ENGINEERING AND PLANNING

OF A RADIO BROADCAST FACILITY

By

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Project Report submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Systems Engineering

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(ABSTRACT)

The radio spectrum is a resource which unlike other resources, is not consumed - it is being wasted when not being used. Effective management of this valuable resource is necessary because of the limited number of channels that are physically available for use.

Without regulation, stations operating on the same channel in the same general area will inevitably interfere with each other and often also with others on adjacent channels. Therefore, the Federal Communications Commission (FCC) regulates the use of this national resource in accordance with rules which have been developed and continue to evolve. These rules relate to all kinds of broadcast services including AM & FM radio and TV.

In defining the technical specifications of a new broadcast facility, the engineer must try to achieve an optimum system design while conforming to all FCC rules and regulations. The design process is divided into a number of stages which include channel and frequency selection, site selection, protection

and interference studies, topographic studies, and an environmental impact statement considering the area in the vicinity of the facilities. These specifications must then be submitted to the FCC as a formal proposal.

This report describes the design approach used in industry to specify the technical details of such a proposal and highlights the tradeoffs which are made at almost every stage of the process. The hardware needed to implement the technical details specified must be selected. Various types and configurations of transmitter-antenna systems and tower configurations are evaluated and an optimum design is sought.

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1. Specification of needs and generalized system layout

1.0 Introduction

Practically every legitimate use of the radio spectrum is made by what is considered a "system". Whatever the specifics of any broadcast system, the process of detailing its' specifications is a coordinated design involving various technical components and considerations.

The first step in this coordinated design activity is to clearly state the purpose of the project and identify the key performance criteria against which the systems' performance must be compared. As the life cycle diagram of Figure 1.1 illustrates, once this has been done the alternatives that can achieve this goal must be evaluated. In this case, the evaluation of alternatives is essentially the selection of a modulation method - Amplitude Modulation (AM) or Frequency Modulation (FM). The type of modulation employed dictates the type of

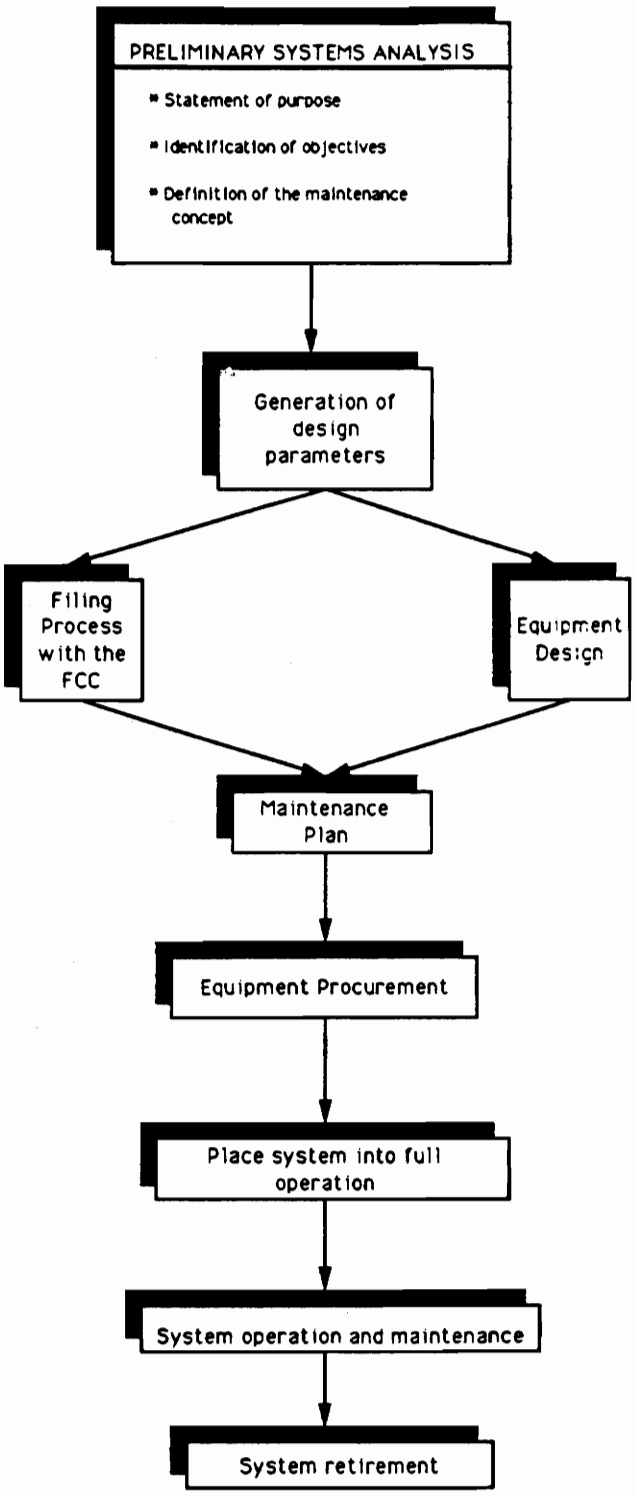


Figure 1.1 System Life Cycle

engineering studies to be carried out and the detailed objectives to be achieved in these studies.

This chapter constitutes the preliminary systems analysis phase of the life cycle.

1.1 Statement of Purpose and Needs Analysis

Great Scott Broadcasting (GSB) conducted a survey and has identified a viable economic project in running a broadcast operation in the city of Lompoc in Santa Barbara county. It is understood that this small southern California town has very high market potential as far as the age group of 15 to 25 years of its' population is concerned. The number of potential listeners is estimated to be about 100,000. GSB, which has operations in many other parts of the country, proposes to target this population group by setting up a broadcast facility with Lompoc as its' primary area of service. GSB has drawn up a preliminary programme outline in which a major portion of its' air time is to be devoted to rock and roll music, keeping its' target population in mind.

1.1.1 System Operational Requirements

The basic requirements of the system are listed below:

- A broadcasting facility providing high fidelity output intended for both stationary and vehicular (mobile) audiences for the city of Lompoc,

California.

- The system is to be deployed such that the station is on the air 17 hours a day with the tentative air-time being 6AM to 10PM. Hence, the maintenance facilities and inventory must be designed in such a way so as to accommodate this crucial availability requirement.

- **Sound Quality**: (i) The frequency range of the system must permit all of the audible components of the original sound to be reproduced. The audible components are all frequencies ranging from 20 to 15,000 MHz.

(ii) The volume range of the system must enable reproduction of the entire range of intensity of the sounds without noise or distortion.

(iii) The reverberation characteristics of the original sound must be conveyed to the listener.

(iv) The spatial impressions must be conveyed to the listener.

- **Environment**: The system must be designed to weather temperatures of 60° to 100°F throughout the year with an average humidity of 60%. The terrain is a mountainous one and accessibility will be limited, at best.

- In order to compete with rival groups vying for a similar facility in the same area of operations, the project of developing the specifications must be drawn up within a time period of 30 days so that an application can be filed

with the FCC by Oct.15 1991.

- The station facilities must be able to accommodate Subsidiary Communications Authorization (SCA) facilities in future expansion ventures. This capability which makes possible the multiplexing of other services simultaneously with normal broadcasting affords additional sources of revenue not specifically limited to advertising.

- The system must be fully operational by Jan.31 1992

- An amount of $400,000 is allocated for the acquisition of all facilities and there is an allowable margin of up to 5% over this limit in final cost estimations.

1.1.2 System Maintenance Concept

The system is expected to have an air-time availability index which is equal to 1.0. Hence, the maintenance facilities must be capable of total system support and equipped to handle any failure in a part of the system. Also, the preventive and corrective maintenance actions must be confined to the off-time, as far as possible.

As per the maintenance plan, preventive maintenance should be emphasized keeping in mind that most manufacturers generally provide technical support throughout the life cycles of their products. However, the FCC requires that every station be continuously monitored to ensure that the specified performance criteria are being met. This requires test equipment on site which

must also be periodically calibrated.

The system maintenance plan must be structured so that the mean time between corrective maintenance actions is one week (10,080 minutes), and the mean time between preventive maintenance actions is one day (1,440 minutes). These requirements imply a total mean time between maintenance (MTBM) given by :

$$MTBM=1 / ((1 / 10,080) + (1 / 1440)) = 1260 \text{ minutes}$$

The turn around time (TAT) should be no more than 60 minutes for the organizational maintenance and 2 days (about 50 hours) for the intermediate maintenance.

Two levels of maintenance support must be provided - organizational maintenance and intermediate maintenance. The depot level maintenance is provided by the manufacturer, who pays for the cost of all repairs and also the cost of transportation of the damaged part to and from the facilities. The two levels of on-site maintenance are structured as shown in the system maintenance concept flow diagram in Figure1.2.

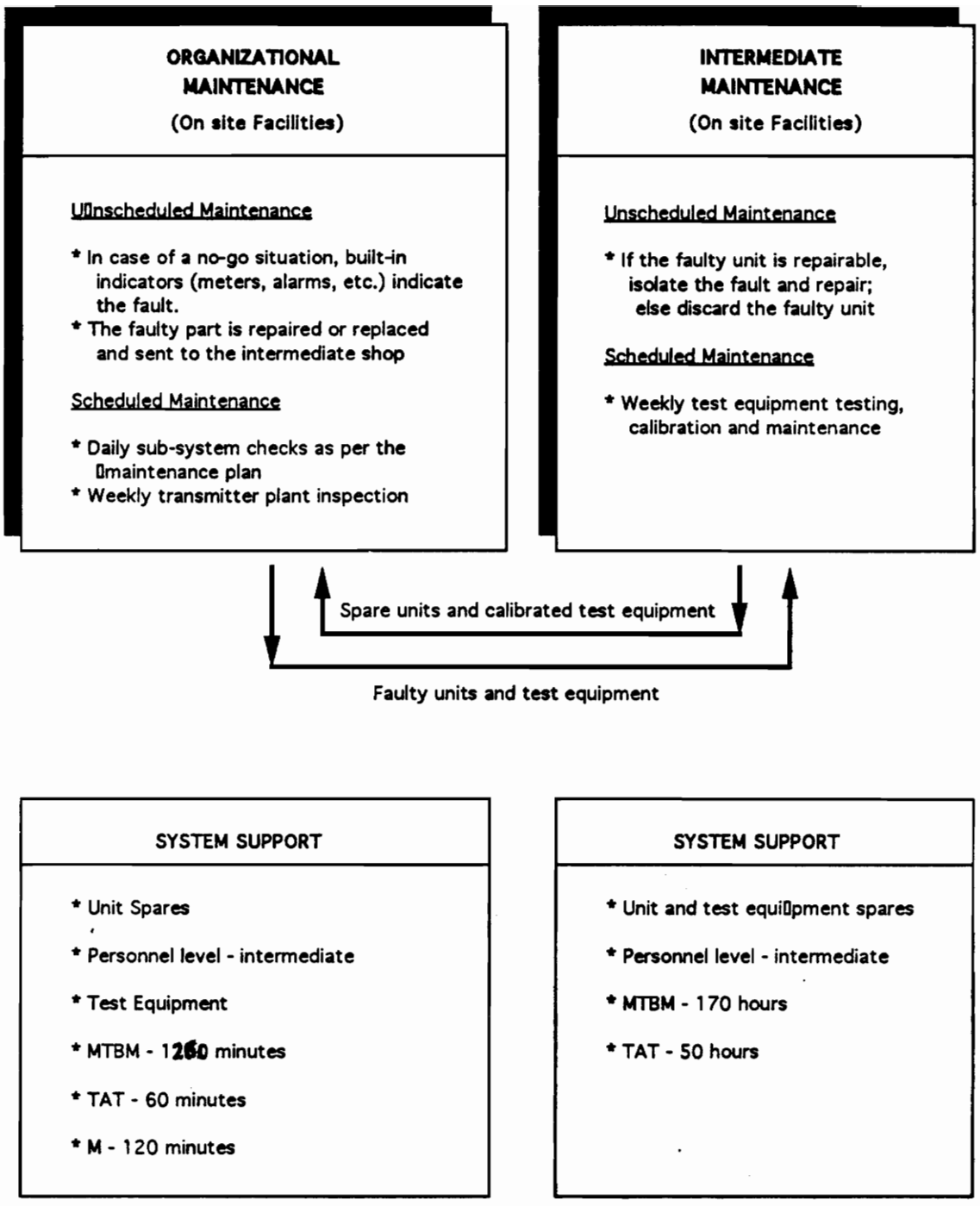


Figure 1.2 System Maintenance Concept

1.2 Selecting A Modulation Method (Ref.[8], Ref [13])

"Current alternating in any electrical system releases electromagnetic energy into the surrounding space. This tendency of alternating current to radiate electromagnetic energy depends on its frequency. The higher the frequency of alternation, the more radiation that takes place. Thus the most fundamental job of a radio transmitter is to generate alternating energy that will radiate into space. This basic emission is a transmitters' **carrier wave**, which alternates at a designated frequency." Imposing information on a carrier wave is called **modulation**. Thus modulation is used to produce a signal - a physical variation that conveys information. "The single frequency that identifies a carrier wave can carry only a single "bit" of information each second. Modulation by a complex signal involves using radio frequencies adjacent to the carrier, both above and below its particular frequency. These additional frequencies are referred to as **sidebands**. The fact that modulation of a carrier wave generates sidebands means that each station must be allotted not just one but a group of frequencies. Such a group is referred to as a **channel**. Modulation is imposed on the carrier wave by the transmitter, which feeds the signal to the antenna, the physical element from which the signal radiates into the surrounding space.

The chief methods of modulation used in broadcasting are amplitude modulation (**AM**) and frequency modulation (**FM**). As the names imply, in the one case information is encoded by varying the amplitude, or strength, of the carrier wave; in the other case, encoding varies its frequency."

With a view to fulfilling the needs as identified in section 1.1, the following features of FM give it a substantial edge over AM:

Reduced Noise : The vhf band of the electromagnetic spectrum, in which FM broadcasting is done is inherently less prone to both natural and man-made noise. Transmission at these frequencies is not via atmospheric refraction, as is the case with the AM band and therefore noise from lightning discharges is limited to substantially smaller distances and is vastly lower and almost negligible. In urban areas, man-made may be a far greater threat. But even this noise level falls off at increasing frequencies, making FM transmission virtually noise free.

"In addition, FM has an improvement factor compared to AM that is proportional to the frequency deviation ratio. There is a sharp threshold in signal level above which noise and interference are suppressed, which results in an increased S/N ratio. This same effect causes a weaker FM signal on the same channel to be suppressed, resulting in greatly reduced co-channel interference. The net result of the above factors is the attainability of a much better signal-to-noise ratio. The lower background noise means that a signal of higher quality and wider dynamic range can be enjoyed."

High Fidelity : "Fidelity is defined as the degree to which a system, or a portion of the system, accurately reproduces at its output the essential characteristics of the signal which is impressed at its input. Uniform frequency

response over the audible range of at least 50 Hz to 15 kHz, very low amplitude distortion (harmonic and intermodulation), very low noise level, and good transient response (uniform time delay versus frequency) are necessary for hi-fi performance. It is much more feasible to design hi-fi characteristics into FM broadcast transmitters than AM broadcast transmitters."

Stereophonic Transmission : "A higher level of realism and listener enjoyment is provided by stereophonic transmission. Again, the wide channel allocations and inherent nature of FM permitted development of a practical stereo broadcasting system and the same continues to be much easier to implement on FM than on AM."

SCA : FMs' wide channel allows for multiplexing Subsidiary Communications Authorization (SCA) services. These added signals are intended for subscribers who pay a fee to receive the transmissions on a special, fixed-tuned set and cannot be picked up on ordinary home receivers. Typical SCA services are background music for stores and offices, readings for the blind, refresher information for physicians, etc. With the advances in Digital Signal Processing (DSP), slow scan video still-pictures can be transmitted via SCA.

1.3 Detailed Identification of Objectives

In response to the basic needs defined above, GSB has initiated a project to come up with the technical specifications as demanded by the FCC. In addition, this project will develop a conceptualization of overall system layout with the associated operational flows between the subsystems and develop a maintenance concept based on this conceptualization. This project defines the scope of this report and its' detailed objectives are developed from the basic needs as listed in the preceding paragraph.

- Identify the channel number and class for the primary area of service i.e., Lompoc, California.

- Specify the exact location of the antenna in geographical coordinates to the nearest second.

- Examine if sharing of the tower structure for this site is possible and if not, provide cost estimates of acquiring the land for the facility. This amount must not exceed $100,000.

- Determine elevation of the site above mean sea level and height of the radiation center above the ground.

- Determine the effective radiated power (ERP) and the height above average terrain (HAAT).

- Determine if a directional antenna is required based on the interference studies with nearby stations.

- Determine the generalized location of the main studio.

- Provide an environmental impact statement certifying that the proposed facility does conform to FCC rules and regulations about the same.

- Design the transmitter-antenna-transmission line system with a view to maximizing efficiency at an optimum cost and bounded by the parameters developed for these parts earlier.

- Select a suitable tower configuration based on the space limitations at the site and the cost limitation specified.

- Develop a generalized system layout and the operational and maintenance flows for the transmitter-antenna system.

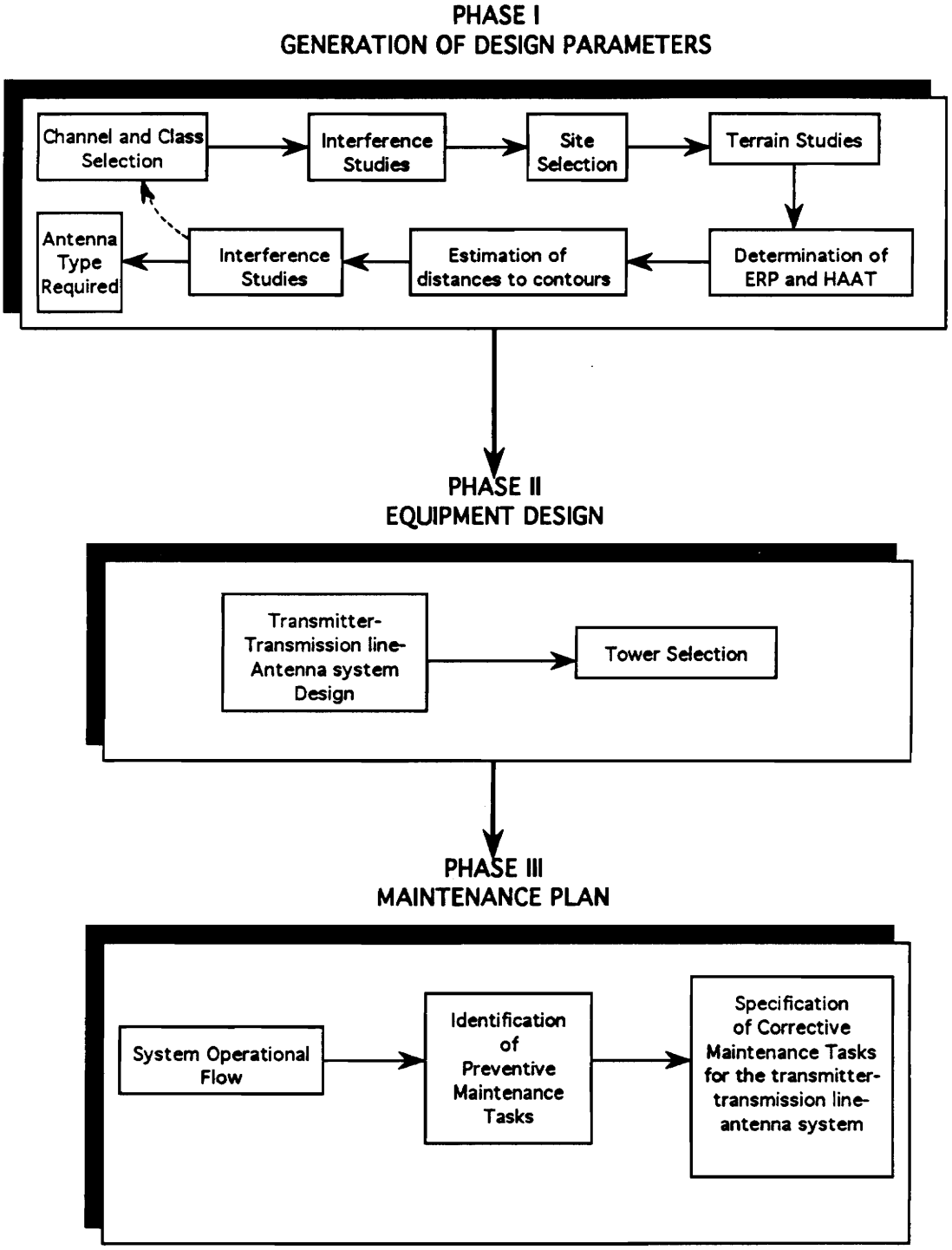


Figure 1.3 Detailed Identification of Objectives

1.4 Generalized System Layout

The basic factors which influence the choice of a particular operational layout are the type of equipment and the limitation of space available to house it. Both these are obtained as results of the engineering studies which are carried out for the facility. In general, however, a compact, simple arrangement of the basic functional elements is the combined studio-transmitter arrangement. It is the simplest form and dictates the least complexity of interconnections between the basic functional units which further implies a minimal amount of maintenance problems. This configuration is illustrated in Figure 1.4.

All of the studio and transmitting equipment is housed under one roof with the antenna nearby. The control room, studios, and transmitter are all clustered together for ease of operation. The transmitter may be located in the control room itself or in an adjacent room where it can be observed through a soundproof window.

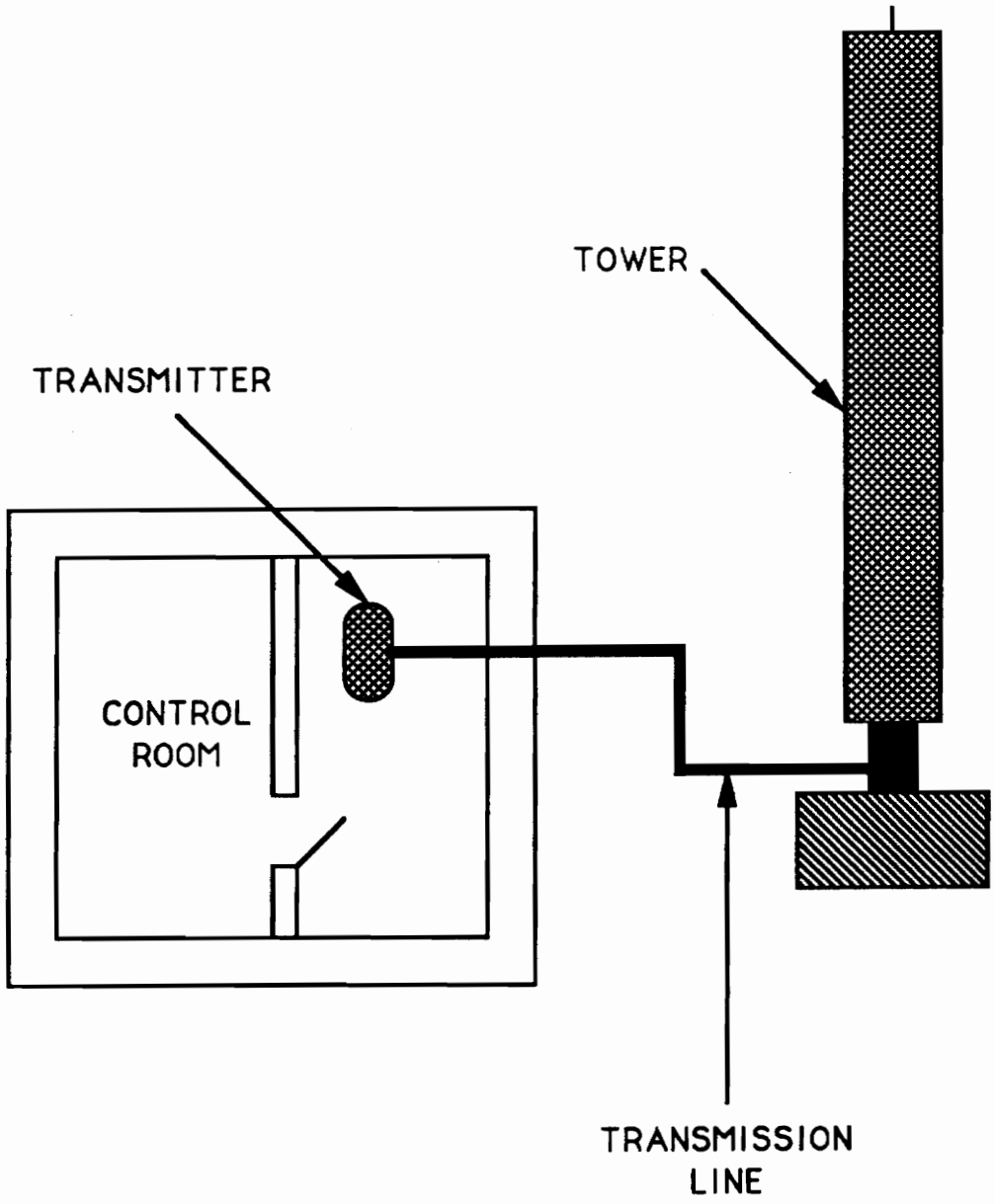


Figure 1.4 Generalized System Layout

2. Generation of design parameters

2.0 Introduction (Ref [8])

"The travelling of the wave energy outward from the antenna is referred to as propagation. As the energy travels it attenuates. This necessarily happens because the energy is being distributed over a progressively larger area. The greater the distance it travels, the more thinly it is dispersed. If all conditions were ideal, the geographical coverage pattern of a transmitter would be circular. Its energy would radiate evenly in all directions, assuming the absence of any deliberate effort to control propagation direction. However, in practice, the wave energy is affected unevenly by a variety of conditions it meets along the way. Conditions that influence propagation patterns include such variables as weather, and physical obstructions. As a result of these and many other variables, actual coverage patterns are usually irregular in shape."

Line of sight waves, or **direct waves** follow a nearly straight path from the transmitter to the receiver and their useful coverage area reaches only to about the horizon. Line of sight distance to the horizon depends on the height of the antenna - the higher an antenna the farther this straight line distance to the horizon. Direct waves use the higher radio frequency bands - VHF, UHF, SHF and EHF.

Ground waves, which are propagated through the surface of the earth, can travel beyond the horizon. They therefore have the potentiality of having a wider coverage pattern direct waves. In practice, however, the distance ground waves travel depends on several factors such as, power and soil conductivity (for example dry, sandy soil is a poor conductor). Ground propogation occurs at low and medium frequencies. AM standard broadcasting depends primarily on ground waves.

Most radio waves, when allowed to radiate above the level of the horizon, lose a lot of their energy to atmospheric absorption. Any remaining energy radiates into space. Waves in the medium frequency and high frequency parts of the spectrum, however, tend to reflect back toward the earth, forming **sky waves**. Sky waves are important to broadcasting because they afford the only method of obtaining long distance radio transmission by land based stations. Some powerful AM broadcast are designed to provide coverage by sky wave at night in addition to ground wave coverage.

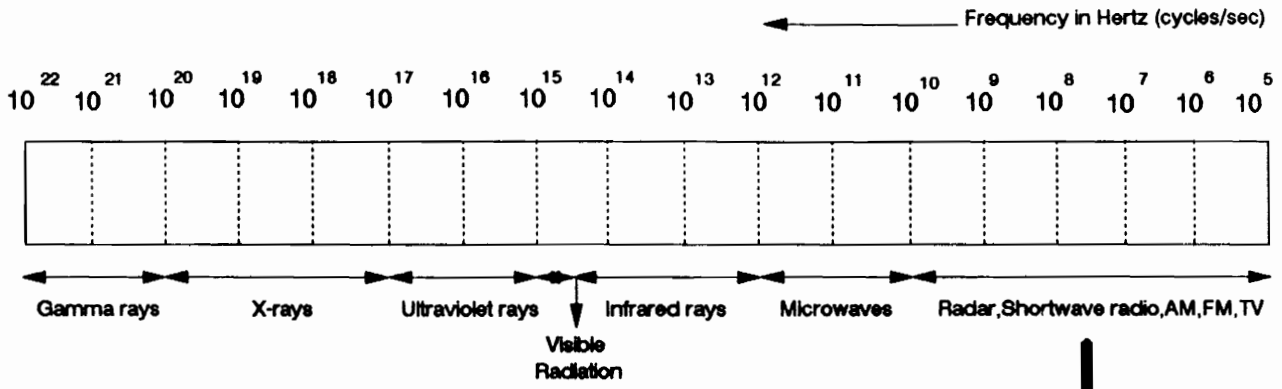
Frequency modulated waves are essentially line of sight or direct waves. They use the higher frequency bands (VHF) . The management of the

spectrum in this band and FCC allotment and licensing procedures are discussed in the following sections.

2.1 Allotment And Licensing (Ref [8] , Ref [10])

Figure 2.1 shows the general composition of the electromagnetic spectrum and tabulates the subdivisions of the radio frequency part of it. "Like other natural resources, the spectrum is developed in relation to supply and demand. On the supply side, it has intensive and extensive margins. On the intensive margin, technical advances have improved the use of the spectrum along its dimensions of time, space, and frequency. At the extensive margin, technology is now making it possible to use the spectrum at higher and higher frequencies. Demand for the spectrum reflects mainly growth in levels of population and per capita income and changes in taste."

The "radio spectrum is today not only a resource but a scarce resource in specific spectral regions, services, and geographic areas. Scarcity reflects in part the fact that the spectrum, though it is not depleted by use as some other resources, is subject to degradation and pollution which stem from congestion and intolerable interference. Pollution in this context refers to the decreasing utility of the spectrum for radio communications due largely to its growing use for noncommunication purposes." This situation warrants the role of national spectrum managers such as the Federal Communications Commission



Very-low frequencies (vlf)	10 to 30 kHz
Low frequencies (lf)	30 to 300 kHz
Medium frequencies (mf)	300 to 3000 kHz
High frequencies (hf)	3 to 30 MHz
Very-high frequencies (vhf)	30 to 300 MHz
Ultrahigh frequencies (uhf)	300 to 3000 MHz
Superhigh frequencies (shf)	3,000 to 30,000 MHz

Figure 2.1 Composition of the Electromagnetic Spectrum

(FCC) , with control over all nongovernment spectrum and the Director of Telecommunications Management, with control over the government spectrum.

In accordance with national allocation plans, the FCC allots channels to particular geographical locations. National allotment tables designate one or more FM and television channels to each US community of sufficient size to warrant allotments. The final regulatory step in the activation of channels is to license particular users. A license confers upon a user the right to activate a designated channel in a designated locality under specific conditions as to time, power, and other requirements.

"Frequency modulation broadcasting occupies a block of frequencies running from 88 to 108 MHz in the VHF band (30-300 MHz). The channel width is set at 200 kHz (0.2 MHz) allowing for 100 channels in the 88-108 MHz band. Channels are identified by the numbers 201 to 300 in the regulations and the first 20 channels (numbers 201 to 220) are reserved exclusively for noncommercial educational (public) use." The commercially available channels are listed in Table 2.1.

FM stations are divided into three main classes, designated A, B, and C. These are determined by the coverage necessary to various types of intended service, which is dependent upon radiated power and antenna height. "Antenna elevations as well as power enters into a formula that defines the classes, but the maximum power/height combination is 100,000 watts and 2,000 feet. A special noncommercial group, Class D, is authorized to operate on very low power (10 watts or less) to enable educational institutions to take advantage

of radio with minimum investment. Class D stations, having only secondary status, are allowed to operate only if they can find a vacant channel that will not interfere with other classes of stations." The specific maximum values of antenna height above average terrain (HAAT) and effective radiated power (ERP) for the various station classes are listed in Table 2.2.

Table 2.1 FM Broadcast Channels

Frequency MHz	Channel No.	Frequency MHz	Channel No.	Frequency MHz	Channel No.
92.1	221	96.7	244	101.3	267
92.3	222	96.9	245	101.5	268
92.5	223	97.1	246	101.7	269
92.7	224	97.3	247	101.9	270
92.9	225	97.5	248	102.1	271
93.1	226	97.7	249	102.3	272
93.3	227	97.9	250	102.5	273
93.5	228	98.1	251	102.9	275
93.7	229	98.3	252	103.3	277
93.9	230	98.5	253	103.7	279
94.1	231	98.7	254	104.1	281
94.3	232	98.9	255	104.5	283
94.5	233	99.1	256	104.9	285
94.7	234	99.3	257	105.3	287
94.9	235	99.5	258	105.7	289
95.1	236	99.7	259	106.1	291
95.3	237	99.9	260	106.5	293
95.5	238	100.1	261	106.9	295
95.7	239	100.3	262	107.1	296
95.9	240	100.5	263	107.3	297
96.1	241	100.7	264	107.5	298
96.3	242	100.9	265	107.7	299
96.5	243	101.1	266	107.9	300

Table 2.2 Maximum ERP and Antenna Height for FM Stations

Class	ERP (kW)	HAAT meters (ft.)
A	6	100 (328)
B1	25	100 (328)
B	50	150 (492)
C3	25	100 (328)
C2	50	150 (492)
C1	100	299 (981)
C	100	600 (1968)

2.2 FM Frequency Search And Channel Allocation

One of the first steps in the generation of design parameters, if not the first step is to determine the frequency and channel on which the station will operate. The FCC has a *Table of Allotments* (contained in paragraph 73.202 of the rules and regulations) which lists the channels designated for use in communities in the U.S., its' territories and possessions. Applications may be filed to construct an FM broadcast station only at the communities and on the channels contained in this table of allotments.

The table lists channels 285A (104.9 MHz), 262B1, 281B1, and 294B as allotments to the city of Lompoc, California. Of all the channels allotted to the town by the FCC, the one on which a vacant frequency exists is chosen. Procedurally, if no such channel exists then request for a new allotment may be submitted to the Commission. The channel allotments are updated by the FCC every so often (about every 6 months) as the need for new allotments arises. Upon further inquiry, it is found that 285A has a vacant frequency (104.9 MHz). The next step is to determine the interference of this frequency with co-channels and adjacent channels in the area.

2.3 Interference Studies (Ref [8])

As was mentioned in the introduction, the frequency band to which a station is assigned determines the type of propagation path or paths it will follow. This in turn determines its potential area of coverage. FM broadcasting is done at in the VHF range of the electromagnetic spectrum. The signals normally travel in a line of sight and because of this fact, the area served depends on the height of the antenna above average terrain (HAAT) and the gain of the antenna. These areas of coverage may overlap causing **interference** among stations operating close to each other. This interference may occur because of other stations on the same channel (**co-channel interference**) and also from other stations on adjacent channels (**adjacent channel interference**).

In the near vicinity of a transmitter, where the power level of signals is extremely high, sidebands spread beyond the limits of the stations' designated channel into adjacent channels. Rapid initial attenuation of signals limits adjacent channel interference to the immediate vicinity of transmitters. Nevertheless, to avoid adjacent channel interference within a given community several unoccupied channels must be left between occupied channels. This limits the number of stations that can be licensed to any single locality.

Co-channel interference can be prevented by spacing stations far enough apart geographically so as to prevent their signal contours from overlapping. It is for this purpose that the FCC requires that each class of stations

must be spaced at a certain minimum distance from every other class of station in its' vicinity. These minimum distances are listed in Table 2.3.

In view of the above arguments, in order to get a rough idea of the location of a broadcast facility, an area clear of any co-channel and adjacent channel interference must be marked out. Since numerous stations may co-exist in a given search radius around a "study point", the search is commonly performed with the aid of a computer. Many commercial programs are available for this purpose and the basic mechanism is the reading of an FM station database and a plot showing the minimum separation arcs of every other station in the area.

Table 2.3 Minimum Distance Separation Requirements

Relation	Co-channel	200 kHz	400/600 kHz	10.6/10.8 MHz
A to A	115	72	31	10
A to B1	143	96	48	12
A to B	178	113	69	15
A to C3	142	89	42	12
A to C2	166	106	52	15
A to C1	200	133	75	22
A to C	226	165	95	29
B1 to B1	175	114	50	14
B1 to B	211	145	71	17
B1 to C3	175	114	50	14
B1 to C2	200	134	56	17
B1 to C1	233	161	77	24
B1 to C	259	193	105	31
B to B	241	169	74	20
B to C3	211	145	71	17
B to C2	241	169	74	20
B to C1	270	195	79	27
B to C	274	217	105	35
C3 to C3	153	99	43	14
C3 to C2	177	117	56	17
C3 to C1	211	144	76	24
C3 to C	237	176	96	31
C2 to C2	190	130	58	30
C2 to C1	224	158	79	27
C2 to C	249	188	105	35
C1 to C1	245	177	82	34
C1 to C	270	209	105	41
C to C	290	241	105	48

2.3.1 Allocation Situation

Appendix C shows the output of a program which reads FM databases supplied by the FCC and picks out all those stations which fall in the specified search radius. According to the channel specified, the corresponding co-channel and adjacent channel stations are picked out and then classified as either "close", "short" or "clear" depending on the minimum distance requirement as compared to the actual distance from the proposed facility. Table 2.4 shows the distances to the pertinent co-channel and adjacent channel stations from the proposed FM operation. As indicated, with the exception of KCAQ (FM), all distances comply with the minimum separation requirements listed earlier. The database information shows that KCAQ (FM) is licensed to Oxnard, California, and operates on channel 284B (104.7 MHz) with 2.85 kW ERP and 482 meters HAAT. The table also shows the two stations that are "close" to the minimum distance requirement, although clear of it. These are KIQO and KOHD. The "close" and "short" stations are plotted with the help of a computer graphics program. The plot shows the minimum distance arcs of the two "close" stations - KIQO and KOHD and the "short" station - KCAQ and it is examined for the areas that are clear of their of their minimum distance arcs.

Unless a suitable site can be selected in the "clear regions" of Figure 2.2, Section 73.215 of the Commissions' rules will become applicable and will require that suitable protection be provided to the existing facility.

Table 2.4 FM Allocation Situation For The Proposed Operation At Lompoc

Channel	Call	City/State	Geographic Coordinates	Actual Separation	Required Separation
285A	Proposed	Lompoc, CA	N 34° 36' 38" W 120° 28' 36"	--	--
282A	Allotment	Shafter, CA	N 35° 28' 58" W 119° 16' 34"	146.2	31
283B	KIQO	Atascadero, CA	N 35° 21' 38" W 120° 39' 21"	84.8	69
284B	KCAQ	Oxnard, CA	N 34° 20' 53" W 119° 20' 07"	108.8	113
285A	KOYZ (CP)	Lenmore, CA	N 36° 16' 17" W 119° 44' 28"	196.0	115
285B1	PRM	Lenmore, CA	N 36° 02' 58" W 119° 29' 08"	183.3	143
286B	KKGO	Los Angeles, CA	N 34° 13' 45" W 118° 04' 04"	225.5	113
287B	KKXX	Delano, CA	N 35° 30' 53" W 119° 03' 41"	163.5	69
288A	KOHD (CP)	Guadalupe, CA	N 34° 53' 54 W 120° 35' 28"	33.6	31
231B	None within	100 km.	--	--	15
232B	None within	100 km.	--	--	15

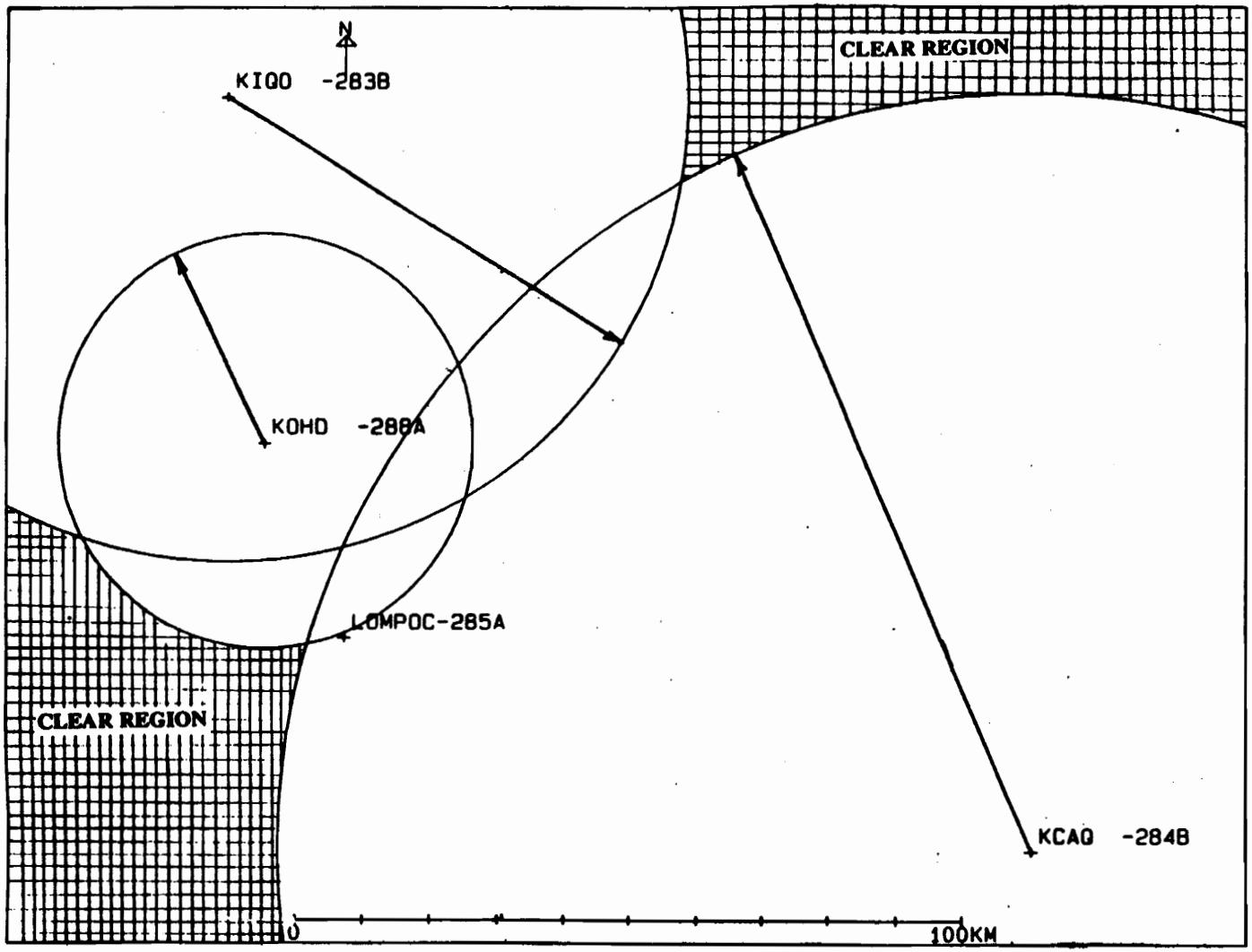


Figure 2.2 Minimum Separation Distance Plot

2.4 Site Selection (Ref [3], Ref [12])

In selecting a suitable site, the following factors must be taken into account :

(i) On the basis of the effective radiated power and antenna height above average terrain employed, a minimum field strength of 70 dB above 1 μV/m (dBu), or 3.16 mV/m, should be provided over the entire principal community to be served.

(ii) "The location should be such that the station will maximize coverage to the city of license while minimizing interference. In general, the transmitting antenna should be located in the most sparsely populated area available at the highest elevation available. The location of the antenna should be so chosen that line-of-sight can be obtained from the antenna over the principal city to be served ; in no event should there be a major obstruction in this path." In this way, except for nulls, which may occur at locations very close to the tower, shadow effects caused by buildings will be minimized and the maximum field strength will be centered in the desired area.

(iii) Attention must be paid to avoid the possible hazard of the proposed antenna structure to aviation and the proximity of the proposed site to airports and airways.

(iv) In general it is more economical in the long run to accomodate for possible future expansion in the initial construction. Thus, it is more desirable to have extra space available to start off with so that the disruption of the

functioning operation is minimized if and when the ownership decides its' operations.

(v) The transmitter / antenna site must be conveniently accessible. Even an unattended plant requires a daily inspection, and a site with difficult access should be tolerated only when there is absolutely no otherwise suitable alternative.

(vi) "Assuming a conventional guyed tower of a uniform cross-section, for which the outermost guy anchors are spaced at 80% of the towers' height from the base, the minimum rectangular land area necessary to accommodate the guy anchors has dimensions of 120% X 140% of the towers' height". Hence, land availability in becomes a critical issue.

(vii) Ready availability of utilities should assure the necessary power and telephone line facilities.

Based on the above guiding principles, it is found that no suitable site is available in the "clear" regions. Hence, we are forced to choose a site that is short-spaced with another station. Figure 2.3 is an exhibit, on a USGS 7.5 minute series topographic quadrangle map of Lompoc Hills, California, of the exact coordinates of a location which satisfies all of the above criteria. Since the site is short spaced with channel 284B (KCAQ), it is mandatory to conduct additional studies and ensure that KCAQ is adequately protected as required by the FCC rules.

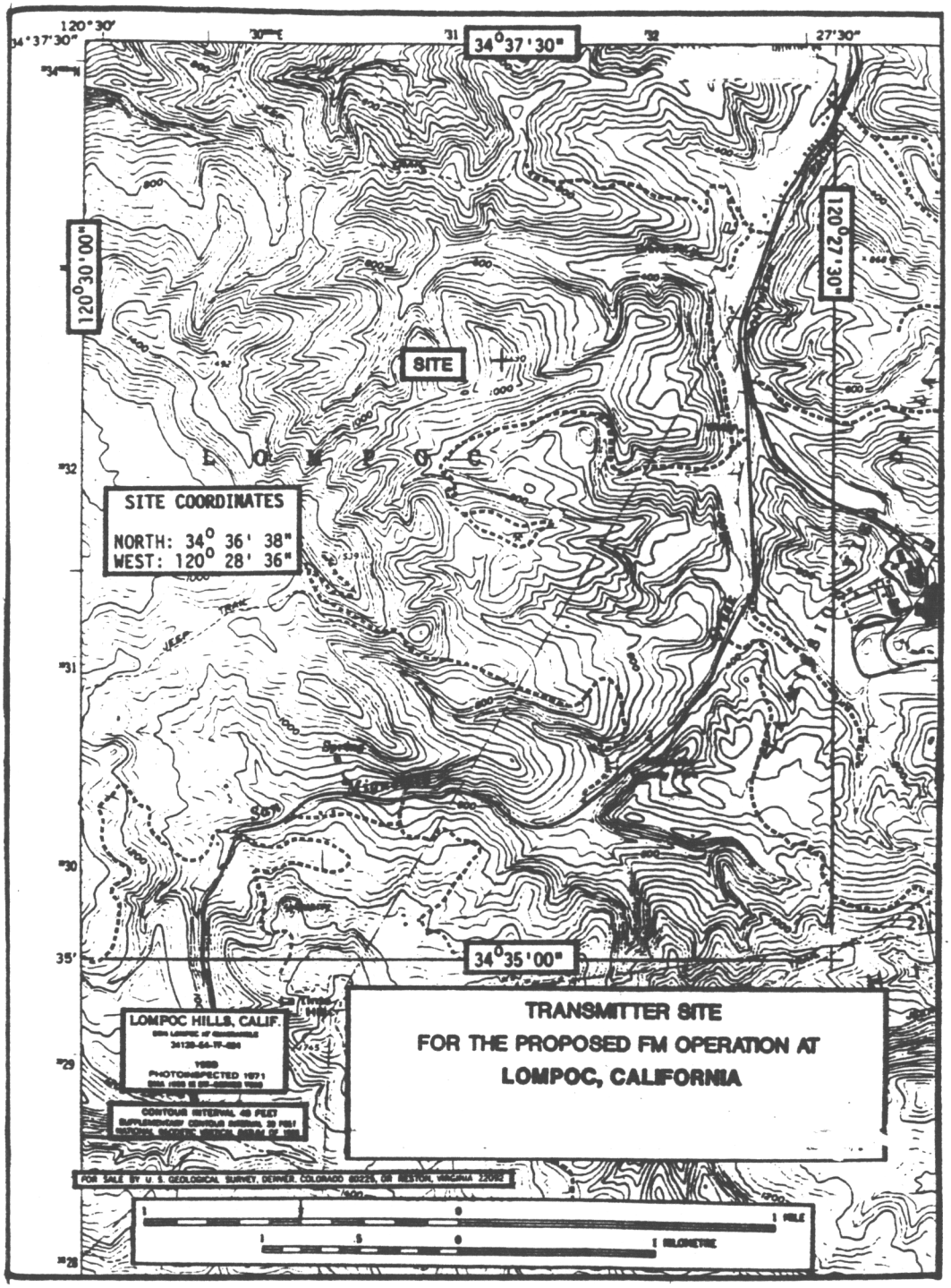


Figure 2.3 The Transmitter Site for the Proposed FM Operation

Courtesy : Cohen, Dippell & Everist, P.C., Washington D.C.

Once the site has been located, the next step is a study of the terrain in the area to determine what the height of the antenna above average terrain and what its' effective radiated power is.

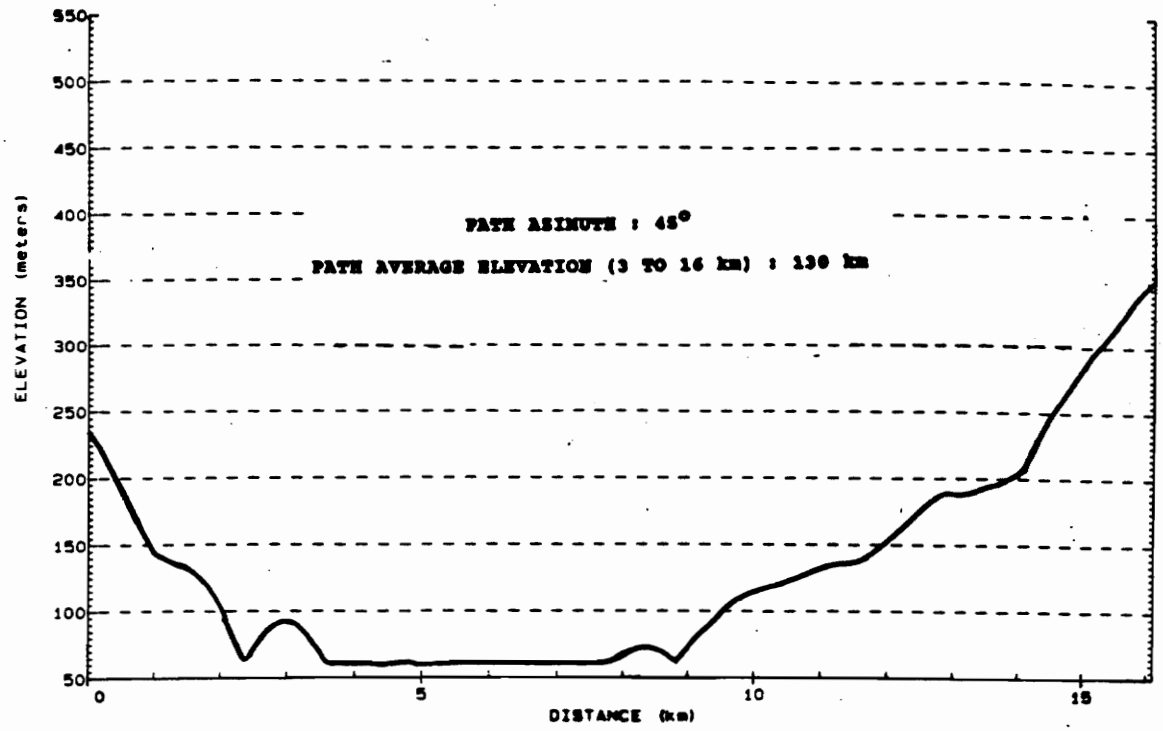
2.5 Terrain Studies (Ref [12], Ref [13])

In order to determine the height of the transmitter above average terrain as specified by the FCC the following procedure must be followed :

(1) Profile graphs must be drawn for eight radials beginning at the antenna site and extending 16 kilometers from it. This is as per convention and the requirement of the FCC rules. The radials must be drawn for each 45° of azimuth starting with True North.

(2) The profile graph for each radial should be plotted by contour intervals of from 12 to 30 meters and, where the data permits, at least 50 points of elevation (generally uniformly spaced) should be used for each radial.

Figures 2.4(a), 2.4(b), 2.4(c) and 2.4(d) are exhibits of the terrain profiles at every 45° radial from the proposed site. The following worksheet shows how the antenna height above average terrain is computed once the height of the center of radiation of the station has been determined.



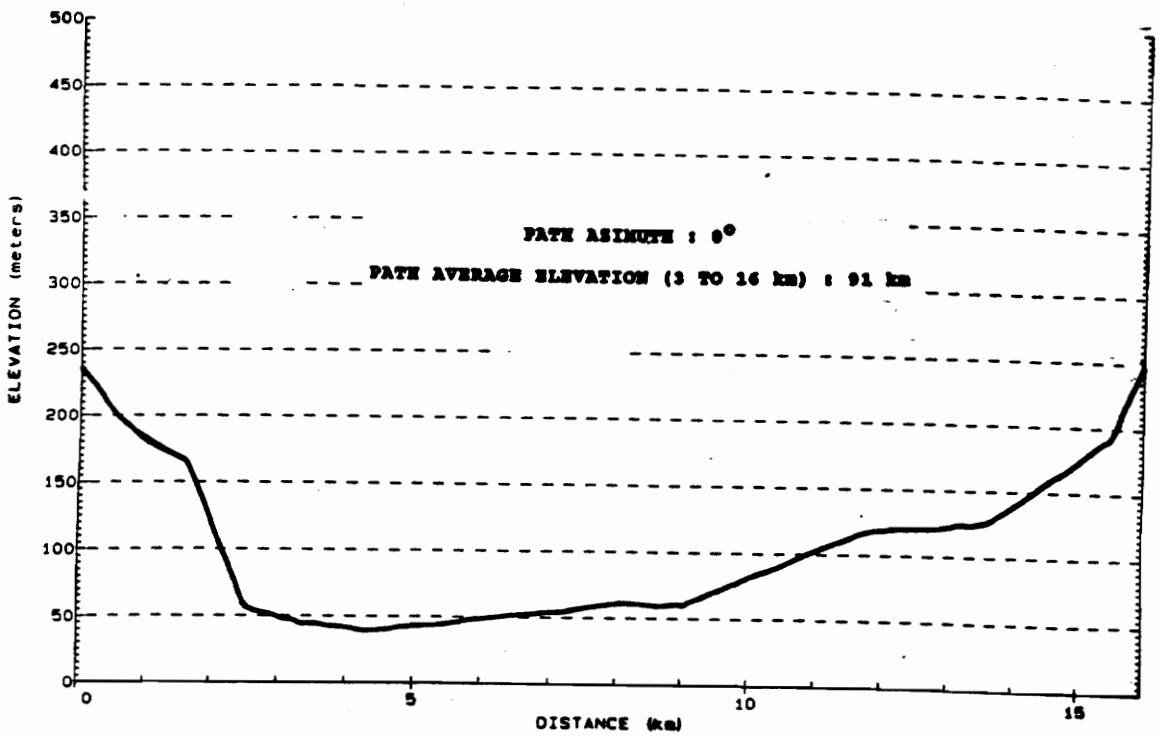


Figure 2.4 (a) Terrain Profile Plot : 0° and 45° Azimuth

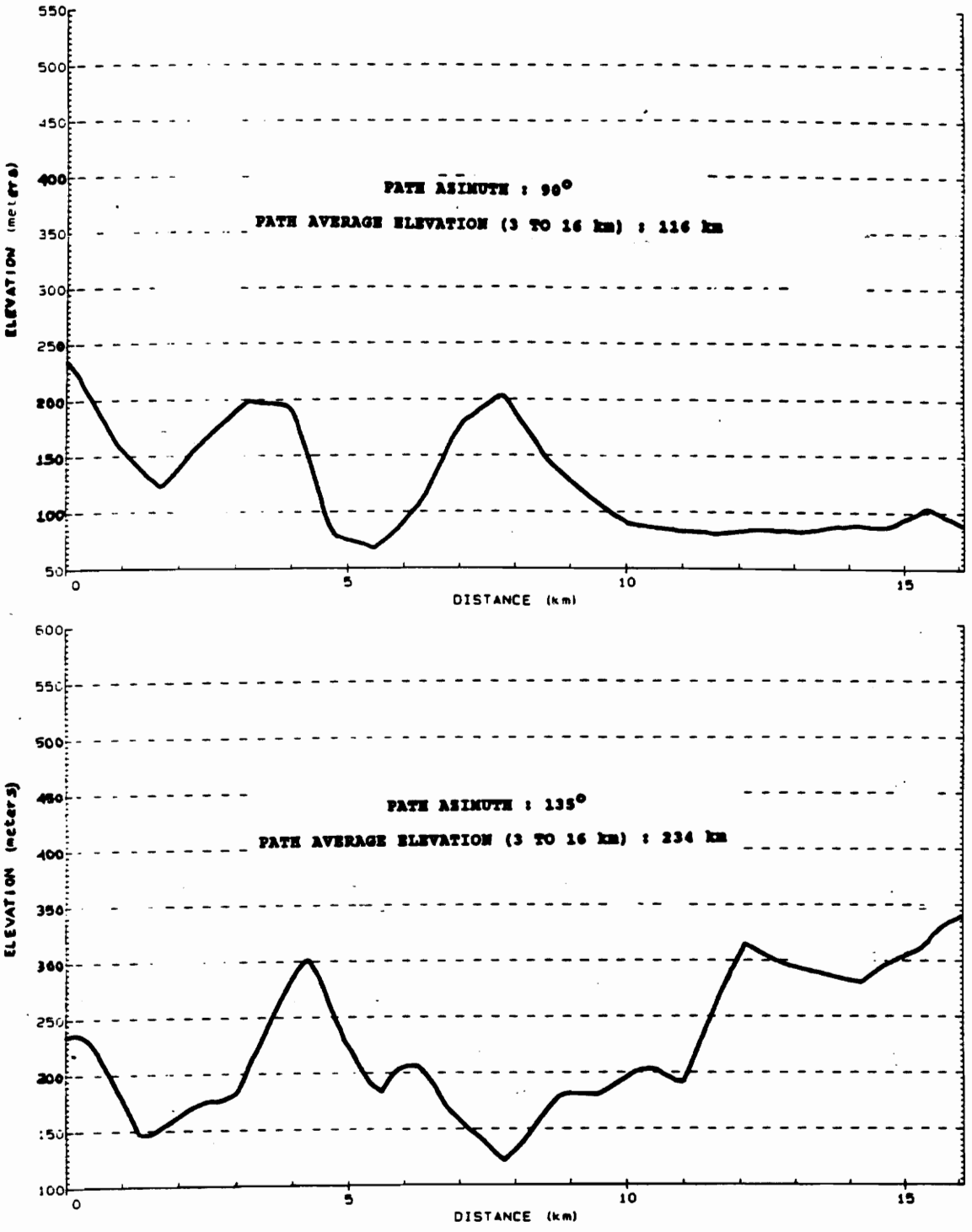
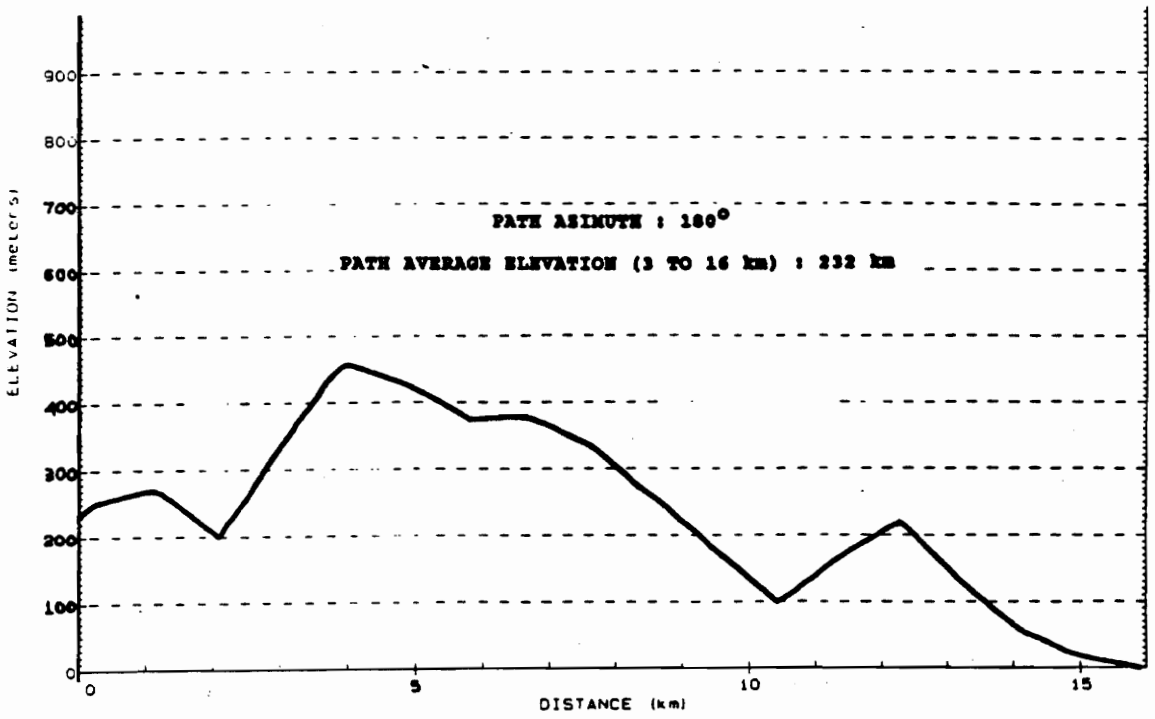


Figure 2.4 (b) Terrain Profile Plot : 90° and 135° Azimuth



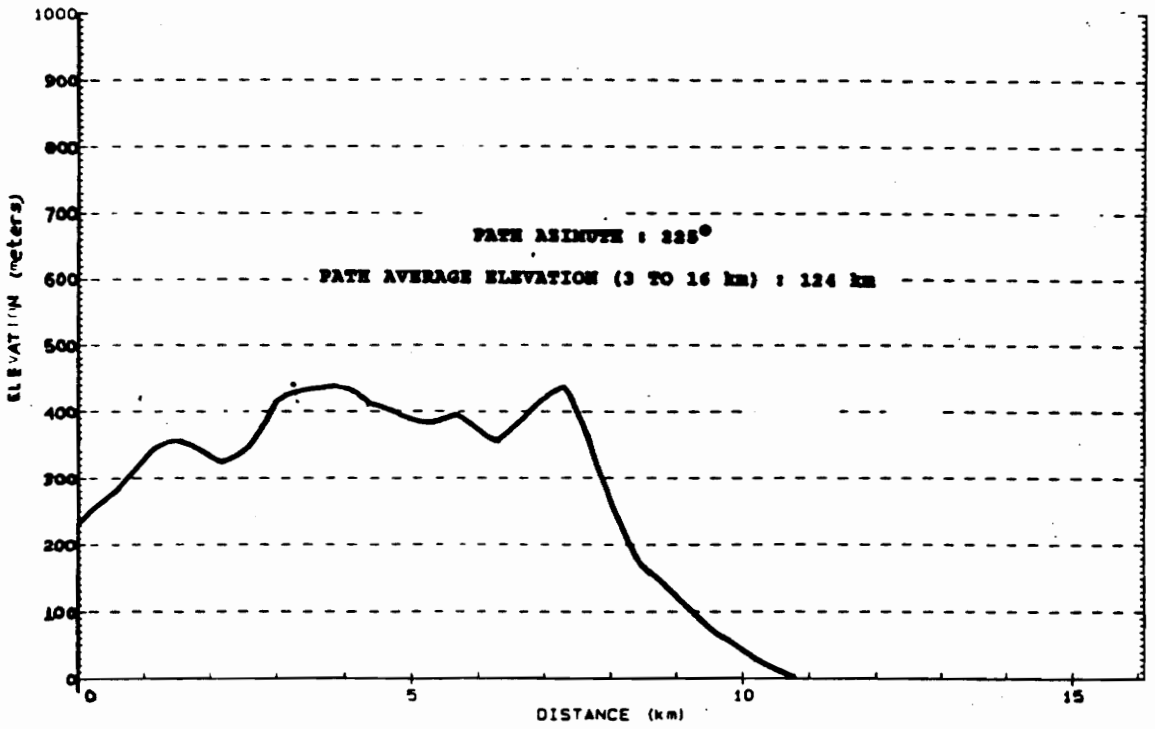
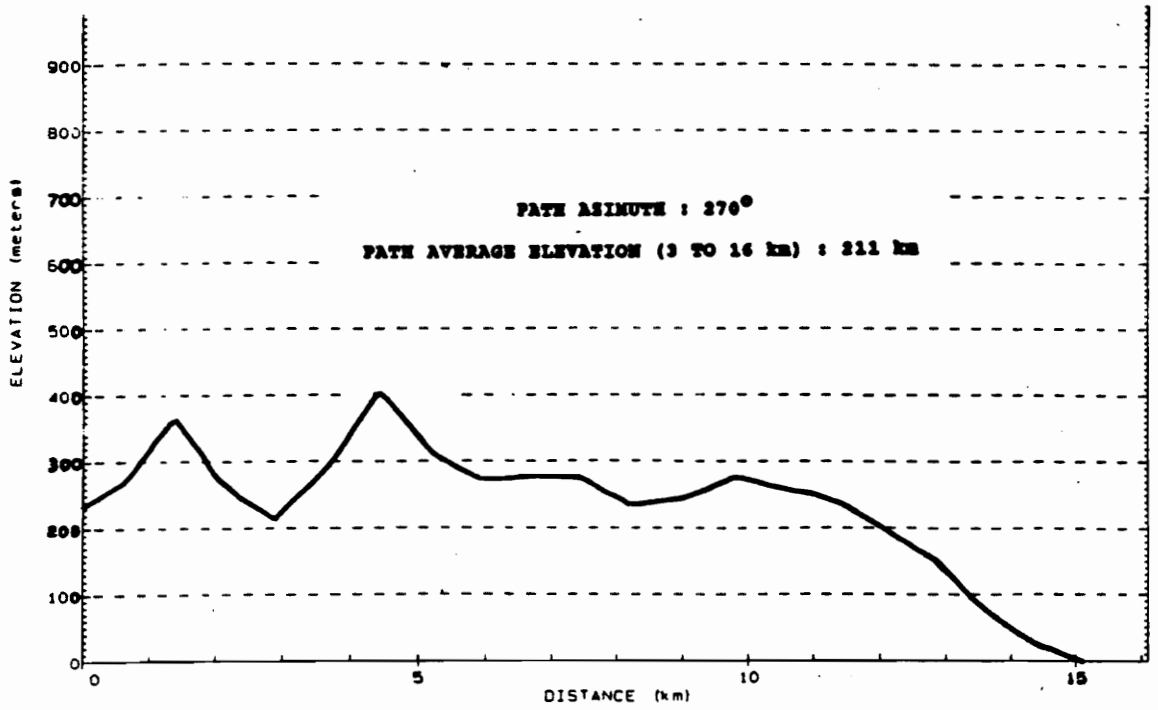


Figure 2.4 (c) Terrain Profile Plot : 180° and 225° Azimuth



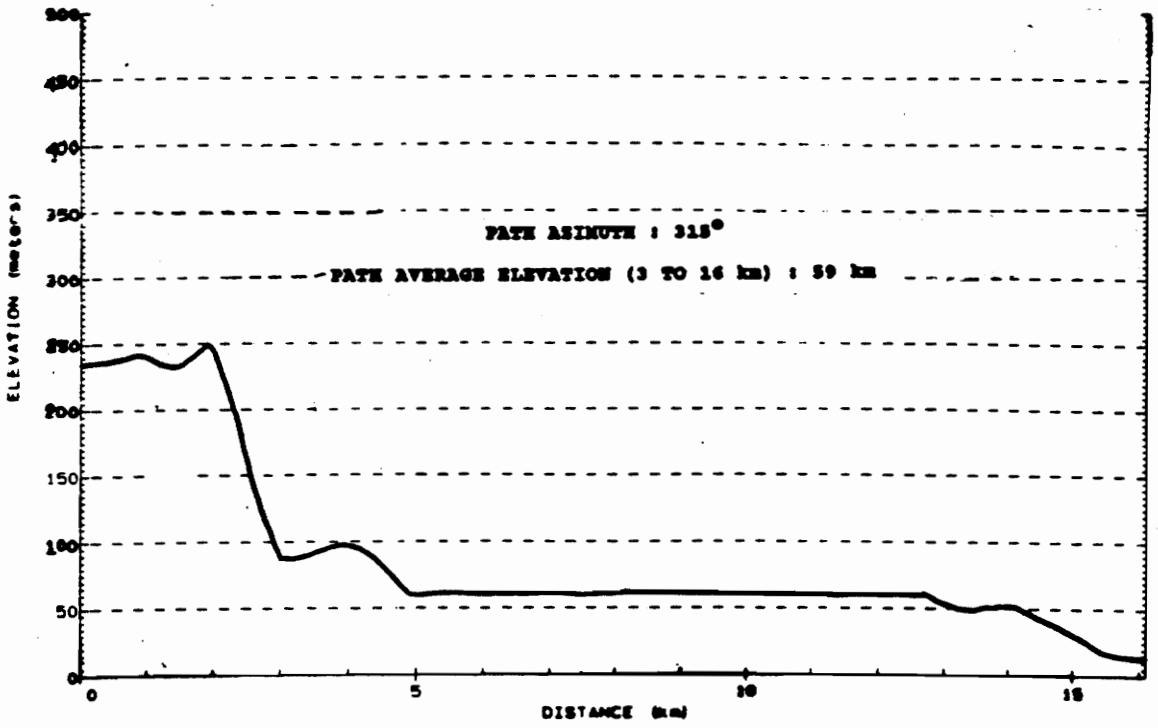


Figure 2.4 (d) Terrain Profile Plot : 270° and 315° Azimuth

RADIAL BEARING	AVERAGE ELEVATION 3 TO 16 (meters)
0	91
45	130
90	116
135	234
180	232
225	124
270	211
315	59

The average of the elevations in each direction (i.e. every 45 degree radial bearing) taken together is about 150 meters above mean sea level as shown in the table above. This means that the height of the center of radiation of the station (i.e. the height of the center of its' radiating element - the antenna), must be not more than 250 meters (i.e., 150+100) above the mean sea level. As it turns out, the height of the proposed site is 344.4 meters above mean sea level. This means that the site is "too high" for the level of effective radiated power allowed for a class A station (which is proposed) and suitable adjustments must be made in the power of the antenna so as to fulfill the requirement of maximum allowable height-ERP combination.

EFFECT ON DESIGN :

Since the site has been determined as exceeding the maximum allowable height, the antenna height must be chosen somewhat arbitrarily. This number arrived at is usually a figure which represents a practically convenient height and we chose 100 feet as our tower height. This height will ensure that the center of radiation is clear of all trees in the area and the line of sight is not obstructed by any other natural or man-made objects in its' vicinity. Also, it will ensure that a 60% first Fresnel zone clearance which is very important to FM reception, is provided.

The Fresnel zone is the area around the propagating signal which is not influenced by the presence of the ground. The presence of the earths' surface changes the propagation of radiation at FM frequencies and the field intensity is always considerably less than the calculated free space value. This is because of the reflected waves and induction fields and secondary effects of the ground.

In order to ensure that the Fresnel zone requirements are met by the proposed antenna height, the following procedure must be executed. The equation for determining the midpath first Fresnel zone radius is given by :

$$R = 1140 (d / f)^{1/2}$$

where : d = path length in miles

f = frequency in MHz

R = First Fresnel zone radius in feet

Once the radius of the first Fresnel zone is known, then it must be ensured that the transmitting antenna and the target service area are cleared by at least 60% of this value. If there is any less clearance, signal strength will be lost. Clearance is most critical around the middle of the path from the transmitting antenna to the target area.

Figure 2.5 is an exhibit of a terrain profile in the direction of the city of Lompoc. In practice, such a terrain profile should be studied for every degree in the direction of the target area in order to ensure the Fresnel zone clearance. The software used to generate the profile plots automatically computes the required radius and the Fresnel zone line confirms that the clearance is achieved.

The rules require that for class A stations, the height and ERP be such that the net effect is to have a class reference distance of 24 kilometers. This means that the 1mV/m contour for the given height using the F(50,50) curve of Appendix A must not extend beyond 24 kilometers (after rounding to the nearest km.).

Our new center of radiation is 372 meters above mean sea level (344.4+27.6). The F(50,50) curve is read "backward" to find the ERP which would give us a 24 kilometer class distance for a radiating element height of 372 meters. This number turns out to be 1.19 kW. Thus, because of the excessive height of our radiating element, we have to cut back on the ERP. Note, however that we will still be operating at the maximum allowable limits for a class A station with these parameters.

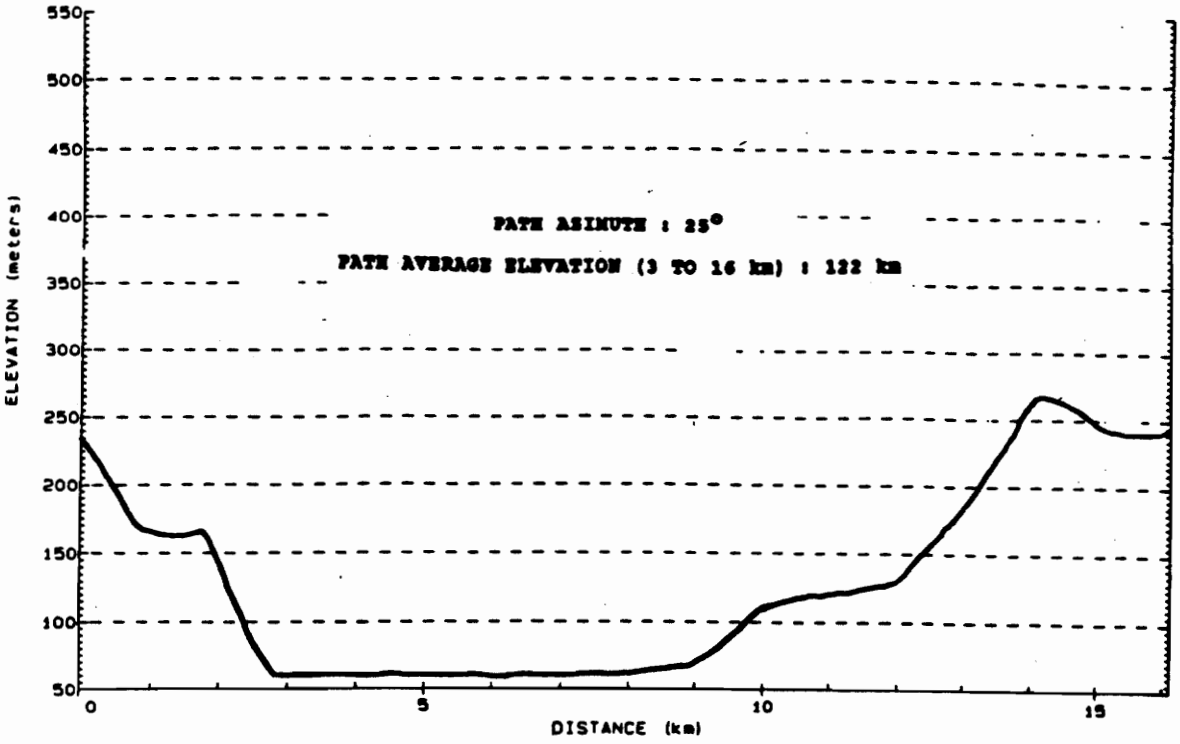


Figure 2.5 Terrain Profile In The Direction Of Lompoc

Based upon the computed values of ERP and antenna HAAT, the coverage contours (the 60 dBu and 70 dBu contours) using the F(50,50) curves must be drawn. These are shown in Figure 2.6.

Finally, as the facility is short-spaced with KCAQ, the following additional procedure must be executed :

(i) Compute and plot the 1.0 mV/m and the 0.25 mV/m curves of the proposed station using the F(50,50) and the F(50,10) curves respectively.

(ii) Compute and plot the 0.5 mV/m curves of the existing facility using both the F(50,50) and the F(50,10) curves.

Figure 2.7 shows an exhibit of these plots on a map of the region. It can be seen that the F(50,50) and the F(50,10) curves of the proposed operation are clear of the F(50,10) and the F(50,50) curves of the existing facility. Thus the protection as required by the FCC are provided by the favorable nature of the terrain in the direction of the existing facility.

2.5.1 Design Implications

The above results lead to the conclusion that we may use an omnidirectional antenna at Lompoc and still be clear of any objectionable interference caused by this operation. An omnidirectional antenna is one which has a uniform radiation pattern in every direction. The use of a directional antenna is thus not called for and this greatly simplifies the design process and equipment clearance procedures of the FCC.

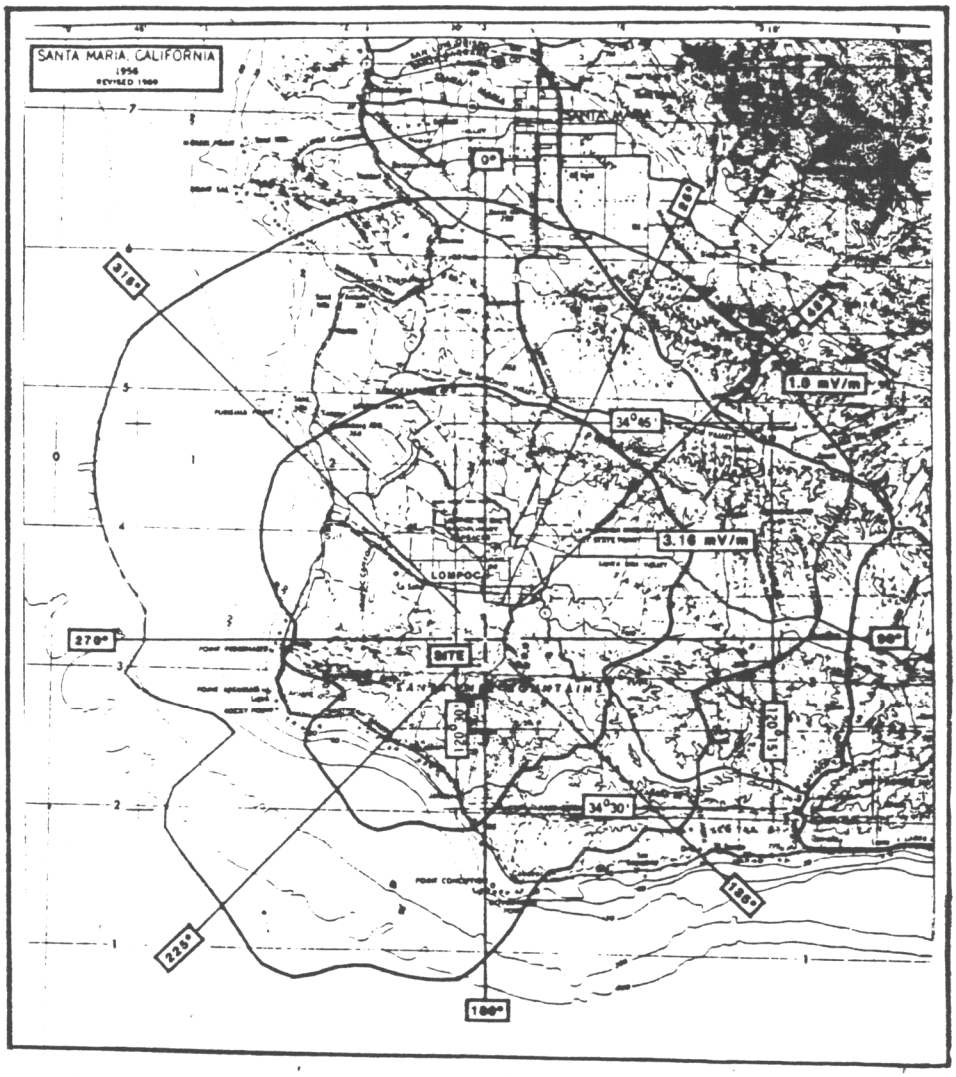


Figure 2.6 The Computed Coverage Contours

Courtesy : Cohen, Dippell & Everist, P.C., Washington D.C.

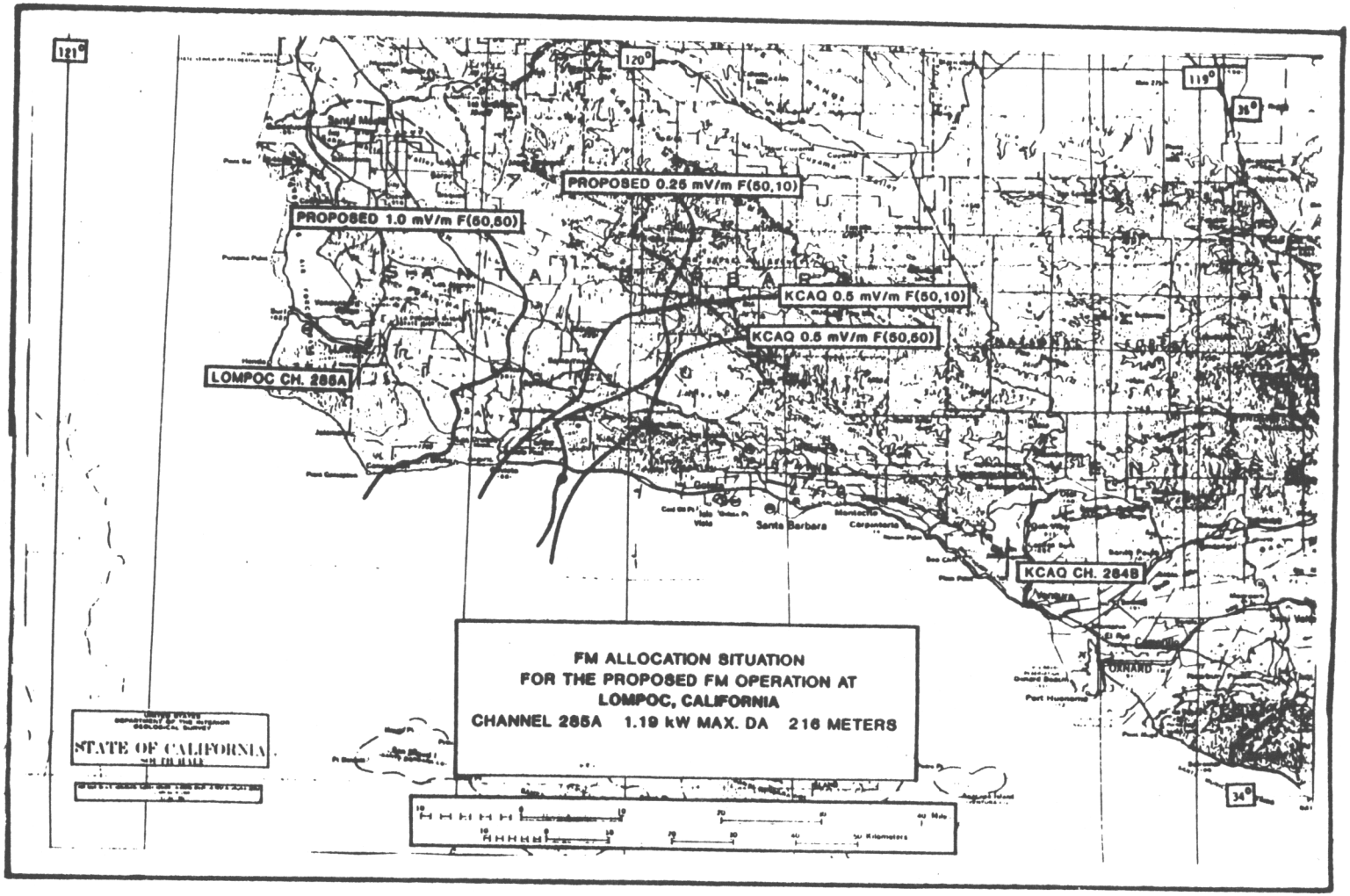


Figure 2.7 Interference Studies of the Proposed Operation

Courtesy : Cohen, Dippell & Everist P.C., Washington D.C.

3. Generalized system design

3.0 The Antenna (Ref [6], Ref [7], Ref [13])

Once the effective radiated power from a particular location has been determined, the antenna for FM broadcasting must be carefully chosen in order to cover the service area properly. The maximum ERP should be achieved with a proper balance between antenna gain and transmitter power. There are several different makes and types of antennas offered to the broadcaster. In deciding which one to specify or purchase, the engineer should consider the power gain, azimuth and elevation patterns, beam tilt and null fill requirements. These are explained in the following sections.

3.1 ERP and Antenna Polarization

Antennas for FM broadcasting use linear horizontal, vertical or circular polarization. Of these, circular polarization must be used if vehicular reception is to be effective. This type of polarization reduces the fading that is otherwise encountered and which degenerates vehicular reception quality considerably. When a circularly polarized signal is reflected, its' sense is reversed. A receiving antenna of one polarization is "blind" to a signal having opposite polarization. Thus, receiving antennas will not be affected by "ghosting" of the signal due to reflection.

This circular polarization may be achieved by intermixing vertically and horizontally polarized antennas or by installing a circularly polarized antenna. Circular polarization by a circularly polarized antenna is superior to an equivalent polarization produced by a combination of horizontally and vertically polarized radiating elements because of the following reasons :

(i) Dual antennas have the disadvantage of additional weight and higher wind and icing load than that of a circularly polarized antenna array.

(ii) Combined horizontally and vertically polarized antennas are usually more expensive than circularly polarized antennas.

(iii) In circularly polarized antennas, the number of bays required is much less than a comparable dual polarization system which needs individual horizontal and vertical elements alongwith a power divider.

Because of the above-sited reasons, we shall select a circularly polarized antenna for the broadcasting facility proposed at Lompoc, California.

3.1.1 Gain of the Antenna

As was mentioned earlier, the desired effective power to be radiated from the antenna must be generated using a balanced combination of transmitter output power and antenna power gain. The other factor which plays a significant role in deciding these values of gain, is the transmission line loss.

The generalized relationship used to decide the parameters of the transmitter-transmission line-antenna system is as follows:

ERP = Transmitter output power X Antenna power gain X Transmission line efficiency

The question of using a high power transmitter with a low gain antenna, or a high gain antenna with a low power transmitter, to achieve the same ERP is a design tradeoff issue and it is usually decided without solid engineering information. If the presence of the ground is disregarded, there would be no electrical difference what combination of transmitter power and antenna gain is used for a given ERP. Therefore the terrain determines the final choice from an

engineering viewpoint. This design principle is explained further in the following paragraph.

Of the total ERP emanating from the antenna, half of it is wasted because it occurs above the terrain elevation pattern and goes into outer space. Of the other half, the terrain interacts with the signal, reflecting it and this may cause multipath problems.

The antenna can be designed so as to reduce both these effects. In essence, the attempt is to "focus" the radiation pattern at the primary area of service, minimizing, both, the signal lost by radiation into outer space as well as the degenerative effects of reflection off of the terrain. This focusing can be achieved by increasing the number of bays in the system and by physically tilting the system to "look" toward the area of service.

The small physical size of each FM antenna lends itself to stacking. When individual units (called bays) are stacked, each will contribute its' gain to the total gain. Because of stacking, the beam is narrower and it can become highly directional. Also the energy lost to outer space is reduced as the number of bays is increased.

Alternative 1: Use a high power transmitter with a low gain antenna.

Because of a low gain antenna, the antennas' beamwidth will be much wider and as a result, considerable energy will strike the ground to be reflected from the terrain near the transmitting site. However, in the case of Lompoc the site terrain will not cause multipath problems as a result of these

reflections and a 2 to 3 bay antenna corresponding to a power gain of about 1.2 is a viable alternative.

Alternative 2: Use a low power transmitter with high gain antenna.

The large number of bays in a high gain antenna lead to a highly directionalized beam which is not a pressing need in the case of Lompoc because of a good surrounding terrain. Also, as the number of bays increases, the size of the antenna will be large and the tower cost to support the antenna against its' dead weight and wind resistance will be higher than that which is justifiable.

From the antenna gain, the transmitter output power can be determined, allowing for the transmission line efficiency.

3.1.2 VSWR Bandwidth

One of the more critical specifications that an antenna has is its' VSWR (Voltage Standing Wave Ratio) bandwidth.

If the antenna system has a narrow bandwidth, the sideband energy generated by high frequency components of the baseband leaves the transmitter and travels up the transmission line to the antenna. If there is mismatch at the sideband frequency, some of the sideband energy will be reflected back down through the line to the transmitting unit, which will reflect it back up again. When this reflected energy is radiated through the antenna unit, it will be out of phase with the other power being radiated and will interfere with it. This is a major

cause of multipath effects produced at the source and this situation is totally avoidable by choosing an inherently broadband antenna design. Having a VSWR bandwidth of at least 260 kHz (with less than a 1.08:1 standing wave ratio across that band) is imperative for good system performance.

3.2 The Transmission Line (Ref [7])

The RF carrier from the transmitter will be routed to the antenna system over coaxial transmission lines. These lines have their own characteristics and there are problems if operation is contrary to these characteristics. So when a new line must be selected, a general understanding of the coax line will help make better decisions and maintain the line over its' life cycle. It is useful to keep in mind during the deliberations and calculations in trying to make a selection that a good line and installation will last for many, many years, and with only a minimum of problems and very little maintenance. The main factors in the selection are the power loss of the line and the power handling capability of the line.

3.2.1 Power Handling Ability

The two main factors which affect both the losses and the power handling ability are the diameter of the line and the type of dielectric that is used. A larger diameter line will have less loss than a smaller diameter line of the same

length. Lines which use Teflon spacers and air dielectric have the least loss for a given diameter.

"A coax line will have a natural impedance value that is called the surge impedance or characteristic impedance. This values is not the same for all coax lines but is dependent upon the diameter of each conductor, the spacing between the conductors and the insulating material ". The line with the larger inner conductor will have the lower impedance.

3.2.2 Losses

"There will be a loss of power as the signal travels along the line. The determining factors for this loss are the resistance of the conductors and the leakage across the dielectric. Both the RF resistance and the leakage will increase as the frequency is increased, so the rating is definitely related to the frequency. As a yardstick, the ratings are based on 100-foot sections of the line ". The only way this rating can be improved is by using a larger diameter line. "The larger diameter will have a greater conductor surface and less RF resistance, and the wider spacing between the conductors will reduce the leakage.

Although one cannot improve the rating, standing waves will deteriorate the rating by producing the higher losses. Since the rating is based on 100-foot sections, the longer the line, the greater the total losses."

3.2.3 Type of Line

"There are many choices when it comes to coax line, but basically these fall into two types - rigid or flexible. Each of these has its own advantages, disadvantages and electrical characteristics. The rigid line will come in 20-foot sections that are bolted together at the flanged ends. This line requires elbows to turn corners or change direction, and it takes more installation time. But, if repairs must be made, they are easier.

The flexible line will be one continuous piece, flanged at both the ends. This can make the installation go faster and the mounting is simpler. But, one must be sure of the length to order and a large spool of this line is a bit tougher to handle. Also, repairs done on this line are far more difficult."

3.3 The Transmitter (Ref [9])

"The object of an FM transmitter is to convert the audio input signal (from the microphone) to a frequency- modulated RF output signal at a specified frequency. Basically there are two different methods to produce the frequency modulated signal. One process is called the *direct method* and this is typical of commercial FM transmitters in current use. In the direct method, the frequency of the oscillator is varied directly by the audio modulating signal, usually by applying the audio signal across a varactor that is part of the frequency

determining circuit of the oscillator " A simplified block diagram of a direct FM transmitter is shown in figure 3.1.

"The microphone audio signal is fed to a preemphasis network, which emphasizes or favors the higher audio frequencies. The purpose of pre-emphasis is to compensate for poorer signal-to noise ratio at the higher audio modulating frequencies. The pre-emphasized signal is amplified and then passed through a peak limiter or clipper which limits or clips the peaks of the audio signal. This clipping process creates audio harmonic distortion which is filtered by the "splatter" filter. The audio signal is then applied to the varactor of the oscillator at a level determined by the setting of the peak deviation control. This control limits the amount of frequency modulation caused by the audio signal. The oscillator operates at a frequency much lower than the transmitter output frequency. The frequency multiplier multiplies the oscillator frequency to reach the operating frequency of the transmitter. The amount of deviation or modulation is also multiplied. The output of the multiplier is then fed to an RF driver amplifier and then to the final power amplifier. Since the signal is frequency-modulated rather than amplitude modulated, a class C RF power amplifier can be used resulting in better efficiency."

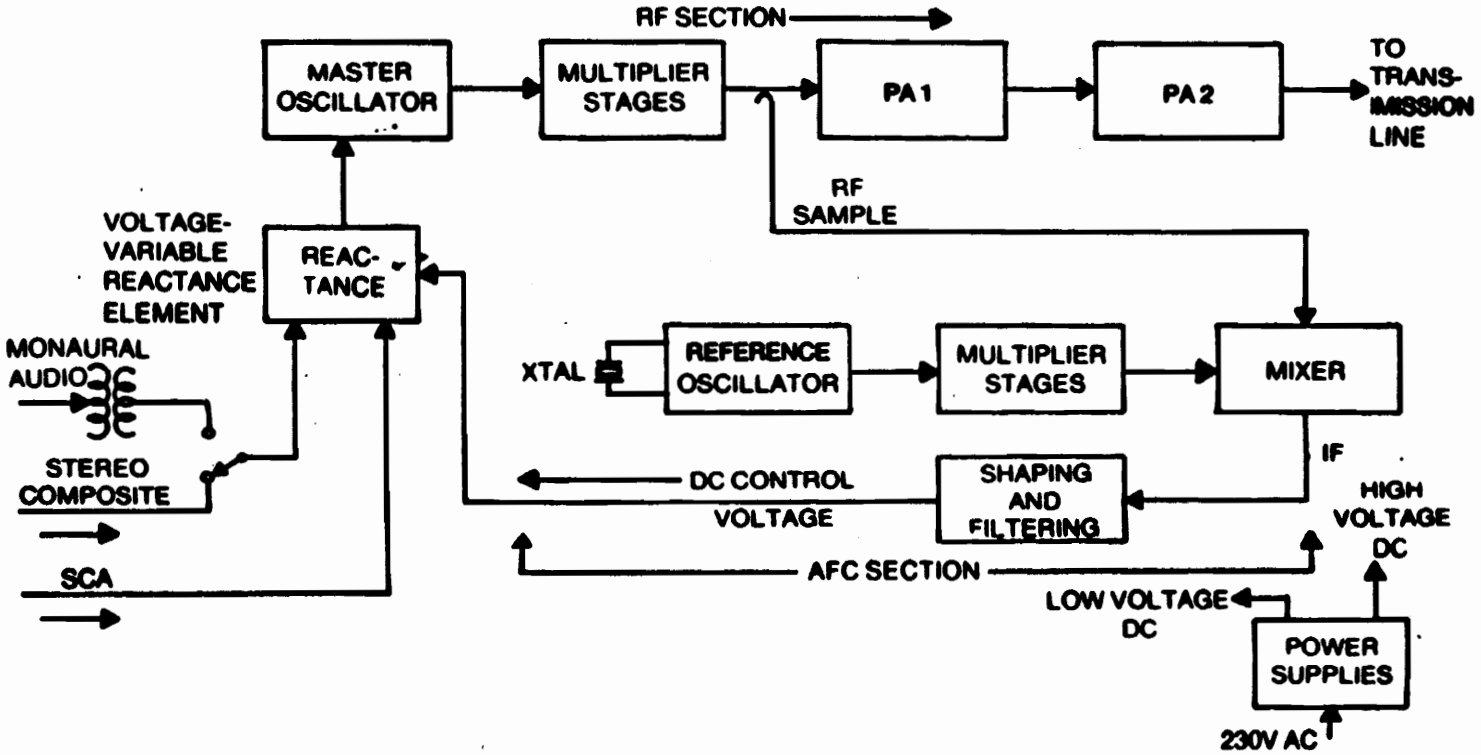


Figure 3.1 Basic Direct FM Transmitter Ref[9]

3.4 Transmitter - Transmission Line - Antenna Specifications

Antenna power output (ERP) = 1.19 kW

Antenna gain = 1.2

Power required at the antenna input terminals = (1.19 / 1.2) ~ 1 kW

Transmission line loss = 0.1 dB / 100 feet

Length of line required = 500 feet

Total transmission line loss = (0.1 * 5) = 0.5 dB

This transmission line loss of 0.5 dB corresponds to a power ratio of 1.12 which means that because of the losses in the length of the line, the power required at the input of the line would be a factor of 1.12 times the power delivered to the antenna input terminals.

Power required at the transmitter line output = (1 * 1.12) = 1.12 kW

Transmitter power output = 1.12 kW

3.5 The Tower (Ref [13])

Basically, two tower structure options are available whose relative advantages and disadvantages are discussed below:

(i) Self-supporting tower:

Advantage: Requires less ground area at the base of the tower. The area required is roughly a square about 15% of the overall height of the structure.

Disadvantages: (a) Much more expensive as compared to the guyed tower.

(b) Whip forces tend to be larger in a tall, slender self-supporting tower with a heavy weight on top (such as an antenna) than in a guyed tower.

(ii) Guyed tower:

Advantages: (a) Cheaper cost. Most guyed towers today are built with a uniform cross section and, in many instances, a constant weight in cross section. This makes for cheaper fabricating and easier and cheaper stacking during erection.

(b) The whip forces tend to be smaller because the guys, in effect, form a very large base.

Disadvantage: Needs a larger land area as compared to the self supporting structure - a square plot of side about 75% of the overall height of the structure.

Figure 3.2 shows a vertical sketch of the tower dimensions proposed for the operation, as arrived at from the value of antenna height above average terrain (HAAT) calculations. Since the site is not in the near vicinity of any airports and the tower erection would not pose a serious hazard to aviation in the area, it is not proposed to equip the antenna tower with any high intensity lights.

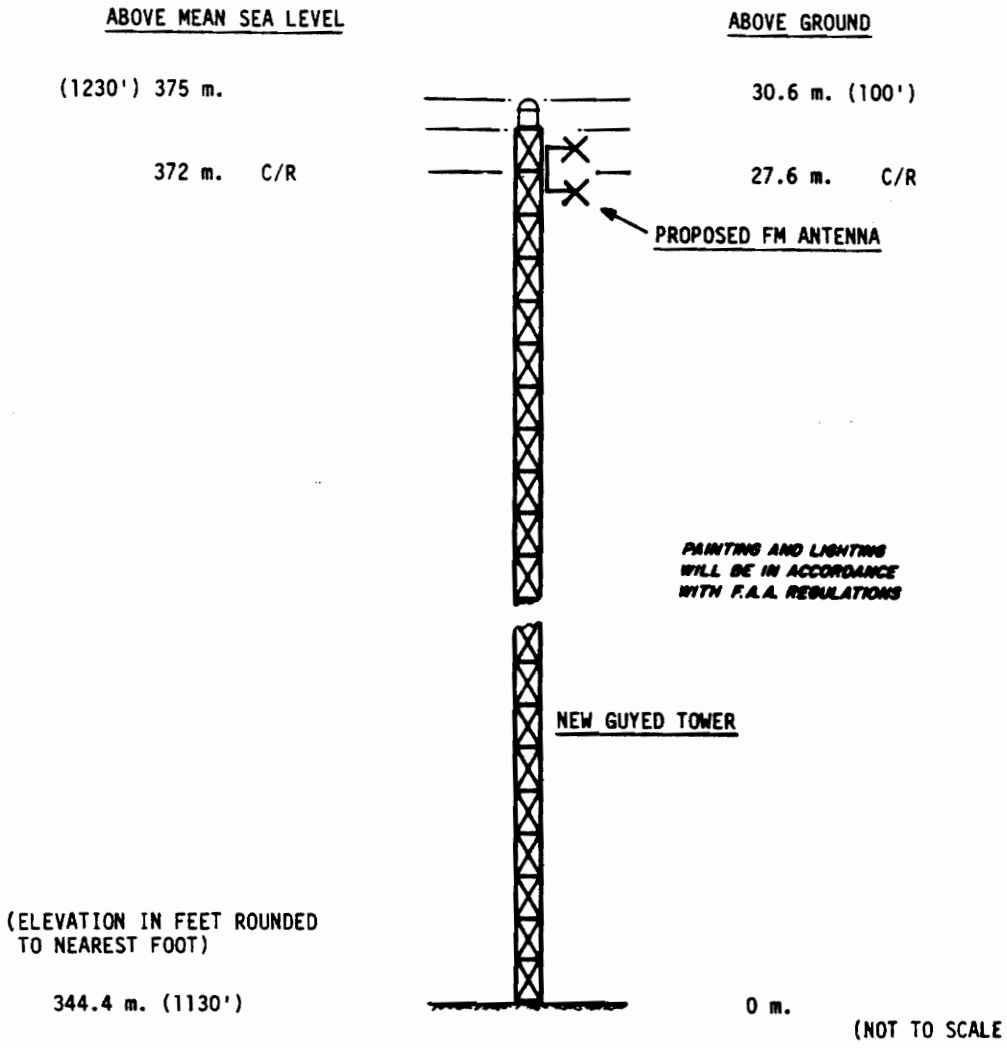


Figure 3.2 The Proposed Tower Configuration

4. Maintenance plan

4.0 General Considerations (Ref [7])

Broadcast equipment generally gives reasonably trouble free performance year after year, but it all depends on how well preventive maintenance is executed. Although a manufacturers' warranty usually covers corrective maintenance, a failure means loss of valuable air-time and this situation can be avoided by detailed maintenance plan.

In general, preventive maintenance consists of the following procedures: inspect, clean, tighten, lubricate, tube-check and FCC station proof. The details of the station proof procedure can be obtained in most manufacturers' manuals. The maintenance procedures specified here are more generic in their applicability to all FM broadcast facilities.

- In order to ensure an efficient transmitter-transmission line-antenna system performance, all equipment must be kept free of dust and oily

deposits. Dust is described by most literature on maintenance techniques as the number one enemy. Dust accumulation can and usually does result in pre-mature equipment failure by preventing proper heat dissipation, by changing electrical values of components, causing arcing and by preventing proper electrical contact in relays and switches.

- Routine visual inspection should be made. All connections involving screw type terminals should be periodically checked.

- Check all moving and rotating items for proper function and lubrication.

- Keep switches and relay contacts clean.

- Low current circuits sometimes use small fuses. It is good maintenance practice to change them once a year.

4.1 The Transmitter Plant (Ref [7])

This major subsystem generates the modulated signal, receives the audio from the studio area, impresses the audio on the carrier as modulation and sends it to the antenna system for radiation. As the block diagram of Figure 4.1 indicates, the transmitter subsystem basically consists of an ac power input, an audio input signal and a stereo generator to preprocess the audio signals before they are fed to the transmitter input which produces the RF power output to the transmission line.

AC Power Input : Since we have a low power unit, we will be working with a 230V AC single phase supply. This ac power will be brought to the building over high-voltage mains, then stepped down to 230 V by transformers. It will then be fed to a main power entrance, where there is fuse protection. Then it will be distributed throughout the building. One of the circuits feeds the transmitter which should have its' own circuit breaker. The maintenance routine for the power supply is outlined in Figure 4.2.

The Transmitter Unit : Anytime that the transmitter is in operation, it must comply with all rules specified by the Commission relating to its' power, operating frequency, percentage modulation and other performance criteria. The specific maintenance details will have to be adjusted once the system

has been installed and depending on its' make, model, manufacturers' recommendations, etc.

It is mandatory to monitor certain features of the transmitter such as the modulation level by an FCC approved modulation monitor, and in addition FM stereo requires an FCC approved stereo monitor. Monitoring within the transmitter is done by various metering circuits. The maintenance routine is outlined in Figure 4.3.

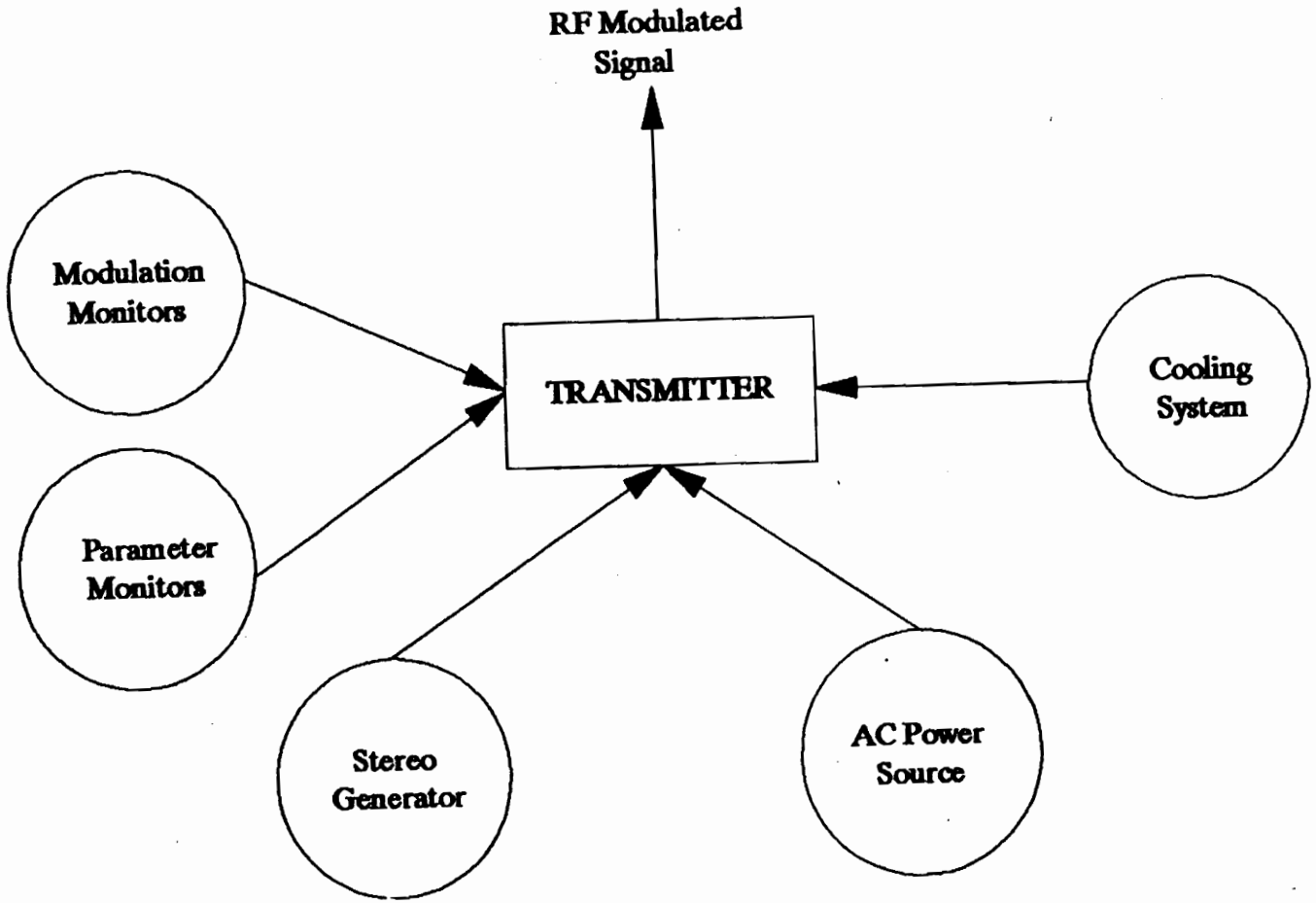


Figure 4.1 Transmitter Plant Block diagram

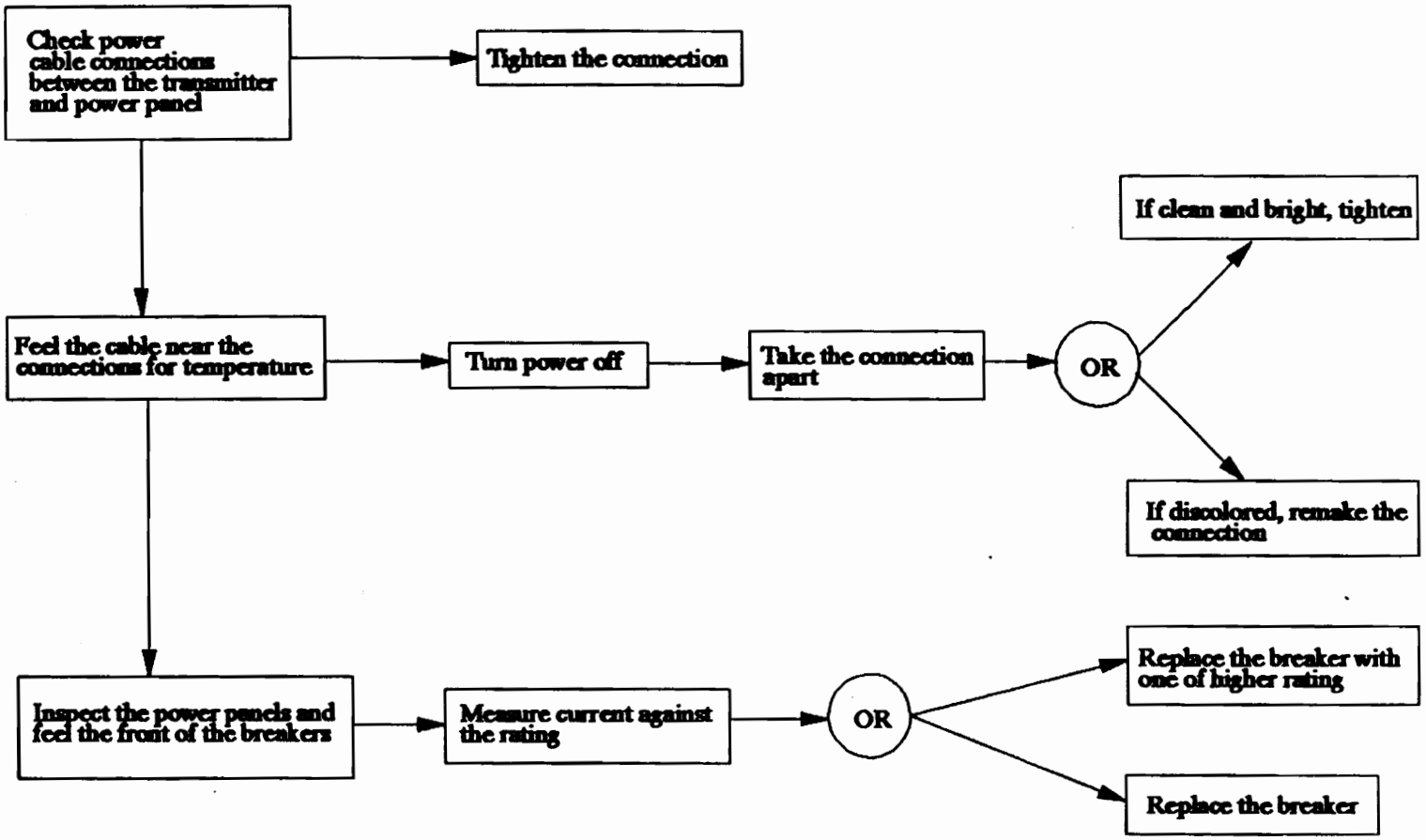


Figure 4.2 Power Supply Maintenance Flow

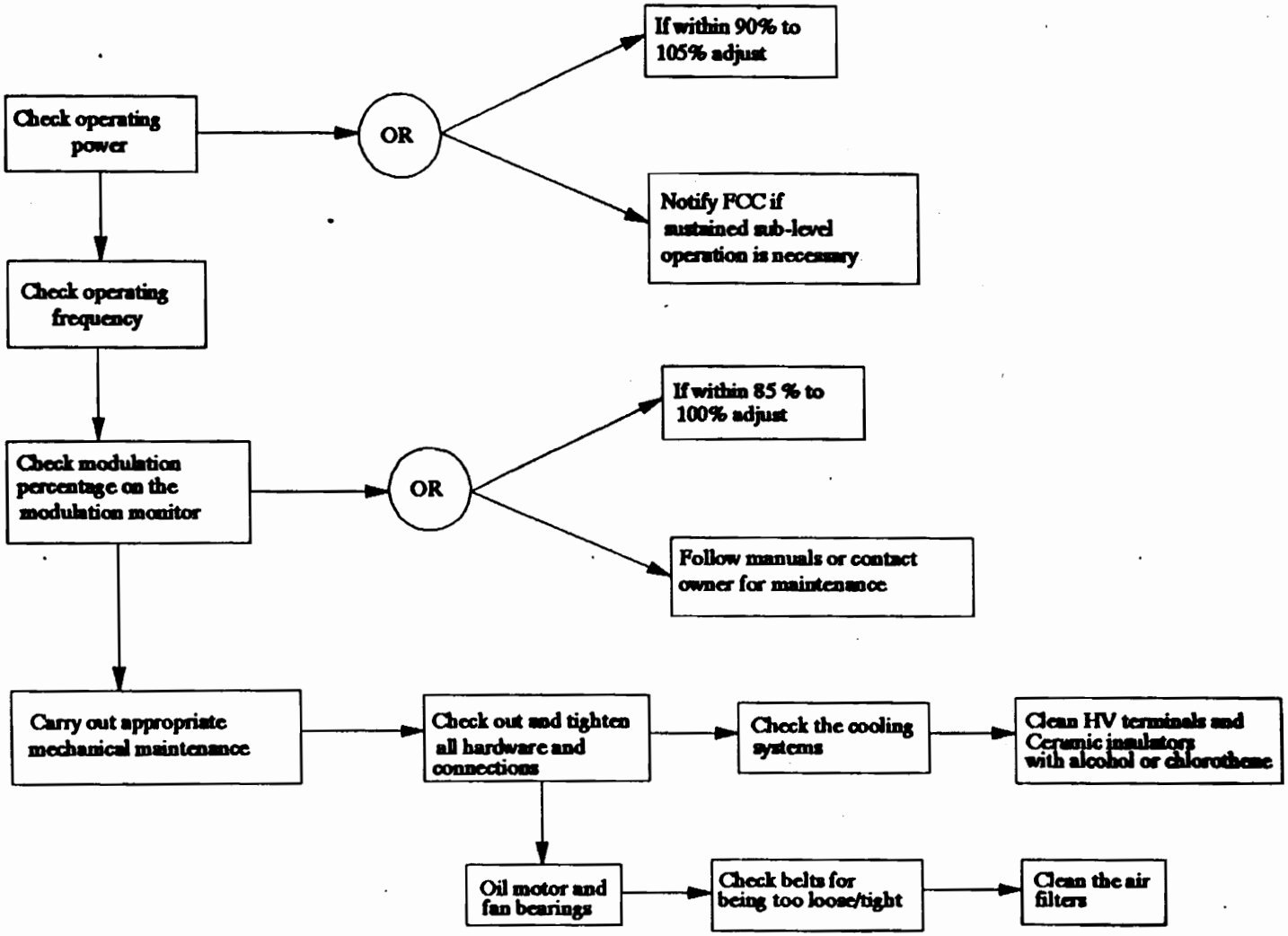


Figure 4.3 Transmitter Unit Maintenance Flow

4.2 The Transmission Line

A well selected line with adequate reserves in its' specifications and a careful installation will generally have a long life. It requires some routine inspections from time to time and a daily check of the VSWR and gas pressure. Also, physical damage because of accidents and electrical damage caused by faults in the antenna itself must be quickly spotted and attended to.

Daily VSWR Checks : The VSWR should be read at sign-on and at sign-off. At signoff, after the effects of RF heating resulting from a full days' operation under power, the VSWR may be poorer than at sign-on. Poor and drastically differing VSWR readings are indications of problems such as a poor connection, or even an antenna problem.

Daily Pressure Checks : On pressured lines, there should be a check of the line pressures each day. An automatic dry air pump which keeps up the line pressure may run continuously if there is a large leak. Also gas used to pressurize the line will be wasted if there is a leak in the line.

Physical Damage Checks : Because of the outdoor environment of the line, it is exposed to the effects of weathering, rodents and accidents. The line VSWR will rise as a result of physical damage and cause inefficient

operation of the system. The routine for the maintenance actions required for the lines is outlined in Figure 4.4.

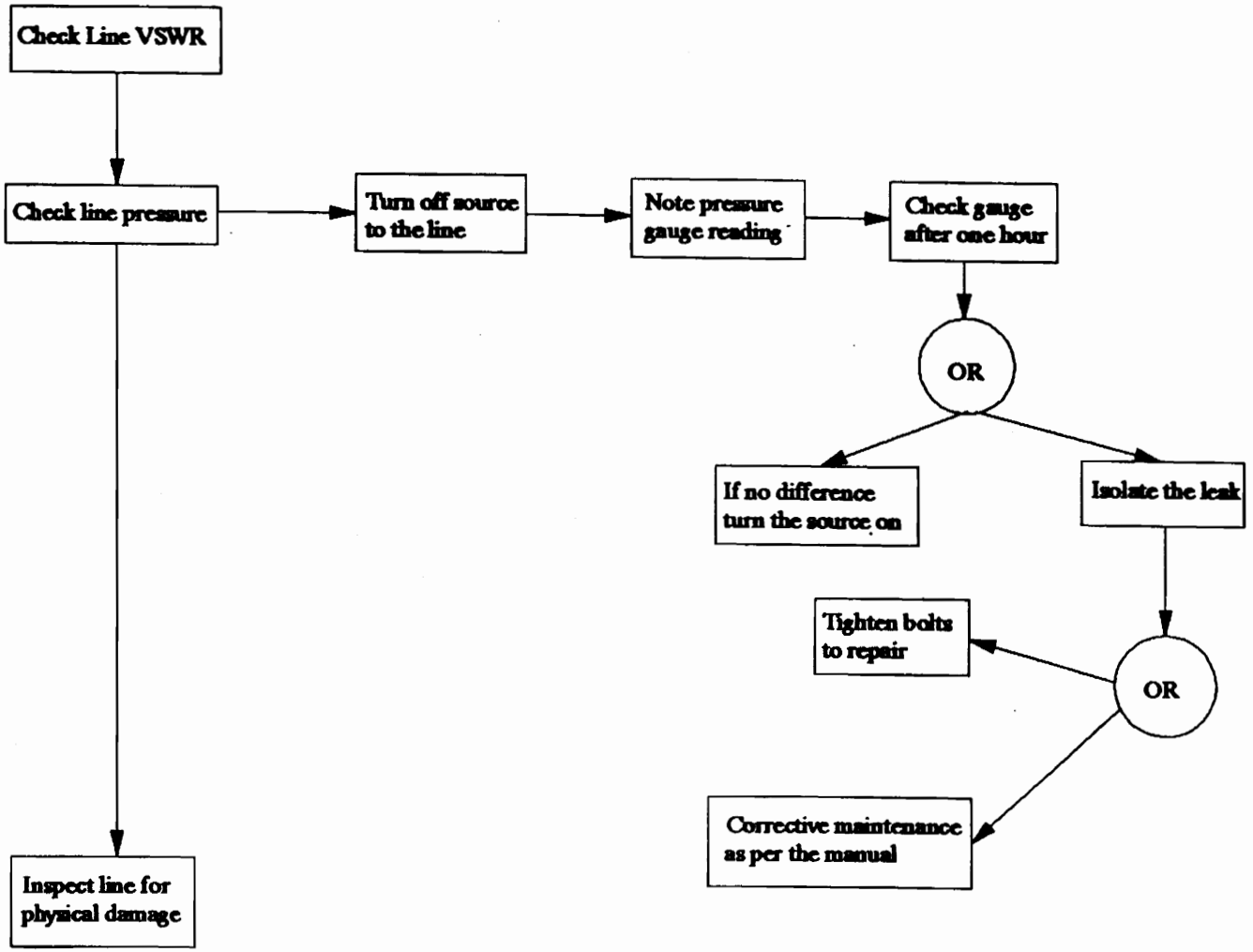


Figure 4.4 Transmission Line Maintenance Flow

4.3 The Antenna-Tower System

In the maintenance of the antenna system, as in the maintenance of other broadcast systems, one rule is important - keep the system clean. Antenna components should be inspected and cleaned regularly. An important part of the antenna maintenance procedure is to make a visual inspection of all its' elements. Broken insulators or other damaged equipment should be replaced at once. The recommended maintenance flow is shown in Figure 4.5.

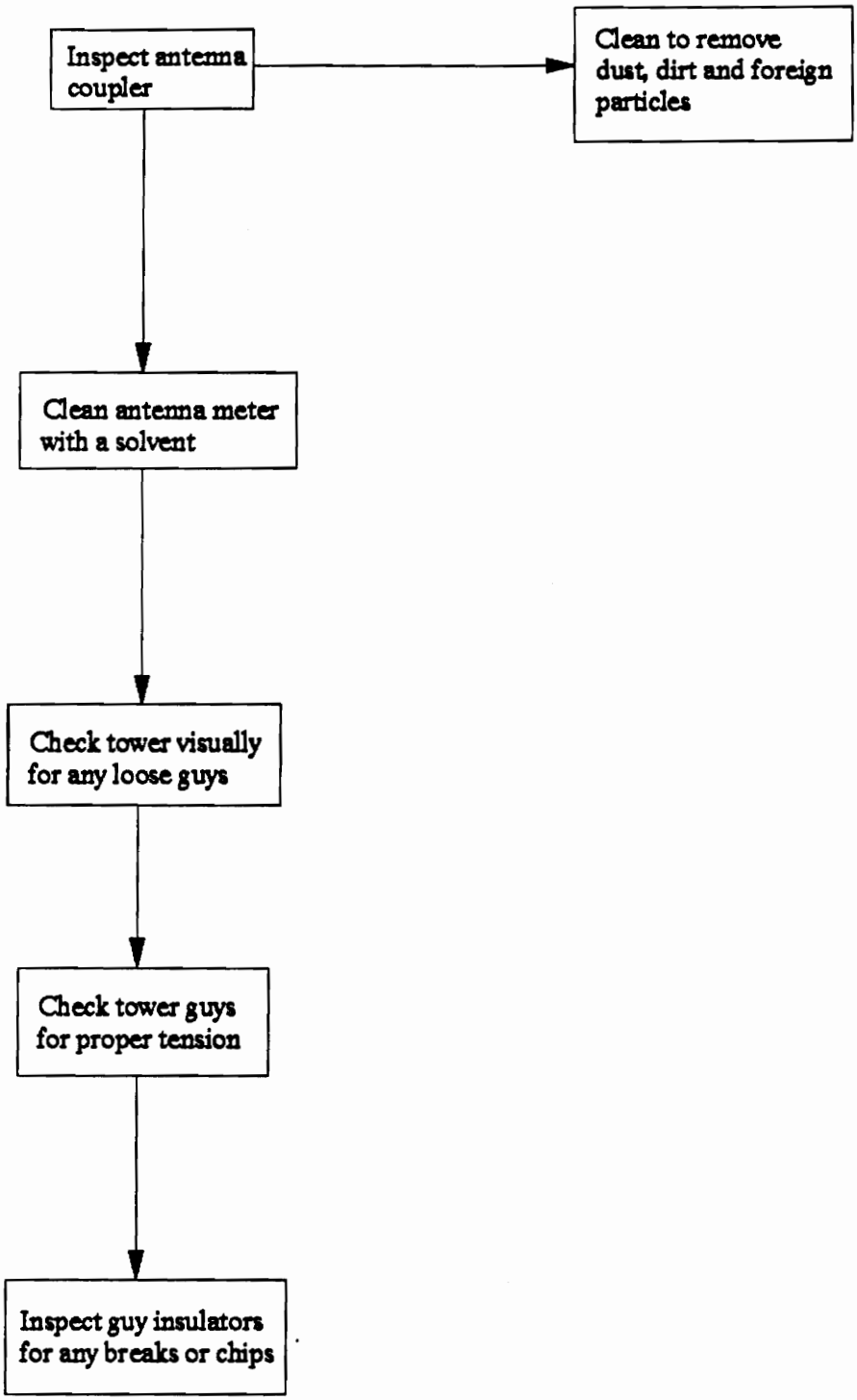


Figure 4.5 Antenna - Tower Maintenance Flow

5. Design summary

This report has recommended the following specifications for the proposed FM operation at Lompoc, California.

- In Section 1.2, it was suggested that an FM facility be chosen to fulfill the desired objectives. This is because of FMs' technical superiority over AM. The advantages cited include reduced noise, high fidelity, stereophonic transmission and the possibility of SCA in future expansion ventures.

- Chapter 2 dealt with the engineering studies necessary to specify the facility. The data are required by the FCC to process the application for constructing a new facility. The station channel number, class and frequency were decided as per the discussion in Section 2.3. Their values are as follows:

Channel : 285

Class : A

Frequency : 104.9 MHz

- Next, interference studies were carried out in the vicinity of the proposed facility to find a region which would be clear of any objectionable interference as per standards set by the FCC. The selected site has coordinates : 120° 28' 36" longitude and 34° 36' 38" latitude.

- Once the site was selected, terrain profiles were plotted at 45 degree incremental radial bearings and the average elevation of the site above average terrain was computed in Section 2.6. This value was found to be 344.4 meters. Since this value is above that allowed for a Class A station, we had to cut back on the power radiated by the antenna in order to conform to the rules. This power is the ERP which is 1.19 kW.

- Next, interference studies were carried out to verify that although the station is short-spaced with another one in the area (KCAQ), the terrain in the direction of KCAQ prevents any objectionable interference between the two stations.

- With the values of HAAT and ERP determined as 216 meters and 1.19 kW respectively, the antenna was chosen in Section 3.1. The considerations were the terrain profile in the direction of Lompoc, the polarization and VSWR bandwidth. The following are the antenna specifications arrived at :

Polarization : Circular

Antenna gain : 1.2

VSWR bandwidth : >260 kHz

- Next, in Section 3.2, the transmission line was selected based on the power rating, losses and the type of line. The type selected is a rigid line with a loss of 0.1dB/foot.

- In Section 3.4, the output power of the transmitter required was determined based on the transmission line loss and ERP requirement. This is 1.12 kW.

- Finally, the type of tower structure to support the antenna was selected in Section 3.5. It was decided that a guyed tower will adequately serve the purpose because the area of the acquired site is not a limiting constraint.

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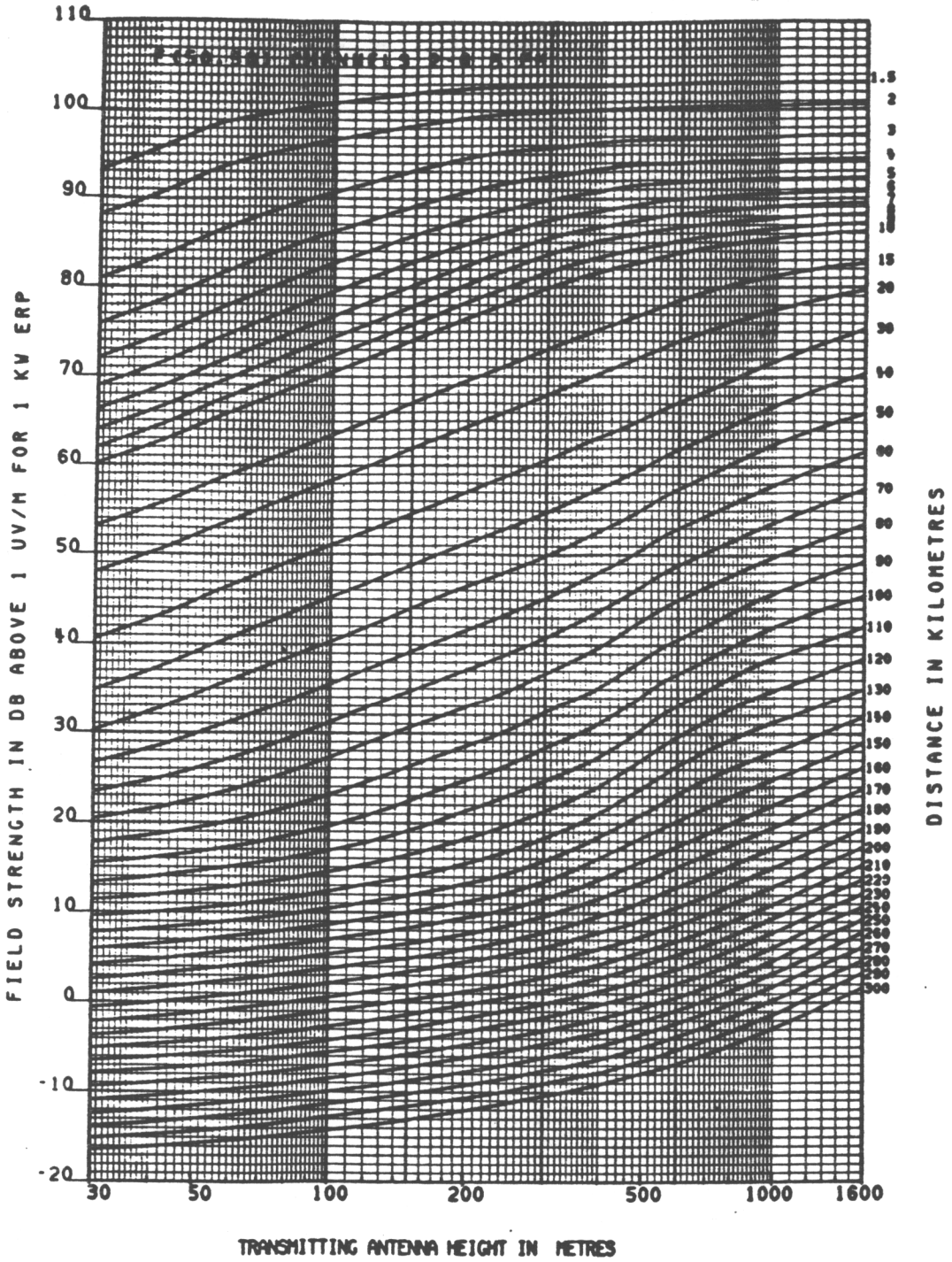
appendix A

Federal Communications Commission approved F(50,50) curves.

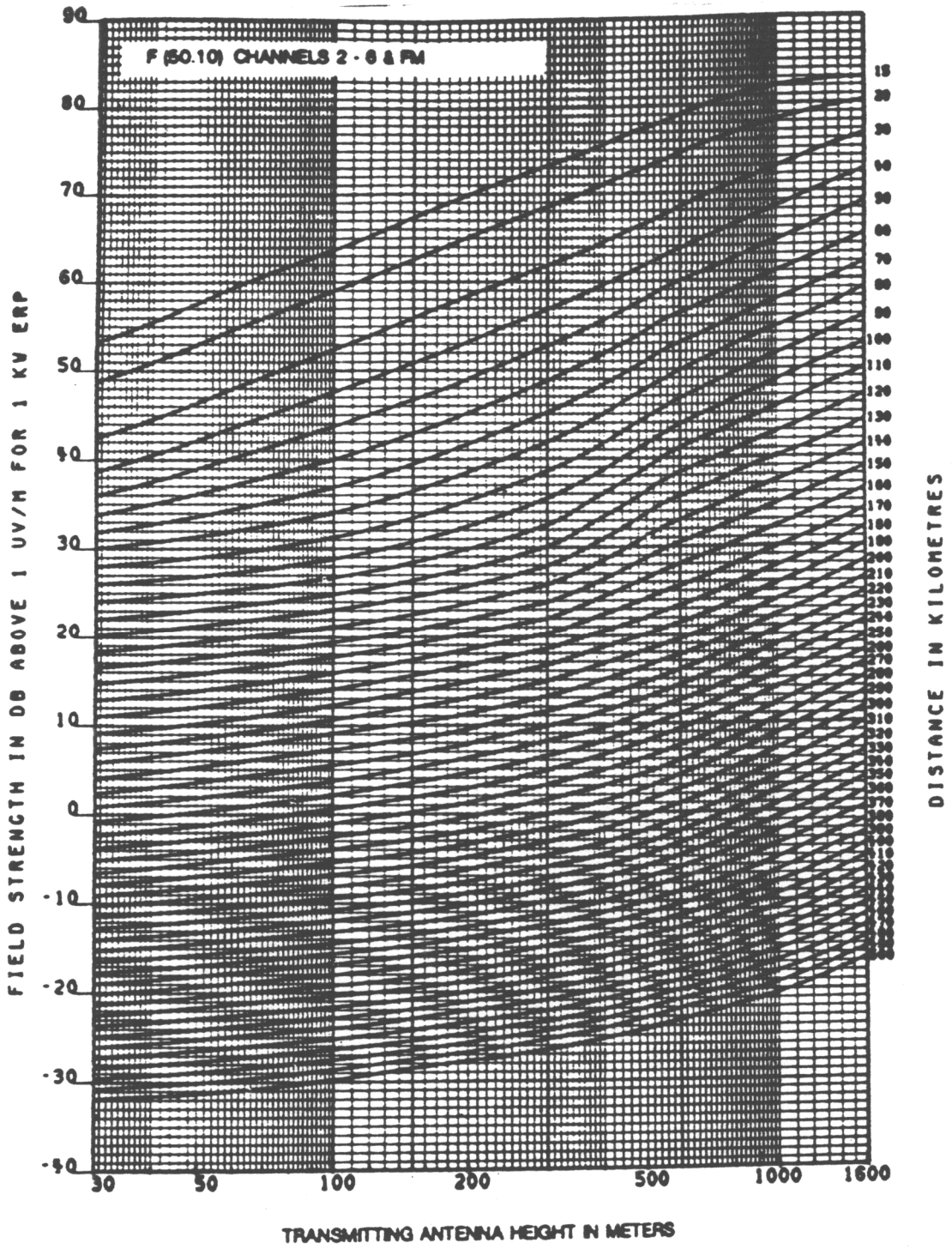
Source : Reference 12


FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 1 KW ERP
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
30
50
100
200
500
1000
1600
TRANSMITTING ANTENNA HEIGHT IN METRES
DISTANCE IN KILOMETRES

appendix B

Federal Communications Commission approved F(50,10) curves.

Source : Reference 12


F (50.10) CHANNELS 2 - 6 & FM
FIELD STRENGTH IN DB ABOVE 1 UV/M FOR 1 KW ERP
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
30
50
100
200
500
1000
1600
TRANSMITTING ANTENNA HEIGHT IN METERS
DISTANCE IN KILOMETRES

appendix C

Sample program run for reading FM databases to search all relevant stations within the specified search radius.

Database files used: F40120, F40130

ATTENTION : CANADIAN AND MEXICAN SEPERATIONS USED
Target Label: VATECH Channel 285A N Lat 34-38-24.0 W Lon. 120-27-30.0
Search Radius: 300.00 km

CALL	CHAN		H ERP	V ERP	H HAAT	V HAAT	H R/C	V R/C	ST	DA	AZ TO AZ FROM	DIST RDST (KM)
KIQO	283B	LIC	5.6	5.6	427	427	762	762	N	N	35-21-38 347.40	81.9
Atascadero							CA	104.5			120-39-21 167.29	69.0
Midway Broadcasters, Inc.									880610		BLH-810803AI	CLOSE
53A6C7400091AD46												
KCAQ	284B	LIC	2.85	2.85	482	482	705	705	N	N	34-20-53 107.19	108.1
Oxnard							CA	104.7			119-20- 7 287.82	113.0
Sunbeam Radio Partners									890317		BMLH-880906KE	SHORT
A303DB200091AD46												
	285A	VACANT							N	N	34-38-24 .00	.0
Lompoc							CA	104.9			120-27-30 .00	115.0
									900329		-	SHORT
8C571D000092965D												
NEW	285A	APP	3.0	3.0	100	100	274	274	N	N	34-37-26 222.68	2.4
Lompoc							CA	104.9			120-28-35 42.67	115.0
NOE-WAL Broadcasting									901231		BPH-900522MH	SHORT
05795E8000937D8C												
NEW	285A	APP	1.20	1.20	216	216	372	372	N	Y	34-36-38 207.13	3.7
Lompoc							CA	104.9			120-28-36 27.12	115.0
Great Scott Broadcasting									901231		BPH-900518MM	SHORT
AECF818000938183												
NEW	285A	APP	0.33	0.33	305	305	442	442	N	N	34-35- 1 226.86	9.2
Lompoc							CA	104.9			120-31-53 46.81	115.0
Lompoc Minority Broadcasters Partnership									901231		BPH-900518MO	SHORT
46A4EF4000938182												
NEW	285A	APP	.50	.50	236	236	393	393	N	Y	34-44- 9 7.33	10.7
Lompoc							CA	104.9			120-26-36 187.34	115.0
Lee Wardlaw Jaffurs									901026		-900516MS	SHORT
CEA6BF2000937E34												
NEW	285A	APP	0.7	0.7	207	207	364	364	N	Y	34-44-13 7.78	10.9
Lompoc							CA	104.9			120-26-32 187.79	115.0
Lion's Share Broadcasting									901231		BPH-900504MD	SHORT
1AD4E20000937665												
	285B1	VACANT							N	N	36- 2-58 29.10	179.6
Tipton							CA	104.9			119-29- 8 209.66	143.0
									910611		-	CLEAR
301C7AE00092DEDC												

Database files used: F40120, F40130

ATTENTION : CANADIAN AND MEXICAN SEPERATIONS USED
Target Label: VATECH Channel 285A N Lat 34-38-24.0 W Lon 120-27-30.0
Search Radius: 300.00 km

CALL	CHAN		H ERP	V ERP	H HAAT	V HAAT	H R/C	V R/C	BT	DA	AZ TO AZ FROM	DIST RDST (KM)
KQYZ	285A	CP MOD	3.00	3.00	65	65	133	133	N	N	36-16-17	19.49	192.3
Lemoore							CA	104.9			119-44-29	199.91	115.0
Lemoore Wireless Company, Inc.									910613		BMPH-900531IB		CLEAR
DF85AA4000937E57													
KQYZ	285A	LIC	3.00	3.00	56	56	126	126	N	N	36-17-11	20.61	195.5
Lemoore							CA	104.9			119-41-21	201.06	115.0
Lemoore Wireless Company, Inc.									910611		BLH-810327AC		CLEAR
EFD3DB800091AD46													
KOCN	285A	LIC	1.80	1.80	183	183	416	416	N	N	36-33- 9	330.90	244.0
Pacific Grove							CA	104.9			121-47-17	150.13	115.0
C.R. Pasquier Properties, Inc.									910507		BLH-900518KF		CLEAR
BA83810000926A89													
KLOAFM	285A	LIC	0.75	0.75	0	0	780	780	N	N	35-37-24	65.76	275.2
Ridgecrest							CA	104.9			117-41-10	247.35	115.0
Kloa Radio									890601		BLH-790226AF		CLEAR
F0CE1A000091AD46													
NEW	285A	APP	1.10	1.10	141	141	282	282	N	N	33-25-51	116.21	296.4
San Clemente							CA	104.9			117-35-47	297.81	115.0
On the Beach Broadcasting									900116		-850712UP		CLEAR
F30126A00091AD46													
NEW	285A	APP	1.00	1.00	146	146	289	289	N	Y	33-25-50	116.21	296.4
San Clemente							CA	104.9			117-35-47	297.82	115.0
Portola Broadcasting Corporation									900809		BPH-850712VJ		CLEAR
F4C03BC00091AD46													
KOHD	288A	CP	.160	.160	409	409	507	507	N	N	34-53-54	337.15	31.1
Guadalupe							CA	105.5			120-35-28	157.07	31.0
Armando Garcia									901128		BPH-840629IA		CLOSE
001260600091AD48													
KKUR	288A	LIC	.100	.100	414	414	645	645	N	N	34-20-57	107.12	108.1
Ojai							CA	105.5			119-20- 7	287.76	31.0
Michael R. Thomas									891218		BLH-881122KB		CLEAR
01E6D2400091AD48													

Vita

Manish Madan was born on April 4th, 1969 in Yol, India. He received his Bachelor of Science degree in Electrical Engineering in 1990 from the College of Engineering, Pune which is affiliated to the University of Poona. He enrolled for the Master of Science program in Systems Engineering at Virginia Polytechnic Institute and State University in Fall 1990.

During the summer of 1991, while a graduate student at VPI&SU, Manish worked as a summer intern for Cohen, Dippell & Everist, P.C., a consulting engineering group in Washington, D.C.. He was responsible for developing software and upgrading existing programs used by the company for utilizing the FM, AM and TV station databases received from the FCC.

He will receive the Master of Science degree in Systems Engineering from VPI in May 1992.