

# The Complete Handbook of Radio Transmitters

by Joseph J. Carr

KT Here's a guide for all radio enthusiasts who want a complete overview of transmitters, their design and construction, their specifications and circuits, and how to use them. Starting with the fundamentals of circuits, transistors and tubes, Carr covers every conceivable subject related to transmitters of all kinds: AM, SSB, DSB, FM, PM and CW. It's especially a practical sourcebook for any radio operator, containing basic facts coupled with just enough theory to make the subject crystal clear.

After you've been introduced to the basics of transmitter circuitry, along with some background on transmitters in general, Carr explains one concept after another in logical order: amplifier circuits, frequency generation, matching, coupling networks, and neutralization. Everything a you could want to know about transmitters is here—there's even a big Chapter on power supplies. And every popular transmission mode is covered.

That isn't all, though. After you learn how various transmitters work, you'll learn how to tune them, troubleshoot them, test and measure them, maintain and repair them, avoid interference, and use appropriate safety measures when working with them. Once you get on the air—or if you are already—this book will make sure you know just how to get the most from your transmitter.



Author Joseph Carr is an electronics engineer with the U.S. government. He has written several other TAB books on electronics subjects, and makes his home in Arlington, VA.

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# THE COMPLETE HANDBOOK OF RADIO TRANSMITTERS

A practical guide to radio transmitters and  
their circuits from power supply to antenna!



BY JOSEPH J. CARR

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1980



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BY JOSEPH J. CARR



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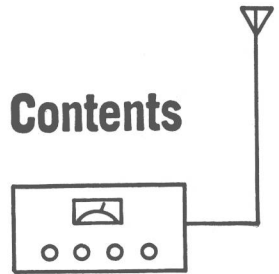
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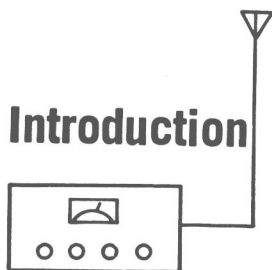
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## Introduction



During the dawn hours of the radio era, transmitting stations smelled heavily of battery acid and ozone. Ozone, that smelly oxygen product of the pyrotechnics is created by high-energy electrical sparks. Radio transmitters of that time were spark gaps. In fact, many early amateur radio operators went on the air for the first time using the spark coil salvaged from the family Model-T Ford. They transmitted by keying the low-voltage primary of the coil, and coupling the secondary to the antenna system. A little later, high-power radio signals were sent on their way from an Alexanderson alternator, a mechanical AC generator of high frequency.

It was not until after World War I that vacuum tube transmitters came into their own, and even then they did not completely displace the spark transmitter until 1939 when sparks were outlawed by the FCC. Those early tube transmitters were puny affairs by today's standards. By the outbreak of World War II, however, multikilowatt transmitters were on the air, and the vacuum tube generation of rf energy was firmly established.

For the first two decades of the transistor era, the solid-state power amplifier could not keep pace with the vacuum tube at radio frequencies. Only a few watts could be generated from transistors. But today, a whole new look is upon low-power to medium-power transmitters. It is almost unheard of to see a tube-type transmitter mobile radios operating from CB through UHF. All of these low-power transmitters are now solid state. Similarly, transistors have

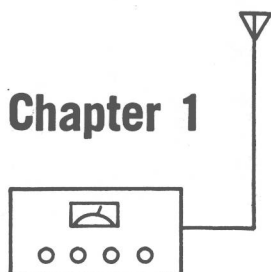
made serious inroads into the medium power (100 watt to 300 watt) high-frequency transmitter market. Although a few rigs are solid state up to the final amplifiers, where tubes are used, most of them now use transistors. Solid-state HF linear amplifiers with 100 to 300 watts of power are common, and 1000-watt amplifiers are not unknown.

In this book we are going to consider the basic circuitry and design practices used in radio transmitters in the high-frequency through low UHF region. Although we would like to cover from DC to daylight, space considerations limit us to the most popular ranges. The main thrust of this book will be practical, with just enough theory to lead you into a better understanding of the device called transmitter.

Joseph J. Carr



## Chapter 1



# Radio Transmitters—An Overview

What is a radio transmitter? A radio transmitter is an instrument that will produce an rf signal with sufficient power to be transmitted to a distant location via an antenna system. Radio transmitters abound in dozens of formats. A radio transmitting station might consist of a multikilowatt transmitter, such as the Collins 40,000-watt FM broadcast model shown in Fig. 1-1. This transmitter requires seven large racks to hold the circuitry and consumes huge amounts of electrical power. A large multikilowatt rig can actually heat a small building. One of the standard practices of radio station owners in this energy-conscious era is to divert the transmitter heat into the forced air ducts of the station buildings to supplement—in some cases supplant—the regular heating equipment.

### SHORTWAVE TRANSMITTERS

A radio station might also be a multimewatt installation such as the Voice of America transmitting location in Greenville, NC (Fig. 1-2). This station produces radio frequency power that is measured in the *millions* of watts. The antenna farm for this installation is, to say the least, extensive.

### TWO-WAY RADIOS

Alternatively, a radio station might be a small hand-held portable (Fig. 1-3) producing 1 to 5 watts, or a mobile installation (Fig. 1-4), also producing only a few watts. These land mobile, amateur

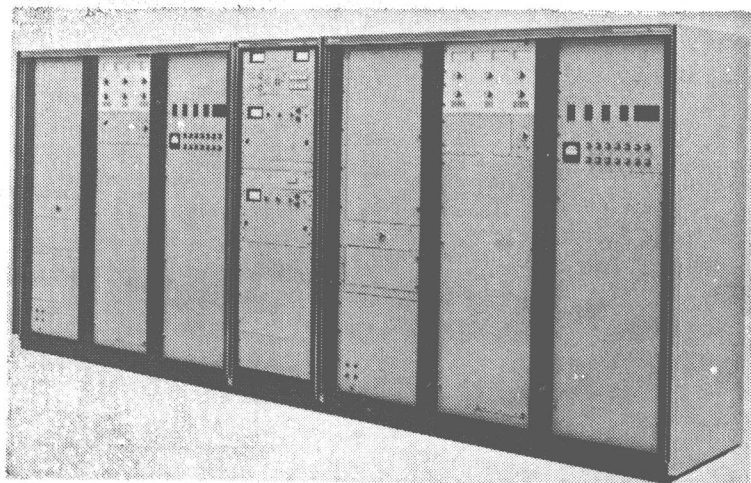


Fig. 1-1. 40-kW Collins FM broadcasting transmitter (courtesy of Collins/Rockwell).

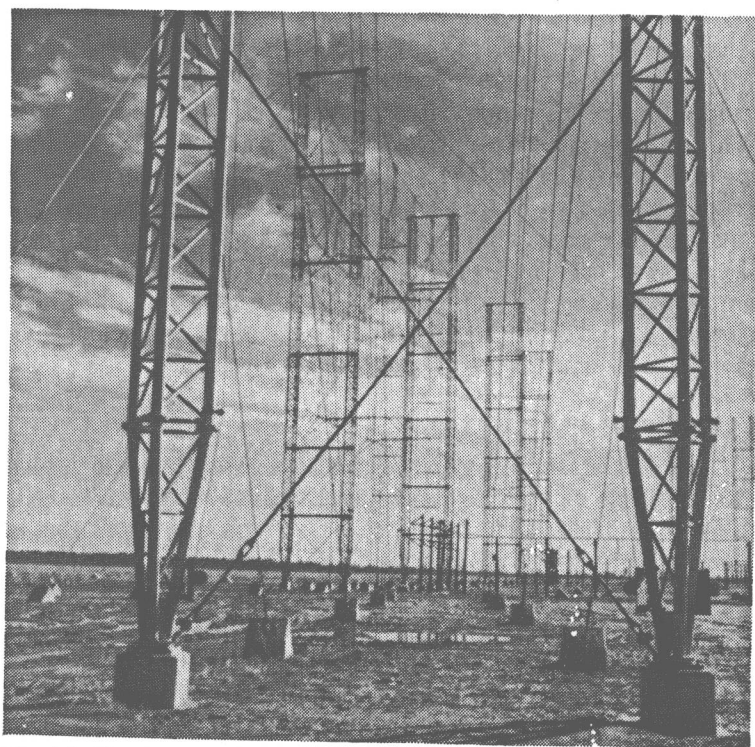


Fig. 1-2. Megawatt antenna farm (courtesy of The Voice of America).



radio and marine devices are usually frequency modulated (FM) and operate in the VHF and UHF bands. Regardless of the power level and physical configuration, however, they are still radio transmitters. In these cases, though, they are *transceivers*—combined *transmitters* and *receivers*. The transceiver is a self-contained two-way radio station, which sometimes even includes the antenna.

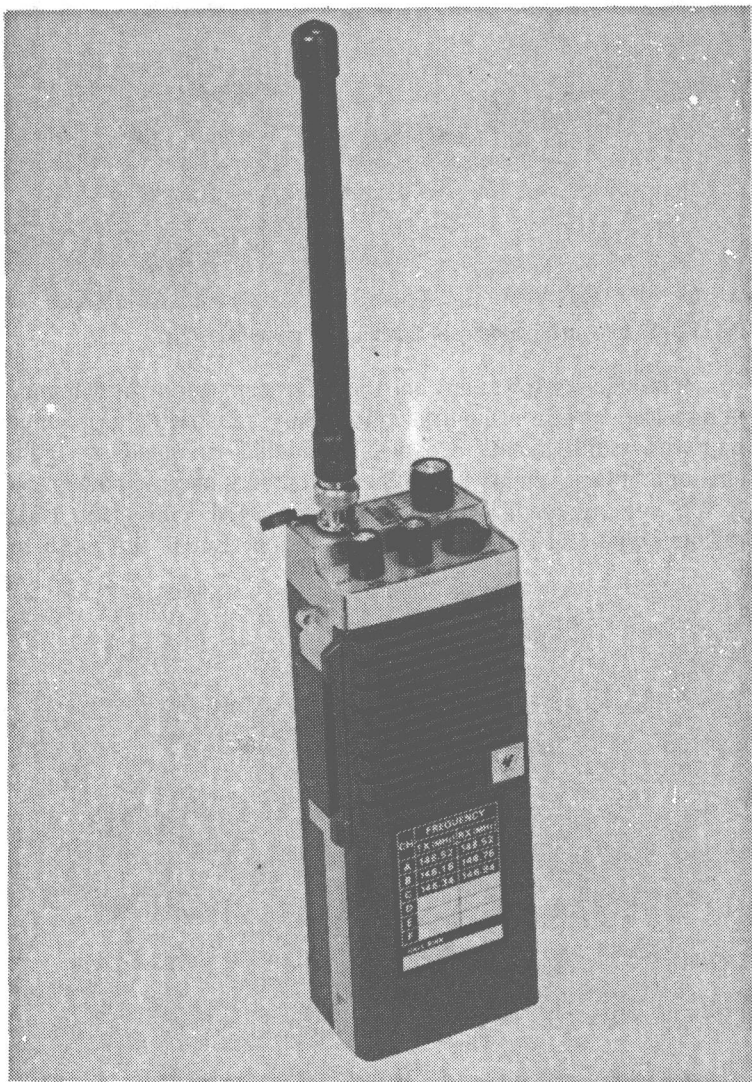


Fig. 1-3. Portable hand-held transceiver (courtesy of Yaesu).

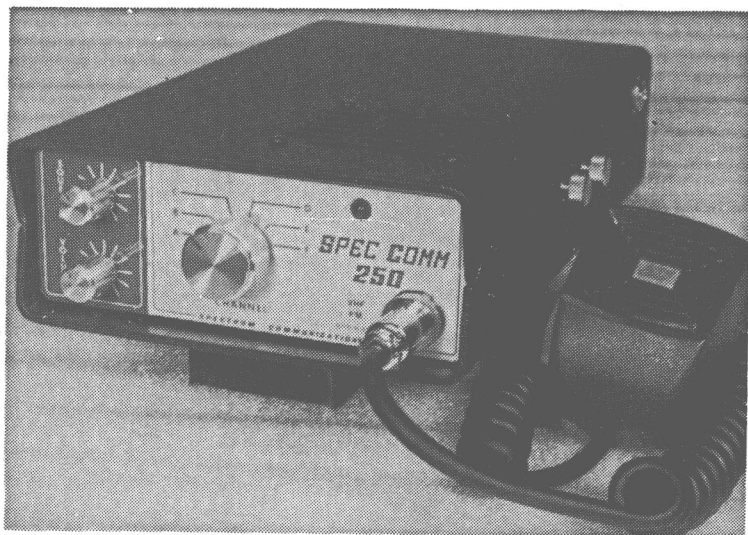


Fig. 1-4. Mobile unit (courtesy of Spectrum Communications).

It is difficult to place any one type of transmitter in the category of a typical amateur radio transmitter. Any transmitter class, save only the multikilowatt broadcast models, are used by radio amateurs in one activity or another. Amateurs use radiotelegraph (CW), several forms of radiotelephone (AM, SSB, and FM) radioteletype (RTTY), and even television. But if one were to

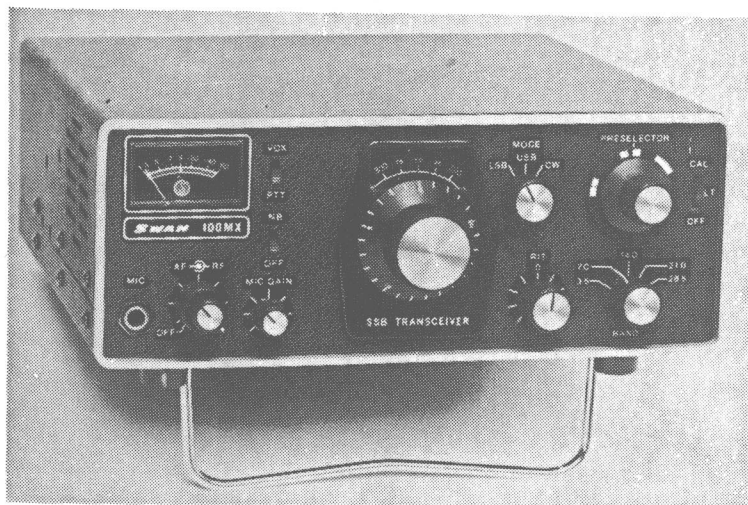


Fig. 1-5. Solid-state HF SSB rig (courtesy of Swan).



venture out and proclaim any one transmitter as the *standard* or *typical* type, it would have to be the single-sideband 100-watt to 300-watt transceiver. Figures 1-5 and 1-6 show modern SSB transceivers that use analog and digital readout, respectively. At one time, amateur transmitters were relatively simple devices using low technology. But the modern SSB transceiver will use such high technology circuits as digital readouts, phase-locked loop frequency control and solid-state circuits (including the final amplifiers).

The simplest amateur radio transmitters have only two stages: an oscillator and a final power amplifier. The oscillator generates the radio frequency, while the power amplifier boosts it to the desired power level. The output of the final amplifier is passed through an impedance matching circuit to the antenna, where it was radiated in the form of an electromagnetic radiation. This type of simple transmitter is called a *master oscillator power amplifier* (MOPA) transmitter. If the carrier, as the rf output signal is called, is turned on and off to form a code the transmitter is a radiotelegraph transmitter. But if some form of modulation, such as speech, is applied to the carrier, then a radiotelephone (or one of the other classes) is realized.

In this book we will consider radio transmitter theory and practice. Both practical circuits and radio transmitter theory are given. We hope that a fair balance is realized. The principal thrust will be toward the radio amateur, but radio broadcast engineers and two-way radio service technicians should find the book equally useful.