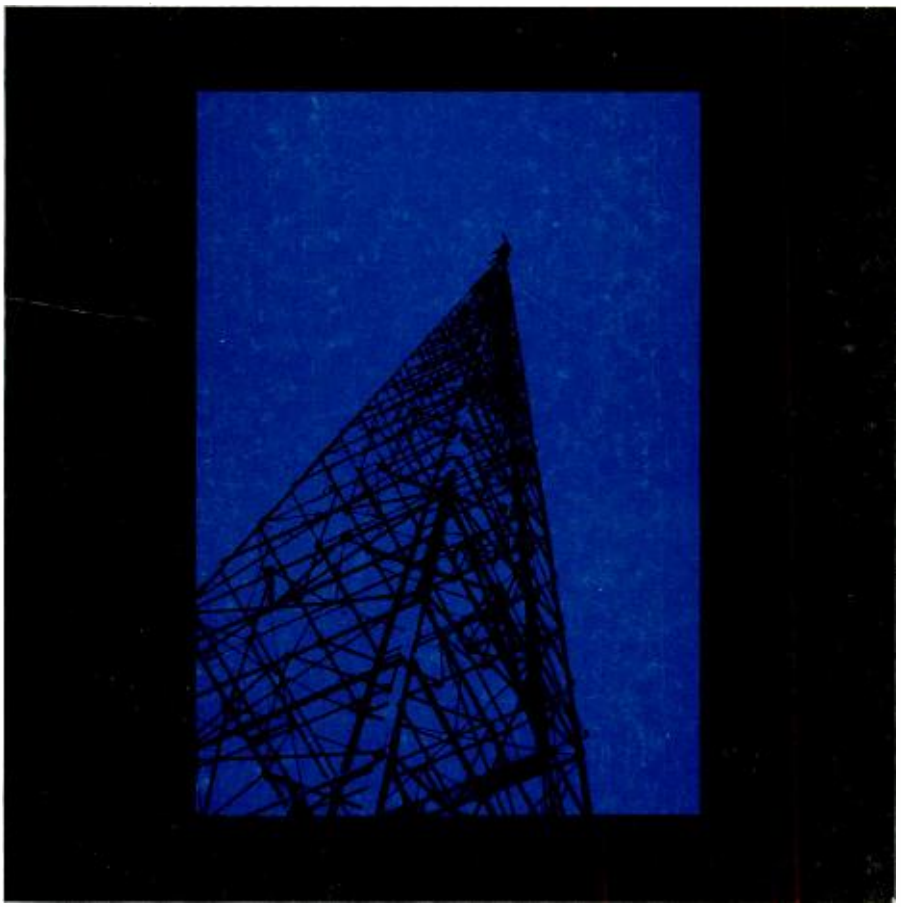
Broadcast Operator Handbook

Federal Communications Commission



Broadcast Operator Handbook

Radiotelephone
3rd Class Operators' Permit

Broadcast Endorsement

FIRST EDITION
March, 1976

Prepared by the staff
of the
Field Operations Bureau

Federal Communications
Commission

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Contents

Contents

Introduction

This manual is intended to serve as a practical study guide for those applicants interested in obtaining the Radiotelephone Third Class Operator Permit with the endorsement to operate broadcast radio stations. It should also prove helpful as a concise reference for those operators already active in the field of broadcasting.

For general information on operator licenses and permits see FO Bulletin NO. 4. This bulletin, examination schedules and application forms may be obtained by writing to any FCC field office, or the Federal Communications Commission, Washington, D.C. 20554.

To obtain a Radiotelephone Third Class Operator Permit, the applicant must successfully complete examination elements one and two. Operating privileges under this class license include operation of aeronautical land stations, marine coast stations, and some ship stations. To obtain operating privileges at broadcast stations, the applicant must also complete examination element nine.

Element One consists of basic law. Provisions of laws, treaties, and regulations with which every operator should be familiar are covered.

Element Two consists of basic operating practice. Radio operating procedures and practices generally followed or required in communicating by means of radiotelephone stations are covered.

Element Nine consists of basic broadcast. Basic regulatory matters applicable to the operation of AM, commercial FM, and noncommercial educational FM broadcast stations are covered. In some areas of application, the regulations are less stringent for noncommercial educational FM stations licensed to operate with a transmitter output power of 10 watts or less than for other, more powerful, stations. It is assumed that the operators at such stations will be aware of the differences and no attempt has been made to explain them in this text.

This manual has been made as complete and accurate as possible and the examinations have been prepared from the material contained herein. Nonetheless, applicants should

not expect the questions to be limited to or necessarily resemble the examples and problems given in the text or sample test. Although not required, practical knowledge of broadcast station equipment and operating procedures is desirable for those who take element nine.

When the term "third class operator" is used in this manual, it means a person holding a Radiotelephone Third Class Operator Permit endorsed for broadcast station operation. The term "license" is used generally in this manual to denote an authorization from the Commission. It includes "license", "permit", and "authorization". The expression "Federal Communications Commission Rules and Regulations" has been shortened to "the rules".

Chapters I and II concern basic law (element 1) and basic operating practice (element 2). The remaining chapters and the sample test are devoted to basic broadcasting (element 9).

Readers are invited to submit comments and suggestions to:

Federal Communications Commission
File 1400
1919 M Street, NW
Washington, DC 20554

1

Basic Law

Background

The Federal Communications Commission was created by the Communications Act of 1934 for the purpose of regulating interstate and foreign commerce in communication by radio and wire. One of the general powers given to the Commission is the authority to prescribe the qualifications of station operators, to classify them according to the duties to be performed and, except in certain cases, to issue commercial operator licenses only to United States citizens and nationals.

Station Licenses

In several ways a station license may be likened to a vehicle license. Almost anyone, if they choose, may own a motor vehicle, but this vehicle may be used on a public road only after a vehicle license has been issued by the state. This license assigns a unique combination of letters and numbers to the vehicle, defines the purpose, in broad terms, for which the vehicle is to be used (personal transportation, farming, commercial etc.) and imposes a requirement that the licensee ensure that the vehicle is used in accordance with a set of regulations, called a motor vehicle code.

Similarly with a station license; the document assigns a unique station identification, states the purpose for which the station is to be used (broadcasting, business, aviation etc.) and requires that the licensee comply with the Federal Communications Commission Rules and Regulations.

Operator Licenses

To continue with the analogy, it is not enough for the owner of a motor vehicle to have a vehicle license. If the vehicle is to be driven, it must be under the control of someone who has a personal operator's license. Other passengers in the vehicle may use or adjust certain equipment such as the radio or air conditioning but the essential functions—steering, braking and accelerating—must be under the direct control of a licensed operator.

At a radio broadcast station, whenever it is "on the air" it must be under the control of a licensed operator. Other, unlicensed persons may use the microphone (announce), run the tape decks, edit news programs and so forth, but the hour-by-hour technical control of the transmitting system—involving modulation, operating power and, possibly, antenna pattern—are the responsibility of the operator.

Depending on the radio service, an operator may need a first class or second class license, a third class permit or no license at all. In those cases where, because of the nature of the radio service, the rules do not require the operators to be licensed, the station licensees are under a special obligation to maintain control over the stations and to provide for their proper functioning and operation.

Obtaining New Licenses

To obtain a commercial Radiotelephone Third Class Operator Permit and the endorsement for broadcast station operation, an applicant must first submit the appropriate application forms and fee to the Commission field office having jurisdiction over the place where he wishes to be examined. If the applicant passes the examination and there are no doubts as to his nationality, character, or physical condition, a license will be routinely issued.

To qualify for the third class permit with the broadcast endorsement an applicant must pass three multiple-choice examinations with a score of 75% in each test. There are no age, experience or educational requirements. The three tests are:

- Basic Law (element 1)
- Basic Operating Practice (element 2)
- Basic Broadcast (element 9)

An applicant who passes the examinations in law and operating practice, but not in broadcasting, will receive a third class radiotelephone permit *without* the broadcast endorsement and may not be an operator at a broadcast station.

Term of License/Renewal

An operator license is normally issued for a five year term and may be renewed during the last year. If an operator files an application for renewal before the expiration date, he may post a copy of that application where the license was posted and continue to operate, even though he may not receive his renewed license until after the expiration date of the old license. An operator license may also be renewed without re-examination during a one year "grace period" following its expiration date. The license is *not valid* during this period and the operator must wait until the renewed license is issued before resuming operation of a station.

Operators who file for renewal after the one year "grace period" must be re-examined before they can obtain another license.

Example: Your license expires June 30, 1976

(1) You apply for renewal May 5, 1976 and post a copy of the renewal application. You may continue to operate a broadcast station even though your new license does not arrive until July 18th.

(2) You apply for renewal July 3, 1976. Your license expired two days earlier and *you may not* operate until you actually receive your new license. Of course, there is no need to post a copy of the application, as you have no authority to operate.

(3) You apply for renewal July 10, 1977. Sorry. Your license expired over one year ago. To obtain a license you must take the written examination again.

Duplicate and Replacement Licenses

Should an operator license become lost, mutilated, or destroyed, or if the operator's name has been changed, a duplicate or replacement license may be requested by filing an application with the Commission field office which issued the original license. If the old license is available, it must accompany the application for a duplicate or replacement; if it is found later, it must be returned to the Commission for cancellation.

Posting Operator Licenses

Most third class operator permits are required to be posted at the operator's place of duty. When an application for a duplicate, replacement, or renewal of a commercial operator license is submitted, the license then held, if available, must accompany the application. In this case the operator may post a signed copy of the application submitted by him in lieu of the license document.

Cancelling Operator Licenses

If the holder of a lower class license qualifies for a higher class license, the lower class license will be cancelled upon issuance of the new license.

Failing an Examination Element

An applicant who fails a commercial operator examination element will be ineligible to retake that same element for a two month period.

Official Notice of Violation

Operators are expected to abide by the Commission's rules governing the station they are operating. An operator who violates these rules may be served with a written notice calling these facts to his attention and requesting a statement concerning the matter. FCC Form 793 may be used for this purpose. Within ten days from receipt of such notice, the operator must send a written reply to the office of the Commission originating the official notice.

Suspension of Operator Licenses

The Commission has the authority to suspend the license of any operator who has:

(1) Violated any provision of any act, treaty, or convention binding on the United States which the Commission is authorized to administer, or any regulation made by the Commission under any such act, treaty, or convention;

(2) failed to carry out a lawful order of the master or person lawfully in charge of the ship or aircraft on which he is employed;

(3) willfully damaged or permitted radio apparatus or installations to be damaged;

(4) transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning;

(5) knowingly transmitted false or deceptive communications;

(6) knowingly transmitted a call signal or letter which has not been assigned by proper authority to the station he is operating;

(7) willfully or maliciously interferred with any other radio communications or signals;

(8) obtained or attempted to obtain, or has assisted another to obtain, an operator's license by fraudulent means.

An order of suspension will be in writing and will take effect 15 days after it is received. During those 15 days, the operator may apply to the Commission for a hearing on the order of suspension. Upon receipt of such application the order will be held in abeyance until the conclusion of the hearing at which time the Commission may

- affirm the order of suspension which becomes effective immediately,
- modify the order of suspension, or
- cancel the order.

Inspection of Radio Stations

Representatives of the Commission have the authority to inspect all radio installations, associated with stations required to be licensed, at a*ny* reasonable hour. If a station is transmitting, it is considered to be a reasonable hour; this includes nights and weekends. The purpose of an inspection is to ascertain whether in construction, installation and operation the station conforms to the requirements of the rules and regulations governing radio communications.

Provisional Certificates

In circumstances where it is a hardship for an applicant to travel to the nearest Commission office or field examination point for an examination, the applicant may apply for a Provisional Radio Operator Certificate (PC3). This certificate conveys the same authority to operate broadcast stations as the Radiotelephone Third Class Operator Permit with the endorsement for broadcast station operation.

No examination is required but each application contains a printed statement which must be signed by a first class radiotelephone operator employed by a broadcast station which certifies that he has instructed the applicant in the operation of a broadcast station.

The provisional certificate (PC3) has three restrictions:

(1) It is valid for 12 months only and may not be extended

(2) It is not renewable

(3) It may be issued to a person only once during his lifetime

If an operator who holds a PC3 passes the written examination (elements 1, 2 and 9), his provisional certificate will be cancelled and he will be issued the regular third class permit with the broadcast endorsement. If, however, he fails to pass the

test, his provisional certificate will not be cancelled but will remain valid until its expiration date.

Station Logs

A number of radio services require the keeping of logs. The logs shall not be erased, obliterated, or willfully destroyed. Generally, necessary corrections may be made to a log by the person originating the entry.

Distress Traffic

Each station licensee shall give absolute priority to radio communications or signals relating to ships or aircraft in distress. The control of distress traffic is the responsibility of the mobile station in distress. Any station which becomes aware that a mobile station is in distress may retransmit the distress message when there is reason to believe that the distress call it has intercepted has not been received by any station in a position to render aid.

Operation During Emergency

The licensee of any station (except amateur, standard broadcast, FM broadcast, noncommercial educational FM broadcast, or television broadcast) may, during a period of emergency in which normal communication facilities are disrupted as a result of hurricane, flood, earthquake, or similar disaster, utilize such station for emergency communication service in communicating in a manner other than that specified in the instrument of authorization.

False Distress and Rebroadcasting

No person within the jurisdiction of the United States shall knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent signal of distress, or communication relating thereto, nor shall any broadcasting station rebroadcast the program or any part thereof of another broadcasting station without the express authority of the originating station.

Penal Provisions

Any person who knowingly and willfully violates any provision of the Communications Act shall, upon conviction for first offense, be punished by a fine of not more than $10,000 or by imprisonment for a term not exceeding one year, or both. For a second offense he shall be punished by a fine of not more than $10,000 or by imprisonment for a term not exceeding two years, or both.

Any person who willfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission or imposed by any international treaty or convention which the Commission enforces, may, upon conviction, be punished by a fine of not more than $500 for every day during which such offense occurs.

Secrecy of Communications

No person shall divulge or publish the existence, contents, or substance of any communications to any person other than the person to whom the communication was directed. No person having received any intercepted communication shall use that communication or information for his own benefit or the benefit of another not entitled to receive it. The above does not apply to receiving, divulging, publishing, or utilizing the contents of any radio communication which is broadcast or transmitted by amateurs or others for the use of the general public, or which relates to ships in distress.

Harmful Interference 6

Harmful interference is any emission, radiation, or induction which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio communications service.

Priority of Communications

The order of priority for communications in the mobile services shall be as follows:

1. Distress calls, distress messages, and distress traffic.
2. Communications preceded by the urgency signal.
3. Communications preceded by the safety signal.
4. Others.

Summary

An operator license is normally valid for 5 years. If an application for renewal is made before the license expires and a copy of this application is posted, the authority of the operator continues without interruption.

If an application for renewal is submitted after expiration but within one year of the expiration date the license may be renewed without examination but the operator has no authority to operate from the date of expiration until the renewed license is issued. This year during which re-examination is not required is referred to as the "grace period".

An application for renewal filed more than one year after the expiration date will not be accepted and re-examination will be required before a license can be issued.

Duplicate and replacement licenses may be obtained from the Commission's field office which issued the original document.

In most cases third class operator permits are required to be posted at the operator's place of duty.

A notice of violation is sent to operators who violate the Commission's rules and regulations. A written reply must be sent within 10 days of receipt of the notice.

An operator's license may be suspended for any of a number of violations. An operator who receives an order of suspension has 15 days in which to request a hearing (if desired). The order of suspension will be held in abeyance until the hearing is completed.

Representatives of the Commission may inspect a radio station at any reasonable hour.

In circumstances where it is a hardship to travel to the nearest Commission office or field examination point, an applicant may obtain a Provisional Certificate in lieu of a Third Class Permit with Broadcast Endorsement. As this certificate is valid for only one year and may not be extended or renewed,

holders of this certificate are advised to arrange to take the written examination for the Third Class Permit at their earliest opportunity. The Provisional Certificate is intended for the convenience of station licensees who are located at a considerable distance from Commission examination points and may find it difficult to obtain licensed operators. It is not intended to provide for an apprenticeship period for prospective operators.

2

Basic Operating Practice

A licensed radio operator should remember that the station he desires to operate should be licensed by the Federal Communications Commission. In order to prevent interference and to give others an opportunity to use the airwaves, he should avoid unnecessary calls and communications by radio. He should remember that radio signals normally travel outward from the transmitting station in many directions and can be intercepted by unauthorized persons.

Before making a radio call the operator should listen on the communications channel to insure that interference will not be caused to communications which may be already in progress. The operator should be courteous at all times.

Station identification should be made clearly and distinctly to avoid unnecessary repetition of call letters and to enable other stations to clearly identify all calls.

An operator normally exhibits his authority to operate a station by posting a valid operator license or permit at the transmitter control point.

While a radio transmitter is in a public place it should at all times be either attended by or supervised by a licensed operator or the transmitter should be made inaccessible to unauthorized persons.

A radio transmitter should not be on the air except when messages are being transmitted. The operator of a radiotelephone station should not press the push-to-talk button except when he intends to speak into the microphone. Radiation from a transmitter may cause interference even when voice is not transmitted.

When radio communications at a station are unreliable or disrupted due to static or fading, it is not a good practice for the operator to continuously call other stations in attempting to make contact because his calls may cause interference to other stations that are not experiencing static or fading.

A radiotelephone operator should make an effort to train his voice for most effective radiocommunication. His voice should be loud enough to be distinctly heard by the receiving

operator but should not be too loud since it may become distorted and difficult to understand at the receiving station. He should articulate his words and avoid speaking in a monotone as much as possible. The useful range of the transmitter is affected to some extent by the loudness of the speaker's voice. If his voice is too low, the maximum range of the transmitter cannot be attained and if his voice is too loud, the range may be zero due to the signals becoming distorted beyond intelligibility. In noisy locations operators sometimes cup their hands over the microphone to exclude extraneous noise. Normally, the microphone is held from 2 to 6 inches from the operator's lips.

It is important in radiotelephone communications that operators use familiar and well known words and phrases in order to insure accuracy and save time from undue repetition of words. Some radio operating companies, services, networks, associations, etc., select and adopt standard procedure words and phrases for expediting and clarifying radiotelephone conversations. For example in some services, "Roger" means "I have received all of your last transmission", "Wilco" means "Your last message received, understood, and will be complied with", "Out" or "Clear" means "This conversation is ended and no response is expected", "Over" means "My transmission is ended, and I expect a response from you", "Speak slower" means "Speak slowly", and "Say again" means "Repeat".

In radiotelephone communications a "phonetic alphabet" or word list is often useful in identifying letters or words that may sound like other letters or words of different meaning. For example "group" may sound like "scoop", or "Bridge" may sound like "ridge". A phonetic alphabet word list consists of a list of 26 words, each word beginning with a different letter for identifying that particular letter. If the letters in "Group" are represented in the phonetic alphabet by Golf, Romeo, Oscar, Uniform, and Papa, the word "Group" is transmitted as "Group, G as in Golf, R as in Romeo, O as in Oscar, U as in Uniform, P as in Papa".

In making a call by radio, the call sign or name of the called station is generally given three times followed by the call letters of the calling station given three times.

In testing a radiotelephone transmitter the operator should clearly indicate that he is testing, and the station call sign or name of the station, as required by the rules, should be clearly given. Tests should be as brief as possible.

If a radio station is used only for occasional calls, it is good practice to test the station regularly. Regular tests may reveal defects or faults which, if corrected immediately, may prevent delays when communications are necessary. Technical repairs or adjustments to radio telephone communication stations are made only by or under the immediate supervision and responsibility of operators holding first or second-class licenses.

When a licensed operator in charge of a radiotelephone station permits another person to use the microphone and talk over the facilities of the station he should remember

that he continues to bear responsibility for the proper operation of the station.

If an operator wishes to determine the specifications for obstruction marking and lighting of antenna towers, he should look in Part 17 of the Rules and Regulations of the FCC. If he wishes to determine the specifications for a particular station, he should examine the station authorization issued by the Commission.

3

The Operator

Definition

The operator at a broadcast station is the person who is on duty and in actual control of the transmitting system. He must sign the operating log when going on duty and *again* when going off duty.

Required Licenses

The holder of any third class permit with the broadcast endorsement or any second class or first class license may operate AM and FM broadcast transmitters (at certain "critical" directional AM stations, all operators must have first class licenses). However, only the holder of a radiotelephone first class license may perform transmitter maintenance or be designated as a chief operator. No other duties in a broadcast station require an FCC operator license.

Posting

At each station where a person is employed as an operator, he must post either his permit or Form 759 (Verification of Operator License or Permit). The permit (or Form 759) must be posted either at the transmitter, extension meter location, or the principal remote control point. The word "post" has been loosely defined to mean either affixing the license to the wall, or inserting it in a folder or binder which is retained at the posting location. Form 759 is used only by an operator who is employed at more than one station. Such an operator must post his original license at one station and a certified Form 759 at all other stations. The form may be obtained from any of the Commission's field offices; part A is completed by the applicant and part B by the licensee or general manager of the radio station where the form is to be posted. The Commission does not verify the form and there is no fee connected with it.

Primary Responsibility

The primary responsibility of an operator is to ensure that the transmitting system is operating properly, in accordance with the terms of the station license and the Commission's rules. In some stations an operator's responsibility may encompass both an AM and an FM transmitting system. An operator may be employed for other duties, such as announcing or editing, but only to the extent that these other duties do not interfere with his primary responsibility.

Place of Duty

The rules require that the operator must be on duty at one of three locations—

- at the transmitter,
- at an authorized remote control point, or
- where the extension meters (if any) are located.

At any of these locations, the required monitors and meters must be placed so that the operator can readily observe any deviations from normal operation. Although the operator is not required to remain in one position at all times, he must remain close enough to the operating position to observe the monitors and meters and maintain station operation in strict accordance with the station authorization and the rules.

Permitted Adjustments

Unless performed under the immediate and personal supervision of a first class radiotelephone operator, a third class operator may make only the following adjustments to the transmitting system (using external controls):

(1) Turn the transmitter on and off.

(2) Compensate for voltage fluctuations in the primary power supply.

(3) Maintain modulation levels within prescribed limits.

(4) Effect routine changes in the operating power.

(5) Change between differing radiation patterns provided only the activation of switches is required.

Item (1) is self-explanatory; modulation is covered in a separate chapter. Items (2), (4) and (5) are discussed below and are also mentioned in other sections of this manual.

Primary Power Supply

Like most users of electricity, a broadcast station depends on a utility company for the power to run its transmitter and other equipment. For proper operation of the transmitter, this power should be supplied at a constant voltage. In practice, the voltage does not remain at some constant value but increases or decreases depending on the ability of the utility company to respond to the demands of its users. As the voltage changes, the output of the transmitter (the operating power) also increases and decreases. To maintain a station's operating power at its authorized value, operators are permitted to make minor adjustments to compensate for those changes in the primary power supply; the exact nature of those "minor adjustments" will depend on each particular transmitter. *Figure 3–1* illustrates this concept.

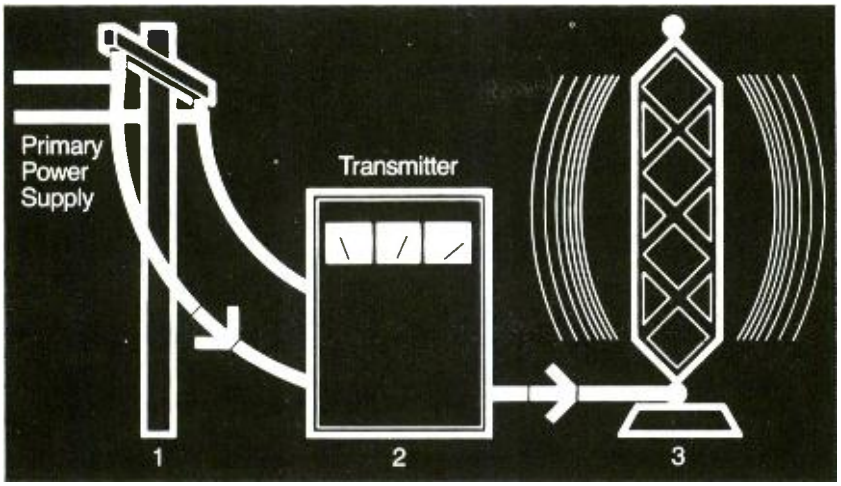


Figure 3–1

Primary power supply. In order to compensate for changes here (1), the operator is permitted to make adjustments here (2) to maintain the output power (3) at a constant level.

Skywave Interference

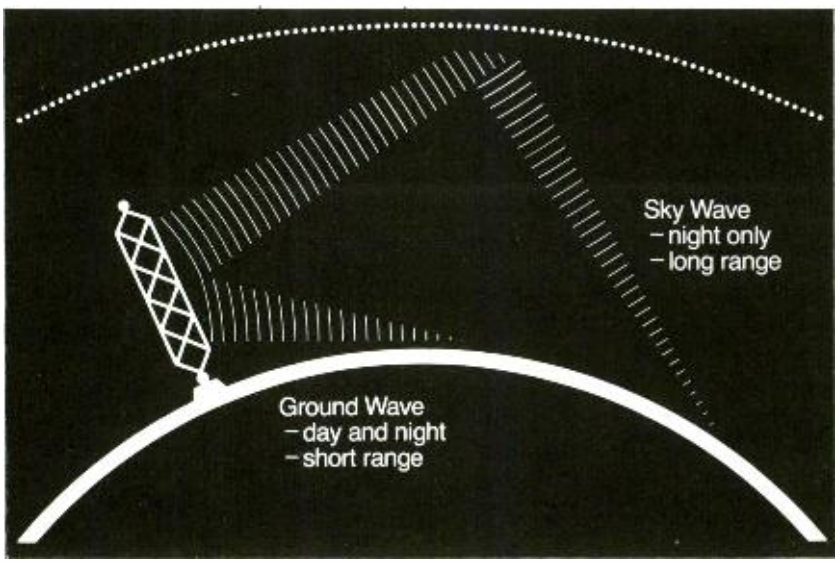


Figure 3–2

Ground wave and skywave radiated by AM station.

In the daytime the signal from an AM broadcast station travels over the ground and reaches listeners no more than a few hundred miles away. At night that same signal is also reflected by the atmosphere and may be received by listeners several thousand miles away. See *Figure 3–2.*

This explains why someone driving across Wyoming at night, for example, may hear programs broadcast from New Orleans and San Francisco in addition to a local station. While useful in some types of communications, this phenomenon can cause interference between broadcast stations. To eliminate or at least minimize this "skywave interference" many stations are required to cease operating, reduce power, or change from one antenna pattern to another at *sunset,* and return to daytime operating conditions at *sunrise.* (Other times may be specified by the station license). Provided these changes are routine in nature, they may be performed by third class operators. FM stations are not affected by the skywave phenomenon and their coverage re-

mains the same both day and night; therefore they operate at all times with one antenna pattern and constant operating power.

Presunrise Service Authority

As previously discussed, certain AM stations may operate only during the daytime or must reduce power or change to a more restrictive antenna pattern between sunset and sunrise. This can be a serious inconvenience for both the stations and their listeners, particularly in northern areas during the winter months when sunrise occurs late in the morning. To alleviate this problem many stations have been authorized to operate prior to sunrise using specified antenna patterns and power. This authorization is known as Presunrise Service Authority (PSA) and is intended to provide for broadcast coverage during the time when many people are preparing for work or school. At stations operating under a PSA, a third class operator may make the necessary changes to the transmitting system. Operators should exercise extreme care to assure that pre-sunrise operation is in compliance with the PSA and that full daytime operation is not resumed until the sunrise time specified in the station license.

Responsibilities of Station Licensees

The station licensee is responsible for ensuring that all third class operators are fully instructed in the performance of all of the above adjustments as well as other duties such as reading meters and making log entries. Printed instructions for all adjustments as well as a chart or list of limiting values for *operating parameters* (voltage, current, power, etc.) which these operators are required to observe and log must be posted at the operating position.

Operation of Audio Equipment By Unlicensed Persons

An announcer or other unlicensed person may adjust any of the controls on the audio console or other audio equipment provided the licensed operator can observe and maintain the level of modulation. Remember, the operator and not the announcer is responsible for the proper operation of the transmitting system.

Summary

The operator at a broadcast station is that person who is on duty and in actual charge of the transmitting system.

The primary concern or responsibility of the operator is to ensure that the transmitting system is operated in accordance with the terms of the station's license and the rules.

A third class operator with the broadcast endorsement may operate:

- all commercial FM stations.
- all noncommercial educational FM stations.
- all AM stations except those with critical directional antenna patterns.

The operator's normal operating position is:

- at the transmitter or
- at the remote control point or
- at the extension meter location.

The operator is authorized to make the following adjustments:

- Turn the transmitter on and off.
- Compensate for voltage fluctuations in the primary power supply.
- Maintain modulation levels within prescribed limits.
- Effect routine changes in operating power.
- Change antenna patterns.

To prevent or minimize skywave interference many AM stations are required to cease operating, reduce power, or change their antenna patterns at sunset. These stations return to their daytime operating conditions at sunrise.

The station licensee must post printed instructions and a chart of operating parameters for the guidance of third class operators.

At each station where a third class licensee is employed *as an operator,* he must post either his permit or Form 759 at:

- the transmitter,
- the remote control point or
- the extension meter location

4

The Fundamentals

Sine Wave

This is a sine wave.

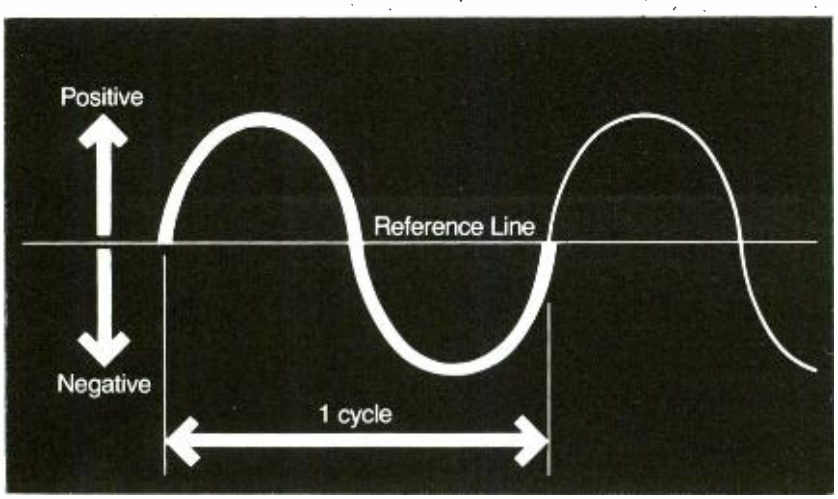


Figure 4–1
Sine wave.

It is a simple but precisely defined curve used to represent the current flowing in a light bulb, the music produced by a hi-fi system and the radio signal emitted by an FM station. Note that it is symmetrical about a reference line. By convention the curve is considered *positive* when above the reference line and *negative* when below. One complete oscillation is known as a *cycle*.

Frequency

The number of cycles which occur within a unit of time is the *frequency* of the sine wave. When discussing radio or sound waves that unit of time is normally one second. The expression "cycles per second" has been replaced by *hertz* (Hz) so that, for example, we speak of the frequency of the electric current in a home as 60 hertz rather than 60 cycles per second. Some examples chosen to illustrate the concept of frequency are:

Lowest note on pipe organ	16 Hz
Human voice	80 to 1200 Hz
Hearing	16 to 16,000 Hz
An AM broadcast station	810,000 Hz

Television (channel 2)	55,250,000 Hz
An FM broadcast station	107,900,000 Hz
Television (channel 30)	567,250,000 Hz
Microwave oven	2,450,000,000 Hz

Any frequency corresponding to a normally audible sound wave, such as is produced by a voice or musical instrument, is called an *audio frequency (AF).* A frequency which is useful for radio transmission is called a *radio frequency (RF).*

Measuring a Sine Wave

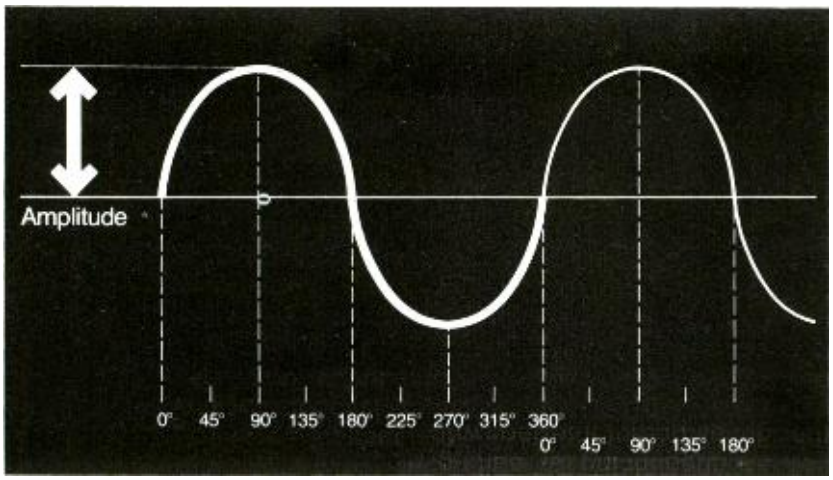


Figure 4–2.

Measuring a sine wave in degrees.

Often it is necessary to examine a single cycle of a sine wave. The distance from the reference line to the highest point on the curve is the *amplitude.* In electronics this amplitude is expressed in *volts* or *amperes.* Note that frequency and amplitude are independent of one another; that is, one can change without affecting the other.

In certain applications it is necessary to measure the length of a cycle in meters or seconds (the time it takes to complete all or part of a cycle). For our purposes a more convenient unit of measurement is the *degree* (°), where one complete cycle is equal to 360 degrees (360°). Then, a half cycle is 180°, a quarter cycle is 90° and so forth. Note in *Figure 4–2* that after the sine wave has reached 360° it begins again at 0°.

This method of describing the length of a cycle in degrees has the very important advantage that it does not depend on frequency or actual physical length. Whether we are talking about 60 Hz or 60,000 Hz, the length of one cycle will always be 360°.

In *Figure 4–3* we have drawn a circular race track with four runners at the starting line.

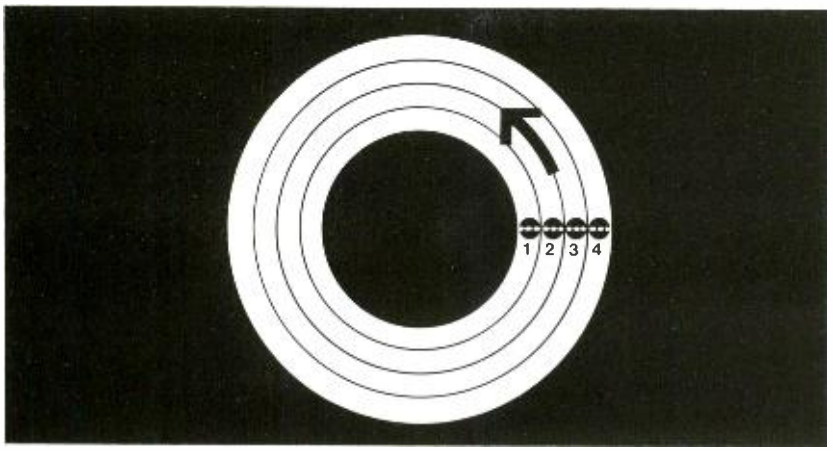


Figure 4–3.

A circular race track. All four runners are at the starting line.

In *Figure 4–4* the race has begun and several laps have been completed. We have chosen (arbitrarily) to show the positions of the runners at the instant runner #2 crosses the starting line.

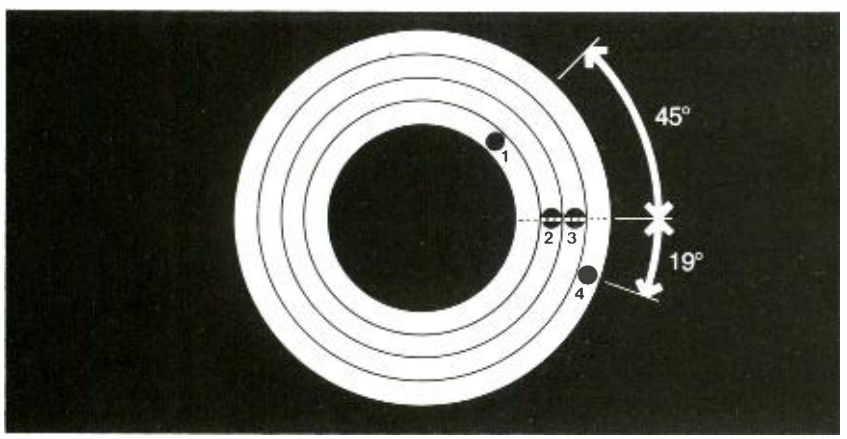


Figure 4–4.

The race track after several laps have been completed.

Normally the positions of runners #1 and #4 would be described as so many feet—or seconds—ahead or behind of runner #2. But since this is a circular track and a circle consists of 360° we can describe their *relative* positions in degrees. Using runner #2 as a reference, we can say that runner #1 is 45 degrees ahead (+45°) and runner #4 is 19 degrees behind (−19°). The difference between runner #3 and runner #2, the reference, is of course, 0°.

Note that in this example we can describe the positions of the runners relative to a reference without knowing how large the track is or how fast the runners are moving. In brief, we have used *degrees* to measure a difference in *time* without knowing the true time.

If we use the term *phase* to indicate this difference in time that is measured in degrees we can summarize the situation shown in *Figure 4–4* in the following way:

Runner	#1	#2	#3	#4
Phase	45°	0°	0°	−19°

The phase of runner #2, the reference, will always be 0°.

We can now list the important ideas we have attempted to illustrate with this example.

- *Phase* implies a difference in time.
- This difference is measured in degrees.
- A *reference* is required.
- Phase must be identified as ahead of or behind the reference.

As an exercise, consider the problem if runner #4 is chosen as the reference. Verify that the phase of runner #1 would be +64° and that of runners #2 and #3 would be +19°. What would the respective phases be if #1 or #3 were selected as the reference?

Ratios

When comparing several quantities it is sometimes advantageous to examine their relative differences rather than the absolute differences. A relative difference can be determined by calculating the *ratio* of one quantity to another. Consider the case of four objects whose weights are given by:

Object A = 8 pounds
B = 7 pounds
C = 11 pounds
D = 15 pounds

The absolute difference between A and C is 3 pounds but the weight of A *relative to C* is:

$$\frac{A}{C} = \frac{8}{11} = 0.73$$

If we continue to use C as a reference we can calculate the remaining ratios and list them in a table.

$$\frac{B}{C} = \frac{7}{11} = 0.64$$

$$\frac{C}{C} = \frac{11}{11} = 1.0$$

$$\frac{D}{C} = \frac{15}{11} = 1.36$$

Object	A	B	C	D
Ratio	0.73	0.64	1.0	1.36

The ratio of the reference object (to itself) must, of necessity, always be 1.0.

Verify that if D had been chosen as the reference, the ratios would be:

Object	A	B	C	D
Ratio	0.53	0.47	0.73	1.0

We will show how these concepts of *phase* and *ratio* are used in broadcasting in the chapter on directional AM stations.

Voltage, Current, and Resistance

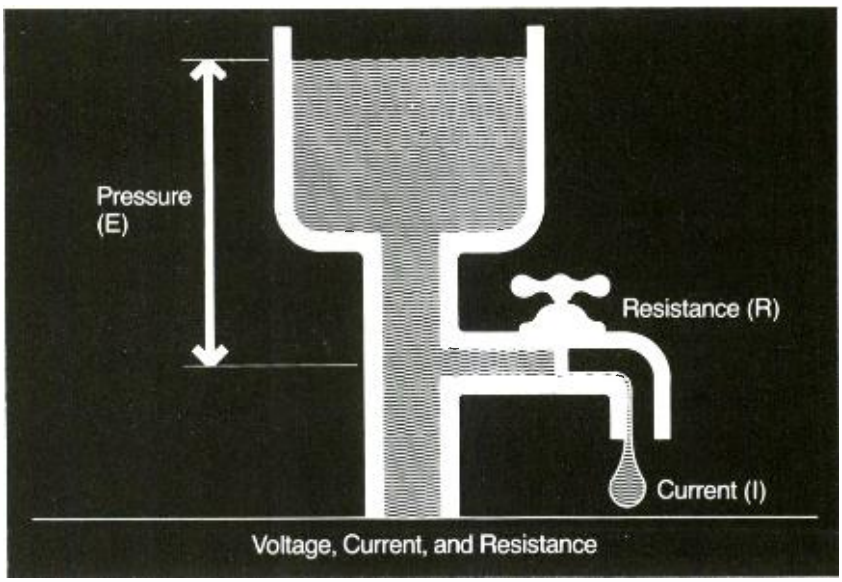


Figure 4–5

Water tower analogy of voltage, current and resistance.

A stream of electrons in motion in a wire is known as current (I) and is measured in *amperes* (A). One ampere is 6,280,000,000,000,000,000 electrons flowing past some point in a wire in one second. It may be compared to the flow of water in a pipe, measured in gallons per minute. The pressure or force which causes these electrons to move is the voltage (E) measured in *volts* (V). *Voltage* is comparable to the height of a water tower used to develop pressure for a town's water system—the higher the tower, the greater the pressure. Anything which acts to restrict or oppose the flow of current is *resistance* (R) measured in ohms (Ω). This may be compared to the size of the opening in the valve—the smaller it is, the greater will be its resistance to the flow of water. In electrical work, voltage (E) can be measured with a voltmeter, current (I) with an ammeter, and resistance (R), with an ohmmeter.

The three terms are related by the equation:

Voltage (E) = Current (I) $\times$ Resistance (R)

$$(1)\quad E = IR$$

This basic equation can be algebraically re-arranged to two other forms:

$$(2)\quad I = \frac{E}{R}$$

$$(3)\quad R = \frac{E}{I}$$

By definition, a pressure of 1 volt will cause a current of 1 ampere to flow through a resistance of 1 ohm.

For example, a one hundred watt light bulb has a resistance of 121 ohms. When used in a household electrical circuit of 110 volts, it will cause 0.91 amperes to flow in the circuit.

Examples:

(1) $E = IR$
$E = 0.91 \times 121$
$E = 110$ volts

(2) $I = \frac{E}{R}$

$I = \frac{110}{121}$

$I = 0.91$ Amperes

(3) $R = \frac{E}{I}$

$R = \frac{110}{0.91}$

$R = 121$ ohms

Power

Power is defined as the rate at which an electrical circuit performs work. The unit of electrical power, called the *watt,* is equal to one volt multiplied by one ampere. The equation for power is:

(1) P (watts) = E (volts) $\times$ I (current)
P = EI

From the previous discussion of voltage, current and resistance, we know that voltage (E) can also be expressed as:

$E = IR$

This value can be substituted for the voltage (E) in equation (1) giving us the equation:

(2) $P = (IR) \times I$
or $P = I^2R$

In *Figure 4–6* the 6 volt battery causes a current of 0.25 amperes to flow through a resistance of 24 ohms.

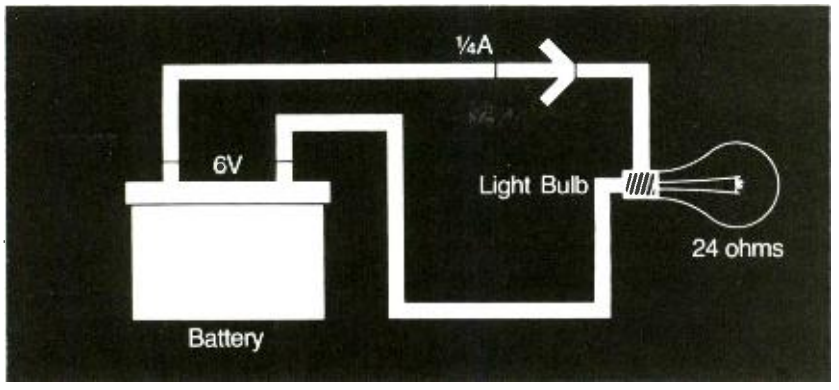


Figure 4–6
A simple electrical circuit

Knowing the current and the resistance of the light bulb we can calculate the power used by the bulb, from formula (2)

$$P = I \times I \times R$$
$$= \frac{1}{4} \times \frac{1}{4} \times 24$$
$$= 1.5 \text{ watts}$$

From the current and the battery voltage we can calculate the power supplied by the battery, from formula (1)

$$P = I \times E$$
$$= \frac{1}{4} \times 6$$
$$= 1.5 \text{ watts}$$

These two equations for determining power lead to the same answer; they will be used in the chapter on operating power when we discuss the *direct* and *indirect* methods of power measurement.

Common Prefixes

When discussing electrical quantities such as power or frequency, the numbers are often so very large or small that it is awkward to keep track of the zeroes. To avoid this, we use several standardized prefixes:

- Mega—1,000,000 (symbol: M)
  4 megahertz = 4,000,000 Hz
  92.3 MHz = 92,300,000 hertz

- Kilo—1,000 (symbol: k)
  23.2 kilowatts = 23,200 watts
  1370 kHz = 1,370,000 hertz
  1.2 kV = 1200 volts

- Milli—1/1000 (symbol: m)
  315 mA = 0.315 amperes
  48 mA = 0.048 amperes

In calculations involving these expressions they must first be reduced to the basic units, i.e., volts, amperes, watts, etc.

Example: To find the power in a circuit having a current of 750 mA and voltage of 20 kV:

$$P = EI$$
$$P = 20kV \times 750\ mA$$

It is necessary to convert 20 kV to 20,000 volts and 750 mA to .75 amperes

$$P = 20{,}000 \times .75$$
$$P = 15{,}000 \text{ watts}$$
$$\text{or } P = 15kW$$

AM and FM Frequency Bands

The AM broadcast band extends from 535 kHz to 1605 kHz. All AM stations are assigned to a frequency within that band beginning at 540 kHz and increasing in 10 kHz steps. See *Figure 4–7*

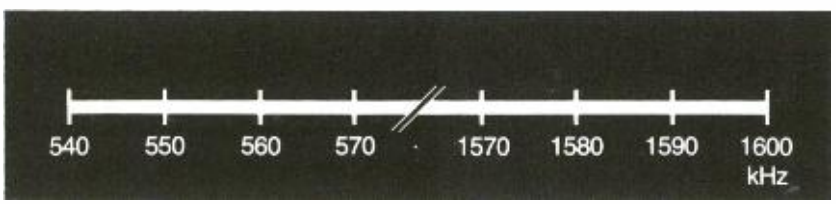


Figure 4–7
Standard (AM) band.

FM stations are considerably higher in frequency in the band 88 MHz to 108 MHz. The lowest station is at 88.1 MHz and each succeeding station is 0.2 MHz higher, the highest being at 107.9 MHz.

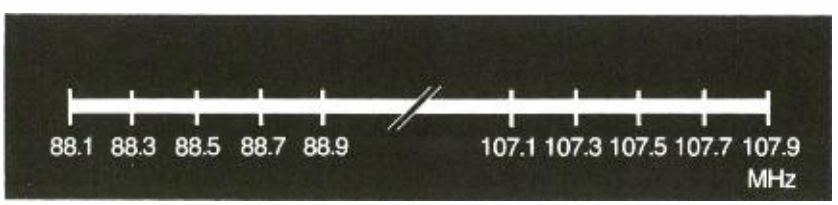


Figure 4–8.
FM band.

Operating Parameters

The quantities such as voltage, current, power, phase, etc., are called *operating parameters;* they were mentioned briefly in the chapter on OPERATORS. All broadcast stations are assigned specific operating parameters and operators must be familiar with them and the limits within which they must be maintained.

Summary

A sine wave is a mathematical model useful in representing or describing radio signals.

By convention, sine waves are drawn symmetrically about a reference line.

The amplitude of a sine wave is the distance from the reference line to the highest point on the curve.

The basic unit of a sine wave is the cycle.

The number of cycles that occur in one second is the frequency of the sine wave, measured in hertz (Hz). 1 Hz = 1 cycle per second.

One cycle is equivalent to 360 degrees (360°).

Phase requires a reference and is measured in degrees ahead of or behind that reference.

A stream of electrons in motion is called current (I). Current is measured in amperes (A) with an ammeter.

The pressure which causes the current to flow is voltage (E). Appropriately enough, it is measured in volts (V) by a voltmeter.

Resistance (R) opposes the flow of current. The unit of resistance is the ohm and its symbol is the greek letter "omega"(Ω).

In an electrical circuit if a voltage causes current to flow the circuit is doing work. The rate of doing work is called power (P) which is measured in watts (W).

Physical Quantities	*Units*
Voltage (E)	Volt (V)
Current (I)	Ampere (A)
Resistance (R)	Ohm (Ω)
Power (P)	Watt (W)
Frequency (F)	Hertz (Hz)

Prefixes

kilo (k) means 1000	1 kV = 1000 V 6.3 kW = 6300 W 910 kHz = 910,000 Hz
mega (M) means 1,000,000	106.3 MHz = 106,300,000 Hz
milli (m) means $\frac{1}{1000}$	12 mA = $\frac{12}{1000}$ A or .012 A

In calculations involving kilo- or milli- the terms must first be reduced to the basic units (volts, amperes, ohms, watts).

Standard broadcast band (AM)	535–1605kHz (535,000 to 1,605,000 Hz)
FM broadcast band	88–108 MHz (88,000,000 to 108,000,000 Hz)

Quantities such as voltage, current, power, etc., are known as operating parameters.

5

Modulation

Amplitude and Frequency Modulation

Modulation means *change.* In broadcasting, an audio-frequency signal (voice, music, etc.) is used to modulate or change the radio-frequency signal produced by the transmitter. The radiofrequency (RF) signal which has not been modulated or changed is *called* the *carrier* and resembles the sine wave shown in the previous chapter. In an AM (amplitude modulation) station the carrier is changed from this

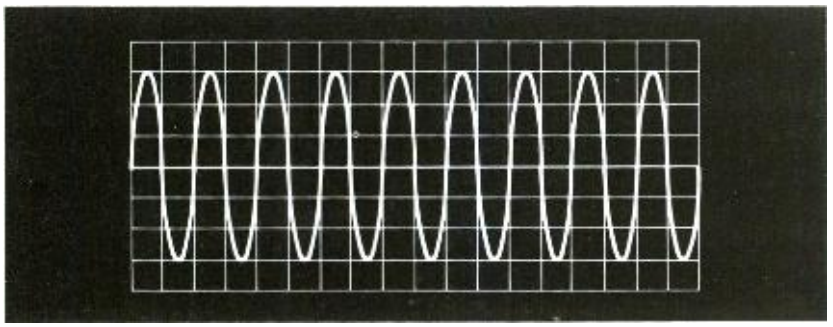


Figure 5–1.

Unmodulated carrier

to something like this.

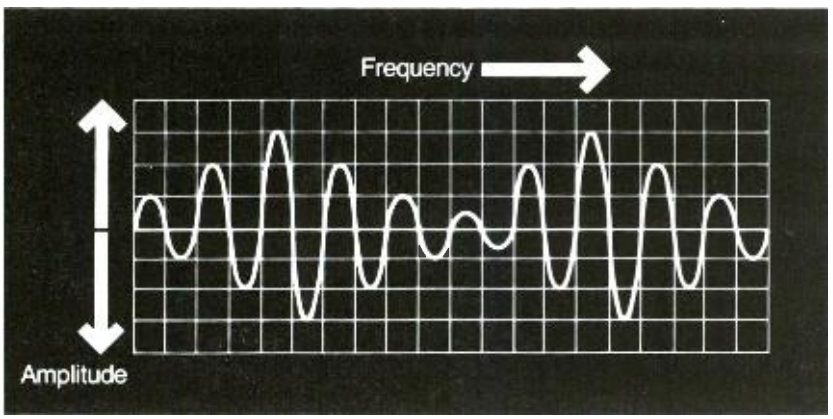


Figure 5–2.

Amplitude modulated carrier (frequency is constant—amplitude is changed).

In an FM (frequency modulation) station the carrier is changed from this:

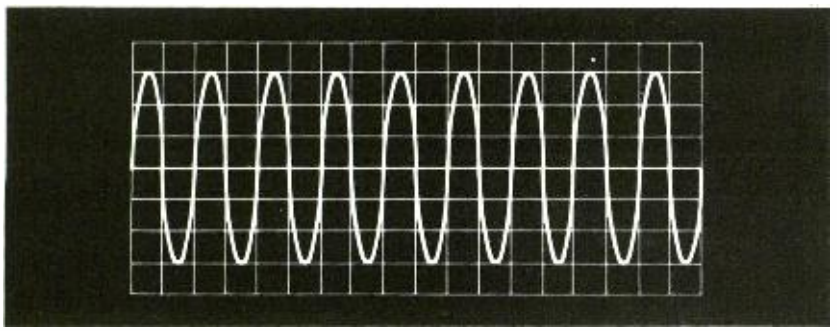


Figure 5–3.
Unmodulated carrier

to this.

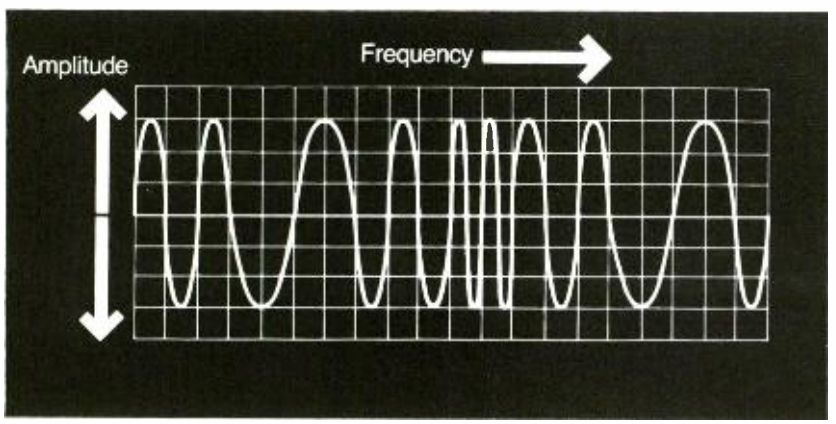


Figure 5–4.
Frequency modulated carrier. (amplitude is constant—frequency is changed).

A comparison of *Figures 5–1* and *5–3* shows that both carriers look alike. It is how we change or modulate the carrier that determines whether a station is AM or FM.

Modulation Units

The amount of modulation or change is measured in percent. Zero percent (0%) modulation corresponds to the unmodulated carrier as drawn in *Figures 5–1* and *5–3*. An explanation of other levels of modulation such as 50% or 100% is beyond the scope of this manual.

It is sufficient to know that the higher the percentage of modulation, the more the carrier has been changed and that modulation greater than 100% is possible.

Positive and Negative Modulation

Modulation can be divided into *positive* modulation and *negative* modulation. Generally they are about equal so that if, for example, the level of positive modulation is 60%, the level of negative modulation will also be 60%. However, they are *not always the same* and because of this the monitors used to measure modulation are able to measure positive and negative modulation separately.

The Audio Signal

Whenever a person speaks into a microphone or plays a record or tape an *audio signal* is produced in the wires leading to the transmitter. This audio signal (or audiofrequency signal) varies widely from one instant to the next and may look something like this.

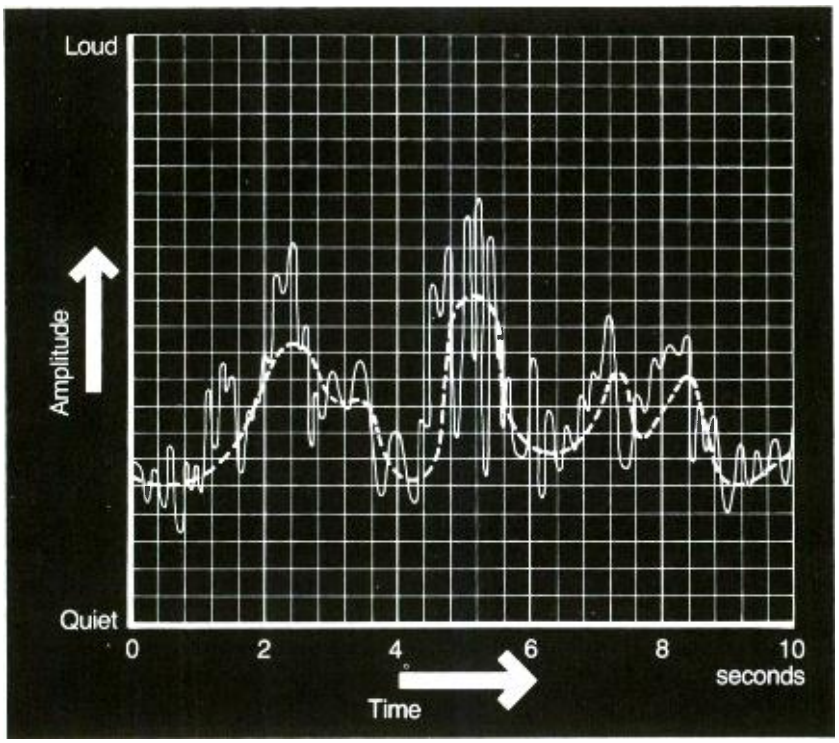


Figure 5–5
Representation of an audio signal.

The solid line represents the actual audio level, (or volume) at any instant; as can be seen, it varies rapidly and resembles a series of peaks and valleys. The dashed line represents the average audio level and might be thought of as the curve that would be obtained if the areas under the peaks were used to fill in the valleys.

It also varies with time but more slowly than the instantaneous audio signal.

Audio Controls

The audio signal is controlled both manually and automatically in a broadcast station. The manual controls are the *master gain controls* and the *channel gain controls* (also called attenuators or pots). Referring to *Figure 5–6* it can be seen that each source of audio signal has its own control which is used to adjust the audio level separately on each channel. The master control affects all of the channels simultaneously. These controls are similar to the "volume" control on a stereo amplifier.

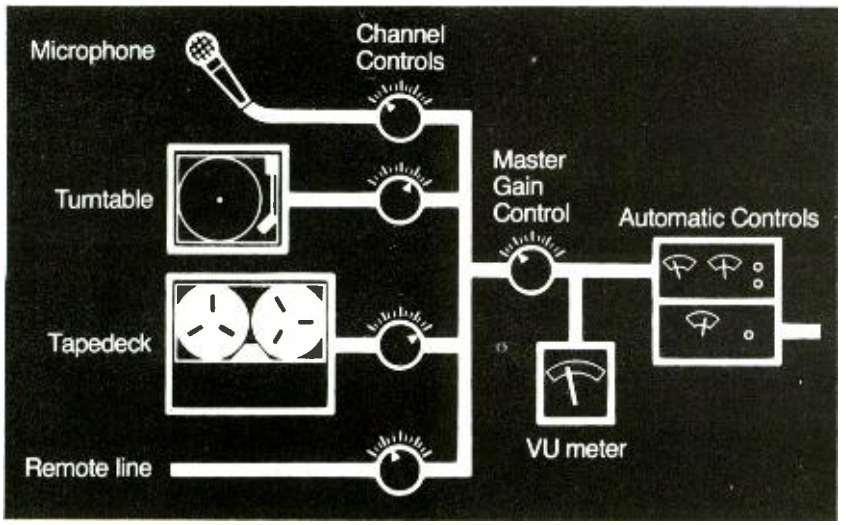


Figure 5–6
Audio controls

The *VU meter* (volume units) measures the *average* audio level. The operator should watch this meter and adjust the channel pots and master gain control to keep the audio signal within the range determined by the station's chief operator. This meter must *not* be used to measure modulation. Modulation can be measured only by the modulation monitor.

The automatic controls are known by many names such as automatic gain control (AGC) limiter, compression amplifier, loudness controller or peak controller but all basically serve two purposes: to raise the average audio level and at the same time limit the audio peaks to prevent excessive modulation.

Every operator must know how to adjust both manual and automatic controls in the event that such action is necessary to keep the modulation level below the prescribed limits. Quoting from the rules* ". . . an operator holding a third class permit endorsed for broadcast station operation may make adjustments to maintain modulation levels of the transmitter within prescribed limits. . . It is the responsibility of the station licensee to insure that each operator is fully instructed in the performance of all the above adjustments. . ."

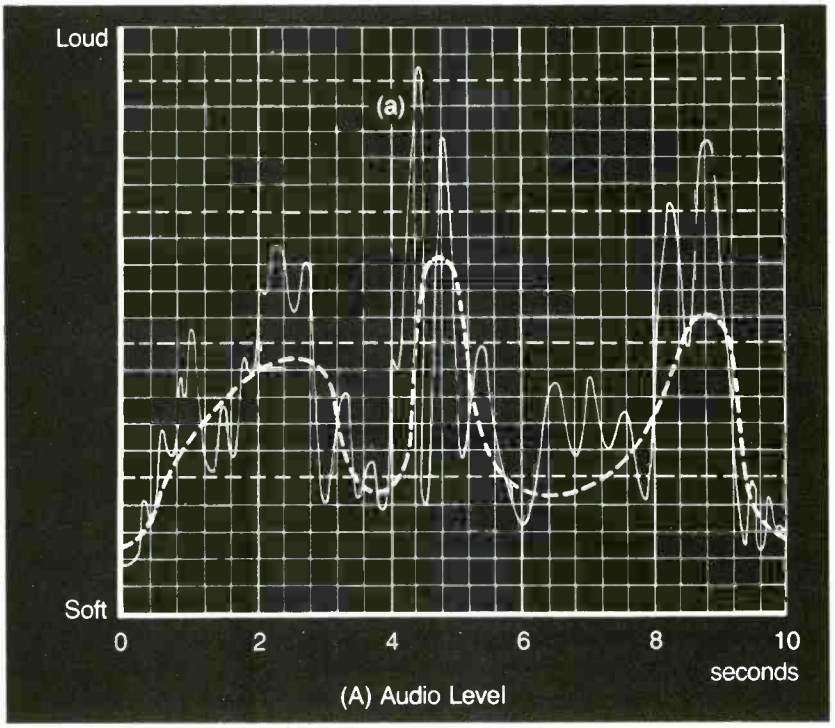
Average and Peak Modulation

After the audio signal has left the last limiter or amplifier, it goes to the transmitter where it modulates the radio-frequency carrier. The average audio level determines the average level of modulation and, more importantly,

each audio peak causes a modulation peak.

This relationship can be understood by comparing the following two figures:

* For a more complete statement refer to those sections of the rules pertaining to "Operator Requirements".



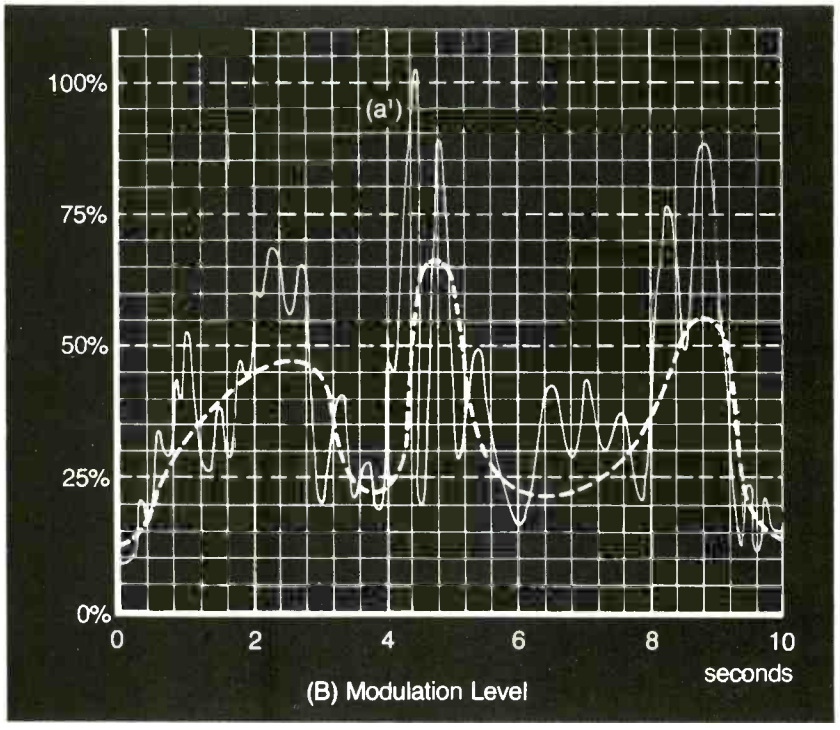


Figure 5–7

Comparison of audio and modulation levels.

(A) represents an audio signal that has modulated a transmitter. (B) represents the resulting modulation. As before, the dashed line is the average level. Note that each audio peak causes a

modulation peak and that the louder the audio signal is, the higher will be the modulation level.

In this instance the peak marked (a) is sufficiently loud to modulate the transmitter more than 100% (a').

We are now ready to discuss the most difficult concept in this chapter and perhaps in this entire manual.

Peaks of Frequent Recurrence

In *Table 5–1* the audio and modulation levels shown in Figure 5–7 have been recorded over a 10 second interval. In that interval it can be seen that only one modulation peak exceeds 100%, three exceed 87%, four exceed 75% and almost all exceed 25%.

Modulation Peak	*Occurrence*
100%	One every 10 seconds
90%	One every 10 seconds
87%	Three every 10 seconds
75%	Four every 10 seconds

Peaks that occur about once every minute are considered "infrequent"; if they occur about once a second, they are "frequent". The dividing line is a repetition rate of *about once every ten seconds.* Using this as a guideline we can say that, in this case, the modulation exceeds 87% *on peaks of frequent recurrence.* It also exceeds 100% but not on peaks of *frequent recurrence.*

Moduation limits are given in terms of "Peaks of Frequent Recurrence"

Note that, with normal program material, the peaks will not occur at regular intervals and that some judgment must be used in deciding whether the modulation peaks are frequent or not.

Modulation Limits

Keeping in mind that positive and negative modulation must be observed separately, the rules concerning modulation can be summarized as:

(1) At any radio broadcast station the modulation must not exceed the following limits on peaks of frequent recurrence.

	Type of Station	
Modulation	AM	FM
Positive	125%	100%
Negative	100%	100%

At an AM station the positive modulation peaks must never exceed 125%.

(2) Peak modulation should be maintained at a reasonable level, i.e., 85%. This is intended to mean that in cases where loud sounds are trans-

mitted they should modulate the carrier 85% or more. This does not mean that a program consisting entirely of whispered conversation or soft music must at any time modulate the carrier 85%.

At an FM station, for example, negative modulation peaks should rarely exceed 100%, but it is desirable that the highest peaks reach 85% (depending, of course, on program content).

The *average* level of modulation is not governed by the rules and, of course, is largely dependent on the program material and the audio equipment. It could reasonably be expected to be between 25% and 75%.

Overmodulation

If the limits given above are exceeded, the transmitter is *overmodulating* and the condition must be corrected immediately by reducing the audio signal with the appropriate channel attenuator, the master gain control, or the automatic controls. In AM stations, overmodulation distorts the signal; in both AM and FM stations it may cause interference to other stations.

Modulation Monitor

The modulation monitor is a device, separate from the transmitter, that is used to measure and display the level of modulation which the transmitter is actually producing. It has two main features (see *Figure 5–8*). The meter indicates the average level of modulation on two scales. The percent scale is the correct one for the operator to use and is calibrated from 0 to 110% (or higher). The decibel (dB) scale is added for the convenience of conducting certain tests and may be disregarded for regular program operation.

Although this meter is useful for observing the average level of modulation it is important to remember that the Commission *does not specify modulation limits in terms of average values.*

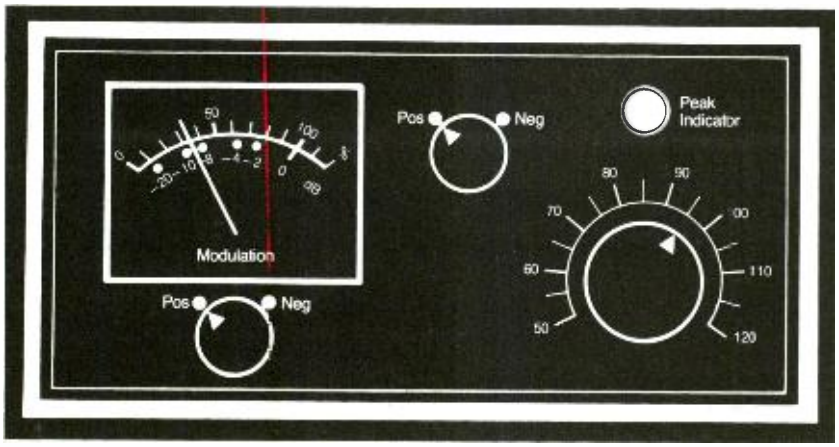


Figure 5–8

Modulation monitor. Other configurations are possible.

The other feature is the peak indicator. It works in this manner. Select either positive or negative modulation with the switch. Turn the dial to the modulation level to be checked.

Whenever the modulation peaks exceed this level, the light will come on. In the example given in *Figure 5–7*, if the operator had set the dial to 100%, the light would have flashed briefly only once during the 10 seconds. If the dial had been set to 75%, the light would have been out for about 4 seconds, flashed twice, been off again for another 3 seconds and then flashed twice again.

Inoperative Modulation Monitor

If the modulation monitor becomes inoperative, a station may continue to operate without the monitor for up to 60 days without notifying the Commission provided some other acceptable means is employed to measure the modulation.

At any station employing an alternate means of measuring modulation, the chief operator or other qualified person must ensure that all operators are instructed in its operation and use.

Summary

Modulation occurs when either the amplitude or frequency of a radio frequency carrier is changed.

Modulation is measured in *percent*.

The amount of modulation is determined by the amplitude (or loudness) of the audio signal.

The audio signal is adjusted by means of a channel gain control (attenuator, pot, etc.), a master gain control, or automatic control.

The VU meter on the control console follows the average level of the audio signal and does not indicate the value of modulation peaks.

The modulation monitor (1) measures the average level of modulation and (2) can be set to indicate when modulation peaks exceed some predetermined percentage (by the peak "indicator" or "flasher").

Modulation limits are specified in terms of *peaks of frequent recurrence*.

Generally, modulation should equal or exced 85% on peaks of frequent recurrence but may be lower depending upon program material.

Modulation may not exceed

AM

100% on negative peaks of frequent recurrence.
125% on positive peaks *at any time*.

FM

100% on both negative and positive peaks of frequent recurrence.

If the modulation monitor becomes defective the station many continue to operate by using some other acceptable means to observe the modulation.

6

Operating Power

Definition

The unit of electrical power was defined in the chapter on FUNDAMENTALS as the *watt* (W). Two equations for calculating power were given:

$$(1)\ P = E\,I$$
$$\text{and } (2)\ P = I^2R$$

Both of these equations are used at broadcast stations.

Operating Power

In broadcasting, the power radiated by the antenna determines both a station's area of coverage and the distance at which one station may cause interference to another. This power is sometimes called antenna power or antenna input power or more commonly, operating power. The latter term will be used throughout this manual.

Transmission Line

The line that connects the transmitter with the antenna is called an *RF transmission line* or, simply, *transmission line.*

Direct and Indirect Methods

The most straightforward and usual method for determining operating power is by measuring the power or current flowing directly into the antenna, hence the name "direct method". To do this the measurements must be made somewhere between the output of the transmitter and the input of the antenna.

If the measurements are made at any other point in the system, the operating power can only be calculated indirectly. The result is generally not as accurate as when the direct method is used.

Except under certain conditions, AM stations must use the direct method. FM stations may use either the direct or indirect method at the discretion of the station licensee. The indirect method is most commonly employed.

Antenna Resistance and Current

In order to calculate the operating power at an AM station, it is sufficient to know only two quantities—the resistance of the antenna and the current flowing into the antenna. The resistance was measured and recorded when the antenna was

erected. Unless a change occurs in the antenna system, the resistance will remain at this measured value, such as

R = 35 ohms

The resistance is not controllable by the operator and is not read on any meter. The antenna current is obtained from a meter installed at the base of the tower and known as the antenna ammeter. Many stations employ a remote antenna ammeter which measures the current at the base of the antenna but displays it on a meter inside the station for the convenience of the duty operator. The use of a remote antenna ammeter does not imply that the station is operated by remote control.

Common Point Resistance and Current

At any AM station equipped with a directional antenna system—that is, one that has two or more towers—the antenna current is measured at the single point from which all of the towers are fed. This is called the *common point* and the associated meters are the *common point ammeter* and the *remote common point ammeter*. The antenna resistance will have been determined at this point and is called the *common point resistance*. *Figure 6–1* illustrates the difference between directional and nondirectional stations. The symbol for current, I, has a subscipt "a" to identify it as antenna current.

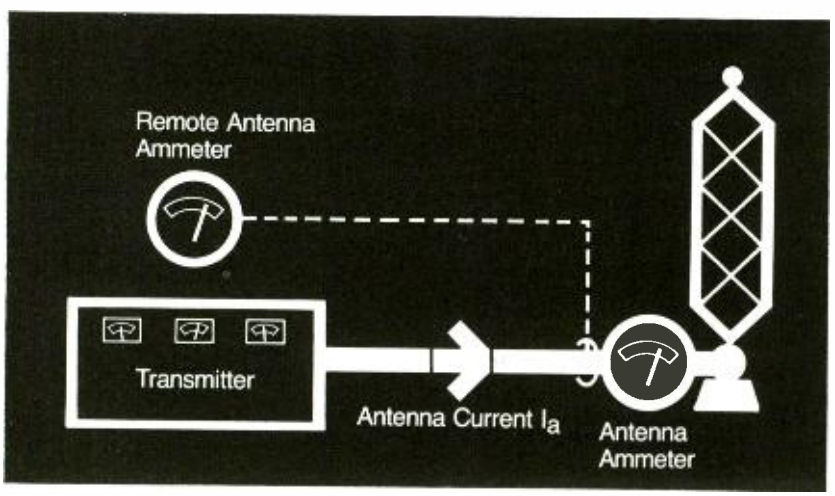
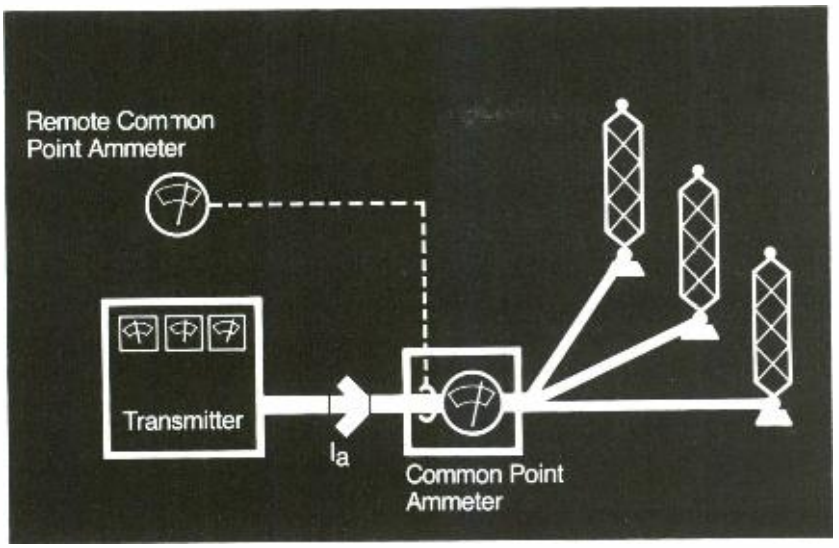


Figure 6–1

(a) Nondirectional AM station.



(b) Directional AM station.

Direct Method—AM

Knowing the antenna current (I_a) and antenna resistance (R) it is a simple matter to calculate the operating power by the direct method. Note that equation (2) must be used ($P = I^2R$)

Example 1. If the antenna ammeter reads 8.2A and the antenna resistance is 14.9 ohms, calculate the operating power by the direct method.

$$P = I_a^2R$$
$$= (8.2) \times (8.2) \times (14.9)$$
$$= 1002 \text{ watts or approximately 1 kW}$$

Example 2. If the remote common point ammeter reads 11.9A and the common point resistance is 35.3 ohms, the operating power as determined by the direct method is:

$$P = I_a^2R$$
$$= (11.9)^2 \times (35.3)$$
$$= 4999 \text{ W or approximately 5 kW}$$

Direct Method—FM

In FM stations, all of which operate at much higher frequencies than AM stations, it is difficult to measure the antenna current accurately. A station which elects to determine its operating power by the direct method must install and calibrate a special meter in the transmission line, called an RF transmission line meter. This meter may be calibrated in watts, percent of authorized power or other units. Unless the power can be read directly, the operator must compare the actual reading to a chart or table to determine the true operating power.

For several reasons, stations may not always use the direct method to determine their operating power. The one reason most likely to concern the operator is *equipment failure.* If the transmission line meter (FM) or normal and remote antenna ammeters (AM) become defective, it is not possible to calculate the operating power directly, so the operator must resort to an *indirect method.* The technique is the same for both AM and FM and involves measuring the power going into the transmitter, multiplying this by the *efficiency* (F) of the transmitter and assuming this to be approximately equal to the true operating power.

Transmitters consume electrical power in many ways but most of it is in the final power amplifier that feeds the antenna system. The voltage and current which provide the power for this amplifier are referred to as *plate voltage* (Ep) and *plate current* (Ip). The input power is calculated by using equation (1) shown at the beginning of this chapter.

$$P = EI$$

or

$$P \text{ (input)} = E_p \times I_p$$

If the transmitter were 100% efficient all of this input power could be delivered to the antenna. In practice much of this power is wasted, usually in the form of heat, which reduces the transmitter efficiency (F) to between 35 and 90%. The operating power is now determined indirectly from the transmitter input power by the formula.

$$P = E_p \times I_p \times F$$

See Figure 6–2.

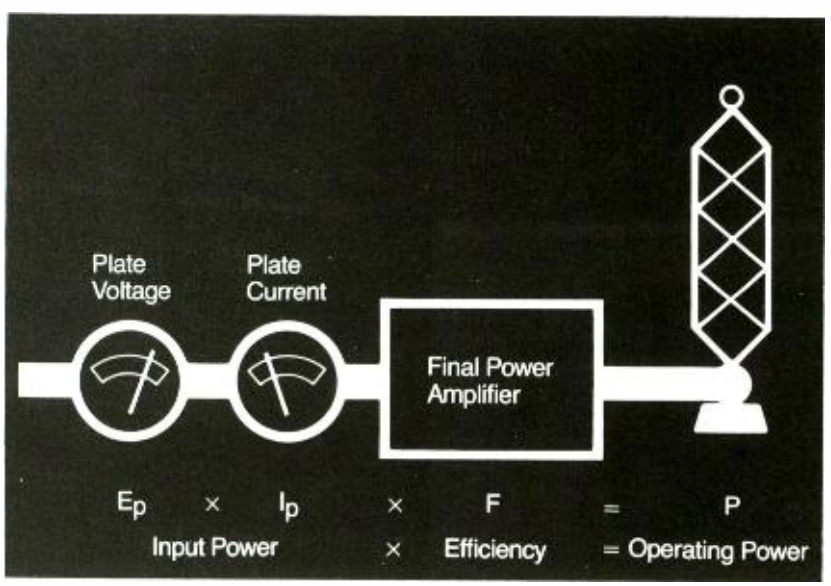


Figure 6–2

Diagram for calculating antenna power by indirect method.

Example 3. If the plate voltage is 3009 volts, plate current 0.382 amperes and transmitter efficiency 71.5%, calculate the operating power by the indirect method.

$$P = E_p \times I_p \times F$$
$$= (3009) \times (0.382) \times (.715)$$
$$= 822 \text{ watts}$$

Transmitter Efficiency Factor (F)

The efficiency factor (F) will be provided by the chief operator.

Effect of Modulation on Meters

One characteristic of AM is that modulation causes the antenna current to increase, resulting in greater radiated power which extends a station's area of coverage and is the reason AM stations try to maintain the average level of modulation as high as possible. Antenna current measurements made with the carrier modulated will cause an error in the determination of a station's operating power. Therefore, in an AM station, the antenna current must be read when the carrier *is not being modulated.* In fact, as a general rule—

Any meter which is affected by modulation must be read when the carrier is unmodulated.

The reading should be made at a natural break in the program or the operator may introduce a deliberate pause.

Example 4. In a 1000 watt station the antenna resistance is 52 ohms. When the announcer speaks into the microphone the antenna current reads as high as 5.1 amperes. When the announcer stops talking, the antenna current drops to 4.39 amperes. Calculate the operating power by the direct method.

(A) $P = I_a^2R$
$= (5.1) \times (5.1) \times (52)$
$= 1353$ watts

Wrong! This is far too high and would cause the operator to believe that the station was operating above its authorized power.

(B) $P = I_a^2R$
$= (4.39) \times (4.39) \times (52)$
$= 1002$ watts
CORRECT!

Limits

In all stations the operating power must be maintained as near as is practicable to the authorized value but not less than 90% nor more than 105% of this value. These limits should be considered as applying to short term variations only; consistent day-to-day operation at 95% or 105% of authorized power is not acceptable. If it becomes technically impossible to operate with the authorized power, a station may operate at *re-*

duced power for up to 30 days provided the Commission is notified by the 10th day. If the power becomes excessive and the operator cannot reduce it by means of any of the permitted adjustments and a first class operator is not present, the station must stop transmitting until it has been restored to proper operation.

Operator Duties

Since any station employing third class operators must post the upper and lower limiting values of all operating parameters the operator will generally not have to calculate the exact operating power—except in one instance. If an AM station is using the *indirect* method of power measurement, the operator must calculate either the transmitter input power ($E_x \times I_p$) or output power ($EP \times I_p \times F$) and record that value in the operating log for each entry of plate voltage and plate current.

Example 5. An AM station has an authorized operating power of 50,000 watts and an antenna resistance of 610 ohms. Its normal antenna current is 9.05 amperes.

$P = (9.05)^2 \times (610) = 49{,}961$ watts

At 105% power, $P = 52{,}500$ watts and $I = 9.27A$

$P = (9.27)^2 \times (610) = 52{,}419$ watts

At 90% power, $P = 45{,}000$ watts and $I = 8.59A$

$P = (8.59)^2 \times (610) = 45{,}010$

Note: the results do not check exactly because the antenna current is only given to two decimal places.

An operator at this station must maintain the antenna current between 8.59A and 9.27A, and as close to 9.05A as possible.

When using the indirect method both E_p and I_p can vary and the station must post a graph or chart showing which *pairs* of values are within limits.

Summary

The operator on duty is responsible for measuring and adjusting the station's operating power.

This power can be measured by either the direct or indirect method.

In the direct method, measurements are made at the base of the antenna (AM), the common point (AM-directional) or in the transmission line (FM).

In the indirect method, measurements are made at the input of the final amplifier.

FM stations may use either the direct or indirect methods. Most use the indirect method.

- Direct—RF transmission line meter at output of transmitter.
- Indirect—$E_p \times I_p \times F$

AM stations must use the direct method except in special circumstances.

- Direct—I_a^2R where I_a is antenna (or common point) current and R is antenna resistance.
- Indirect—$E_p \times I_p \times F$

If an equipment failure prevents the operator from using the direct method he must use the indirect method.

At all stations where third class operators are employed, the upper and lower limiting values must be posted for (where appropriate): antenna current, common point current, transmission line meter values, plate voltage and plate current.

Normally the operator is not required to calculate the operating power but must maintain the transmitter within specified limits of voltage and current.

Exception: In an AM station using the indirect method the duty operator must calculate and log $E_p \times I_p$ or $E_p \times I_p \times F$

The operator must maintain the operating power as close to the authorized value as possible. Stations may not operate at excessive power (over 105% of authorized value).

Stations may operate at reduced power (under 90% of authorized value) if technical reasons prevent full power operation.

7

Directional AM Stations

Nondirectional Antennas

An AM broadcast station which radiates a signal equally in all directions is called nondirectional. Such a station requires only one tower for its antenna and is most effective when it is located near the center of the community it is licensed to serve, as in *Figure 7–1.*

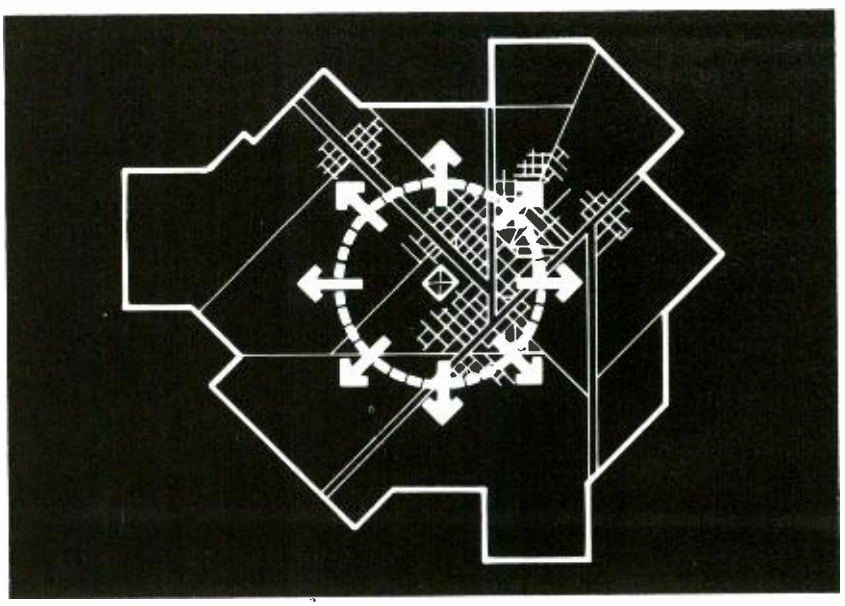


Figure 7–1

Nondirectional antenna. The signal is radiated equally in all directions.

Directional Antennas

A station which is required to control the radiation of its signal in some directions must use a *directional antenna system.* Such a station might be located on the edge or even outside of its community and may wish to increase its signal in that direction or may have to reduce its power in another direction to prevent interference to another station. All directional antennas have two or more towers.

Figure 7–2 shows two stations, A and B, serving different communities but operating on the same frequency. Station "A" is located outside of its community and therefore a directional antenna helps it to put more of its signal in the desired

area. Also, to prevent interference to station "B", the system has been designed to radiate very little signal in that direction.

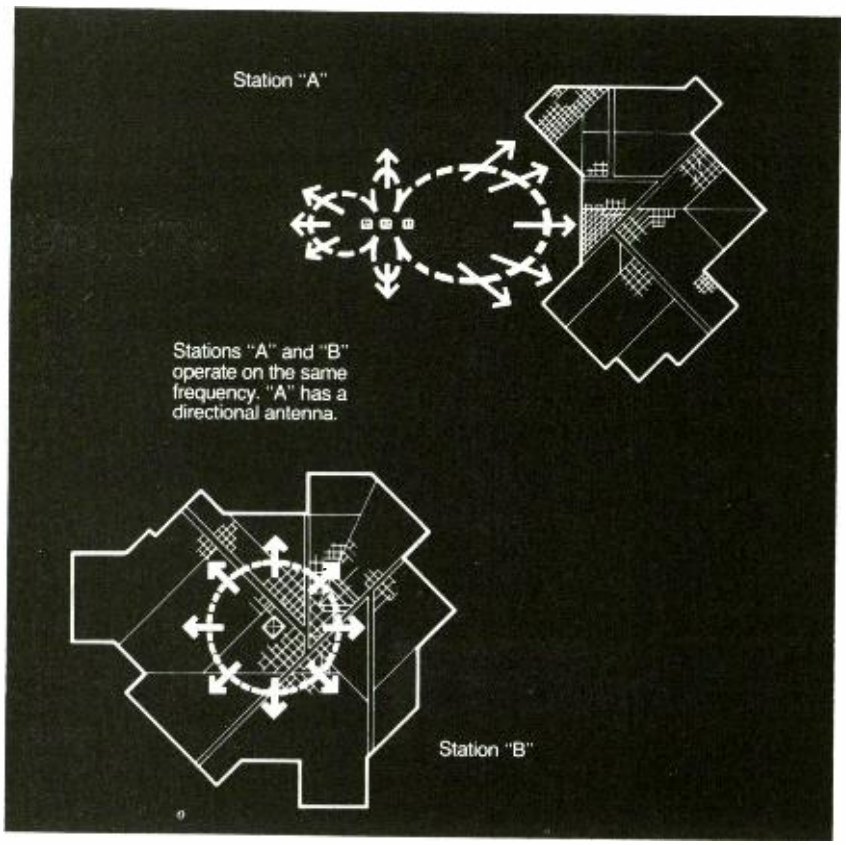


Figure 7–2

Directional and nondirectional stations.

Directional Antennas —Design

Many factors influence the design of an antenna system which will produce the desired radiation pattern. In an ideal situation the pattern is determined by:

- Size and shape of towers
- Number of towers
- Placement of towers
- *Phase of current* in each tower
- *Relative amplitude of current* in each tower

In practice the antenna pattern will also be influenced by:

- Surrounding terrain
- Ground moisture
- Nearby structures (water towers, power lines)
- Weather
- —and other factors

Note that after an antenna system has been constructed the only two factors that are readily controllable are the *phase* and *relative* amplitudes of the RF currents in each tower.

For the more technically minded, the basis of all directional antennas, regardless of type, is *wave interference*. Each tower radiates

a radio wave. In some directions these waves cancel one another; in other directions, they reinforce. The heart of the problem is to produce the cancellations and reinforcements in the desired directions.

Phasor

In a nondirectional station the transmitter supplies the radiofrequency signal (the antenna current) directly to the antenna. In a directional station, it is necessary that this RF signal or current first be divided properly among the towers.

In *Figure 7–3* it can be seen that the device which divides and distributes the RF current is called a *phasor.* The current flowing from the transmitter to the phasor is the *common point current.* This common point current is used to calculate the operating power of a directional AM station. The current which flows from the phasor to each tower is called *antenna base current.* This current can be measured with an ammeter installed at the base of each tower.

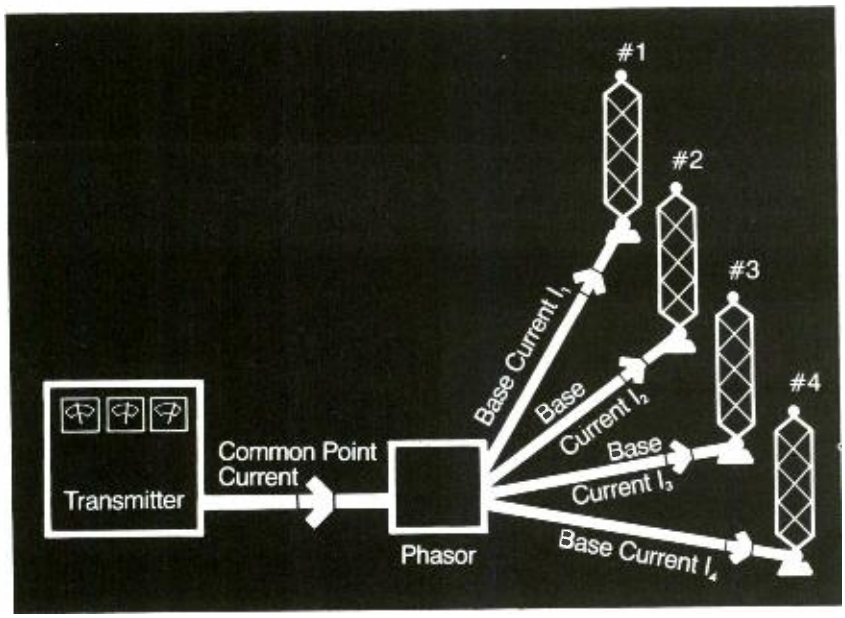


Figure 7–3
Phasor

Usually the current is divided unequally so that more will flow to one tower than to another. For example, a set of readings taken on the base ammeters in *Figure 7–3* above might show the following:

Tower	#1	#2	#3	#4
Base current	2.45A	5.9A	6.6A	4.7A

Phase

In addition to regulating the amount of the current flowing to each tower the phasor introduces a time shift so that, as the RF signal is divided, the fractional part transmitted to one tower may arrive at that tower before or after the remaining signal arrives at the other towers. In the chapter on FUNDAMENTALS this difference in timing was called *phase* and was measured in

degrees. If tower #3 is used as a *reference*, typical phase values for the four tower array shown in *Figure 7–3* might be:

Tower	#1	#2	#3	#4
Phase	18°	−144°	0°	105°

This says that the phase of the current in tower #1 is 18° ahead (+18°) and that in tower #2 is 144° behind (−144°) the current in the reference tower. The difference in phase between tower #4 and the reference tower is +105° (105° ahead).

Current Ratio

Because the antenna pattern depends on the *relative* amplitudes of the base currents, the base current measurements of the four tower antenna system must be converted into another form. Again using tower #3 as a reference the following *ratios* can be calculated:

$$\frac{\text{Tower \#1}}{\text{Tower \#3}} = \frac{2.45}{6.6} = 0.37$$

$$\frac{\text{Tower \#2}}{\text{Tower \#3}} = \frac{5.9}{6.6} = 0.89$$

$$\frac{\text{Tower \#3}}{\text{Tower \#3}} = \frac{6.6}{6.6} = 1.0$$

$$\frac{\text{Tower \#4}}{\text{Tower \#3}} = \frac{4.7}{6.6} = 0.71$$

This says that the ratio of the current in tower #1 to that in tower #3 is 0.37, and so on. These are called *antenna base current ratios;* it is the ratios and not the actual currents which determine the directional pattern.

Antenna Monitor

Both current ratios and phase are measured with an *antenna monitor.* This device is connected to a pickup loop mounted on each tower which "samples" the current flowing in that tower. It automatically compares these sample currents and displays the phase and what is called a *loop sample current ratio.*

Most antenna monitors operate in basically the same manner. The operator first selects the reference tower to check the calibration (phase = 0°, current ratio = 1) and follows this with readings taken from each of the other towers. The operator then compares these readings with the values posted by the station licensee to ensure that the directional antenna system in operating properly. In a three tower array the authorized and measured values for the loop sample current ratios might be:

Tower	#1	#2	#3
Loop Sample Current Ratios	0.360	1.0	0.910
Posted limits	0.342–0.378	1.0	0.865–0.955
Actual measured values	0.371	1.0	0.894

Figure 7–4 shows a typical antenna monitor with the phase and loop current meters.

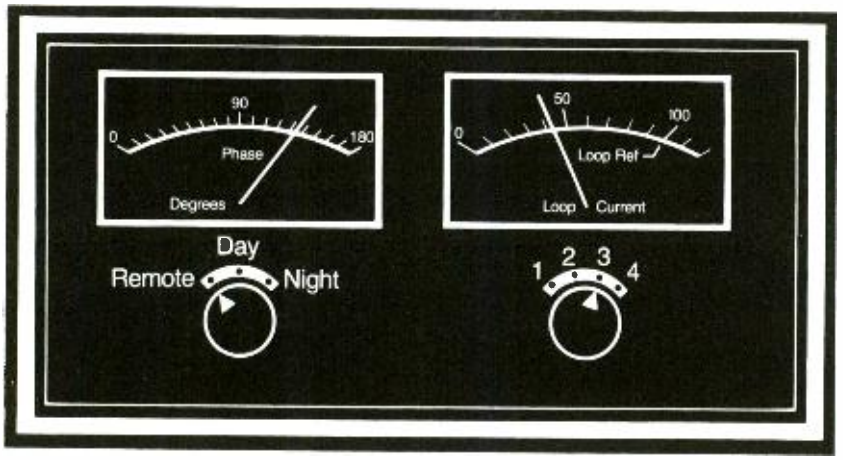


Figure 7–4
An antenna monitor.

The meter is to be calibrated so that the reference tower has a loop current of 100; the current ratios can then be read as decimal fractions by dividing the meter reading by 100, i.e., a loop current reading of 47 means a current ratio of 0.47, a reading of 22 means a ratio of 0.22, etc.

Phase indications can be read directly from the phase meter.

Table 7–1 contains values taken from the license of a hypothetical station with four towers. Note that the sample current ratios are not related to the base current ratios.

Tower	#1	#2	#3	#4
Phase	0	21°	−144°	105°
Base Current Ratio	1.0	0.980	0.238	0.506
Antenna Monitor Sample Current Ratio	1.0	1.0	0.417	0.882

Operators at directional AM stations must be familiar with the operation of antenna monitors, including those steps necessary to determine if the phase is ahead (+) or behind (−). Instructions are usually provided by the chief operator.

A Directional AM Station

Figure 7–5 depicts a directional antenna system showing the relationships between phasing unit, common point current, base currents, and the loop sampling system.

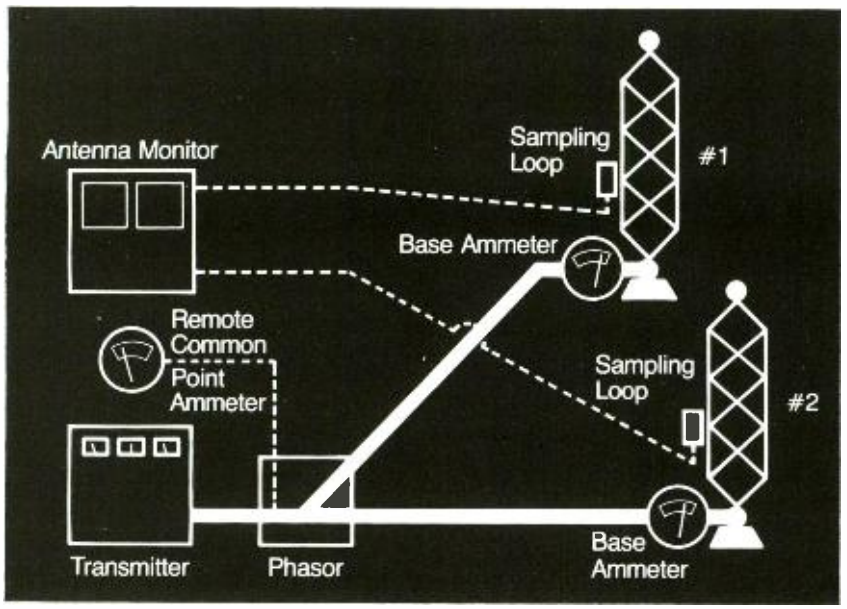


Figure 7–5.
Elements of a directional AM station.

Defective Antenna Monitor

If the antenna monitor becomes defective a station may continue to operate without it provided the station licensee complies with other requirements described in the rules.

Summary

A nondirectional antenna radiates equally in all horizontal directions.

A directional antenna radiates more of its signal in some directions than in others.

To produce a directional pattern an antenna system must have two or more towers and (usually) differences in antenna base current amplitude and phase.

The transmitter produces a single radiofrequency signal that is distributed to the individual towers by the phasor.

Phase and current ratio are always given with respect to a reference tower. Phase is measured in degrees and may be ahead of (+) or behind (−) the reference.

Tower	#1	#2	#3
Phase	90°	0°	−51°
Base Current Ratio	0.222	1.0	0.711
Antenna Monitor Sample Current Ratio	0.81	1.0	1.0

Tower #2 is the reference tower.
Tower #1 Phase is 90° ahead of Tower #2.
Tower #3 Phase is 51° behind Tower #2.

The ratio of the base current in Tower #1 to that in Tower #2 is 0.222.

The ratio of the *sample current* in Tower #3 to that in Tower #2 is 1.0 (i.e., they are equal).

An antenna monitor is used to measure loop sample current (also called antenna monitor sample current) ratios and phase.

The authorized values for phase, base current ratios and loop sample current ratios are given on each directional station's license. Stations employing third class operators must post the upper and lower limits of these operating parameters.

If the antenna monitor becomes defective, a station may continue to operate without it provided it complies with other requirements described in the rules.

8

Meters

Definition

In a broadcast station, meters are used to measure power, phase, voltage, current, and modulation. Most meters can be characterized by 3 important features.

(1) Purpose
(2) Units
(3) Scale

The *purpose* of a meter is that particular variable it is designed to display such as plate voltage, antenna current, modulation, or other parameter. It should be shown on an identification plate attached to or adjacent to each meter.

The *units* identifies the exact quantity displayed such as percent, amperes or milliamperes, volts or kilovolts, and is usually printed on the face of the meter by the manufacturer.

The *scale* refers to the series of marks and numbers on the face of the meter. *Figure 8–1* shows a segment of the scale on a voltmeter.

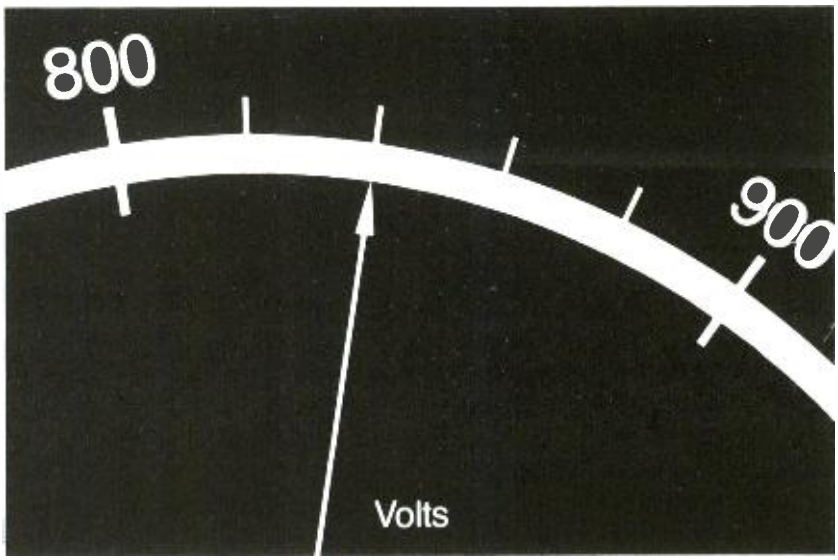


Figure 8–1
A segment of a volmeter scale.

There are 5 divisions between the numbers 800 and 900 (always count the spaces, not the marks).

$$900—800 = 100 \text{ volts}$$

$$\frac{100 \text{ volts}}{5 \text{ divisions}} = 20 \text{ volts/division}$$

Since the needle is two complete divisions above 800 volts, the meter reads 840 volts.

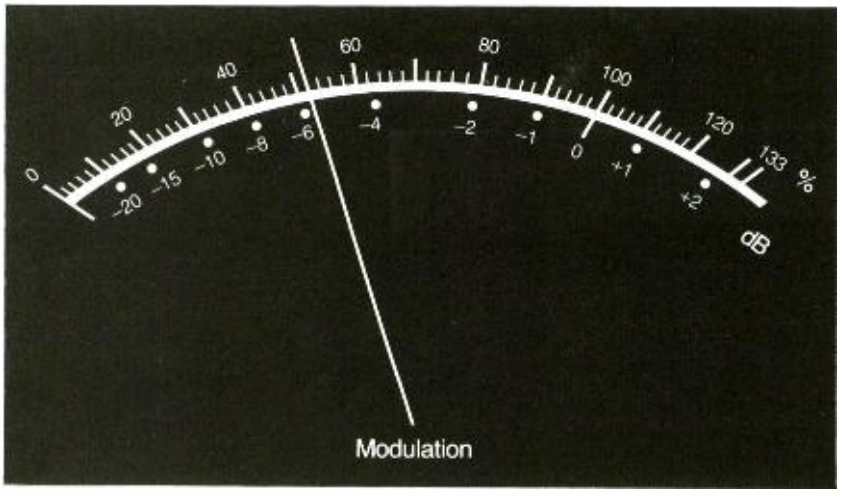
A common error is to assume that each division of the scale always represents 1, 10, or 100. If an operator had done that in this case he might have read the meter as 820 volts which, obviously, is incorrect.

Typical Meters

Following are some examples of meters commonly found in broadcast stations.

Practice reading each meter and check the results with the discussion and answer which follows each example.

A.



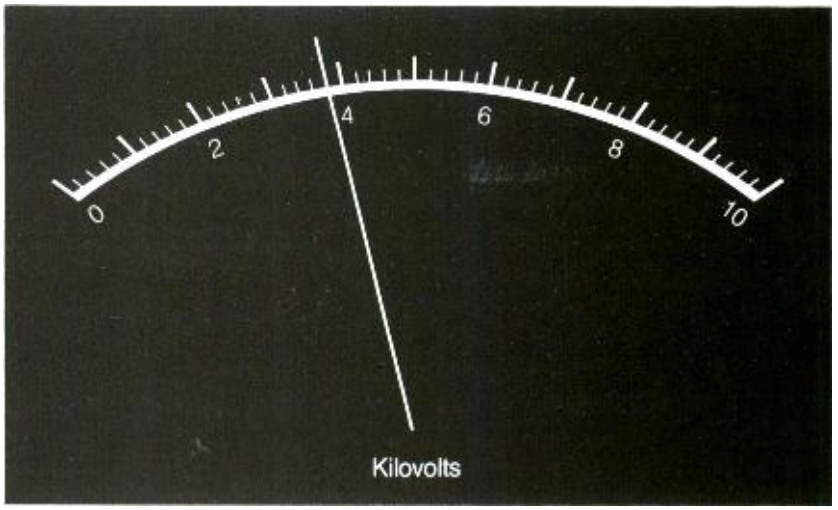
This is part of a modulation monitor and indicates the average level of modulation. The percent scale may be either above or below the decibel (dB) scale. *Disregard the dB scale.*

$$60\% - 40\% = 20\%$$

$$\frac{20\%}{10 \text{ divisions}} = 2\% \text{ per division}$$

Answer: Average modulation is 52%.

B.



This is a typical voltmeter.

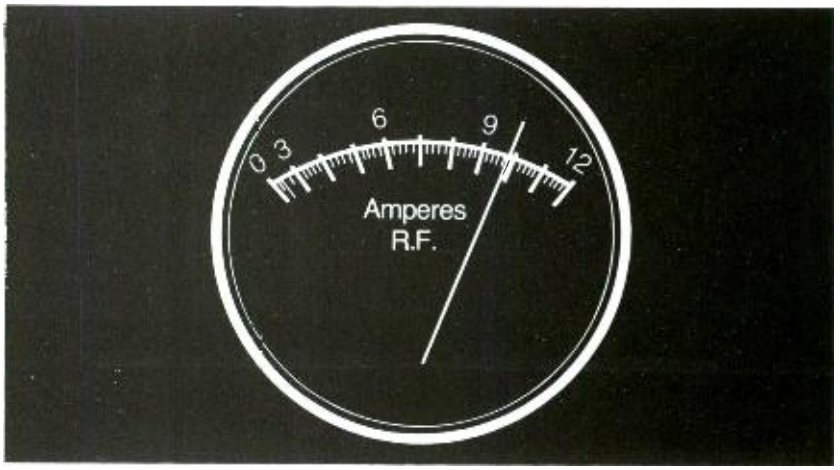
$$4\ \text{kV} - 2\ \text{kV} = 2\ \text{kV}$$

$$= 2000\ \text{volts}$$

$$\frac{2000\ \text{volts}}{10\ \text{divisions}} = 200\ \text{volts per division}$$

Answer: The pointer is 1 division below 4 kV (4000 volts); therefore, the plate voltage is 3800 volts (3.8 kV).

C.

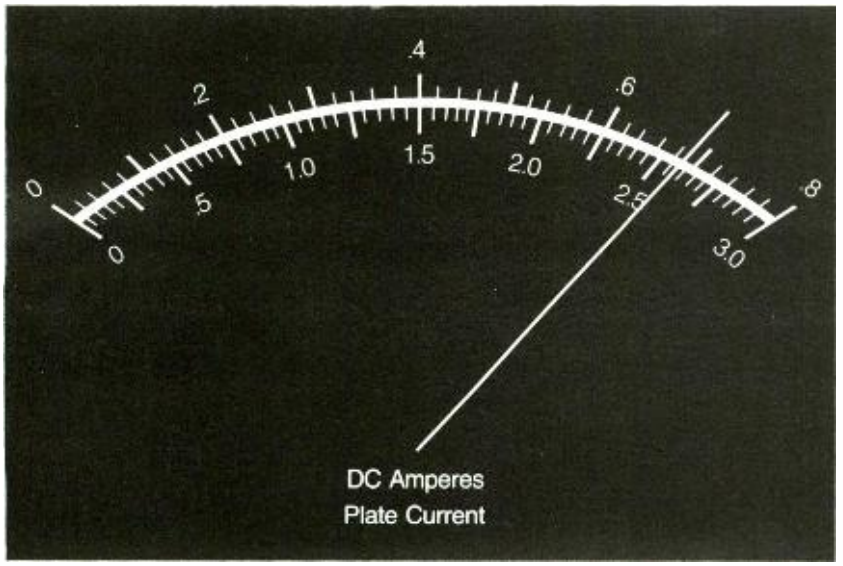


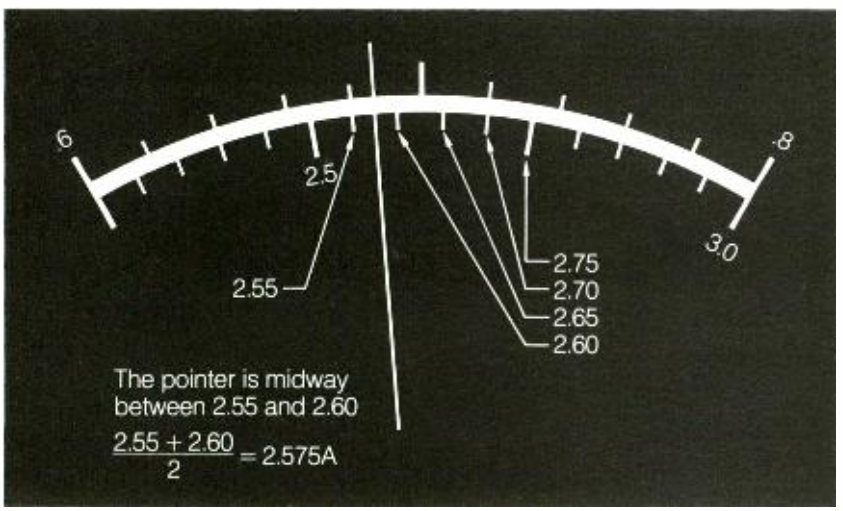
This is an ammeter; it measures current which, in this case, is RF (radiofrequency) current. This type of meter is used for antenna current and common point current. Note that the scale is not uniform but is compressed toward the left. This results from the design of the meter.

$$12\ \text{A} - 9\ \text{A} = 3\ \text{A}$$

$$\frac{3\ \text{A}}{15\ \text{divisions}} = 0.2\ \text{A/division}$$

Answer: The common point current is 9.9 amperes.





This ammeter is slightly more difficult to read; it was designed with two scales to permit broader application.

If the station were using the upper scale—

$$0.8\ A - 0.6\ A = 0.2\ A$$

$$\frac{0.2A}{10} = 0.02\ A/division$$

The needle is approximately 4⅓ divisions above the 0.6 A mark.

$$4.33 \times .02\ A = 0.0866$$
$$= 0.087$$

Answer: Therefore the plate current is 0.6 A + 0.087 A = 0.687 A

On the lower scale—

$$3.0\ A - 2.5\ A = 0.5\ A$$

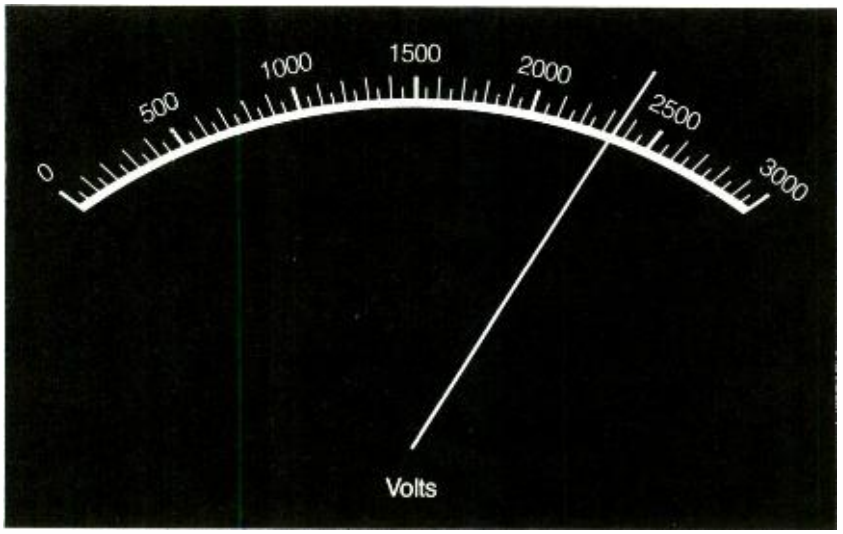
$$\frac{0.5A}{10} = 0.05A/division$$

The pointer is 1½ divisions above 2.5 A

$$1.5 \times 0.05\ A = 0.075\ A$$

Answer: In this case the plate current is 2.5 A + .075 A = 2.575 A

E.



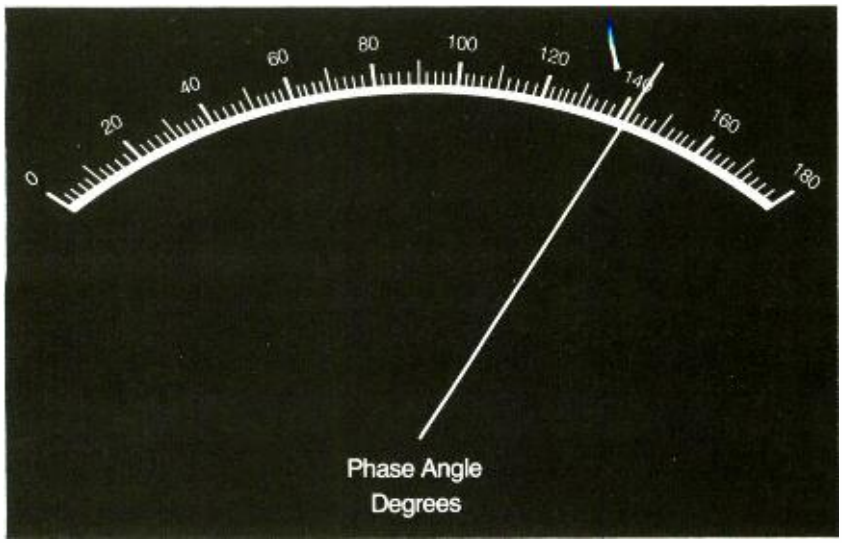
This is another voltmeter but here the units are volts rather than kilovolts.

$$2500\ V - 2000\ V = 500\ V$$

$$\frac{500\ V}{10} = 50\ V/division$$

Answer: This plate voltage is 2350 volts (2.35 kV)

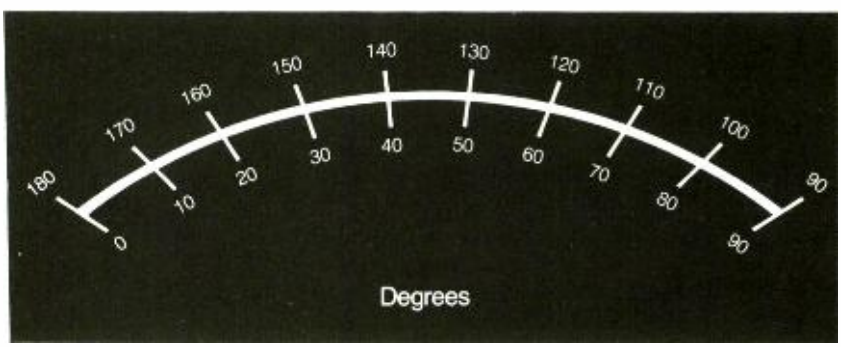
F.



This meter is from an antenna monitor and shows the phase difference between the reference and other towers of a directional antenna.

Some meters have two scales, from 0° to 90° on the bottom and 90° to 180° (reversed) on the top.

G.



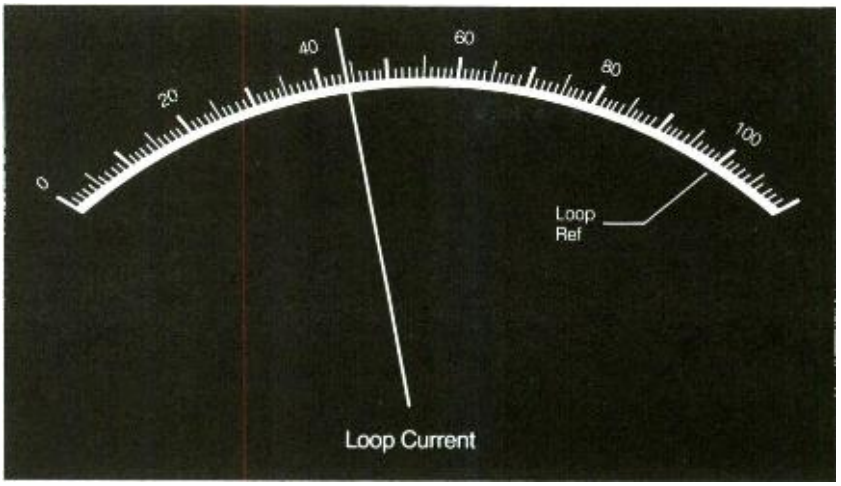
The scale is selected by controls on the monitor.

Returning to meter "F":

$$160° - 140° = 20°$$

$$\frac{20°}{10} = 2°/\text{division}$$

The phase angle is 142°. In this example, it is not known if the phase is ahead (+) or behind (−); however, actual antenna monitors are equipped with means to determine this. One such means is a button on the control panel. When it is depressed, the needle will move a slight distance to the right or left. From instructions supplied by the manufacturer the operator can determine from this movement if the current in the sampled tower leads or lags the current in the reference tower.



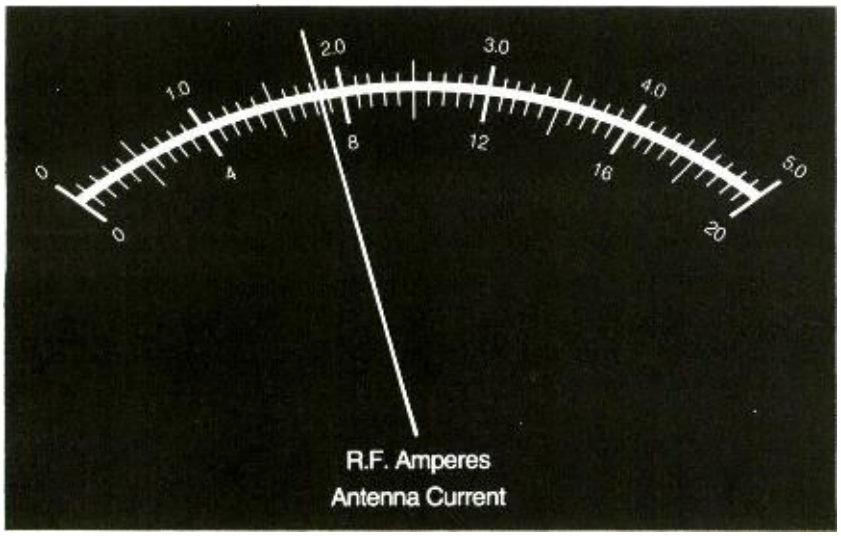
This meter is also part of an antenna monitor. It does not indicate absolute values of base currents but instead is *proportional* to the actual base currents present in the antenna towers. It is used in the following way.

The scale is simple and straightforward. Each division represents 1. The meter shown above reads 44.

(1) If the monitor has been calibrated so that the sample current in the reference tower reads 100 (note: Loop Ref. on meter) the current *ratio* for every other tower can be read directly from the meter. In this instance the *ratio* of the sample current in this tower to the sample current in the reference tower is 0.44.

(2) If the sample current in the reference tower is any value other than 100, for example 96, the current *ratio* must be *calculated*. For this particular tower it is

$$\frac{44}{96} = 0.458$$



This is another dual scale meter. It indicates antenna current and could be either the normal or remote meter.

The upper scale presents no difficulty. Each division represents 0.1 amperes and, therefore, the antenna current is 1.85 A.

If the lower scale is used:

$$8\ A - 4\ A = 4\ A$$

$$\frac{4\ A}{10} = 0.4\ A/division$$

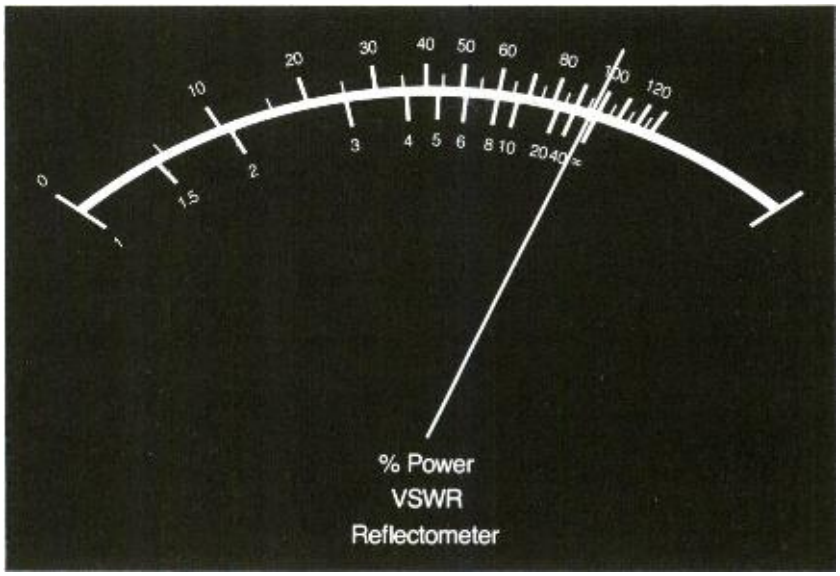
The needle is 1½ divisions *below* 8 A.

$$1.5 \times 0.4\ A = 0.6\ A$$

$$8\ A - 0.6\ A = 7.4\ A$$

The antenna current is 7.4 amperes. Of course, if the operator had noticed that the lower scale is 4 times that of the upper, he could have obtained a reading by multiplying

$$4 \times 1.85\ A = 7.4\ A$$



This is one type of RF transmission line meter used by FM stations which determine their operating power by the *direct* method. The upper scale displays *percent of authorized power;* the lower scale should be disregarded.

Each division represents 5 percent. The needle is about 1½ divisions above 90 percent so that this station's actual power is 97½ percent of its authorized (licensed) power:

Example: If an FM station is authorized 39 kW operating power, this meter would have been calibrated to read 100 percent when the transmitter output was 39 kW. The transmitter output power at the time this reading was taken was 97½ percent of 39 kW.

$$.975 \times 39{,}000\ \text{W} = 38{,}025\ \text{watts}$$
$$(38.025\ \text{kW})$$

Importance of Accuracy

The following illustration emphasizes the importance of accuracy and demonstrates the effect of small errors. In each of the three cases below a segment of the antenna ammeter at a nondirectional 1 kW AM station having an antenna resistance of 83.33 ohms is shown. Since this is an AM station, the readings were taken with *no modulation* (0%). The meter readings will be used to calculate the station's power, using the equation $P = I^2R$.

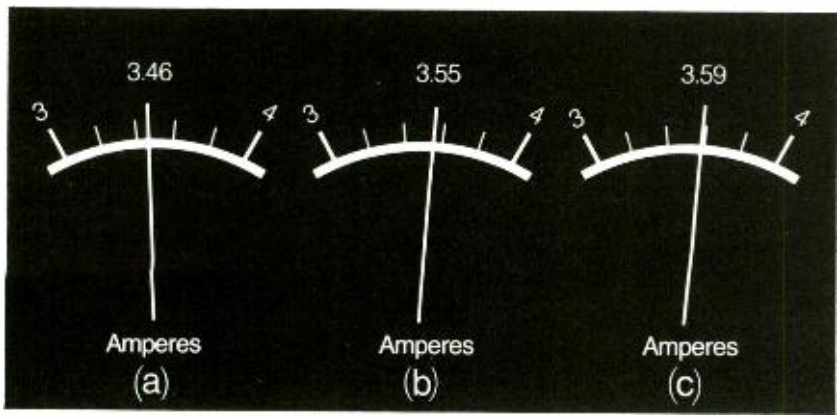


Figure 8–2

Antenna ammeter at AM station—3 cases.

In *Figure 8–2* (a) the antenna current is 3.46 amperes.

$(3.46)^2 \times 83.33$ ohms = 998 watts

This is the value of antenna current which results in the authorized operating power.

In *Figure 8–2* (b) the antenna current is 3.55 A.

$(3.55)^2 \times 83.33$ ohms = 1050 W.

This value of antenna current results in the maximum permissible operating power (105% of 1000 W).

The pointer in *Figure 8–2* (c) indicates 3.59 A.

$(3.59)^2 \times 83.33$ ohms = 1074 watts

In this case the station is exceeding the upper limit of its authorized operating power.

Note that the difference between (b) and (c) is very small; a careless reading of (c) might have lead an operator to believe that the antenna current was only 3.55 amperes—the upper limit—when in fact the operating power exceeded the permissible limit.

Obviously, the station in example (c) should reduce its power. What is not so obvious but is still required by the rules is that the station in example (b) should also reduce its power. The actual operating power of broadcast stations should be maintained as near *as is practicable* to *the authorized power.*

Extension Meters

In stations where, because of the design of the building, it is difficult to locate the transmitter and monitors sufficiently close to the operator the station licensee may, without further authority, install *extension meters.* These indicate the actual operating parameters of the transmitting system but are physically located external to the transmitter.

The transmitter must be in the same building as the operator and no more than one floor above or below. Plate voltage, plate current, antenna current, common point current,

and RF transmission line indications (as appropriate) must be observed at the extension meter location. The modulation monitor may be installed at the extension meter location, or at the transmitter location provided the extension meter location is also equipped with a percentage modulation meter and peak indicating device.

If a station is equipped with a type approved antenna monitor, it must be installed at the transmitter, but external meters may be provided at the extension meter location.

Extension meters resemble those which have been discussed in the text and should be read in the same manner.

9

Remote Control

Definition

A broadcast station is said to be operated by *remote control* when the control point for the transmitting system is not located at the transmitter site. The transmitter and control point may be as little as a hundred yards apart but usually the separation amounts to several miles. Stations require special authorization from the Commission to operate by remote control and equipment must be installed at the control point which will permit the operator to perform all monitoring and operating functions required by the rules.

The remote control point and transmitting system are normally connected by telephone lines which serve three purposes—

(1) Carry program material from studio to transmitter.

(2) Permit operator, with special equipment, to control transmitter (on/off; raise/lower power, etc.)

(3) Transmit meter indications from transmitter site to the remote control point.

Malfunctions Resulting In Improper Control

If any part of the remote control system malfunctions resulting in *improper control*, the station must *immediately* cease operating by *remote control*. If, at that time, an operator is present at the transmitter and takes control, the station may remain on the air. If an operator is *not immediately* available at the transmitter site, the station must cease operation until one arrives at the transmitter and takes control or until repairs are effected.

An example of this type of malfunction could occur at an AM station where the operator is unable to change from a nondirectional to a directional antenna at sunset as required by the terms of the station license. Unless there is an operator present at the transmitter who can take control and make the required change, the station must cease transmitting.

Malfunctions Resulting In Inaccurate Meter Readings

If any part of the remote control system has a malfunction which results in inaccurate meter readings, the station must cease operating *by remote control within one hour.* Notice that the station has the same choices as above only now it has one hour in which to take the required action.

If, for instance, an operator noticed the plate current read zero ($I_p = 0$) but a check of the antenna current showed the transmitter to be operating properly, the station could continue to operate *by remote control* for one more hour. At the end of that time the station must have posted an operator at the transmitter to take control or repaired the malfunction or turned the transmitter off.

10

Antenna Lighting

General Requirements

Because of the potential hazard to aircraft most broadcast station antennas or supporting structures are required to be painted with alternate orange and white bands and have aviation red obstruction lights installed and operating. The exact number and placement of the lights depends upon individual circumstances. The exact specifications are contained in each station's license. *Figure 10–1* illustrates some typical lighting configurations.

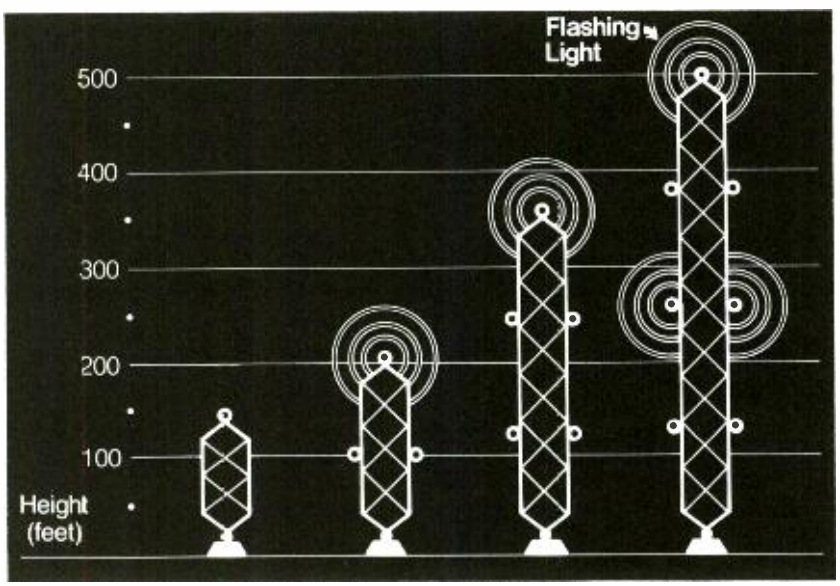


Figure 10–1

Antenna lighting on towers of various heights.

Towers Less Than or Equal to 150 Feet

Not all towers under 150 feet are required to be lighted, but those which are must have two steady-burning red lights installed at the top. These lights must be displayed from sunset to sunrise and may be controlled either manually, by a light sensitive device (photocell), or by a clock mechanism or may be left burning continuously.

Towers Over 150 Feet

Towers over 150 feet in height which are required to be lighted will normally have a flashing red beacon installed at the top and other flashing beacons or steady-burning red lights, as appropriate, installed at intermediate levels. The exact number and placement of these lights depends upon the height of the tower. Generally, towers over 450 feet high require one or more flashing beacons installed at appropriate intermediate points. Both the top and all intermediate lights must be kept burning continuously or controlled by a light sensitive device (Photocell) which will turn them on and off automatically. If this device fails to work properly, the lights must be turned on and left burning continuously until the device is repaired.

Daily Check

If an automatic failure alarm system is not installed, the tower lights must be observed for proper operation once each day and the time of this observation noted in the operating log. A station operated by remote control must have some means of checking its tower lights from the remote control point or have someone view the lights daily.

Malfunctioning Lights

If *any* light is known to be extinguished or malfunctioning, this fact must be noted in the operating log.

If *any top light* or *any flashing beacon* is known to be extinguished or malfunctioning and this cannot be corrected within 30 minutes, the station must notify the nearest Flight Service Station or office of the Federal Aviation Administration (FAA) by telephone or telegraph. The identification of the Flight Service Station and the date and time of the notification must be entered in the operating log. When the light is restored to service the station must again notify the FAA and record the date and time of this notification in the operating log.

Summary

Most broadcast antenna towers must be lighted.

These lights must be checked daily and the time of this check noted in the operation log.

If the lights are controlled by a light sensitive device and this device malfunctions, the lights must be turned on and left burning continuously.

If *any top light* or *any flashing beacon* fails and cannot be restored within 30 minutes, the FAA must be notified promptly. Refer to Section 17.49(c) of the Rules for the exact logging requirements.

11

FM: Stereo and SCA

Monophonic and Stereophonic Broadcasting

In monophonic broadcasting only one audio signal is transmitted and it requires only one speaker for true reproduction. Television and AM radio are examples of monophonic broadcasting. In stereophonic broadcasting two audio signals are combined and transmitted over a single channel in such a way that a listener with a stereo receiver can separate the two signals for reproduction through separate speakers. The reason for using two signals is to afford the listener a sense of the spatial distribution of the original sound sources. The stereo signal may also be received and reproduced through a monophonic system; in that case, however the spatial distribution effect will be lost.

In addition to monaural (monophonic) operation, an FM station may, without further authority, broadcast stereo programming provided its modulation monitor is approved for stereophonic operation. There are no additional logging or monitoring requirements.

SCA

An FM station may also transmit signals other than stereo within its assigned channel, but for this it requires a *Subsidiary Communications Authorization (SCA).* Programs transmitted under authority of an SCA cannot be received without a special receiver or adaptor.

SCA programs are used mainly for subscription background music but may also carry detailed weather forecasting, special time signals or other material of a broadcast nature intended for business, professional, educational, religious, trade, labor, agriculture or other special interest groups. The operator must be able to monitor and control the SCA programming.

SCA Logs

Station identification announcements need not be made on SCA programs; however, each licensee must maintain an SCA *program log* in which a general description of the material transmitted is entered daily.

In order to develop the proper signal, stations transmitting SCA programming employ special modulation techniques using "subcarriers". An *operating log* must be maintained for the SCA subchannel showing:

1. The time the SCA subcarrier generator is turned on and off.

2. The time modulation is applied to and removed from the SCA subcarrier.

Summary

An FM station may broadcast stereo programming without special authorization.

A subchannel which carries programs separate from the main program may also be inserted, but the station must have a Subsidiary Communications Authorization (SCA).

Both program and operating logs must be maintained for the SCA subchannel.

12

Emergency Broadcast System (EBS)

Purpose

The Emergency Broadcast System (EBS) was developed for the purpose of providing the President of the United States and the heads of state and local governments with a means of communicating with the general public in the event of a major or widespread emergency.

National EBS

The National EBS can be activated only on orders from the President. The activation notification (Emergency Action Notification—EAN) will be sent to the major radio and TV networks, the American Telephone and Telegraph Company (A, T & T), the Associated Press (AP) and the United Press International (UPI). From these points the EAN will be disseminated throughout the country by teletype and broadcast.

Activation Procedures

When the National EBS is activated, *all* broadcast stations *must* take the following actions:

(1) Receive EAN via AP/UPI teletype or network line or EBS monitor receiver. Continue to monitor for further instructions.

(2) REFER TO EBS CHECKLIST!

(3) Authenticate EAN. This applies to AP/UPI subscribers and network affiliates only.

(4) Discontinue normal programming and broadcast the first, short announcement given in CHECKLIST.

(5) Transmit attention signal.

At this point participating stations broadcast the appropriate announcement given in the CHECKLIST and continue to monitor for further instructions. A participating station either remains on the air, or removes its carrier but stands by to transmit immediately, depending on whether it is a primary or alternate station. This designation should be marked on the front cover of every CHECKLIST.

Nonparticipating stations also broadcast the announcement given in their CHECKLIST, but then remove their carriers from the air (stop transmitting) for the duration of the emergency.

Termination Procedures

During an emergency, *all* stations continue to monitor for an Emergency Action Termination (EAT). Upon receipt, refer to the CHECKLIST, authenticate the EAT (if appropriate), broadcast the required announcement and resume normal programming.

EBS Checklist

The EBS CHECKLIST is a large folder which contains, in abbreviated form, the correct procedures and announcements for each station to use in the event of a test or real emergency. Every station must have a checklist which should be kept where it is readily accessible to all operators and other persons responsible for taking action during tests and actual emergencies.

Attention Signal

This is described in both the rules and the EBS CHECKLIST. Station licensees must ensure that all operators and any others who may have to take action during tests and actual emergencies have been instructed in the procedures for transmitting the attention signal.

Closed Circuit /Teletype Tests

This section applies only to these stations which are network affiliates or AP/UPI subscribers. In the event of a *closed circuit or teletype test* the operator should refer to the CHECKLIST for instructions. The regular program should not be interrupted nor should the test message be broadcast.

EBS Monitor Receiver

All stations, including 10 watt noncommercial FM stations, must install and operate, during their hours of broadcast operation, equipment capable of receiving Emergency Action Notifications and Terminations transmitted by other radio broadcast stations. This equipment is normally referred to as an *EBS monitor receiver* and need be no more than a receiver tuned to a designated station. If such is the case, someone must listen to the monitor at all times during the hours of station operation. More commonly the EBS monitor is equipped with a circuit that mutes the loudspeaker. When this type of monitor receives an *attention signal*, it activates an alarm and loudspeaker, which in turn alerts the operator to take appropriate action.

Transmission Tests of the Attention Signal and Test Script

All stations are required to conduct periodic tests of the EBS. This test, called the *EBS Transmission Test,* consists of two announcements and the attention signal, as outlined in the EBS CHECKLIST. Ten watt noncommercial FM stations, which are exempt from having the capability to transmit the attention signal will conduct the test without the attention signal, but as otherwise described in the CHECKLIST. Stations are not required to take any action upon *receipt* of an EBS transmission test.

Logging Requirements

Record in the operating or program log

- EBS transmission test (as described above)
- teletype tests (if applicable)
- closed circuit tests (if applicable)
- emergency action notifications and terminations including all significant events
- all broadcasts made pursuant to an emergency action

Local Level EBS

An emergency broadcast system may also be activated at the state and local levels by the appropriate officials in accordance with plans prepared at those levels. All stations which are voluntarily participating, may, at the discretion of management, follow the procedures given in the CHECKLIST. Nonparticipating stations should remain on the air with normal programming.

Summary

The Emergency Broadcast System is a means of communicating with the general public in an emergency.

Stations may participate or not participate at the national, state or local levels. Note that *all* stations *must* have an EBS monitor receiver, *must* conduct tests and *must* respond to a national level emergency notification. The term "participate" is used in the sense that stations may elect to participate or not participate in the broadcasting of emergency communications.

The EBS CHECKLIST outlines the correct procedures and announcements for every station to use in a test or a real emergency. All operators should be familiar with the instructions.

13

Malfunctions

Malfunction

In this chapter the more common malfunctions an operator is likely to encounter at a radio broadcast station are discussed. Following each example is a brief summary of the appropriate action to be taken by the operator. It is assumed that, the operator has been unable to correct the problem using permitted adjustments. (Refer to the rules or the chapter on THE OPERATOR for a discussion of permitted adjustments).

The term "malfunction" is to be understood in the usual sense of "failure to function properly" and can be applied either to the transmitting system or the metering and monitoring equipment.

Serious Malfunction

Whenever the transmitting system is observed operating

(1) beyond the posted parameters, or
(2) in any other manner inconsistent with the rules, or
(3) in any other manner inconsistent with the terms of the station license

and

the adjustments a third class operator is permitted to make cannot correct the condition

and

a first class radiotelephone operator is not present *then* the transmitter must be turned off.

All AM and FM stations:

Modulation monitor fails

Continue operating; notify station licensee who will arrange for alternate means of monitoring

Overmodulation

A *serious malfunction;* see above

Overpower

A *serious malfunction;* see above; (e.g., Could happen at sunset when operator unable to reduce from daytime to nighttime power)

Underpower

Continue operating; notify station licensee; (e.g. Could happen at sunrise when operator unable to increase power to daytime conditions)

EBS monitor fails

Notify station licensee; monitor using other radio receiver if available

Tower lighting—any top light or any flashing beacon fails

Notify station licensee; notify FAA if unable to correct within 30 minutes; make entry in operating log

Tower lighting—intermediate (side) light fail

Notify station licensee; make entry in operating log

Plate voltmeter or plate ammeter fails

Notify station licensee

AM stations:

Remote antenna ammeter fails

Use regular antenna ammeter; read and log antenna current once each day for each mode of operation

Remote and regular antenna ammeters fail

Determine operating power by the indirect method; log the product $E_p \times I_p$ or $E_p \times I_p \times F$ for each entry of E_p and I_p; log the value of F daily, for each mode of operation.

FM stations:

Plate voltmeter or plate ammeter fails

Monitor power by means of RF transmission line meter

RF transmission line meter fails

Determine power by indirect method

Stations operated by remote control:

Malfunctions resulting in improper control

Cease operating by *remote control* immediately; station may continue or resume broadcasting only if an operator takes control at transmitter

Malfunctions resulting in inaccurate meter readings

As above except stations have one hour to correct malfunctions or post operator at transmitter or turn transmitter off.

Directional AM stations:

Remote common point ammeter fails

Use regular common point ammeter; read and log antenna base currents once each day for each mode of operation

Remote and regular common point ammeters fail

Determine operating power by the indirect method; log the product $E_p \times I_p$ or $E_p \times I_p \times F$ for each entry of E_p and I_p; log the value of F daily, for each mode of operation

Antenna monitor fails

Continue operating; notify station licensee

Antenna fails to switch from daytime to nighttime pattern

A *serious malfunction;* see above

Antenna fails to switch from nighttime to daytime pattern

A *serious malfunction;* see above

Stations employing extension meters:

Malfunction of any component of the extension meter system

The pertinent entries required in the station's operating log must be read and logged from the meters located at the transmitter or incorporated in the antenna monitor. If the malfunction affects indications of modulation, another acceptable means of measuring modulation must be provided at the extension meter location.

14

Station Identification

When

Every broadcast station is required to identify itself

- at the beginning (sign on) and ending (sign off) of each period of operation.
- hourly, as close to the hour as feasible, at a natural break in the program.

Content

The official station identification to be used at those times shall consist of the *station's call letters* followed by the name of the *community or communities* specified in its license as the station's location. The name of the licensee as stated on the station's license may be inserted between the call letters and the station location, if desired. *No other insertion is permissible.*

This is KIIS, Los Angeles

This is WMCA, Strauss Communications in New York.

In accordance with station policy other remarks may be added, either before or after the required identification.

"At 1290 on your dial, this is WAGE, Leesburg, the heart of the hunt country."

Special theme songs and anthems are also permitted, but not required.

Optional Station Identification

If the operator identifies the station at other than the required times he is not obliged to use the official format.

However, there is a condition to the foregoing, and it is an important one.

"A licensee shall not in station identification announcements, promotional announcements or any

other broadcast matter either lead or attempt to lead the station's listeners to believe that the station has been assigned to a city other than that specified in its license."

Example: Station XXXX is licensed to SUBURBIA. It broadcasts an announcement (either at the required time or any other time). "This is XXXX, covering the greater PRINCIPAL CITY area." The announcement violates the rules since it appears designed to lead listeners to believe that XXXX is licensed to PRINCIPAL CITY rather than SUBURBIA.

15

Documents and Logs

Rules and Regulations

The Federal Communications Commission was established by an act of Congress on July 1, 1934 (The Communications Act of 1934). This act empowered the Commission to ". . . make such rules and regulations . . . as may be necessary in the execution of its functions". In general the *rules and regulations* describe the organization of the Commission, the allocation of frequencies, the rules governing each radio service and various radio matters. The rules are divided into 40 parts of which Part 13, Commercial Radio Operators, Part 17, Antenna Structures and Part 73, Radio Broadcast Services, are of particular concern to broadcast station operators.

Station License

Every broadcast station must have a *license issued by the Commission* to conduct a broadcast service. This license contains information such as call letters, community, studio location, hours of operation, and technical specifications. It is sometimes referred to as a *station authorization* or instrument of authorization.

Lesser Grade Operators

At broadcast stations, those operators who do not possess a first class radiotelephone license are known as *lesser grade operators*. All stations which employ lesser grade operators must post *printed step-by-step instructions* for those adjustments which the lesser grade operators are permitted to make and a *chart* or *tabulation* of upper and lower limiting values of *operating parameters* required to be observed and logged.

Availability of Logs and Records

The following documents are normally examined during an inspection by representatives of the Commission and must be made available upon request.

- Station license.
- Operator licenses.
- Program, operating, and maintenance logs.
- Equipment performance measurements.
- Copy of the most recent antenna resistance or common point impedance measurements submitted to the Commission.
- Copy of the most recent field intensity measurements to establish performance of directional antennas.

• The "public file" which contains various records to be maintained locally for public inspection. This file may not necessarily be kept at the station but must be at a location convenient to the public in the station's community.

Since the operator may be the only person present during an inspection it is important that he know where these documents are kept.

Logs—General

The licensee of every broadcast station is required to maintain operating, program and maintenance logs as described in the rules. In practice, each log is kept by station employees competent to do so and *having actual knowledge of the facts.*

Normally, the program log is maintained by either an announcer or operator however, only a licensed operator may keep the operating log. All entries in the maintenance log must be made by the holder of a first class radiotelephone license (he may be a second class operator in a noncommercial educational FM station with power of 1KW or less).

The person(s) who maintains the operating and program logs must sign the appropriate log when starting duty and *again* when going off duty. *Two signatures* are required; initials only are insufficient as is the practice of signing a log only once followed by the times the operator went on and off duty.

All logs must be orderly and *legible.*

Key letters and abbreviations may be used if they are explained elsewhere in the log.

Each *sheet* must be numbered and dated.

Each log entry must include a notation as to the time the action was taken or observation made.

Time entries shall be in *local* time. Indicate whether advanced (daylight savings) or nonadvanced time.

No completed log shall be erased, obliterated or destroyed within the period of retention (normally 2 years).

If a correction must be made before the person keeping the log goes off duty, he should strike out the erroneous portion and write in the correct entry.

If a correction must be made after the person who kept the log has signed it, an explanation must be made on the log or attached to it. Only certain employees or officers of the licensee, as listed in the rules, may make such a correction.

Some stations use automatic logging equipment for their program and operating logs. The regulations governing the use of this equipment can be found in Part 73 of the rules.

Operating Log

The *operating log* is a technical record of the day-to-day operation of a broadcast station. Only a licensed operator may make entries in this log, and they should be timely and accurate.

The following rules apply to either AM or FM stations:

- log the operating parameters (required transmitter and monitor meter readings) before adjustments are made to the transmitting system.
- if adjustments are made, log the corrected values also. If any parameter exceeded the prescribed tolerance, add a notation describing the corrective action.
- if the value of any parameter is affected by modulation, read the value *without* modulation. Operators at AM stations frequently read the antenna current while the carrier is being modulated; the resulting reading is higher than it would have been had the carrier been unmodulated (0% modulation).
- in preparing the operating log original data may be recorded in rough form and later transcribed into the log.

Specific entries required for both AM and FM stations are:

(1) The time each station goes on the air and the time it goes off (the time the station begins to supply power to the antenna and the time it ceases to do so).

(2) Tower lights

(a) If manually controlled, the time they are turned on and off.

(b) The time of the daily check for proper operation.

(c) Extinguishment or malfunction of any tower light—refer to the chapter on ANTENNA LIGHTING and Section 17.49(c) of the Rules.

(3) A notation concerning either activation or tests of the Emergency Broadcast System (Refer to the chapter on EBS).

Additional entries required at the time each station begins operation (in each mode) and thereafter at intervals not to exceed 3 hours are:

AM	FM
Plate voltage (E_P)	Plate voltage (E_P)
Plate current (I_P)	Plate current (I_P)
Antenna current or common point current	RF transmission line meter reading only if *direct method* used

And, in the case of directional AM stations—

Phase

Antenna monitor sample currents *or* remote antenna base currents *or* current ratios

Furthermore, in any AM station (directional or nondirectional) which determines operating power by the *indirect* method ($P = E_I I_I F$), the value of F—the efficiency factor—applicable to each mode of operation must be entered in the operating log *once* each day. Each value of F must be accompanied by a notation explaining how it was derived.

Mode

The word *'mode'* refers to a unique combination of transmitter, operating power and antenna pattern. For example, if an AM station is operating at 1000 watts with a nondirectional antenna, that is its mode of operation. If it reduces power to 250 watts and changes to a directional pattern at sunset, that is a different mode of operation. If it shifted from a main to an alternate main transmitter at midnight that is a third mode and if, at 6:00 a.m., under a Presunrise Service Authority, it increased power to 500 watts, that is a fourth mode of operation for that station.

Summary

The Federal Communications Commission's rules and regulations derive their authority from the Communications Act of 1934.

A station license authorizes a radio station to conduct a broadcast service. It contains the station's call letters, community, operating parameters, and other technical and legal information including special operational instructions.

Stations employing lesser grade operators must post instructions for those adjustments which the lesser grade operators are permitted to make and a tabulation or chart of the upper and lower limiting values of the parameters required to be observed and logged.

Each station must maintain operating, program, and maintenance logs.

Each log must be maintained by employees competent to do so and having actual knowledge of the facts.

All required entries in the operating log must be made by a licensed operator.

All required entries in the maintenance log must be made by a first class radiotelephone operator (or a second class operator in a noncommercial educational FM station with 1KW or less of operating power).

The operating and program logs must be signed when starting duty and again when going off duty.

No log shall be erased or obliterated.

Corrections are to be made by striking out the erroneous portion, writing in the correct entry and initialing the correction.

The value of any parameter affected by modulation must be read without modulation.

The actual time of observation must be recorded for each log entry.

A mode of operation is a particular combination of transmitter, operating power, and antenna pattern.

If an operator

- puts a station on the air,
- changes transmitters,
- changes operating power or
- changes antenna patterns,

he has begun a new mode of operation and must log all required operating parameters.

Thereafter, he must record a set of readings at least every 3 hours.

If at those or any other times adjustments must be made to the transmitting apparatus, the operator must record a set of readings both before and after the adjustments.

In addition to the above, the operator must make routine entries in the operating log of the time the station goes on and off the air, the daily check of tower lights, and the monthly test of the EBS.

In an AM station using the indirect method to calculate power, the operator must log the product $E_P \times I_P$ or $E_P \times I_P \times F$ for each entry of E_P and I_P. The value of F must be entered once each day.

16

Related Topics

Many operators, particularly those who intend to become announcers, have expressed interest in the following topics. *However, because they are not directly related to the duties of a third class operator they have not been used as a source of examination questions.*

Program Log

This log is a record of the material broadcast each day and may be kept by any station employee having actual knowledge of the facts (normally the operator or announcer). Although the general requirements relating to logs also pertain to this log, the specific entries are too numerous and detailed to discuss here. Persons charged with the responsibility for keeping the program log should refer to the rules.

Maintenance Log

This log is a record of the maintenance performed on the transmitting system, including calibration checks, periodic measurements, and required inspections. All entries must be made by the holder of a first class radiotelephone license (or second class license if it is a noncommercial educational FM station with operating power of 1 kW or less).

Lotteries

A lottery is any scheme in which *money or a prize of value* is awarded to a person selected by *lot or chance,* if a condition of winning is that a person must have *furnished any money, purchased* a particular product or service, or *have* in his possession a product sold by the sponsor. A station may broadcast advertisements, lists of prizes, or other information about lotteries conducted by a state only if the station is licensed to a location in that state. It may also broadcast information about state-conducted lotteries in adjoining states but only if its own state has a state-conducted lottery.

Telephone Conversations

Before broadcasting a telephone conversation or recording a telephone conversation for later broadcast, the parties to the conversation must be informed of the intention to broadcast the conversation. No notice of broadcast is required for persons originating calls to programs which normally broadcast telephone conversations, as it can be assumed that such callers are aware of the nature of the program.

Rebroadcast

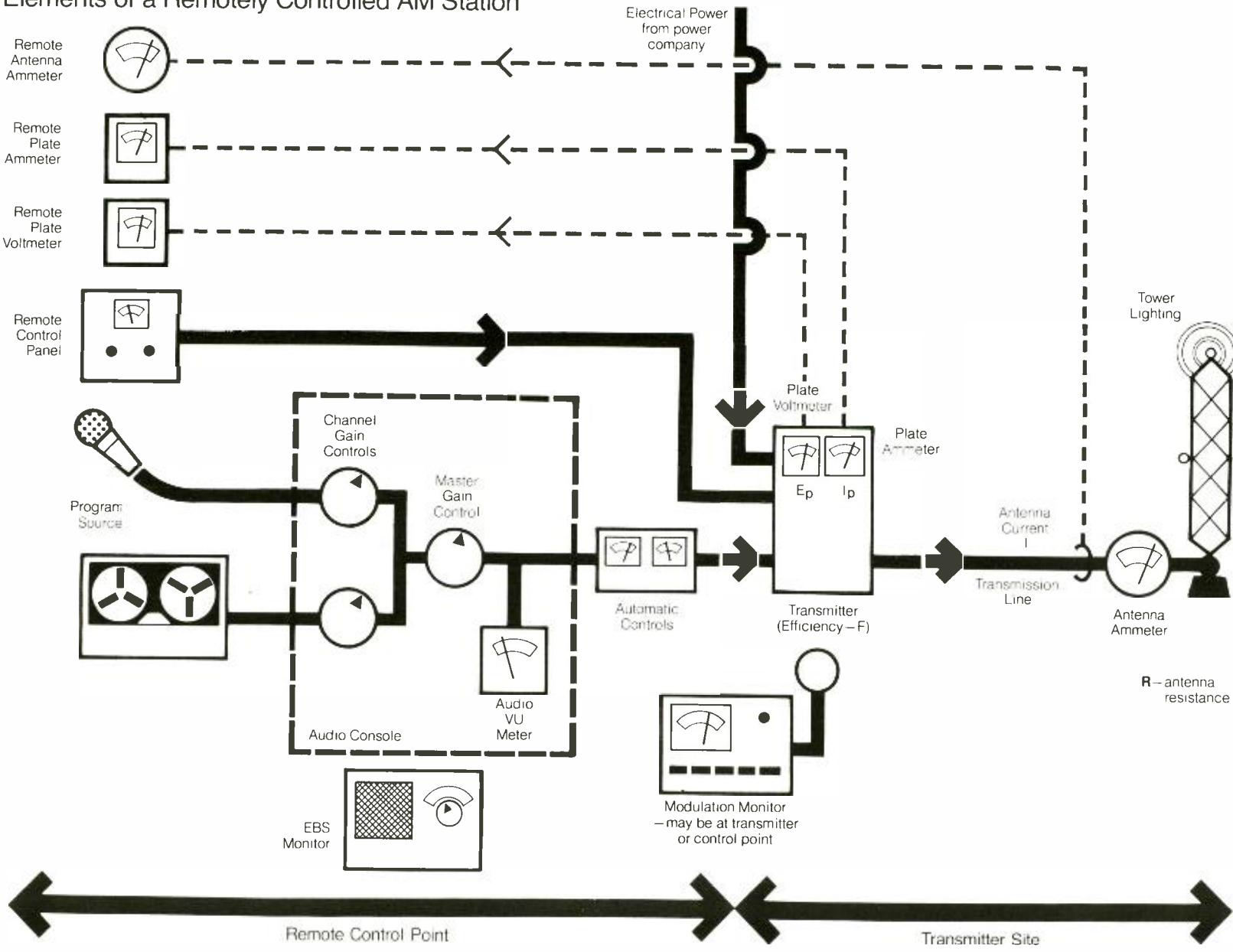
No broadcast station shall rebroadcast the program, or any part of a program, of another U. S. radio station without the express written consent of the originating station.

Taped or Recorded Material

Any taped or recorded program material in which *time* is of special significance or by which an affirmative attempt is made to create the impression that it is occuring simultaneously with its broadcast, must be announced at the beginning as taped or recorded. The language of the announcement shall be clear and in terms commonly understood by the public.

Appendices

Elements of a Remotely Controlled AM Station



FCC Form 352

UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION

File No.: BL-13,040
Call Sign: W S L W

STANDARD BROADCAST STATION LICENSE

Subject to the provisions of the Communications Act of 1934, subsequent Acts, and Treaties, and Commission Rules made thereunder, and further subject to conditions set forth in this license, 1/ the LICENSEE

REGIONAL RADIO, INC.

is hereby authorized to use and operate the radio transmitting apparatus hereinafter described for the purpose of broadcasting for the term ending 3 a.m. Local Time October 1, 1972

The licensee shall use and operate said apparatus only in accordance with the following terms:

1. On a frequency of 1310 kHz.
2. With nominal power of - watts nighttime and 5 kilo watts daytime,

with antenna input power of - watts - directional antenna nighttime	-	current	-	amperes
	-	resistance	-	ohms,
and antenna input power of 5 kilo watts non directional antenna daytime	antenna	current	8.90	amperes
	antenna	resistance	63.0	ohms

3. Hours of operation: Daytime as follows:
   Jan. 7:30am to 5:30pm; Feb. 7:15am to 6:00pm;
   Mar. 6:30am to 6:30pm; Apr. 5:45am to 7:00pm;
   May 5:15am to 7:30pm; June 5:00am to 7:45pm;
   July 5:15am to 7:45pm; Aug. 5:30am to 7:15pm;
   Sep. 6:00am to 6:30pm; Oct. 6:30am to 5:45pm;
   Nov. 7:00am to 5:15pm; Dec. 7:30am to 5:00pm;
   Eastern Standard Time (non-advanced)

Transmitter may be operated by remote control from 73 East Main Street, White Sulphur Springs, West Virginia

4. With the station located at: White Sulphur Springs, West Virginia
5. With the main studio located at:
   73 East Main Street
   White Sulphur Springs, West Virginia
6. The apparatus herein authorized to be used and operated is located at:
   Rural area 0.75 mi. North of
   White Sulphur Springs, West Virginia

   North Latitude: 37° 48' 34.5"
   West Longitude: 80° 17' 59"

7. Transmitter(s): BAUER, FB-5V

(or other transmitter currently listed in the Commission's "Radio Equipment List, Part B, Aural Broadcast Equipment" for the power herein authorized). **

8. Obstruction marking specifications in accordance with the following paragraphs of FCC Form 715: 1, 3, 11, and 21
9. Conditions:
   **ANTENNA: 190' (193' overall height) uniform cross section, guyed, series excited vertical radiator. Ground system consists of 120 equally spaced, buried copper radials 106 to 190 feet in length plus 120 interspaced radials 50 to 106 feet in length.

The Commission reserves the right during said license period of terminating this license or making effective any changes or modification of this license which may be necessary to comply with any decision of the Commission rendered as a result of any hearing held under the rules of the Commission prior to the commencement of this license period or any decision rendered as a result of any such hearing which has been designated but not held, prior to the commencement of this license period.

This license is issued on the licensee's representation that the statements contained in licensee's application are true and that the undertakings therein contained so far as they are consistent herewith, will be carried out in good faith. The licensee shall, during the term of this license, render such broadcasting service as will serve public interest, convenience, or necessity to the full extent of the privileges herein conferred.

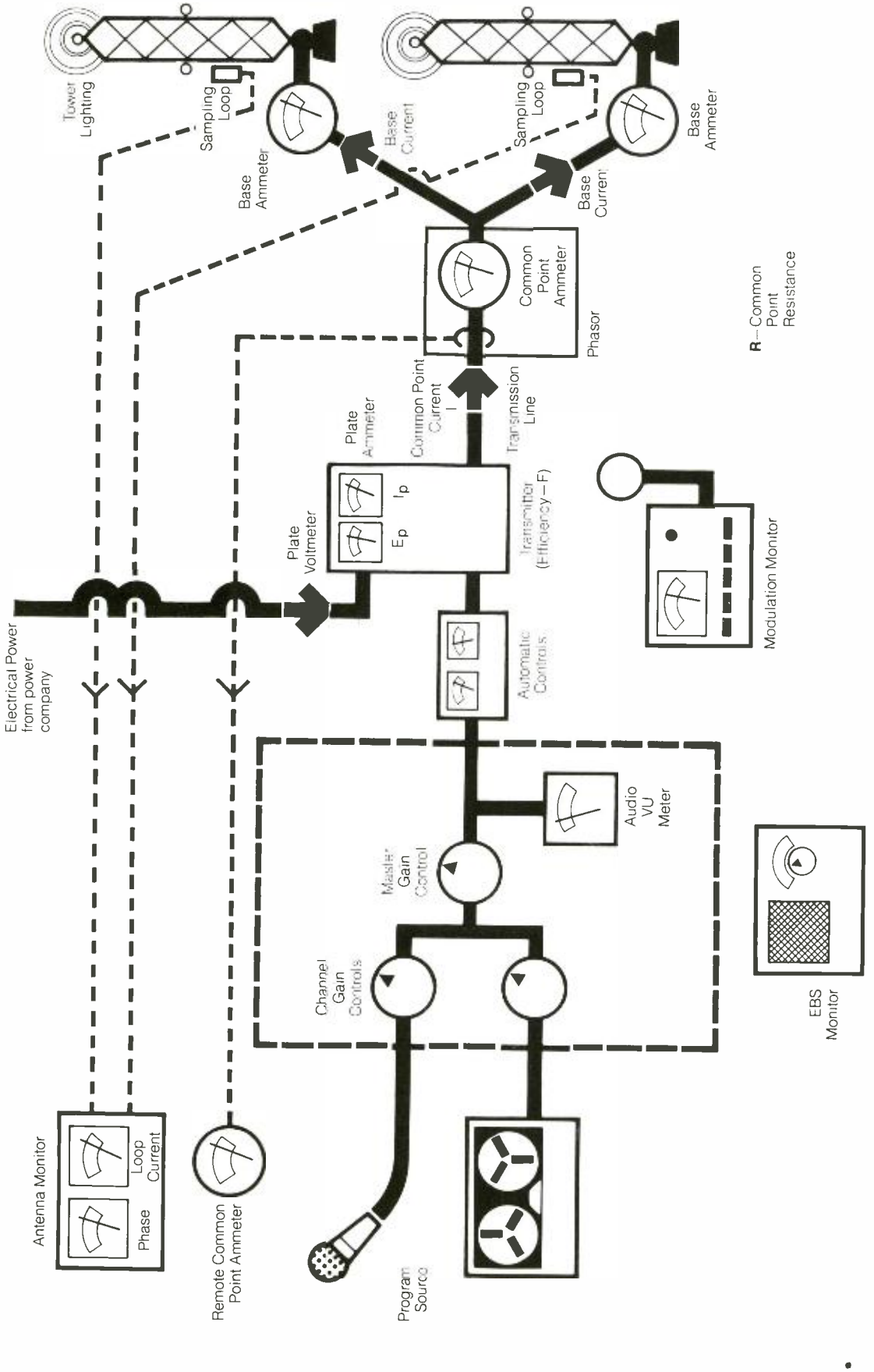
This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequency designated in the license beyond the term hereof, nor in any other manner than authorized herein. Neither the license nor the right granted hereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934. This license is subject to the right of use or control by the Government of the United States conferred by Section 606 of the Communications Act of 1934.

1/ This license consists of this page and pages -

Dated: NOVEMBER 4, 1971

FEDERAL COMMUNICATIONS COMMISSION

Appendix C Elements of a Directional AM Station



FCC Form 352

UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION

File No.: BR-989
Call Sign: K X X O

STANDARD BROADCAST STATION LICENSE
MAIN AND AUXILIARY TRANSMITTERS

Subject to the provisions of the Communications Act of 1934, subsequent Acts, and Treaties, and Commission Rules made thereunder, and further subject to conditions set forth in this license, 1/ the LICENSEE

SAN ANTONIO BROADCASTING, INC.

is hereby authorized to use and operate the radio transmitting apparatus hereinafter described for the purpose of broadcasting for the term ending 3 a.m. Local Time JUNE 1, 1977

The licensee shall use and operate said apparatus only in accordance with the following terms:

1. On a frequency of 1300 kHz.
2. With nominal power of 1 kilo watts nighttime and 5 kilowatts daytime,
   with antenna input power of 1.08 kilowatts – directional antenna nighttime ..... [Common Point current 3.93 amperes; Common Point resistance 70 ohms,]
   and antenna input power of 5.4 kilo watts – directional antenna daytime ..... [Common Point current 8.79 amperes; Common Point resistance 70 ohms]
3. Hours of operation: Unlimited Time.
   Average hours of sunrise and sunset:
   Jan. 7:30 am to 5:30 pm; Feb. 7:15 am to 6:00 pm;
   Mar. 6:30 am to 6:30 pm; Apr. 6:00 am to 7:00 pm;
   May 5:15 am to 7:30 pm; June 5:00 am to 7:45 pm;
   July 5:15 am to 7:45 pm; Aug. 5:45 am to 7:15 pm;
   Sep. 6:00 am to 6:30 pm; Oct. 6:30 am to 5:45 pm;
   Nov. 7:00 am to 5:15 pm; Dec. 7:30 am to 5:15 pm;
   Central Standard Time (Non-Advanced).
   Transmitters may be operated by remote control from 2805 East Skelly Drive, Tulsa, Oklahoma.
4. With the station located at: Tulsa, Oklahoma
5. With the main studio located at:
   2805 East Skelly Drive
   Tulsa, Oklahoma
6. The apparatus herein authorized to be used and operated is located at: North Latitude: 36° 02' 19"; West Longitude: 95° 56' 07"
   8601 South Harvard
   Tulsa Oklahoma
7. Transmitter(s): COLLINS, 820E-1 (Main)
   WESTERN ELECTRIC, 405-B2 (Auxiliary)
   (or other transmitter currently listed in the Commission's "Radio Equipment List, Part B, Aural Broadcast Equipment" for the power herein authorized).
8. Obstruction marking specifications in accordance with the following paragraphs of FCC Form 715: **
9. Conditions: (See Page 1A.)
   **Towers 1, 2, & 4: Paragraphs 1, 3, 12 & 21. Beacons and all obstruction lights shall be flashed, with flashing of towers synchronized so that at any instant two towers are lighted and one tower is not.
   Tower 3: Paragraph 1.

The Commission reserves the right during said license period of terminating this license or making effective any changes or modification of this license which may be necessary to comply with any decision of the Commission rendered as a result of any hearing held under the rules of the Commission prior to the commencement of this license period or any decision rendered as a result of any such hearing which has been designated but not held, prior to the commencement of this license period.

This license is issued on the licensee's representation that the statements contained in licensee's application are true and that the undertakings therein contained so far as they are consistent herewith, will be carried out in good faith. The licensee shall, during the term of this license, render such broadcasting service as will serve public interest, convenience, or necessity to the full extent of the privileges herein conferred.

This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequency designated in the license beyond the term hereof, nor in any other manner than authorized herein. Neither the license nor the right granted hereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934. This license is subject to the right of use or control by the Government of the United States conferred by Section 606 of the Communications Act of 1934.

1/ This license consists of this page and pages 1a, 2, 3, & 4.

Dated: DECEMBER 17, 1975

FEDERAL COMMUNICATIONS COMMISSION

File No. BR-989 Call Sign: K X X O Date: 12-17-75
DA- 2

1. DESCRIPTION OF DIRECTIONAL ANTENNA SYSTEM

No. and Type of Elements: Four, triangular cross-section, guyed, series-excited vertical towers. Two towers used daytime, three used nighttime. A communications type antenna is side-mounted near the top of the W (No. 4) tower.

Height above Insulators: 284' (135°)

Overall Height: 288' (Towers 1 and 3); 290' (Tower 4); 289' (Tower 2)

Spacing Orientation: West to West Center Tower, 273.5' (130°) - Day;
West to East Center Tower, 547' (260°)
East Center to East Tower, 547' (260°) - Night
Line of towers bears 72° true.

Non-Directional Antenna: None used.

Ground System consists of 240 - 43' buried copper wire radials equally spaced about each tower; 120 - 43' to 284' buried copper wire radials alternately spaced. All radials bonded together by a copper wire at a radius of 43' from each tower. Copper strap between transmitter ground and bond straps at each tower.

2. THEORETICAL SPECIFICATIONS

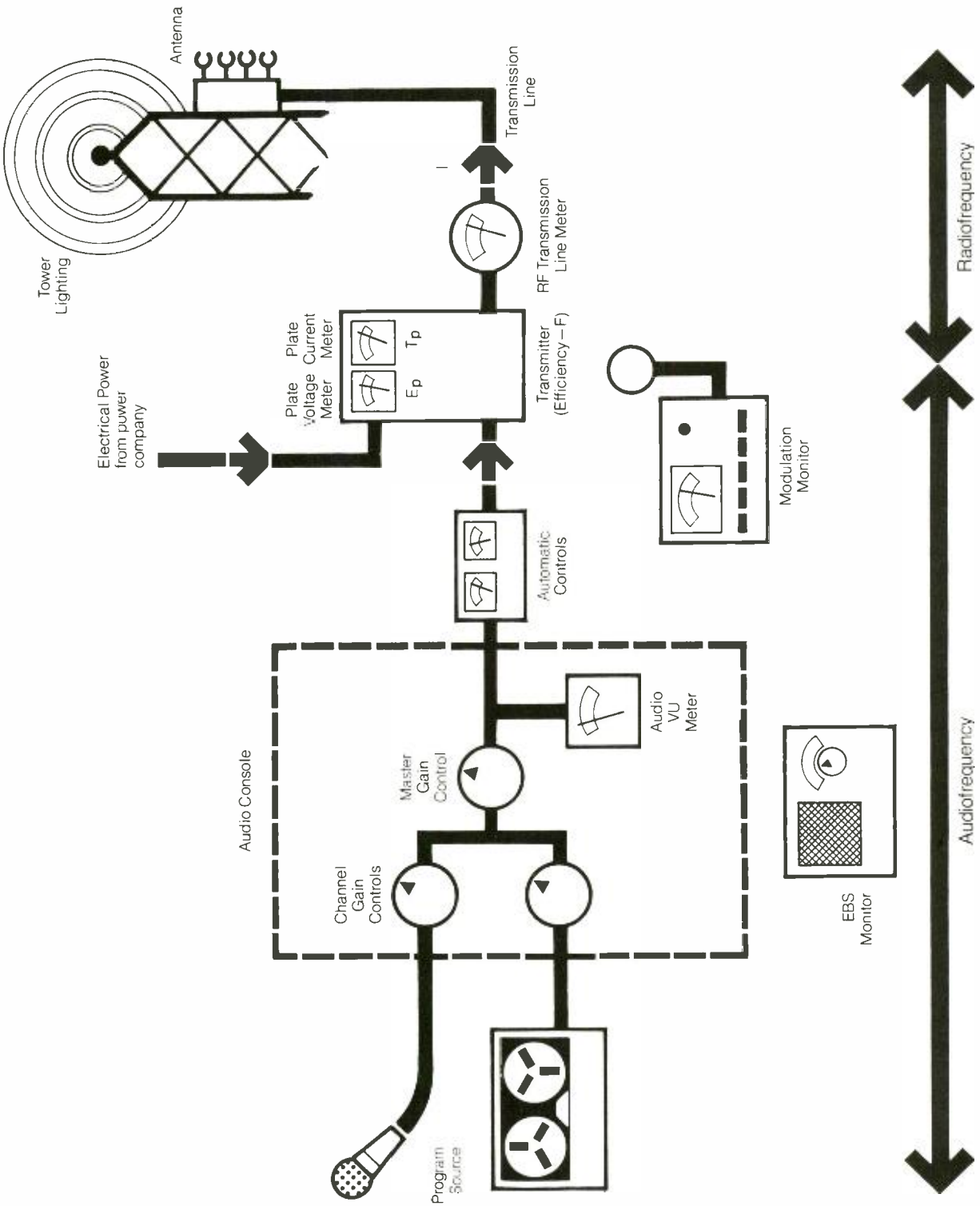
		E(No.1)	EC(No.2)	WC(No.3)	W(No.4)
Phasing:	Night	0°	-9.44°	-	0°
	Day	-	-	0°	-52°
Field Ratio:	Night	0.85	1.36	-	0.65
	Day	-	-	1.0	0.80

3. OPERATING SPECIFICATIONS

Phase Indication:*	Night	17°	0°	-	8°
	Day	-	-	0°	57°
Antenna Base Current Ratio:	Night	0.608	1.0	-	0.473
	Day	-	-	1.0	0.818
Antenna Monitor Sample Current Ratio:	Night	56	100	-	40
	Day	-	-	100	80

*As indicated by Potomac Instruments Antenna Monitor. PM-112

Elements of an FM Station



FCC Form 352-A

United States of America
FEDERAL COMMUNICATIONS COMMISSION

File No. BRH-2019

Call Sign: W F Y N-FM

FM BROADCAST STATION LICENSE

Subject to the provisions of the Communications Act of 1934, as amended, treaties, and Commission Rules, and further subject to conditions set forth in this license,[1] the LICENSEE

FLORIDA KEYS BROADCASTING CORPORATION

is hereby authorized to use and operate the radio transmitting apparatus hereinafter described for the purpose of broadcasting for the term ending 3 a.m. Local Time: FEBRUARY 1, 1979

The licensee shall use and operate said apparatus only in accordance with the following terms:

1. Frequency (MHz) .....: 92.5
2. Transmitter output power ....: 10 kilowatts
3. Effective radiated power ....: 25 kilowatts (Horiz.) & 23.5 kilowatts (Vert.)
4. Antenna height above average terrain (feet) ....: 135' (Horiz.) & 130' (Vert.)
5. Hours of operation .....: Unlimited
6. Station location .....: Key West, Florida
7. Main studio location .....:
   Fifth Avenue Stock Island
   Key West, Florida
8. Remote Control point .....:
9. Antenna & supporting structure: North Latitude: 24° 34' 01"
   West Longitude: 81° 44' 54"
   ANTENNA: COLLINS, 37M-5/300-C-5, Five-sections (Horiz. & Vert.), FM antenna side-mounted near the top of the north tower of WKIZ(AM) directional array. Overall height above ground 155 feet.
10. Transmitter location .....:
    Fifth Avenue Stock Island
    Key West, Florida
11. Transmitter(s).....: COLLINS, 830-F-1A
12. Obstruction markings specifications in accordance with the following paragraphs of FCC Form 715: 1, 3, 11 & 21.
13. Conditions:

The Commission reserves the right during said license period of terminating this license or making effective any changes or modification of this license which may be necessary to comply with any decision of the Commission rendered as a result of any hearing held under the rules of the Commission prior to the commencement of this license period or any decision rendered as a result of any such hearing which has been designated but not held, prior to the commencement of this license period.

This license is issued on the licensee's representation that the statements contained in licensee's application are true and that the undertakings therein contained so far as they are consistent herewith, will be carried out in good faith. The licensee shall, during the term of this license, rendet such broadcasting service as will serve public interest, convenience, or necessity to the full extent of the privileges herein conferred.

This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequency designated in the license beyond the term hereof, nor in any other manner than authorized herein. Neither the license nor the right granted hereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934. This license is subject to the right of use or control by the Government of the United States conferred by section 606 of the Communications Act of 1934.

[1] This license consists of this page and pages --

Dated: JANUARY 28, 1976

FEDERAL COMMUNICATIONS COMMISSION

Appendix G

Sample Examination —Element 9

Questions

1. When the remote control equipment malfunctions and results in improper transmitter control, the

(a) operation by remote control must cease.
(b) power must be reduced by 5%.
(c) power must be reduced by 10%.
(d) station must be taken off the air.
(e) FCC must be notified.

2. The antenna current meter or remote antenna current meter, where provided, should be read

(a) during modulation peaks.
(b) prior to placing the station on the air.
(c) when program material modulates the carrier at the average level.
(d) when the carrier is unmodulated.
(e) once each hour.

3. The PRIMARY concern of an operator on duty at an FM broadcast station should be to

(a) insure that the transmitter is operating within required parameters.
(b) insure "spot" announcements are broadcast and logged properly in the program log.
(c) maintain a "tight board".
(d) keep the station on the air at all cost.
(e) keep the chief operator advised of problems encountered during the shift.

4. A standard (AM) broadcast station determines the operating power by the direct method. The meter indications which must be routinely observed and entered into the operating log are

(a) plate voltage and current, and rf transmission line.
(b) plate voltage and current, filament voltage and modulation.
(c) plate voltage and current, and antenna or common point current.
(d) plate voltage and current, and peak modulation.
(e) plate voltage and current only.

5. The *required* broadcast station identification announcement given during the broadcast day *must* include the

(a) licensee's name and location.
(b) same identification as required during sign-off.
(c) assigned frequency and call sign.
(d) call sign and station affiliation.
(e) assigned frequency and power.

6. Which of the following are *not* required to be recorded in the operating log?

(a) antenna ammeter reading
(b) plate voltage meter reading
(c) plate current meter reading
(d) modulation monitor meter reading
(e) the time the station ceases to supply power to the antenna

7. In the event the modulation monitor becomes defective, an FM broadcast station may be operated without the monitor provided

(a) the audio level control is adjusted at mid-range.
(b) the percentage of modulation is monitored with an oscilloscope or other acceptable means.
(c) the transmitter power is reduced to half of the licensed power.
(d) the operator makes daily entries in the operating log.
(e) a first class operator is on duty.

8. A third class operator on duty at a broadcast station is authorized to

(a) adjust external controls to compensate for voltage fluctuations in the primary power supply.
(b) make transmitter adjustments to maintain the correct operating frequency.
(c) repair an inoperative transmitter in an emergency.
(d) replace defective final amplifier tubes.
(e) make any necessary minor adjustments of internal transmitter controls.

9. If both the antenna ammeter and remote antenna ammeter of an AM broadcast station become defective, the operating power must then be determined by the

(a) RF transmission line meter reading method.
(b) power meter reading method.
(c) indirect method.
(d) final amplifier method.
(e) percentage variance method.

10. If a flashing beacon at some *intermediate* level on an antenna tower burns out, the

(a) operator should notify the local FCC field office.
(b) operator should notify the nearest FAA office or flight service station if it cannot be restored within 30 minutes.
(c) other lights should be left burning continuously.
(d) other lights should be turned off until it is repaired.
(e) local power company should be notified.

11. The operating log must contain

(a) the name of all sponsors of a sponsored program.
(b) the time of all recorded program announcements.
(c) an entry of the time the transmitter begins to supply power to the antenna.
(d) the time station identification announcements were given.
(e) notations concerning maintenance of the transmitter.

12. The Commission's Rules specify that the operating power shall *not* exceed the limit of

(a) 125% of authorized power.
(b) 120% of authorized power.
(c) 115% of authorized power.
(d) 110% of authorized power.
(e) 105% of authorized power.

13. If an automatic alarm system is not in service, observations to insure that tower lights at a station are functioning properly must be made at least once every

(a) three months.
(b) week.
(c) twenty-four hours.
(d) twelve hours.
(e) hour between sunset and sunrise.

14. Entries in the AM or FM station operating log shall be made by

(a) any station employees having actual knowledge of the required facts.
(b) the properly licensed operator in actual charge of the transmitter.

(c) any employee duly authorized to do so by the station licensee.
(d) the full time or contract maintenance operator.
(e) any licensed radio operator.

15. If the modulation monitor peak indicator (flasher) in a standard broadcast station indicates negative peaks of frequent recurrence in excess of 100%, what action should be taken by the operator?

(a) adjust filament voltage to normal.
(b) inform the chief operator.
(c) reduce the transmitter final Plate voltage.
(d) reduce the audio level.
(e) notify the station manager.

16. An operator holding the proper grade of license shall be in actual charge of the transmitting apparatus and shall be on duty at

(a) any location on the station premises so long as he can make the required meter readings at the specified intervals and the equipment is provided with failure alarms.
(b) any location on the station premises if programming and transmitter logging is automated.
(c) any location on the station premises if programming is automated.
(d) the studio console if programming is not automated.
(e) any location on the station premises where the required metering and control equipment is installed.

17. Operating power at an AM broadcast station, when determined by the direct method, is computed or obtained from

(a) the sum of the antenna current plus the plate current.
(b) the square of the antenna current times the antenna resistance.
(c) the antenna current times the square of the antenna resistance.
(d) the plate voltage times the plate current.
(e) the calibrated power meter.

18. An operator at a broadcast station not operated by remote control must post his operator license or permit

(a) at any location at the station where it is readily visible.
(b) where it can be inspected by the public.
(c) at any place where it is available for inspection by FCC representatives.
(d) in the main studio.
(e) at the transmitter or extension meter location.

19. An AM broadcast station is *not* permitted to modulate the carrier to

(a) 0%.
(b) 50% on negative peaks of frequent recurrence.
(c) 85% on positive peaks of frequent recurrence.
(d) 105% on negative peaks of frequent recurrence.
(e) 120% on positive peaks of frequent recurrence.

20. A radio broadcast station operator discovers that his operator permit had expired two weeks previously. The operator may *not* continue to operate the transmitter

(a) until the station manager notifies the FCC.
(b) until a renewed permit has been issued.
(c) until he has been re-examined.
(d) unless an application for renewal is filed immediately and a copy posted.
(e) unless certified to do so by a first class operator.

Answers

1.

(a) CORRECT. When a malfunction results in improper control the rules require that the station must cease operating *by remote control.*
(b) and (c) Neither action is required.
(d) Not required if an operator can take control at the transmitter.
(e) Not required.

2.

(a) Definitely not.
(b) There is no antenna current if the station is not on the air.
(c) No; the reading will be too high.
(d) CORRECT. Modulation = 0%.
(e) The rules require a reading only once every 3 hours.

3.

(a) CORRECT. Remember, we are speaking of the *operator.*
(b) and (c) Important but not primary. Also, the person keeping the program log need not hold an operator license.
(d) No station should be kept on the air "at all cost".
(e) This may be a station's policy, but it is not a part of an operator's official functions.

4.

(a) "RF transmission line meter indication" is associated with an *FM* station.
(b) Neither filament voltage nor modulation is logged.
(c) CORRECT.
(d) Modulation is not logged.
(e) Incomplete.

5.

(b) CORRECT. The required station identification announcements at sign-on, sign-off and during the broadcast day, need only include call letters and station location.

6.

(d) CORRECT. Modulation is *not* required to be logged.

7.

(a) This is not a sensible procedure. An audio control should be adjusted to produce the desired level of modulation; this may not necessarily be at the mid-range of the control.
(b) CORRECT.
(c) A station may operate at reduced power only if it is technically impossible to operate at its authorized power.
(d) and (e) Not required. Stations must still comply with answer (b) if they wish to operate.

8.

(a) CORRECT. Refer to the chapter on the operator.

9.

(a) RF transmission line meters are associated with FM stations.
(b), (d) and (e) None of these expressions are used in broadcasting.
(c) CORRECT. An AM station which cannot measure its antenna current is physically unable to calculate power by the direct method ($P = I^2_a\ R$) and must therefore resort to the indirect method ($P = E_P\ I_P\ F$).

10.

(a), (c), (e) Not required
(b) CORRECT. The FAA must be notified if *any* flashing beacon malfunctions, regardless of its location on a tower.
(d) Definitely not!

11.

(a), (b) and (d) These are program log entries
(c) CORRECT.
(e) Maintenance log entries.

12.

(e) CORRECT.

13.

(c) CORRECT.

14.

(a) Wrong. While knowledge of the facts is very important, the rules do not permit any employee to make entries in the operating log but only a licensed operator in charge of the transmitting apparatus.
(b) CORRECT.
(c), (d) and (e) wrong. Note that having a license is insufficient; the operator must also be in charge of the transmitting apparatus.

15.

(a) Not an authorized adjustment.
(b) and (e) Not required by the rules; may only be necessary if actions taken by the operator to reduce the modulation are ineffective.
(c) This has nothing to do with controlling modulation.
(d) CORRECT. The monitor is indicating *overmodulation;* since the level of modulation is directly dependent on the strength of the audio signal the logical action to take is to reduce the audio level.

16.

(a), (b) and (c). The operator may not be at "any location on the premises" regardless of the equipment installed.
(d) The studio console may not necessarily be a transmitter control point.
(e) CORRECT.

17.

(a) Meaningless.
(b) CORRECT. $P = I^2R$
(c) Meaningless.
(d) $P = E_P I_P$ is the transmitter input power.
(e) Used at some FM stations.

18.

(e) CORRECT.

19.

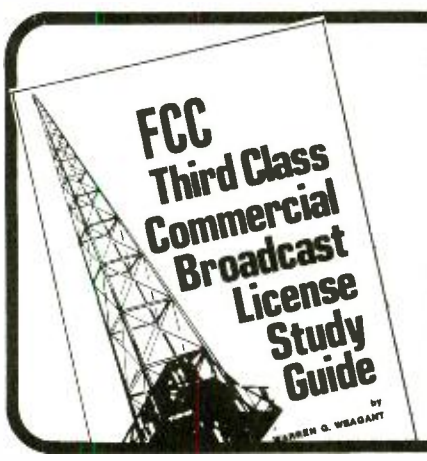
(a) 0% modulation occurs at any break in the programming—a frequent occurrence.
(b) and (c). These are permissible.
(d) This is the correct choice. Neither AM nor FM stations may exceed 100% on negative peaks of frequent recurrence.
(e) In AM stations the limit is 125%.

20.

(b) CORRECT. An operator has continuing authority only when the application for renewal is submitted prior to the expiration date of his license.

☆ U.S. GOVERNMENT PRINTING OFFICE 1976 O—207-327


FEDERAL COMMUNICATIONS COMMISSION
FCC
USA



Tests-Answers Supplement

FCC ELEMENT: NINE
LICENSE: THIRD CLASS ENDORSED
TEST NO: 9-B

Published by
COMMAND PRODUCTIONS
Radio Engineering Division
Post Office Box 26348
San Francisco, CA 94126

1. The holder of a third class operator license, with the broadcast endorsement, may operate AM & FM broadcast transmitters except for:
   a. 5,000 watt FM stations
   b. 5,000 watt AM stations
   c. AM stations with critical directional antenna systems
   d. FM stations with directional antennas over 10,000 feet
   e. all of the above

2. A required broadcast station identification announcement given during the broadcast day must include the:
   a. assigned frequency and call letters
   b. assigned frequency and licensee's location
   c. assigned call letters and station's legal power
   d. call letters, frequency, location and correct time
   e. same identification as required during sign off.

3. An AM broadcast station which radiates a signal equally in all directions utilizes:
   a. one tower
   b. two towers
   c. three towers
   d. four towers
   e. frequency modulation

4. Actual transmitter output power of an FM broadcast station may be determined by:
   a. reading the station FCC license
   b. reading the power factor meter
   c. reading all final output transmitter meters
   d. reading the RF transmission line meter
   e. checking the output voltage of the modulation monitor

5. The operating log must contain:
   a. the time station identification announcements were given
   b. an entry of the time the transmitter begins to supply power to the antenna
   c. the time of all recorded program announcements
   d. the name of the announcer on duty
   e. all of the above

6. To maintain authorized transmitter operating power, the operator should monitor:
   a. utility company supply power
   b. frequency response of the audio control mixer
   c. feedback transmitter circuits
   d. loop current meter readings
   e. all of the above

7. When an AM broadcast station, with an authorized power of 1 KW, has a plate voltage of 3,010 volts, plate current of 0.385 amperes and transmitter efficiency of 85% the station is:
   a. operating beyond authorized power
   b. operating legally
   c. modulating the audio source under 100% signal level
   d. causing interference
   e. over modulating

8. The loop current meter at an AM directional station indicates:
   a. the voltage ratio of each directional tower
   b. the frequency ratio of each directional tower
   c. the proportional amount of antenna base current in a tower compared to a designated reference tower
   d. the proportional amount of base current in a reference tower to a 1 kHz frequency source
   e. none of the above

9. The operator of an AM broadcast station must maintain actual operating power:
   a. at a safe level
   b. within 10% of authorized power output
   c. exactly as station license requirements
   d. as close to the authorized values as possible
   e. plus or minus 20 hertz

10. An operator may use the indirect method to determine operating power of a station when:
   a. antenna current monitor fails to function
   b. antenna tower lights fail to operate
   c. modulation increases above 100%
   d. authorized by the FAA commission
   e. both a and b above

11. What class of operator may perform maintenance work on transmitter equipment?
   a. third class operator
   b. second class radiotelegraph operator
   c. first class operator
   d. FCC authorized operator
   e. anyone authorized by station licensee

12. One million hertz is equal to:
   a. 100 kilohertz
   b. 1,000 kilohertz
   c. 10,000 kilohertz
   d. 100,000 kilohertz
   e. 10 kilohertz

13. A third class operator on duty at a broadcast station is authorized to:
   a. replace defective final amplifier tubes and fuses
   b. adjust internal transmitter control circuits
   c. adjust external controls to compensate for voltage fluctuations in the primary power supply
   d. adjust transmitter to maintain the correct operating frequency
   e. correct station license to reflect actual operating values

14. Using the direct method, an operator may determine operating power of an AM broadcast station by:
    a. reading the antenna voltage meter and multiply the voltage indication by the ohms of resistance of the antenna
    b. reading the antenna current meter and multiply the square of the indication by the ohms of resistance of the antenna
    c. reading the modulation monitor and multiply the percentage of modulation by the resistance of the antenna
    d. muliply the station power factor by the actual operating power of the transmitter
    e. either b or d above

15. An operator will obtain an accurate reading of transmitter operating power if the meter is read:
    a. during 100% modulation with a 1,000 hertz tone signal
    b. before actual sign on of the transmitter
    c. after three hours of tube warm up time
    d. during a natural break in programming when transmitter is modulated 100%
    e. during a natural break in programming when transmitter is unmodulated

16. The Commission's Rules specify that the operating power of a station shall not exceed the limit of:
    a. 125% of operating power
    b. 120% of authorized power
    c. 115% of operating power
    d. 110% of authorized power
    e. 105% of authorized power

17. The operator, at an AM broadcast remote controlled station, is unable to change from a non-directional to a directional antenna at sunset. If no other operator is on duty at the transmitter:
    a. notify station licensee
    b. monitor power by means of RF transmission line meter
    c. use regular common point ammeter
    d. the station must cease transmitting
    e. reduce operating power to 90% of authorized value

18. The VU meter on the audio control console:
    a. indicates the actual value of modulation peaks
    b. does not indicate the actual value of modulation peaks
    c. is the same as a modulation monitor
    d. is 1.414 db lower than the modulation monitor
    e. both a and c above

19. A third class operator with broadcast endorsement may operate:
    a. low power radiotelegraph stations
    b. educational 5 KW television stations
    c. AM broadcast stations with critical directional antennas
    d. both a and b above
    e. none of the above

20. Operating parameters of an AM or FM broadcast transmitter are entered in the:
    a. operating log
    b. engineering log
    c. program log
    d. operation control log
    e. maintenance log

21. The antenna resistance at a 1,000 watt AM broadcast station is 52 ohms. When music is played, the antenna current meter reads as high as 4.9 amperes. During a pause in program audio, the antenna current drops to 4.4 amperes. What is the operating power?
    a. 1,250 watts
    b. 1,000 watts
    c. 208 watts
    d. 416 watts
    e. 10 KW

22. When the utility company supplies a higher voltage than normal, the operator at the transmitter control point must:
    a. notify station licensee
    b. cease transmitting
    c. increase audio volume level
    d. compensate for this change
    e. reduce to nighttime power

23. To calculate operating power of an AM station, by the direct method, measurements are made:
    a. with a volt-ohm meter
    b. with 100% modulation
    c. with an antenna phase meter
    d. at the base of the antenna
    e. at the last stage plate phase circuit

24. An operator holding the proper grade of license shall be in actual charge of the transmitting apparatus and shall be on duty at any location on the station premises:
    a. provided equipment is protected with failure alarms
    b. if programming and transmitter logging is automated
    c. if programming is automated
    d. if programming is not automated
    e. where the required metering and control equipment is installed

25. AM broadcast stations with directional antenna systems utilize phasor equipment to:
    a. regulate the amount of antenna current flowing to each tower
    b. divide and shift the phase of the signal so the RF may arrive at each tower before or after the RF arrives at other towers
    c. regulate the percentage of modulation flowing to each tower
    d. convert three-phase power input to the standard two-phase format
    e. both a and b above

26. Programs transmitted under Subsidiary Communications Authorization:
    a. cannot be received without a special receiver
    b. are broadcast in stereophonic sound
    c. are limited to 1 KW operating power
    d. are activated only by orders from the President
    e. all of the above

27. What should operators be familiar with before communicating with the public during an emergency notification?
    a. operating parameters list
    b. EBS checklist
    c. engineering malfunction chart
    d. EAN teletype termination
    e. auxiliary transmitter operation

28. If an automatic alarm system is not in service, observations to insure that tower lights at a station are functioning properly must be made at least once every:
    a. hour
    b. three hours
    c. twelve hours
    d. twenty-four hours
    e. thirty minutes

29. When a transmitter and monitor equipment are located out of sight from the operator control point, operating parameters of the system may be monitored by:
    a. indirect method
    b. direct method
    c. extension meters
    d. remote phase monitor
    e. directional loop circuit

30. Commercial announcements, station identifications, and public services messages are entered in:
    a. programming control log
    b. program maintenance log
    c. program log
    d. sales service log
    e. maintenance log

31. When inaccurate meter readings occur, resulting from remote equipment malfunctions, a third class operator:
    a. has 60 days to correct malfunction, provided FCC Form #759 is sent to the Commission
    b. has one hour to correct malfunction, and if not corrected operator must turn transmitter off, provided no operator is posted at the transmitter
    c. must cease transmission
    d. determine power by indirect method
    e. make entry in operating log

32. An AM broadcast antenna system must have two or more towers:
    a. to monitor and transmit EBS and SCA signals
    b. for stereophonic transmission
    c. for AM and FM transmission
    d. to produce a nondirectional signal pattern
    e. to produce a directional signal pattern

33. If the photocell that automatically turns on and off the tower lights should fail:
    a. make entry in programming log
    b. repairs must be made within 30 minutes
    c. the lights must be left burning continuously
    d. notify station licensee
    e. notify the Commission

34. A remote antenna ammeter, at AM broadcast stations, must be read:
    a. with a 1,000 hertz test tone
    b. when the transmitter carrier in unmodulated
    c. when the transmitter carrier is modulated 100%
    d. every hour
    e. at the transmitter extension phasor

35. The operating power limitations for a 1,000 watt station are:
    a. 1,050 watts maximum, 900 watts minimum
    b. 1,200 watts maximum, 850 watts minimum
    c. plus or minus 10%
    d. plus or minus 5%
    e. plus or minus 2.5%

36. If equipment malfunction prevents a station from operating at full authorized power, the transmitter may be operated:
    a. at reduced power
    b. at less than 90% of authorized power
    c. at less than 90% but not more than 125% of authorized power
    d. at the auxiliary transmitter location
    e. both a and b above

37. If a correction in a log is made after the person who kept the log has signed off duty:
    a. the next operator on duty must correct the error
    b. the station licensee must file a report with the commission
    c. advise chief engineer of error
    d. an explanation must be written on, or attached to, the log
    e. the correct entry must be posted at the transmitter control point

38. If a flashing beacon at some intermediate level on an antenna tower burns out, the:
    a. operator should notify the nearest FAA office or flight service station if it cannot be restored within 30 minutes
    b. operator should notify the local FCC field office
    c. other lights should be left burning continuously
    d. other lights should be turned off until it is repaired
    e. local power company should be notified

39. An AM broadcast directional antenna:
    a. always consists of two towers in phase
    b. radiates equally in all horizontal directions
    c. radiates more signal strength in some directions than in others
    d. is required for stereophonic transmission
    e. radiates more power than nondirectional antenna

40. Where must operator licenses be posted in the station building?
    a. at the transmitter
    b. at the extension meter location
    c. at the remote control point
    d. both a and b above
    e. any of the above

41. When the remote control equipment malfunctions and results in improper transmitter control, the:
    a. operation by remote control must cease
    b. power must be reduced by 5%
    c. power must be reduced by 10%
    d. station must be taken off the air
    e. FCC must be notified

42. To change an AM station's directional broadcast pattern, a third class operator must:
    a. determine directional pattern by indirect method
    b. activate switches controling the pase and amplitude of RF currents in each tower
    c. activate phasor control circuits by manual control recalibration
    d. notify first class operator
    e. both a and b above

43. The current flowing into an AM antenna and the resistance of the antenna are used to calculate:
    a. operating frequency of the station
    b. antenna phase angle of the station
    c. percentage of modulation
    d. antenna resistance
    e. operating power of the station

44. The percentage of transmitter modulation is determined by the:
    a. volume level of the audio source
    b. authorized power of the station
    c. frequency of the audio source
    d. actual operating power
    e. indirect method

45. If the remote common point ammeter reads 16 A and the common point resistance is 39.1 ohms, what is the actual operating power of an AM directional station?
    a. 626 watts
    b. 24.46 KW
    c. 5 KW
    d. 10 KW
    e. 890 watts

46. How long may an operator broadcast by remote control after a malfunction, causing inaccurate meter readings, is observed?
    a. 30 minutes
    b. one hour
    c. 10 days
    d. 30 days
    e. 60 days

47. A third class operator must be able to:
    a. operate all audio equipment
    b. operate emergency broadcast system reception equipment
    c. use language commonly understood by the public
    d. rebroadcast signals from other transmitters
    e. all of the above

48. When is identification of a broadcast station required to be made?
    a. every three hours
    b. once per day
    c. once per week
    d. hourly, as close to the hour as feasible
    e. every half-hour

49. At directional AM stations where third class operators are employed, what information must be posted by each meter?
    a. upper and lower limits of authorized operating parameters
    b. last stage plate voltage
    c. RF transmission line current limitations
    d. antenna base voltage ratio parameters
    e. all of the above

50. An operator at a broadcast station not operated by remote control must post his operator license or permit:
    a. where is can be inspected by the public
    b. at any location at the station where it is readily visible
    c. in the main studio
    d. where it is available for inspection by FCC representatives
    e. at the transmitter or extension meter location

51. Modulation peaks of frequent recurrance should average:
    a. 110%
    b. 100%
    c. 85%
    d. 70%
    e. 20%

52. What type of transmission is not affected by increased radiation coverage during nighttime operation?
    a. FM
    b. frequency modulation
    c. AM stations
    d. both a and b above
    e. all of the above

53. The radio frequency signal in each tower of a three tower directional station is:
    a. the same frequency
    b. always in phase
    c. always out of phase
    d. one-third of the total operating frequency
    e. none of the above

54. To calculate operating power of an AM directional station, measurements are made:
    a. at the base of the antenna
    b. at the wavelength of the antenna
    c. with the common point ammeter
    d. with the modulation monitor
    e. with a VU meter

55. What should an operator do if a plate voltmeter, ammeter, or antenna monitor fails to function properly?
    a. notify station licensee
    b. notify the Commission within 10 days
    c. notify chief engineer within 30 minutes
    d. replace with new meters at once
    e. continue to log previous meter readings

56. When the antenna ammeter reads 8 amperes at an AM broadcast station and the antenna resistance is 15.6 ohms, calculate the station operating power by the direct method.
    a. 125.8 watts
    b. 1,952 watts
    c. 5,000 watts
    d. 10 KW
    e. 1 KW

57. Without being under the supervision of a first class operator, the holder of a third class license may:
    a. switch to different antenna radiation patterns
    b. correct for fluctuation of primary power supply voltage
    c. change from 5 KW to 1 KW transmitter output power
    d. reduce modulation level to proper amount
    e. any of the above

58. What antenna radiates a signal equally in all horizontal directions?
    a. directional
    b. nondirectional
    c. microwave
    d. VTR remote
    e. unidirectional

59. If both the antenna ammeter and remote antenna ammeter of an AM broadcast station become defective, the operating power must then be determined by the:
    a. power factor method
    b. RF transmission line meter readings
    c. indirect method
    d. phasor feedback method
    e. nondirect method

60. The operating and program log must be signed:
    a. only once followed by the time the operator went on and off duty
    b. only when corrections are made, otherwise initials are required
    c. when starting duty and again when going off duty
    d. after each entry
    e. only once per day

61. Excessive modulation peaks over 100% negative peak at FM broadcast stations may cause:
    a. interference to other stations
    b. distortion of the audio signal
    c. home receiver equipment damage
    d. both a and b above
    e. all of the above

62. 7.3 kilowatts equals:
    a. 73 watts
    b. 730 watts
    c. 7,300 watts
    d. 73,000 watts
    e. 730 megawatts

63. The percentage of modulation, at an AM directional station, is determined by the:
    a. phase of the audio signal
    b. frequency of the audio signal
    c. amplitude of the audio signal
    d. amount authorized by the commission
    e. any of the above

64. The technical record of the daily operation of a broadcast station is:
    a. maintenance log
    b. engineering log
    c. operating log
    d. SCA control log
    e. program log

65. The antenna current meter or remote antenna current meter, where provided, should be read:
    a. during modulation peaks
    b. prior to placing the station on the air
    c. when program material modulates the carrier at the average level
    d. when the carrier in unmodulated
    e. once each hour

66. Antenna monitor sample current is:
    a. the same as loop sample current
    b. the same as authorized operating power
    c. the same as actual operating power
    d. the modulation index value for FM transmitters
    e. none of the above

67. If an antenna system contains two towers, out of phase 53 degrees, the frequency broadcast is 1150 kHz, the radiofrequency in each tower is:
    a. 609.5 kHz
    b. 575 kHz
    c. 1,150 hertz
    d. 1150 kHz
    e. cannot be determined

68. Antenna tower lights must be on:
    a. continuously from local sunrise to sunset
    b. continuously from local sunset to sunrise
    c. continuously during hours of station transmission
    d. flashing every 5 seconds
    e. from 4:30pm to 8:30am local time

69. What is utilized to distribute the station signal to all antenna towers in a directional broadcast transmission system?
    a. modulation monitor
    b. remote antenna ammeter
    c. phasor
    d. voltage divider
    e. common point loop circuit

70. What type of transmission is not required to be logged?
    a. plate voltage
    b. antenna current
    c. plate current
    d. FM stereo emissions
    e. both a and c above

71. After an operator checks the tower lights for proper operation:
    a. notify the FAA within 30 minutes
    b. continue to operate by remote control
    c. photocell must be switched to normal function
    d. notify chief engineer immediately
    e. the actual time of the observation must be noted in the operating log

72. What is the first action an operator should take after receiving an Emergency Action Notification (EAN), in addition to listening for additional instructions?
    a. transmit the EBS test tone and turn off transmitter
    b. transmit a 1 kHz tone for 30 minutes, followed by recorded audio
    c. refer to EBS checklist
    d. telephone station licensee immediately
    e. refer to instructions listed on the station license

73. To calculate operating power of an FM broadcast station, where are measurements made?
    a. in the final plate voltage circuit
    b. in the final RF amplifier buffer stage
    c. in the transmission line
    d. at the utility power input to the transmitter
    e. at the sampling loop base connection

74. Stations employing third class operators must post:
    a. operating parameters
    b. base current ratio
    c. antenna radiation
    d. phase angle values
    e. operating frequency

75. The Loop Sample current ratios and posted limits at a three tower AM directional broadcast station are:

	Tower #1	Tower #2	Tower#3
Loop sample current ratios	0.375	1.0	0.810
Posted limits	0.347-0.383	1.0	0.734-0.824

Which of the following is correct?

a. transmitter is in violation of authorized parameters
b. transmission must cease immediately
c. antenna system is operating properly
d. notify station licensee immediately
e. both a and b above

76. When the remote control equipment malfunctions, the station must:
a. continue to monitor and log entry in operating log
b. cease modulation, broadcast unmodulated carrier
c. notify chief engineer, continue transmission by remote control
d. replace monitor equipment with auxiliary metering
e. cease operating by remote control immediately

77. During what condition must a third class operator, at an AM broadcast station, cease transmitting at once?
a. transmission line meter fails
b. remote common point ammeter fails
c. antenna monitor fails
d. all of the above
e. none of the above

78. If the modulation monitor peak indicator in a standard broadcast station indicates peaks of frequent recurrence in excess of 100%, what action should be taken by the operator?
a. reduce the transmitter final plate voltage
b. adjust filament voltage to normal
c. inform the chief engineer
d. reduce the audio level
e. notify the station manager

79. What is required by the Commission in regards to antenna tower light procedure?
a. weekly inspection to insure proper operation
b. daily inspection to insure proper operation
c. hourly inspection to insure proper operation
d. sign on inspection to insure proper operation
e. switch on lights daily at 4:30pm

80. A standard (AM) broadcast station determines the operating power by the direct method. The meter indications which must be routinely observed and entered into the operating log are:
a. plate voltage and current, and RF transmission line
b. plate voltage and current, filament voltage and modulation
c. plate voltage and current, and antenna or common point current
d. plate voltage and current, and peak modulation
e. plate voltage and current only

81. Who is responsible for instructing third class operators in performing transmitter adjustments, meter reading, and how to make log entries?
    a. chief announcer
    b. chief engineer
    c. station licensee
    d. program director
    e. any of the above

82. What change in operating parameters and transmitting mode must be recorded in the operating log by an operator?
    a. when the station goes on and off the air
    b. when change of transmitter occurs
    c. when change of antenna pattern occurs
    d. when operating power is increased or reduced
    e. any of the above

83. In the event the remote common point ammeter fails to function, an AM directional station may use the regular common point ammeter:
    a. provided the antenna base currents are read once each day for each mode of operation
    b. provided the antenna base currents are read once per hour for each mode of operation
    c. provided the chief engineer is on duty
    d. if the FCC is notified
    e. if a proof meter reading is performed

84. Required maintenance log entries at an AM broadcast station must be made:
    a. by a licensed radiotelephone operator
    b. by any person knowing the required facts
    c. by a first class operator
    d. by the station licensee only
    e. once per three hours

85. Operating power at an AM broadcast station, when determined by the direct method, is computed or obtained from:
    a. the square of the antenna current times the antenna resistance
    b. the antenna current times the square of the antenna resistance
    c. the plate voltage times the plate current
    d. the calibrated power meter
    e. the sum of the antenna current plus the plate current

86. If a modulation monitor becomes defective, a station may:
    a. cease transmitting immediately
    b. continue to operate for 30 minutes, if repairs can be made during that time
    c. continue to operate if an oscilloscope or other acceptable device is employed
    d. continue to operate if a first class operator is on duty
    e. continue to operate if the chief engineer is on duty

87. A third class operator may adjust the transmitter to:
    a. compensate for frequency fluctuations of the transmitter
    b. compensate for voltage fluctuations in the primary power supply
    c. reduce distortion by making tube changes in transmitter
    d. bring the final output amplifier oscillator to normal values
    e. any of the above

88. A radio broadcast station operator discovers that her operator permit had expired two weeks previously. The operator may not continue to operate the transmitter:
    a. unless certified to do so by a first class operator
    b. unless an application for renewal is filed and a copy posted
    c. until the FCC examination is taken
    d. until the station manager notifies the Commission
    e. until a renewed permit has been issued

89. When a station transmitter fails to function properly within the posted parameters, and meter readings are beyond the terms of the station license, and the third class operator on duty cannot correct the condition:
    a. continue to operate until chief engineer arrives
    b. cease operating immediately
    c. the transmitter must be turned off if a first class radio-telephone operator is not present
    d. the output operating power of the transmitter must be reduced
    e. the licensee must be notified

90. An AM broadcast station is not permitted to modulate the carrier to:
    a. 0%
    b. 25% on negative peaks of frequent recurrence
    c. 85% on positive peaks of frequent recurrence
    d. 105% on negative peaks of frequent recurrence
    e. 120% on positive peaks of frequent recurrence

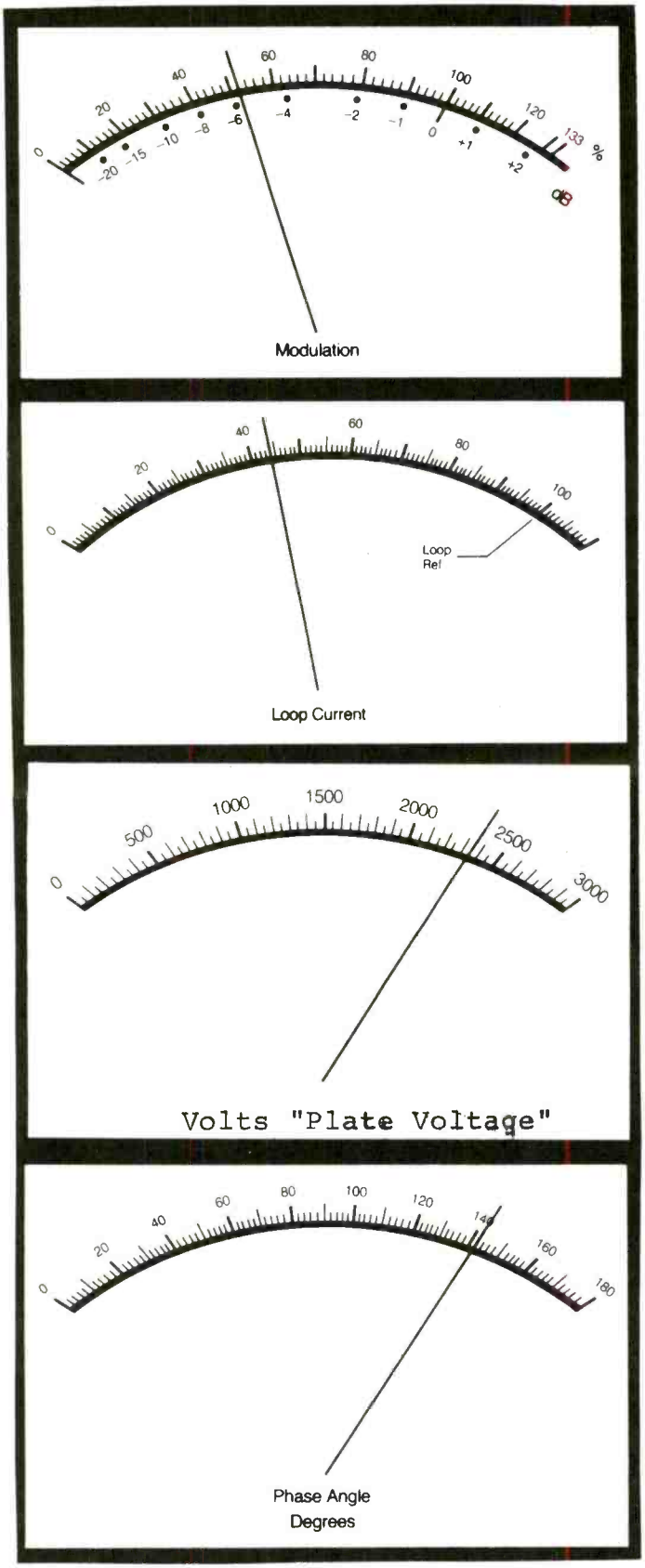
91. 230 milliamperes is equal to:
    a. 23 amperes
    b. 2.3 amperes
    c. 0.23 amperes
    d. 0.023 amperes
    e. 0.0023 amperes

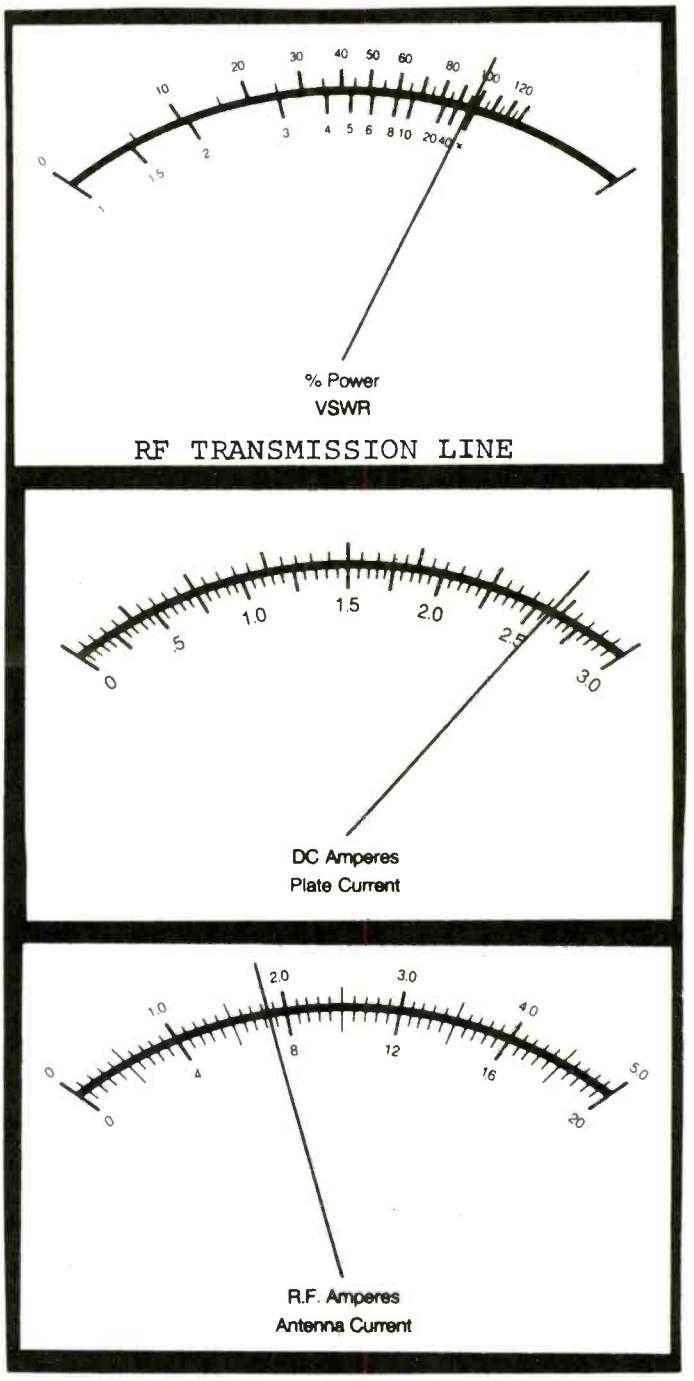
92. The primary concern of an operator on duty at an FM broadcast station should be to:
    a. keep the station on the air at all cost
    b. keep the chief operator advised of problems during the shift
    c. insure that the transmitter is operating within required parameters
    d. insure spot announcements are broadcast and logged properly in the program log
    e. maintain modulation level as high as possible to increase signal strength

93. When a log correction is made before the operator keeping the log goes off duty:
    a. sign and correct the entry within 30 minutes
    b. enter the correct entry on the log and initial old entry
    c. strike out the erroneous entry and sign and date
    d. strike out the erroneous portion and write in the correct entry and initial the correction
    e. obtain a new log form from the station licensee

94. The "VU" meter on the audio control console:
    a. may be used to measure modulation
    b. must not be used to measure modulation
    c. may be used to measure frequency drift of the transmitter
    d. may be used to check the quality of the antenna ammeter
    e. none of the above

TO ANSWER QUESTIONS #95 TO #100, REFER TO THE METERS BELOW:





95. What is the reading on the ANTENNA CURRENT meter?
    a. 2.6 amperes
    b. 144 amperes
    c. 18.5 amperes
    d. 1.84 amperes
    e. 2.35 amperes

96. Using the PLATE VOLTAGE and PLATE CURRENT meters shown, determine the operating power of an AM broadcast transmitter with an efficiency of 86%.
    a. 6.05 KW
    b. 6,000 watts
    c. 520 KW
    d. 5,204 watts
    e. 5,203.85 KW

97. What is the reading on the MODULATION meter?
    a. -6%
    b. 50.2%
    c. -5.9%
    d. +5.9%
    e. 52%

98. The ANTENNA PHASE ANGLE meter indicates what phase?
    a. 142 degrees
    b. 145 degrees
    c. 1.485 degrees
    d. 0.40 degrees
    e. 44 degrees

99. Refering to the RF TRANSMISSION LINE meter, determine the actual operating power of an FM broadcast station, if the authorized power is 33 KW.
    a. 98,000 watts
    b. 44,000 watts
    c. 33,000 watts
    d. 32 KW
    e. 32.175 KW

100. The LOOP REFERENCE meter shows what ratio of sample current in the tower it is displaying to that of the reference tower?
    a. 44
    b. 0.44
    c. 45/100.2
    d. 98%
    e. 44,000 watts

101. Which of the following are not required to be recorded in the operating log?
    a. plate voltage meter reading
    b. plate current meter reading
    c. antenna ammeter reading
    d. modulation monitor meter reading
    e. the time the station ceases to supply power to the antenna

102. Using external controls, what adjustments may a third class operator make to a broadcast transmitter?
    a. turn transmitter on and off
    b. adjust modulation level
    c. activate switches to change transmitter radiation pattern
    d. maintain proper operating power
    e. all of the above

103. Where are monitors and meters to be placed in a broadcast station?
    a. where the operator can readily observe any change from normal operation
    b. in the master control room
    c. in the transmitter room
    d. where the chief engineer may monitor any FCC violations
    e. where the licensee may correct any transmission violations

104. In the event the modulation monitor becomes defective, an FM broadcast station may be operated without the monitor, provided:
a. the audio level control is adjusted at mid-range
b. the percentage of modulation is monitored with an oscilloscope or other acceptable means
c. the transmitter power is reduced to half of the licensed power
d. the operator makes daily entries in the operating log
e. a first class operator is on duty

105. Official station identification consists of:
a. station's call letters followed by the name of the community specified in the station's license
b. station's call letters followed by the name of the licensee listed on the station's license, followed by the location of the station
c. KGO, American Broadcasting Company, San Francisco
d. KGO, San Francisco
e. any of the above

106. Program logs must be maintained by:
a. any FCC licensed operator
b. a first class radiotelephone operator
c. anyone working in the programming department
d. a third class operator
e. station employees competent to do so and having actual knowledge of the facts

107. Entries in the AM or FM station operating log shall be made by:
a. any station employees having actual knowledge of the required facts
b. the properly licensed operator in actual charge of the transmitter
c. any employee duly authorized to do so by the station licensee
d. the full time or contract maintenance operator
e. any licensed radio operator

108. A three tower AM directional broadcast station has the following antenna monitor meter readings:

	Tower #1	Tower #2	Tower #3
Phase	90 degrees	0 degrees	-51 degrees
Base Current Ratio	0.222	1.0	0.711
Antenna Monitor Sample Current Ratio	0.81	1.0	1.0

Which of the following is correct?
a. Tower #1 phase is 90 degrees ahead of Tower #2
b. Tower #2 is the reference tower
c. Tower #3 phase is 51 degrees behind Tower #2
d. both a and b above
e. all of the above

109. A third class operator must immediately turn off a broadcast station transmitter when:
   a. the modulation monitor fails
   b. the transmitter is under power
   c. any top light or flashing beacon fails
   d. either plate voltmeter or plate ammeter fails
   e. none of the above

110. An AM broadcast station may operate with an inoperative modulation monitor:
   a. when a volt-ohm meter is utilized
   b. for 60 days without notifying the Commission if an alternate means of measuring modulation is utilized
   c. when a "VU" meter is connected in the transmitter final circuit
   d. for one hour, then transmission must cease
   e. when a first class operator files form #759 with the FCC

111. The standard operating location for an operator on duty is at the:
   a. transmitter
   b. remote control point
   c. extension meter location
   d. both a and b above
   e. any of the above

112. When may a DAYTIME station operate prior to actual sunrise?
   a. only during a local emergency
   b. when the auxiliary transmitter is being tested
   c. after obtaining Presunrise Service Authority (PSA)
   d. when the FAA approves
   e. all of the above

113. When may an unlicensed announcer, or other person, adjust audio modulation levels, and operate equipment such as tape recorders, microphones, turntables, and audio console?
   a. when a licensed operator is on duty at the transmitter control point and is monitoring modulation volume levels
   b. after passing an examination given by the licensee
   c. when operating low power educational stations
   d. when programming is recorded on tape for future broadcast
   e. any of the above

114. To avoid interference to other stations at sunset, some broadcast stations must:
   a. reduce power
   b. sign off the air
   c. switch to directional antenna operation
   d. change from one antenna pattern to another
   e. any of the above

115. The FM broadcast band of frequencies are:
   a. 88 hertz to 1605 hertz
   b. 88 MHz to 108 MHz
   c. 535 kHz to 1605 kHz
   d. 535 kHz to 108 kHz
   e. 88 MHz to 535 MHz

ELEMENT NINE ANSWERS

1-C	24-E	47-B	70-D	93-D
2-E	25-E	48-D	71-E	94-B
3-A	26-A	49-A	72-C	95-D
4-D	27-B	50-E	73-C	96-D*
5-B	28-D	51-C	74-A	97-E
6-A	29-C	52-D	75-C	98-A
7-B*	30-C	53-A	76-E	99-E*
8-C	31-B	54-C	77-E	100-B*
9-D	32-E	55-A	78-D	101-D
10-A	33-C	56-E*	79-B	102-E
11-C	34-B	57-E	80-C	103-A
12-B	35-A	58-B	81-C	104-B
13-C	36-E	59-C	82-E	105-E
14-B	37-D	60-C	83-A	106-E
15-E	38-A	61-D	84-C	107-B
16-E	39-C	62-C	85-A	108-E
17-D	40-E	63-C	86-C	109-E
18-B	41-A	64-C	87-B	110-B
19-E	42-B	65-D	88-E	111-E
20-A	43-E	66-A	89-C	112-C
21-B*	44-A	67-D	90-D	113-A
22-D	45-D*	68-B	91-C	114-E
23-D	46-B	69-C	92-C	115-B

* SOLUTIONS:

#7- P=IxExF, thus 0.385 x 3010 x 0.85 (85% = 0.85) = 985.02 or aprox. 985 watts. A station must operate between 90% to 105% of authorized power; thus: 90% = 0.9 x 1,000 = 900 watts. 105% = 1.05 x 1,000 = 1,050 watts. Since the actual power is 985 watts, the station is operating within the high and low power limitations.

#21- $P=I^2R$, thus solve using antenna current during no modulation (i.e. music), P= 4.4 squared x 52 = 19.36 x 52 = 1,006.72 watts, or aprox 1 KW.

#45- $P=I^2R$, thus P= 16 squared x 39.1 = 256 x 39.1 = 10,009.6 watts. or aprox 10 KW.

#56- $P=I^2R$, thus P= 8 squared x 15.6 = 64 x 15.6 = 998.4 watts, or aprox 1 KW.

#75- Since 0.375 is between 0.347 and 0.383 for Tower #1. Tower #2 is exactly 1.0. Tower #3 reading is 0.810 is between 0.734 and 0.824, thus the station is operating within prescribed authorized limits.

#96- P=IxExF, thus 2.575 x 2,350 x 0.86 (86% = 0.86) = 6,051.75 x 0.86 and thus equals 5,204 watts.

#99- Disregard LOWER meter scale. Read upper scale (0 to 120). The upper scale displays percent of authorized power. The meter reads 97 1/2%. To find operating power simply multiply 0.975 (97 1/2%) times 33,000 which equals 32,175 watts, or 32.175 KW.

#100- Simply divide the meter reading (44) by the loop reference (marked on the meter (100). Thus, 44 divided by 100 = 0.44.

COMMAND PRODUCTIONS

ANSWER SHEET

ELEMENT ONE

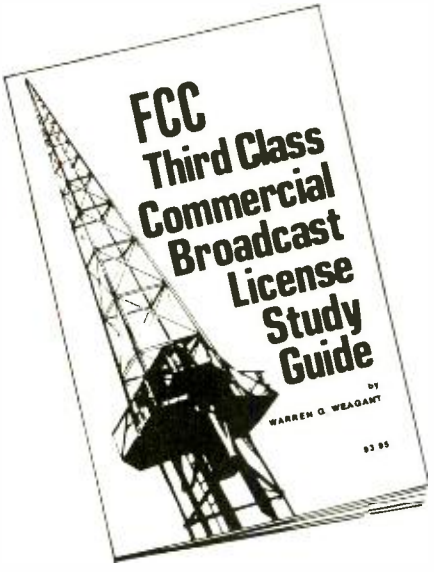
1. B
2. E
3. C
4. C
5. B
6. C
7. A
8. B
9. E
10. B
11. D
12. C
13. E
14. C
15. A
16. D
17. E
18. B
19. B
20. E

ELEMENT TWO

1. D
2. D
3. C
4. C
5. A
6. E
7. B
8. A
9. D
10. A
11. E
12. D
13. C
14. B
15. D
16. E
17. B
18. B
19. E
20. D

ELEMENT NINE

1. A
2. A
3. E
4. E
5. D
6. C
7. B
8. E
9. A
10. C
11. B
12. E
13. D
14. B
15. C
16. B
17. C
18. C
19. A
20. E
21. D
22. E
23. E
24. E
25. C
26. C
27. A
28. B
29. A
30. C
31. B
32. C
33. D
34. C
35. A
36. B
37. C
38. E
39. C
40. E
41. E
42. D
43. A
44. C
45. A
46. E
47. A
48. C
49. C
50. E



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