

FREQUENCY MODULATION

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In its meteoric history of the past twenty years commercial broadcasting's progress has been cumulative. This has been true all the way down the line; receiving sets have graduated from crystal type of instruments to the modern push-button multiple-tubed console models; transmitters have been transformed from one-room studio-control combinations to modern plants like Radio City in New York as the need for larger facilities demanded. During 1939, attention has been directed to a new system of broadcasting known as frequency modulation which completely reverses the present method of radio transmission and threatens to obsolete the now-used amplitude modulation equipment as well as the 40,000,000 radio receiving sets in this country.

Staticless Radio

This basic invention, which has received an unusual amount of publicity in recent months, was patented in 1933 by Major Edwin Armstrong. According to the inventor, his purpose, when he first started his experiments, was to eliminate noise and interference and produce a staticless reception. The result, according to observers, is not only staticless radio but a high fidelity reception which borders on perfect sound reproduction.

Among the claims made for it as a superior method of broadcast transmission is that it possesses characteristics whereby it is possible to eliminate all kinds of disturbances including atmospheric static, electrical noises and background signal interference.

Without going into technical detail, the basic difference between frequency and amplitude modulation is in the method of transmitting sound on sound wave. In the latter system each station is allotted a narrow wave on which to operate. To get its signals over this

band, the station has to use considerable power, with varying strength determined by the type of sound desired to be transmitted. AM signal is not constant and, because the power behind it is not at one level, varies and fades. In the frequency modulation system of transmission high frequencies are used because of the need for a wider band for the individual station. In this manner the signal is allowed a wider band on which it travels from side to side. Sound is imposed on the carrier wave by "wobbling" its frequency over a wave band instead of varying the power. Frequency modulation starts with a wave that maintains its amplitude at all times but a wave that is always changing its frequency in accordance with changes in the sounds affecting the microphone. Power is constant, thus eliminating fading.

Present FM Activity

In 1935 Major Armstrong demonstrated his FM system before the Institute of Radio Engineers. Since then FM transmission has graduated from the laboratory stage into the practical experimental period of its development. Several broadcasters have evidenced an interest in this work. Pioneers in the development of FM transmission are John Shepard II, whose Yankee Network has invested over \$250,000 in a transmitter at Paxton, Mass., to carry on further experiments in this new field; Franklin Doolittle of WDRC, Hartford, whose experimental transmitter has a regular schedule of programs; and John V. L. Hogan of WQXR, New York. Interest among commercial broadcasters has reached a point where an organization of stations experimenting and other interested parties has been organized. At the first meeting 49 organizations interested in frequency modulation attended.

Of the twenty odd stations authorized to operate using frequency modulation at the end of 1939 at least nine were broadcasting on a definite experimental schedule. It is estimated that before Spring there will be an additional twenty. Receiving set manufacturers are keeping up with the trend and four companies have announced the introduction of new lines of FM sets, with more to follow.

HIGH FREQUENCY BROADCAST STATIONS

The term "high frequency station" means a station licensed on frequencies above 25,000 kilocycles for transmission of aural programs for the purpose of experimentation.

LOCATION Town and State	Call Letters	Licensee	Power Watts	Frequency (kc) or Groups
Albany, N. Y.	W2XOY	General Electric Co.	150	43200
Alpine, N. J.	W2XMN	Edwin H. Armstrong	40000	42800, 117430
Avon, Conn.	W1XEH	Travelers Broadcasting Service Corp.	150	42460
Avon, Conn.	W1XSO	Travelers Broadcasting Service Corp.	1000	43200 (C.P. only)
Bethesda, Md.	W2XMC	McNary & Chambers	100	42600 (C.P. only)
Boston, Mass.	W1XK	Westinghouse E. & M. Co.	1000	42600 (C.P. only)
Boston, Mass.	W1XKA	Westinghouse E. & M. Co.	50	42220
Carteret, N. J.	W2XOR	Bamberger Broadcast'g Service	1000	43400 (C.P. only)
Chattanooga, Tenn.	W4XBW	WDOD Broadcasting Corp.	100	26000
Cincinnati, Ohio	W8XNU	The Crosley Corp.	1000	25950
Cleveland, Ohio	W8XNT	United Broadcasting Co.	50	42340
Columbus, Ohio	W8XVH	WBNS, Inc.	250	43000 (C.P. only)
Dallas, Tex.	W5XD	A. H. Belo Corp.	100	25300
Denver, Colo.	W9XLA	KLZ Broadcasting Co.	100	25400
Detroit, Mich.	W8XWJ	Evening News Asso.	500	42060
Fairhaven, Mass.	W1XEQ	E. Anthony & Sons	100	42300
Flushing, N. Y.	W2XQO	Knickerbocker Broadcasting Co.	100	25500
Georgetown, D. C.	W3XO	Jansky & Bailey	1000	43200 (C.P. only)
Holden, Mass.	W1XSQ	Worcester Telegram Pub. Co.	1000	44400 (C.P. only)
Kansas City, Mo.	W9XA	Commercial Radio Equipm't Co.	1000	26000
Kansas City, Mo.	W9XBA	WHB Broadcasting Co.	100	26100
Kansas City, Mo.	W9XER	Midland Broadcasting Co.	500	42460
Los Angeles, Calif.	W6XDA	Columbia Broadcasting System	100	42300
Los Angeles, Calif.	W6XKG	Ben S. McGlashan	1000	25950
Los Angeles, Calif.	W6XRE	Ben S. McGlashan	500	42300, 116950 and 350000
Memphis, Tenn.	W4XCA	Memphis Comm. Appeal Co.	250	26150
Meriden, Conn.	W1XPW	WDRG, Inc.	1000	43400
Milwaukee, Wisc.	W9XAO	The Journal Co. (The Milwaukee Journal)	1000	42600 (C.P. only)
Milwaukee, Wisc.	W9XAZ	The Journal Co. (The Milwaukee Journal)	500	42260 (C.P. only)
Minneapolis, Minn.	W9XHW	Columbia Broadcasting System	50	42300
Nashville, Tenn.	W4XA	The Natl. Life & Accidt. Ins. Co.	1000	26150

LOCATION Town and State	Call Letters	Licensee	Power Watts	Frequency (kc) or Groups
New York, N. Y.	W2XDV	Columbia Broadcasting System.	50	42300
New York, N. Y.	W2XJI	Bamberger Broadcasting Service	100	25300
New York, N. Y.	W2XQR	John V. L. Hogan	1000	43200
New York, N. Y.	W2XVP	City of New York Municipal Broadcasting System	1000	26100 (C.P. only)
New York, N. Y.	W2XWF	William G. H. Finch	1000	42180
New York, N. Y.	W2XWG	National Broadcasting Co., Inc.	1000	42600 (C.P. only)
Oklahoma City, Okla.	W5XAU	WKY Radiophone Co.	100	26125
Paxton, Mass.	W1XOJ	Yankee Network, Inc.	50000	43000 (C.P. only)
Philadelphia, Pa.	W3XIR	WCAU Broadcasting Co.	100	42140
Rochester, N. Y.	W8XAD	WHEC, Inc.	1000	42600 (C.P. only)
Rochester, N. Y.	W8XVB	Stromberg-Carlson Tel. Mfg. Co.	1000	43200 (C.P. only)
Sargents Purchase, N. H.	W1XER	Yankee Network, Inc.	500	42340
Schenectady, N. Y.	W2XDA	General Electric Co.	50	43200
South Bend, Ind.	W9XH	South Bend Tribune	100	26050
Springfield, Mass.	W1XKB	Westinghouse E. & M. Co.	1000	42380
Springfield, Mass.	W1XSN	Westinghouse E. & M. Co.	1000	42600
St. Louis, Mo.	W9XOK	Star Times Publishing Co.	100	25300
St. Louis, Mo.	W9XPD	Pulitzer Publishing Co.	100	25900
Superior, Wis.	W9XJL	Head of Lakes Broadcasting Co.	250	26100
Superior, Wis.	W9XYH	Head of the Lakes B'casting Co.	1000	43000 (C.P. only)
Yonkers, N. Y.	W2XAG	Carman R. Runyan, Jr.	5000	117190

Pending Applications*

Addison, Ill.	not assigned	Moody Bible Institute of Chicago	1000	43000
Allison Park, Pa.	not assigned	Westinghouse E. & M. Co.	1000	42600
Alpine, N. J.	not assigned	Yankee Network, Inc.	50000	43000
Atlanta, Ga.	not assigned	Atlanta Broadcasting Co.	1000	42800
Atlanta, Ga.	not assigned	W. J. Holey	100	43200
Binghamton, N. Y.	not assigned	Howitt-Wood Radio Co.	1000	42600
Boston, Mass.	not assigned	Boston Edison Co.	250	43200
Chicago, Ill.	not assigned	WGN, Inc.	1000	43200
Chicago, Ill.	not assigned	Zenith Radio Corp.	1000	42800
Columbus, Ga.	not assigned	Columbia Broadcast'g System	1000	43000
Dayton, Ohio	not assigned	Miami Valley B'casting Corp.	1000	42600
Detroit, Mich.	not assigned	James F. Hopkins, Inc.	1000	43400
Greensboro, N. C.	not assigned	North Carolina B'casting Co.	250	42600
Kansas City, Mo.	not assigned	Midland Broadcasting Co.	1000	42600
Los Angeles, Calif.	not assigned	Echo Park Evangelistic Assn.	500	25300
Los Angeles, Calif.	not assigned	The May Dept. Stores Co.	1000	43000
Marshall, N. Y.	not assigned	WIBX, Inc.	1000	43400
Mt. Washington, N. H.	not assigned	Yankee Network, Inc.	5000	42600
Philadelphia, Pa.	not assigned	Pennsylvania Broadcasting Co.	1000	43400
Philadelphia, Pa.	not assigned	Westinghouse E. & M. Co.	1000	42600
Portland, Me.	not assigned	Portland B'casting System, Inc.	1000	43400
Providence, R. I.	not assigned	The Outlet Co.	1000	43400
St. Louis, Mo.	not assigned	Star-Times Publishing Co.	250	43000
Syracuse, N. Y.	not assigned	Central New York Broadcasting Corp.	1000	43200
Syracuse, N. Y.	not assigned	Onondaga Radio B'cast'g Corp.	1000	43000

* All pending applications except the Echo Park Evangelistic Association are for frequency modulation emission.

—F. C. C. Regulations Regarding— High Frequency Broadcast Stations

As of January 1st, 1940

The term "high frequency broadcast station" means a station licensed on frequencies above 25,000 kilocycles for transmission of aural programs for general public reception.

Requirements

A license for a high frequency broadcast station will be issued only after a satisfactory showing has been made in regard to the following, among others:

1. That the applicant has a program of research and experimentation which indicates reasonable promise of substantial contribution to the development of high frequency broadcasting.

2. That substantial data will be taken on the propagation characteristics of these frequencies; on the noise level in different parts of the city; on the field intensity necessary to render good broadcast service; on antenna design and characteristics with respect to propagation; and on other allied phases of broadcast coverage.

3. That the research and experimentation will be conducted by qualified engineers.

4. That the applicant is legally and financially qualified and possesses adequate technical facilities to carry forward the program.

5. That the public interest, convenience and necessity will be served through the operation of the proposed station.

Non-Commercial

A licensee of a high frequency broadcast station shall not make any charge, directly or indirectly, for the transmission of programs, but may transmit the programs of a standard broadcast station or network including commercial programs, if the call letter designation when identifying the high frequency broadcast station is given on its as-

signed frequencies only and the statement is made over the high frequency broadcast station that the program of a standard broadcast station or network (identify by call letters or name of network) is being broadcast. Immediately following any announcement of the call letter designation of a standard broadcast station, the program from which is being broadcast over a high frequency broadcast station, the call letter designation of the high frequency broadcast station shall be given. In case of the rebroadcast of the program of any broadcast station, the FCC regulation on rebroadcasting holds.

No licensee of any standard broadcast station or network shall make any additional charge, directly or indirectly, for the simultaneous transmissions of programs by the high frequency broadcast station, nor shall commercial accounts be solicited by a licensee of a standard broadcast station or network, or by others acting in their behalf upon representation that the commercial program will also be transmitted by a high frequency broadcast station.

Frequency Assignment

The following groups of frequencies are allocated for assignment to high frequency broadcast stations:

<i>Group A</i>	<i>Group B</i>	<i>Group C</i>	<i>Group D</i>
25,300 kc	25,900 kc	26,300 kc	42,060 kc
25,325	25,925	26,500	42,100
25,350	25,950	26,700	42,140
25,375	25,975	26,900	42,180
25,400	26,000		42,220
25,425	26,025		42,260
25,450	26,050		42,300
25,475	26,075		42,340
25,500	26,100		42,380
25,525	26,125		42,420
25,550	26,150		42,460

<i>Group E</i>	<i>Group F</i>	<i>Group G</i>	<i>Group H</i>
42,600 kc	116,590 kc	117,190 kc	Any frequency
42,800	116,710	117,430	above
43,000	116,830	117,670	300,000 kc
43,200	116,950	117,910	excluding band
43,400	117,070		400,000 to
			401,000 kc

A station assigned a frequency in Group A, B, D or F is authorized to operate exclusively with amplitude modulation (maximum band width of emission 30 kc). A station assigned a frequency in Group C, E or G is authorized to operate exclusively with frequency modulation (maximum band width of emission 200 kc). A station assigned a frequency in Group H is authorized to operate with either amplitude or frequency modulation with the above band widths of emission as applicable.

Stations serving the same area will not be assigned frequencies separated less than the following:

<i>Group A or B</i>	<i>Group D</i>
100 kc	160 kc

Group C, E, F, G or H

To be determined

One frequency only in a Group will be assigned to a station. A station assigned a frequency in Group A, B or C will not be assigned another frequency. A station assigned a frequency in Group D may also be assigned a frequency in Group F, and in Group E, also in Group G. In case more than one frequency is assigned to a station, the license authorizes operation on only one of the frequencies at one time.

A license of a station assigned a frequency in Group A or one of the last two frequencies in Group C shall make the necessary observations to determine that no interference is caused in international mobile service and international fixed service respectively; and that the operation is in accordance with international agreements on the assignments of stations to this band. If interference is

caused to such services the licensee may be required to reduce the operating power of the station or cease operation until the Commission deems no further interference will result.

Power

No high frequency broadcast station will be licensed for an output power rating greater than 1000 watts unless the applicant can show that greater power is needed to carry on a special program of research, provided, however, in no case will an operating power greater than 1000 watts be authorized to a station assigned a frequency in Group A or one of the last two frequencies in Group C.

While conducting apparatus experiments and in case adequate signal for reliable service can be delivered with less power, the operating output may be reduced accordingly.

Each high frequency broadcast station transmitter shall be equipped with automatic frequency control apparatus so designed and constructed that it is capable of maintaining the operating frequency within plus or minus 0.01 per cent of the assigned frequency.

Renewal Application

A supplemental report shall be filed with each and made a part of the application for renewal of license and shall include statements of the following, among others:

1. The number of hours operated.
2. Data taken in compliance with licensing requirements of these rules.
3. Outline of reports of reception and interference and conclusions with regard to propagation characteristics of the frequency assigned.
4. Research and experiments being carried on to improve transmission and to develop broadcasting on the very high frequencies.
5. All developments or major changes in equipment.
6. Any other pertinent developments.
7. Comprehensive summary of all reports received.

DEVELOPMENTAL BROADCAST STATIONS

The term "developmental broadcast station" means a station licensed to carry on development and research for the advancement of broadcast services along lines other than those prescribed by other broadcast rules or a combination of closely related developments that can be better carried on under one license.

Licensee and Location	Call Letters	Frequency (kc)	Power	Emission
Bell Telephone Labs., Inc. Whippany, N. J.	W3XDD	560, 900, 1340	50 kw	A3
Bell Telephone Labs., Inc. Whippany, N. J.	W3XPY	43200	5000 w	Special (C.P. only)
Central Broadcasting Co. Mitchellville, Iowa	W9XC	1000	1000 w	A3
Connecticut State College Storrs, Conn.	W1XCS	39540, 139960, 300000- 400000	250 w	A3 & Special
Connecticut State College Storrs, Conn.	W1XEV	26300	500 w	Special
The Crosley Corp. Near Mason, Ohio	W8XO	700	100 kw-500 kw	A3
Natl. Broadcasting Co., Inc. Area of New York, N. Y.	W10XF	1614, 2398, 3492.5, 4797.5, 6425, 9135, 12862.5, 17310, 23100, 30660, 31020, 31140, 31180, 31540, 33340, 33460, 33620, 35060, 35460, 37060, 37140, 37540, 39140, 39460, 39540, 132400, 132680, 133380, 134360, 135340, 137440, 137860, 138140, 138840, 139540, 139960, 162000-168000, 210000-216000, 264000-270000, 300000-400000, 401000 and above	25 w	A1, A2, A3
Natl. Broadcasting Co., Inc. Area of New York, N. Y.	W10XR	Same as above	100 w	A1, A2, A3
The National Life and Accident Insurance Co., Inc. Nashville, Tenn.	W4XFN	300000-400000, 401000 and above	15 w	A3

F. C. C. Regulations Regarding Developmental Broadcast Stations

Licenses for developmental broadcast stations will be issued only after a satisfactory showing has been made in regard to the following, among others:

1. That the applicant has a program of research and development which cannot be successfully carried on under any of the classes of broadcast stations already allocated, or is distinctive from those classes, or combination of closely related developments that involve different phases of broadcasting which can be pursued better under one license.

2. That the program of research has reasonable promise of substantial contribution to the development of broadcasting, or is along lines not already thoroughly investigated.

3. That the program of research and experimentation will be conducted by qualified persons.

4. That the applicant is legally and financially qualified and possesses adequate technical facilities to carry forward the program.

5. That the public interest, convenience and necessity will be served through the operation of the proposed station.

A separate developmental broadcast station license will be issued for each major development proposed to be carried forward. When it is desired to carry on several independent developments, it will be necessary to make satisfactory showing and obtain a license for each.

A Licensee of developmental broadcast stations shall broadcast programs only when they are necessary to the experiments being conducted. No regular program service shall be broadcast unless specifically authorized by the license.

A Licensee of a developmental broadcast station shall not make any charge, directly or indirectly, for the transmission of programs, but may transmit the programs of a standard broadcast station or network including commercial programs, if the call letter designation when identifying the developmental broadcast station is given on its assigned frequency only and the statement is made over the developmental broadcast station that the program of a broadcast station or network (identify by call letters or name of network) is being broadcast in connection with the developmental work. In case of the rebroadcast of the program

of any broadcast station, the FCC Regulation on rebroadcasting holds.

Frequency Allotted

The following frequencies are allocated for assignment to developmental broadcast stations:*

	1,614			
2,396	}	2,398	12,855	37,140
2,400	}		12,870	37,540
3,490	}	3,492.5	17,300	39,140
3,495	}		17,320	39,460
				132,400
4,795	}	4,797.5	23,100	132,680
4,800	}		30,660	133,380
6,420	}		31,020	134,360
6,430	}	6,425	31,140	135,340
			31,180	137,440
8,650	}		31,540	137,860
8,660	}		33,340	138,140
			33,460	138,840
		8,655	33,620	139,540
			35,060	139,960
			35,460	162,000-168,000
9,130	}		37,060	210,000-216,000
9,140	}	9,135		264,000-270,000
				300,000-400,000
				401,000 and above

* Also available for assignment to all other stations in the experimental service.

A license will be issued for more than one of these frequencies upon a satisfactory showing that there is need therefor.

The frequencies suited to the purpose and in which there appears to be the least or no interference to established stations shall be selected.

In cases of important experimentation which cannot be conducted successfully on the frequencies allocated herein, the Commission may authorize developmental broadcast stations to operate on any frequency allocated for broadcast stations or any frequencies allocated for other services under the jurisdiction of the Commission upon satisfactory showing that such frequencies can be used without causing interference to established services.

The operating frequency of a developmental broadcast station shall be maintained in accordance with the frequency tolerance given in Sec. 40.01, provided, however, where lesser tolerance is necessary to prevent interference, the Commission will specify the tolerance.

The operating power of a developmental broadcast station shall not be in excess of that necessary to carry on the program of research. The operating power may be maintained at the maximum rating or less, as the conditions of operation may require.