio amateur.
QST — the official journal of The American Radio Relay League; also a general call preceding a message addressed to all amateurs and ARRL members.
RF — radio frequency.
transformer — a device for converting voltage levels.
voltage — electrical pressure causing electron flow.
volt — the unit of voltage, abbreviated V.
watt — the unit of power, abbreviated W.

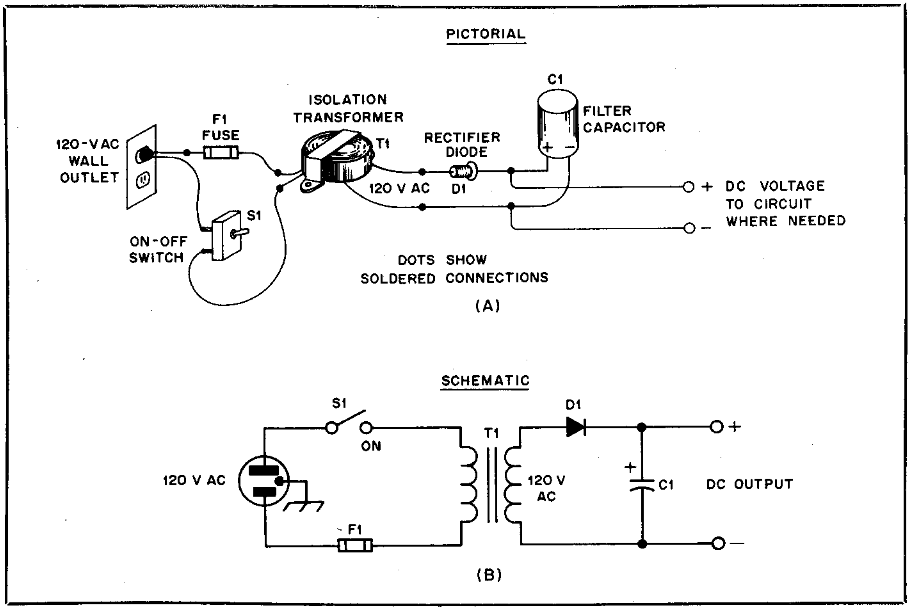


Fig. 2 — A pictorial diagram (A) of a dc power supply that is operated from the standard wall outlet (120 volts ac). D1 changes the ac voltage to pulsating dc voltage, and capacitor C1 removes the small amount of ripple that remains after rectification. The same circuit is shown at B in schematic form.

may or may not be doing work. Voltage is also called "electromagnetic force." That may be a mouthful, but the idea is that voltage is an electrical pressure or force ready to be put to work.

Current is flow of electrons. Electron flow can take place only when there is a voltage (potential difference) and a conductor through which to move. As an analogy, picture two adjacent lakes that we'll call High and Low. Lake High has a water level that is several feet higher than Lake Low. If we cut a small channel between them but put a lock in the channel, no water will flow. But there will be a pressure difference. When we open the lock, water will flow from Lake High to Lake Low until the difference is gone and both lakes are the same level. In electricity, water level in this analogy is similar to voltage, and current is similar to water flow. Electrical current will flow until the potential difference is eliminated or the path is blocked.

DC (direct current) is defined as "A unidirectional current in which the changes in value are either zero or so small that they may be neglected.[2]

What this means is that if we could see dc with our eyes, it would flow in only one direction (like a river) and would appear as a straight line with no humps or bumps. We can see this if we hook up an oscilloscope to the dc-voltage line. The dc will show up on the face of the scope tube as a straight line. Fig. 1 provides a simple illustration of direct current and how it flows. Common sources of dc voltage are flashlight and car batteries. Only dc can be stored in batteries.

We can change alternating currents, the kind of electricity used in homes and business, to dc voltage by *rectifying* and *filtering* it. For example, we can take the voltage from a standard wall outlet (120-V ac), connect it to a transformer (a safety measure to protect us from the high-current voltage source), then pass the ac through a tube or semiconductor rectifier diode. This will give us *pulsating dc* voltage because some of the ac will still be present. These remaining small pulses can then be removed almost entirely by adding a filter capacitor after the rectifier. A simple example of this is given in Fig. 2. A transformer can also be used to increase (step up) the ac-line voltage or lower it (step down).

AC (alternating current) is defined in the IEEE dictionary (note 2) as, "A periodic current the average value of which over a period is zero. *Note:* Unless distinctly specified otherwise, the term *alternating current* refers to a current that reverses at regularly recurring intervals of time and that has alternately positive and negative values."

What does all of this jargon mean? Simply, that ac voltage has a starting point (zero reference) of no value (zero voltage). Then it rises to a particular peak (high) value, falls back to zero and then drops to a negative value that is equal to the peak value. This rise and fall occurs at precise periods. For example, the voltage from our ac wall outlets is rated at 50 or 60 Hz

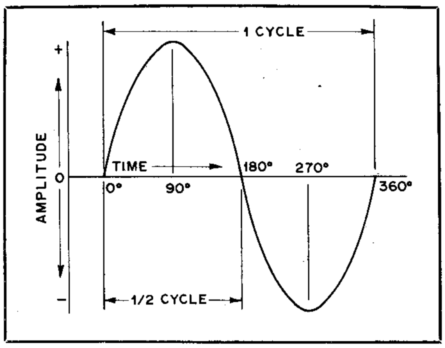
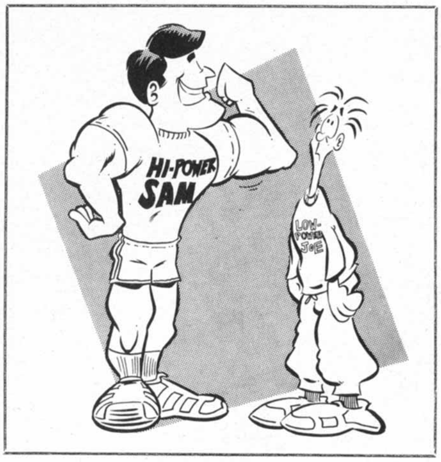


Fig. 3 — Representation of ac voltage, showing how it commences at zero, swings positive, returns to zero, swings negative and returns again to zero. This represents one complete ac cycle.

(hertz), also called "cycles per second." This means the current will travel through one complete cycle — zero to plus, plus to zero, zero to negative and negative back to zero — in a given length of time. This happens 60 times per second with the current from our wall outlet, and may occur several million times per second with the radio-frequency energy that amateurs use to communicate. An ac cycle is illustrated in Fig. 3.

Ac is used mainly to power our homes, to illuminate the bulbs in our lamp, and to operate motors, stoves and the like. On the other hand, most electronic equipment requires a dc-voltage source. So, we feed the ac to a *power supply* (Fig. 2), which changes it to direct current.

The power lines that feed our homes, and that we see crossing the highways and countrysides, carry ac voltage. Some of them convey thousands of volts from the



Classes of U.S. Amateur License

Let's examine, briefly, the structure of the various classes of amateur license available to you if you live in the U.S. Most beginners will start with the lowest grade, the Novice, although some start with the Technician or General license.

Novice: This ticket requires the applicant to pass a Morse code test of 5 words per minute, including numbers and punctuation marks. There are 20 multiple-choice questions, 15 of which must be answered correctly. Novices are not permitted to use voice operation; they are restricted to CW, or the Morse code, in portions of four different frequency bands. These bands are suitable for both worldwide and local communications. The license term is five years, but Novice licenses are renewable.

Technician: This license grade represents stepping stone no. 2. You must have a better understanding of electronic theory (there is a 50-question exam), but the code requirement is the same as for Novices. A Technician has all Novice privileges, plus full (including voice) privileges at VHF (very high frequencies) and UHF (ultra high frequencies).

General: The highest percentage of U.S. hams hold a General class license. The requirements are that you pass a 13-WPM code test, including numbers and punctuation marks. The written examination consists of 50 multiple-choice questions, and is the same test given to Technician applicants. With a General license, you will be able to operate on portions of all amateur bands (1.8 MHz up through the microwave spectrum).

Advanced: This is the last stepping stone to tread upon before going for the big prize — the Extra Class ticket. To qualify for this license, you must take a 50-question theory and rules exam, but the code requirement is 13 WPM, the same as for the General. This license allows you all of the General class privileges, plus some extra voice subbands that Generals must avoid.

Extra: When you're ready to take the Extra test, you've arrived! This license gives you all of the many operating privileges available to hams. Special CW and voice subbands are reserved for Extra Class licensees only. There is a 40-question technical examination, and the code requirement is 20 WPM.

If you have any questions about preparing for or taking an amateur exam, help is available from ARRL Hq. Write to the Club and Training Department, ARRL, 225 Main St., Newington, CT 06111, for the name of a local ARRL instructor or club that sponsors classes. The only book you should need to pass the Novice exam is the ARRL's *Tune in the World with Ham Radio*. It contains an explanation of the basic theory and rules and regulations you'll need to know to pass the written exam, and includes a tape cassette that teaches the Morse code letter by letter.

We do not recommend that you buy "fake books" that contain only what are advertised as the correct answers to FCC exams. Similarly, you should avoid "crash courses" in Amateur Radio. These will not only cost you a fair amount of money, but you'll have no real understanding of the theory. For these reasons, memorizing answers to FCC exams is definitely not recommended. Instead, enroll in a class sponsored by a local radio club. The cost, if any, will be nominal. Again, check with ARRL Hq. to find out where classes are being held.

generating plants to communities many miles distant. This high ac voltage is lowered before it enters our homes. A step-down transformer (located on a nearby power pole) is used for this purpose. The principle of operation for the "pole transformer" is identical to that of the transformer in a dc power supply. The notable difference is in the high amount of power the pole transformer can accommodate. Also, we do not rectify the output from the pole transformer to turn it into dc.

As we mentioned earlier, the RF (radio frequency) energy that amateurs feed to their antennas when transmitting is also ac, but the cyclic rate is very high. For example, a 3500-kHz radio signal goes through its ac cycle 3.5 million times a second. Audio energy (sound waves) is also ac, and the cyclic rate varies constantly when the human voice (or music) is reproduced. The frequency depends on the particular tone at a given instant.

The Matter of Power

Thus far we have discussed voltage and current. But, what about power? In broad terms we tend to think about "power" as a reserve of strength we may call on to perform a task. Car engines are rated in terms of power, or horsepower. Or, someone might say, "He is a powerful man." In the electrical world, power is "the rate of doing work." It is equal to the voltage multiplied by the current. This relationship can be expressed as a simple equation: $P = E \times I$, where P is the power in watts, E is the voltage in volts and I is the current in amperes. Thus, if we had a light bulb that operated from 120 volts, and it required a current of 0.83 ampere to illuminate fully, the bulb would consume 100 watts of power when lit.

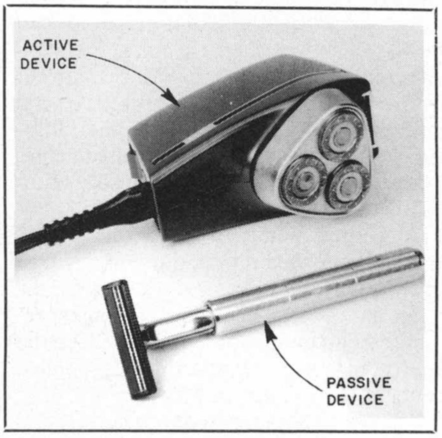


Fig. 4 — Simple pictorial illustration of an active and a passive device (see text).

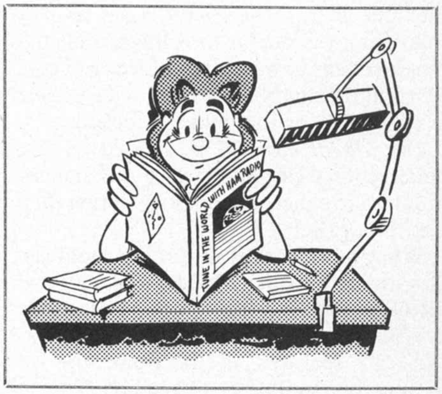
We can see from this that the higher the power consumption of a circuit or appliance, the greater the available current requirement. Power, current and voltage are, therefore, the basis of all electrical circuits. The notable exception is when we use what is called a *passive* circuit, one that requires no operating voltage (and therefore does not consume power). Such circuits do have a maximum voltage, current or power rating, though. This means that we dare apply only a certain amount of signal energy to them, lest they be destroyed by excessive power dissipation, caused by current flowing through them. A circuit or device that requires an operating voltage (and draws current) is called an *active* circuit. (See Fig. 4.)

Getting it Together

If you stayed with me through this discussion, you should have a better understanding of the basics of electricity.

At this juncture you may be saying to yourself, "Sure, it's easy for him to say how easy it is. After all, he's been in this game for a long time!" Well, let me tell you how *I* got started. I was an 8th-grade student when two other fellows and I happened across a book in the school library that described early-day transmitters. We built homemade spark-gap transmitters and antennas from that book, then went blithely on the air, not realizing that a license was required!

Later in life, after getting over the trauma caused by my experience as a



"bootlegger" illegal operator, my interest in radio was rekindled after watching the shipboard operators during WW II. I knew no hams and had no background in electronics. I obtained a copy of *QST,* then borrowed an old *ARRL Radio Amateur's Handbook*. I was off and running! A friend let me borrow her Webcor disk recorder, which I used to transcribe my own CW sending (after I learned the code with a hand key). I recorded some pages from *QST,* but put the text on the disks backwards, starting at the bottom of the page and working toward the top. This prevented me from memorizing the text. Meanwhile, I sent for an ARRL *License Manual,* and between that and the *Handbook* I prepared for the amateur exam. A month later, I went to the Detroit FCC office and passed my test to become

WN8HHS. I met my first ham on the air! So, I know from experience that if one really wants to be a ham, it can be done — whether or not that person has a knowledge of electrical circuits and FCC regulations.

I hope you've been inspired toward taking that first step into the world of Amateur Radio. Let's get together next month in the pages of *QST* for more basic theory and its practical application to Amateur Radio.

Notes

[1]Direct your request to the ARRL Club and Training Department, 225 Main St., Newington, CT 06111. Ask for the information packet on how to obtain an amateur license.

[2]*IEEE Standard Dictionary of Electrical and Electronic Terms,* published by Wiley-Interscience, a division of John Wiley and Sons, Inc., New York, NY.