# ADVANTAGES OF FM

## *The listener to frequency-modulated programs hears more stations and better music undamaged by interference, natural or man-made.*

**By LEIGH L. KIMBALL***

THE frequencies from 88 to 108 megacycles today embrace the finest system of aural broadcasting which has been available to the public since the beginning of radio history. Yet not so long ago it was believed that any frequency above 30 megacycles was limited strictly to service as far as the horizon and that the generation of large amounts of power at these shorter wave lengths was an impossibility. It took World War II to inspire the miracles of engineering which have made it possible to develop kilowatts of power in the vicinity of 100 megacycles.

The miracles were not confined solely to transmitting developments. Receiving-tube design also advanced, keeping step with transmitter research. A tremendous amount of research was also undertaken on high-frequency antennas and v.h.f. propagation. The accumulated experience led the Federal Communications Commission to assign FM broadcasting to the 88 to 108-megacycle band which only a few years before had been considered an absurd assignment for broadcast service.

How greatly FM has progressed since its original assignment to this frequency band is illustrated by the fact that there are now a number of FM broadcast stations operating with effective power in excess of 200 kilowatts. It is estimated that there are over 1,620,000 FM home receivers in use today. They are common pieces of living room furniture, whereas ten years ago a superheterodyne receiver operating at 100 megacycles would have been even a laboratory curiosity.

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Now comes the question—of what use and what advantage is this new system of broadcasting to the average person? The first advantage is the well-known one of high audio fidelity. The chart in Fig. 1 shows the extended audio range possible with FM. Full frequency response to the limits of human hearing is possible because the 20-megacycle width of the FM broadcast band accommodates wide-band stations with ease, whereas the approximately 1-megacycle wide AM broadcast band poses a problem of frequency conservation. In addition wide-band FM is inherently free from noise.

The FCC has set up frequency-response standards and requires compliance with these standards within + or − 1 db from 50 to 15,000 cycles. Distortion requirements are as follows:

| Modulating Frequency (Cycles) | Maximum Permissible Distortion (%) |
|---|---|
| 50 to 100 | 3.5 |
| 100 to 7500 | 2.5 |
| 7500 to 15000 | 3 |

Before a license is issued, the larger FM Stations are required to submit actual measurements from microphone terminals to antenna showing that the over-all system has the required frequency response and meets distortion specifications.

The advantages of FM are not limited to high-quality program transmission only. FM offers real benefits to broadcast listeners who live beyond the normal nighttime service ranges of AM transmitters.

The degree to which AM broadcasting deteriorates at night is amazing. Millions of listeners in this country who live in rural and semirural areas nightly experience a tremendous reduction in available AM program service. The number of stations in the country has more than doubled since the end of the war. Right now, there are more than 1,970 AM stations on the air or under construction. As a result, most of them are operating under increased interference conditions at night when sky waves

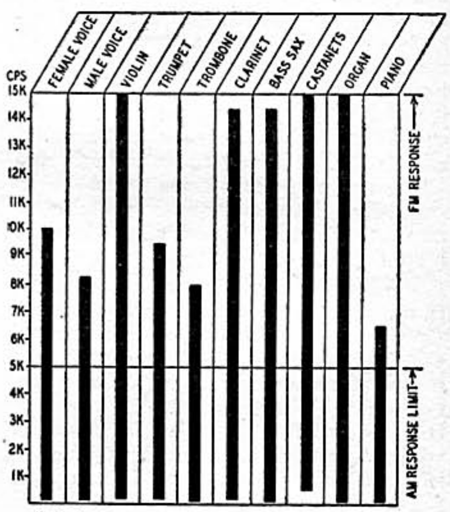
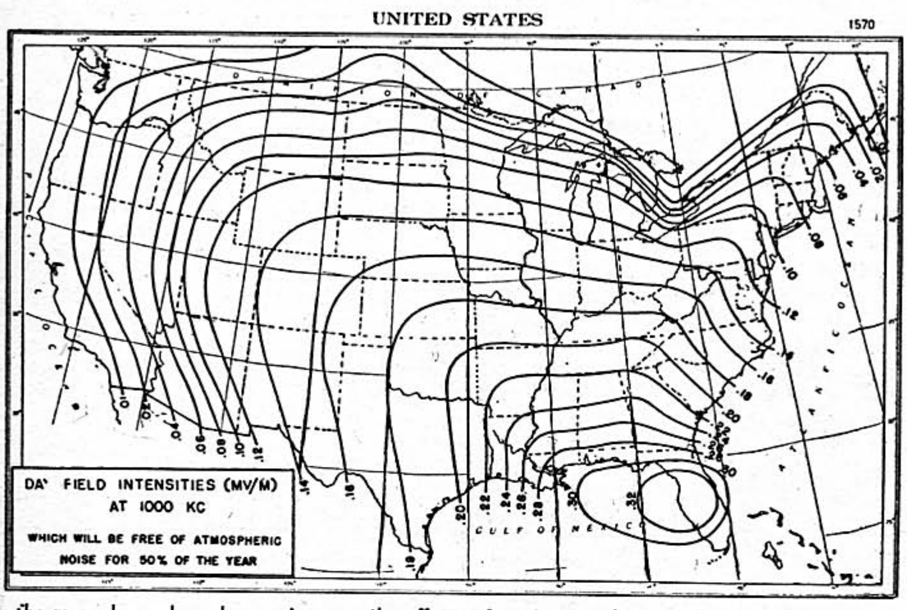



Fig. 1—FM reproduces the full audio range.

cover tremendous distances compared to ground-wave coverage in the daytime. After sundown, these sky waves may travel halfway or further across the country, to interfere with any or all other stations on the same channel. In the early days of broadcasting, when there were fewer stations, sky-wave transmission was a boon—people developed their first keen interest in radio by sitting up into the wee small hours to listen to distant stations. But today, sky-wave propagation in the form of interference from other stations on his channel has become a plague to the broadcaster.

Of the AM stations now licensed, 851 (more than half) are class IV locals, all




The map above shows how serious are the effects of static on ordinary AM transmissions. Many southern areas can have satisfactory radio program service only with static-free FM.

of which are crammed into six of the 101 channels available for AM broadcasting—an average of about 142 stations per channel. These stations range from 100 to 250 watts and serve a radius of anywhere from 20 to 50 miles in the daytime, depending upon frequency and soil conductivity in the area. At night, the interference-free coverage of a local station in most areas is reduced to something less than a 5-mile radius, due to interference from all the other stations on the same channel.

FM coverage area is practically constant. The distance signals can cover at this high frequency is roughly the same during day or night. Interference from other FM stations is much less than with AM because the desired FM signal need be only twice as strong as the interfering signal on an adjacent channel to blanket it completely. A desired AM signal must be 100 times stronger than an interfering AM signal.

Because of these factors, a greater number of FM stations can be assigned in a given area, and can give more complete coverage than a smaller number of AM stations. This is a much more effective system for all concerned—the broadcaster, the time-buying advertiser, and the vast majority of listeners. Because of the stability of FM coverage, it was possible for the FCC to set up a tentative allocation plan to serve as an allocation guide for FM broadcasting throughout the country. The plan provides for two types of FM broadcast stations. The first is the class A station, designed to serve small communities and towns other than the main city of an area and its surrounding rural area. These stations are limited to an effective radiated power (effective radiated power = transmitter output power × antenna power gain × transmission line efficiency between transmitter and antenna) of 1 kilowatt and an antenna height of 250 feet above the average terrain. Twenty FM channels have been set aside for use by class A stations.

The second type is the class B station, designed to render service primarily to a metropolitan district or principal city and its surrounding rural area.

The allocation plan also divides the United States into two areas to tailor the class B stations to the different needs of the country. Area I includes southeastern New Hampshire; all of Massachusetts, Rhode Island, and Connecticut; southeastern New York as far north as Albany-Troy-Schenectady; all of New Jersey, Delaware, and the District of Columbia; Maryland as far west as Hagerstown; and eastern Pennsylvania as far west as Harrisburg. These are generally the more densely populated areas which can better support a larger number of FM stations, but other sections may be added as required. The rest of the country is in Area II.

Class B stations in Area I are licensed to operate with not less than 10-kw effective radiated power with an antenna height of 300 feet and a maximum of 20-kw effective radiated power with an antenna height of 500 feet. If the antenna height is greater than 500 feet, the radiated power must be scaled proportionately but in no case may the radiated power exceed 20 kilowatts. As an example, the radiated power must be reduced to 3 kilowatts for an antenna height of 1,000 feet. Incidentally, this illustrates graphically the relatively tremendous effect upon coverage of height as compared to the effect of power.

The minimum power in Area II is 2 kw and the minimum antenna height is 350 feet. No limit is placed upon the power and antenna height of class B stations in Area II, provided that the new station does not interfere with existing stations. Consequently, stations in this area are able to serve the sprawling rural area. A considerable number of construction permits have been issued for 450-kilowatt stations.

As an example of the way the tentative allocation plan works, 20 class B channels have been assigned to serve the entire metropolitan area of New York City on a constant day-and-night basis. In addition to these 20 channels, there are 13 class A channels available to serve local interests, making available a total of 33 FM stations in the New York area.

The pattern is the same throughout the country. In general and wherever practical, cities have been assigned channels on a population basis. Smaller cities capable of supporting relatively few stations have been assigned relatively few channels, and the larger cities have been assigned correspondingly

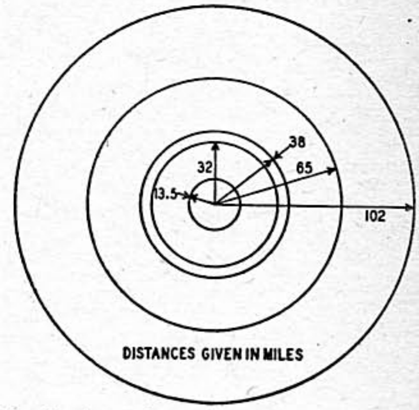



Fig. 3—Approximate ranges of FM stations.

larger numbers of channels. Because of methodical planning by the FCC, the most efficient channel usage for FM broadcasting facilities has been assured.

The map in Fig. 2 illustrates what coverage may be obtained by FM stations according to the coverage prediction system set up by the FCC. It compares the predicted coverage area of one FM station with the coverage ac-

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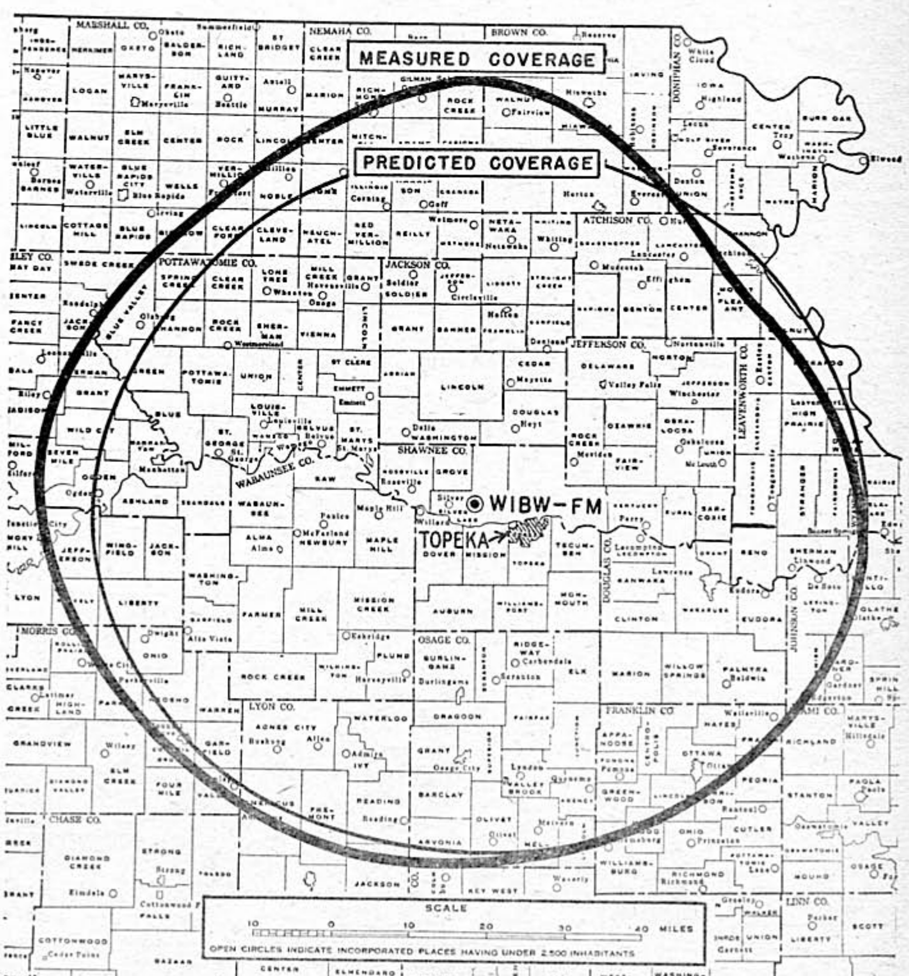


Fig. 2—Correlation between predicted and actual coverage of typical FM broadcast station.

## FM SWEEP GENERATORS

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a 'scope for optimum alignment of all FM and AM receivers and tuners. FM receivers must be properly aligned to take advantage of the high-fidelity and noise-free characteristics of the Armstrong and ratio-detector circuits.

The following is a list of features incorporated in different types of FM-AM signal generators, with a description of each type. The cross index lists popular makes of FM-AM signal generators and the features each includes, as well as their relative prices. Experience indicates that wide-band television sweeps combined with such instruments are impractical and prohibitively expensive. A separate restricted-range r.f. generator with 10-mc sweep has proved more satisfactory.

FREQUENCY RANGE: Continuous coverage from 100 kc to at least 110 mc is essential to cover all services. All frequencies should be fundamental — not harmonics.

NUMBER OF BANDS: More bands mean better dial accuracy. However, an excessive number of bands is time consuming.

FM DEVIATION RANGE: Must be at least ±150 kc wide to permit visual analysis of wide-band FM receivers. An additional narrow deviation range permits accurate alignment of i.f. stages of high-fidelity AM receivers. Calibrated variable deviation is a valuable feature since it enables direct reading of i.f. band width which indicates fidelity response. For example, if the i.f. signal is fed into the converter, the discriminator pattern may be viewed on the 'scope and measured directly in kilocycles on the deviation scale of the generator.

FM SWEEP FREQUENCY: Ability to vary the deviation rate is useful. It permits a point-to-point oscilloscope check through the whole set from speaker to antenna with one setting of the signal generator.

OUTPUT CALIBRATION: It is almost impossible to design a signal generator whose output voltage doesn't drop as the frequency is increased. Response curves therefore have little meaning unless the output level can be corrected with frequency. In addition, a calibrated direct-reading meter can indicate the signal-to-noise ratio, sensitivity, and gain per stage. This is a quick way to find a defective tube or circuit.

AMPLITUDE MODULATION: A variable audio oscillator included means an additional instrument at the same price. It can be used externally to test audio response, speaker and cabinet resonance.

VARIABLE MODULATION PERCENTAGE: Standard feature—should be included but not critical as to percentage of variation permitted.

OSCILLOSCOPE SYNCHRONIZATION: Unless a 'scope is synchronized, it will be impossible to get a stationary pattern. Clip leads can be used to pick up external synchronizing voltages but are inconvenient and apt to introduce phase distortion.

OSCILLOSCOPE PHASING: A phasing control eliminates a double image on the 'scope. Phasing can be adjusted with a potentiometer and condenser hung on the horizontal input terminal, but the usual objection to haywire applies.

ACCURACY: Usual standards prevail. Should be weighed against the type of pointer and scale, since ability to read calibration is equally important. Optimum arrangement would be highest accuracy obtainable plus a large dial, preferably protected and having a knife-edge pointer.

DIAL TYPE: Protected dials retain calibration better than unprotected ones. A large dial and thin pointer permit more accurate reading of calibration.

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tually obtained. The correlation between the two is good. In general, field measurements have shown that FM stations are obtaining coverages very close to what has been predicted.

Fig. 3 illustrates the approximate ranges of various classes of FM stations. There is considerable variation due to local conditions, but they are roughly as follows:

Radius in miles

13.5—Class A station, 1 kw effective radiated power, antenna height 250 feet, in Area I with the maximum permissible interference under FCC standards.

32.0—Class B station, 20 kw effective radiated power, antenna height 500 feet, in Area I with the maximum permissible interference under FCC standards.

38.0—Class A station with no interference such as would be the case for all but the most densely populated sections of Areas I and II, power and height as above.

65.0—Class B station in Area II, power and height as above.

102—Class B station in Area II designed for rural coverage, effective radiated power 160 kw, antenna height 1580 feet above average terrain. (Radio KRNT, under construction at Des Moines, Iowa.)

Today, there are more than 500 FM stations on the air, and the FCC has authorized the construction of over a thousand FM stations to date.

The existing 400 stations provide primary service to an area in which 60 million people live, and it is expected that 1,000 FM stations will be on the air by the end of 1948. These stations will serve 117 million people—84% of the population of the United States.

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The FCC should crack down on persons or companies who have secured construction permits for FM broadcast stations but have failed to erect a station, says the FM Association. A resolution to that effect urges that the FCC be asked to "investigate carefully" all applications for extension of time where construction permit holders have not put their stations on the air within the time specified.

## RADIO QUIZ

By HAROLD GLENN

Check your radio knowledge. Any question may have more than one correct answer and, in at least one case all answers are correct.

1. Mercury-vapor rectifiers are used for their (a) low voltage drop, (b) high peak inverse voltage, (c) heavy current handling.
2. The condenser-input filter is good for (a) light loads, (b) low output voltages, (c) heavy loads.
3. A swinging choke is used to (a) vary the bias, (b) improve voltage regulation, (c) handle more current.
4. Condenser-input filter circuits require insulation protection for voltages (a) equal to d.c. output plus a.c. input, (b) 1.41 x d.c. output, (c) 1.41 x a.c. input.
5. The most common method of coupling r.f. stages together is (a) resistance, (b) transformer, (c) capacitance.
6. Capacitance within a tube is between (a) plate and grid, (b) plate and cathode, (c) grid and cathode.
7. The deflector plates in beam-power tubes take the place of (a) control grid, (b) suppressor grid, (c) plate.
8. A supercontrol radio amplifier has the least amplification when (a) the grid is most positive, (b) the plate is at the saturation point, (c) the grid is most negative.
9. Selectivity in a receiver means (a) louder signals, (b) sharper tuning, (c) grid bias.
10. The output transformer has (a) high primary resistance, (b) step-up turns ratio, (c) low secondary resistance. *(See page 82 for answers)*