NTIA REPORT 84-159

SPECTRUM RESOURCE ASSESSMENT OF THE 7125 - 8500 MHz BAND

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U.S. DEPARTMENT OF COMMERCE • National Telecommunications and Information Administration

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SPECTRUM RESOURCE ASSESSMENT OF THE 7125 - 8500 MHz BAND

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Agency Abbreviations[a]

AF	Air Force, Department of the
AR	Army, Department of the
BPA	Bonneville Power Administration
C	Commerce, Department of
CG	Coast Guard
CIA	Central Intelligence Agency
DOE	Department of Energy
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
HHS	Health and Human Services, Department of
I	Interior, Department of the
ICA	International Communications Agency
J	Justice, Department of
N	Navy, Department of
NASA	National Aeronautics and Space Administration
NG	Non-Government
NSA	National Security Agency
NSF	National Science Foundation
T	Treasury, Department of
TVA	Tennessee Valley Authority
VA	Veterans Administration

[a]agencies listed are those with frequency assignments in the 7125-8500 MHz band identified in this report.

ACKNOWLEDGMENT

The author would like to acknowledge the measurement contributions of John Smilley and Frank Sanders of the NTIA Radio Spectrum Measurement System (RSMS) staff. Messrs. Smilley and Sanders conducted the RSMS measurements contained herein, coordinated the location and scope of the test with appropriate Government field personnel, and reduced the measured data to a usable form.

ABSTRACT

This report is a spectrum resource assessment of the 7125-8500 MHz band. Included is information on frequency allocations, technical standards, spectrum usage, and identification of spectrum-management issues pertaining to this band. The spectrum-management issues addressed were identified, based on band use, for the last five years, for peacetime applications along with expected band use as a result of the Final Acts of WARC-79. (Emergency and/or wartime applications in this band will be the subject of a subsequent assessment.) Recommendations are made to improve the current spectrum-management process to ensure efficient use of this band in the future. Recommendations include modifying certain technical standards, developing sharing criteria among several of the services using this band, and developing a frequency assignment model for fixed operations. Preparation for the upcoming Space WARC, as it pertains to this band, is also discussed.

KEY WORDS

Fixed Service
Fixed-Satellite Service
Interference
Mobile-Satellite Service
Spectrum Management
Spectrum Resource Assessment
7125-8500 MHz Band

SECTION 1

INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA) is responsible for managing the radio spectrum allocated to the U.S. Federal Government. Part of NTIA's responsibility is to "...establish policies concerning spectrum assignment, allocation and use, and provide the various Departments and agencies with guidance to assure that their conduct of telecommunications activities is consistent with these policies" [Department of Commerce, 1983]. In support of these requirements, NTIA has undertaken a number of spectrum resource assessments. The objectives of these studies are to assess spectrum utilization, identify existing and/or potential compatibility problems between systems of various departments and agencies, provide recommendations for resolving any compatibility conflicts, and recommend changes to improve spectrum-management procedures. This spectrum resource assessment considers the 7125-8500 MHz frequency band.

The 7125-8500 MHz frequency band is comprised of several subbands in the allocation tables. In the pre-WARC-79 table, this band is allocated nationally as a Government band for the Fixed, Mobile, and various space Services on a primary basis. Internationally, the bands were allocated for the same services. However, significant changes regarding the relationship of the services in this band were made to the International Telecommunication Union (ITU) Table of Frequency Allocation and adopted in the Final Acts of the World Administrative Radio Conference, 1979 (WARC-79). These changes include the addition of the Fixed and Mobile Services to the previously exclusive Fixed-Satellite portion of the 7250-7300 and 7975-8025 MHz subbands and recognition of the use of the Mobile-Satellite Service in the 7250-7375 and 7900-8025 MHz subbands by footnote. In the national implementation of the WARC-79 results, the 7250-7300 and 7900-8025 MHz subbands are allocated to the Fixed-Satellite and Mobile-Satellite Services on a primary basis with the Fixed Service on a secondary basis. By footnote, the Government Fixed-Satellite and Mobile-Satellite Services in the 7250-7750 and 7900-8400 MHz subbands are limited to military systems. A significant change is that, nationally, existing Government fixed systems operating in the 7900-7975 MHz subband have been downgraded to secondary status. In addition, there is a planned transition between the Defense Satellite Communications System, Phase II (DSCS-II) and Phase III (DSCS-III) Department of Defense (DOD) communications satellites that use the 7900-8025 MHz subband for the satellite up-path that includes use of mobile earth stations. Therefore, the existing Government Fixed-Service systems, which require primary status, operating in the 7900-7975 MHz subband must be relocated to alternate frequencies in the 7/8 GHz band.

The majority of assignments in this frequency band in the United States is for fixed point-to-point microwave communications. A lesser number of frequency assignments for space telecommunications is for DSCS-II links and there is a number of experimental assignments for testing the planned DSCS-III.

There exists a number of studies concerning the use of this band and the sharing potential between the Fixed and Fixed-Satellite Services (see Bibliography). This report updates these previous reports by addressing the use of this band in the last five years and, in particular, the changes in the rules and regulations and the characteristics and deployments of systems which could be expected in response to the Final Acts of WARC-79. Also, as part of this study, alternate spectrum for the Department of Energy (DOE) fixed assignments for the Bonneville Power Administration (BPA) system operating in the 7900-7975 MHz subband is identified.

OBJECTIVES

To provide a technical basis for development of spectrum plans and policies, the following objectives were identified for this spectrum resource assessment.

1. Identify and document the potential problem areas (including band-edge problems with systems in adjacent bands) that may have an impact on the efficient use of the spectrum, and evaluate the electromagnetic compatibility (EMC) among existing and proposed systems.

2. Identify spectrum-management issues pertaining to the 7125-8500 MHz band, which can be expected in response to the results of the Final Acts of WARC-79.

3. Identify available portions of the 7/8 GHz band to reaccommodate BPA fixed-microwave systems operating in the 7900-7975 MHz subband in the Pacific Northwest, and evaluate the EMC between existing operations and the BPA system using these proposed new frequencies.

APPROACH

In order to accomplish the objectives of the 7125-8500 MHz spectrum resource assessment, the following approaches were taken.

1. Frequency allocations pertaining to the 7125-8500 MHz band, including allocation changes resulting from the WARC-79 and other international agreements, and proposals by the IRAC were reviewed and documented.

2. Existing regulations, technical standards, and channeling plans included in the NTIA Manual, FCC Rules and Regulations, Government agency standards, etc., were reviewed to determine the impact of state-of-the-art technology on band usage.

3. The characteristics and deployment of existing systems within the 7125-8500 MHz band, and those that could be expected in response to the results of the WARC-79 and other international agreements were reviewed and documented using the Government Master File (GMF), System Review File (SRV), Non-Government Master File (NGMF), previous NTIA reports and Radio Spectrum Management System (RSMS) Van measurements, and various agency contacts.

4. Spectrum usage, as measured by the RSMS, was reviewed and documented.

5. Compatibility analyses of systems within this band, including the previous spectrum resource assessment, associated studies, analyses made in support of the IRAC system review process, and the RSMS Van measurements were reviewed.

6. The availability and effectiveness of alternate techniques (e.g., channeling plans, frequency assignment model, and sharing criteria) used in frequency management, as well as present assignment practice and procedures, were determined.

7. Specific problem areas requiring additional analysis were identified and outlined.

8. Specific changes to the existing rules, regulations, and practices relating to this band which would improve the overall efficient use were identified.

To assist the DOE in reaccommodating fixed systems operating in the 7900-7975 MHz subband, the following approaches were taken.

1. The existing and planned electromagnetic environment (EME) of the Pacific Northwest (including that of Canada in the coordination zone) in the 7125-8400 MHz frequency range was reviewed and documented.

2. Characteristics of equipment and systems operating in the Pacific Northwest EME were obtained from the GMF, DOE, other affected agencies, and available equipment specification documents, and were then compiled.

3. For each affected frequency assignment, possible alternate frequencies using proposed replacement frequencies or other available frequencies that have sufficient transmit/receive separation as well as a minimum three-percent-diversity frequency separation, were determined.

4. For each alternate frequency, the relative interference-to-noise ratio (INR) for every transmitter/receiver interaction in the environment was determined by automated analysis techniques, using general equipment specifications and free-space propagation loss as inputs.

5. For those interactions exceeding an INR of -10 dB, the INR was recalculated using a terrain-dependent propagation model, the frequency-dependent rejection (FDR) model, and/or antenna directivity characteristics.

6. The advantages of using cross-polarized or high-performance (shrouded) antennas were investigated.

7. The carrier-to-interference ratio (C/I) for those interactions where the INR could not be reduced below -10 dB using the method in the above Approach Number 5, and where alternate spectrum is not available, was calculated as outlined in Electronic Industries Association (EIA) Bulletin 10-C.

8. At least two alternate frequencies were identified for each affected frequency assignment and the qualitative effect of each on the EMC environment was determined. The DOE is in the process of submitting proposed changes of the affected frequency assignments to the Frequency Assignment Subcommittee (FAS). Coordination with Canada is being accomplished through the FAS process.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

GENERAL CONCLUSIONS

The majority of frequency assignments in the 7125-8500 MHz band are for high-capacity fixed-microwave communications. These fixed systems support various operations for numerous Government agencies. Little growth in these operations is expected and a decrease in the number of assignments may occur if the function of the present Radar Microwave Link (RML) networks is reconfigured or replaced by the Federal Aviation Administration (FAA). This band also supports various space radiocommunications. It is allocated, but not used, for operations in the Meteorological-Satellite and Earth Exploration-Satellite Services. The principal user of space radiocommunications is the Defense Satellite Communications System (DSCS) and the Fleet Satellite Communications (FLTSATCOM) Service in the Fixed-Satellite and Mobile-Satellite Services. DSCS is very dynamic in terms of functioning space services, equipments, modes of operation, and terminal deployments. The system consists of geostationary space stations and numerous fixed and mobile earth stations.

Within the past ten years, there have been numerous studies of the issues involving the various uses of this band. The most serious spectrum-management problem was identified as the interference potential of airborne earth stations to terrestrial microwave systems. Therefore, most studies considered this issue and made recommendations to minimize this interference potential. Methods for coordination between earth stations and other earth and terrestrial stations, as well as among space stations, have been developed, and the calculations necessary for coordination contours have been automated via different computer programs. Numerous technical standards for equipments used in this band were also established to further reduce the interference potential between the various stations.

No additional serious spectrum-management problems are expected as a result of the implementation of the Final Acts of WARC-79. However, the recommendations from previous studies concerning the interference potential of the airborne earth terminals to the terrestrial microwave receivers are based on the frequencies used by the DSCS-II. The frequency plan used by the DSCS-III is different and the recommendations proposed may no longer apply to certain situations. Additionally, agency statutory responsibilities during emergencies are an issue of concern, particularly between military transportable and airborne earth stations and terrestrial fixed systems.

For the terrestrial microwave systems, several frequency plans are in use but none are compatible with the other. For long-term management of the band, certain improvements can be made to further minimize compatibility problems and simplify management procedures.

SPECIFIC CONCLUSIONS

1. Technical Standards

Nationally, the technical standards applicable to stations and systems operating in this band are equal to, or more stringent than, the international limits and are adequate with respect to the state-of-the-art technology and spectrum-management procedures.

2. Channeling Plans

Several agencies (e.g., FAA and DOE) utilize channeling plans for their fixed operations. These channeling plans are not compatible with each other and their use in certain congested areas (e.g., the Pacific Northwest) results in inefficient spectrum utilization. Spectrum utilization would be improved by the use of the same center frequencies. A uniform plan could be developed that would incorporate all agency requirements, such as frequency diversity and one-way-radar information transmission, as well as providing standard transmit/receive separations.

3. Assignment Aids

Frequency selection for systems in the Fixed Service often involve complex environments and significant interagency coordination. To assist frequency managers and spectrum analysts in resolving frequency assignment problems, several automated frequency aids are available in addition to conventional manual means. One aid developed by GTE Lenkurt, Inc., is a method for deriving the required C/I for a specified amount of degradation in connection with interference to FDM/FM microwave systems. This procedure is predominately used by GTE Lenkurt when a frequency plan is part of an overall contract for equipment procurement for a particular network or link addition. This calculation method is easily performed and yields good results, but it is time consuming when calculating large numbers of possible interactions since it is a manual procedure. Another assignment aid developed for the Defense Communications Agency (DCA) is the Point-to-Point Microwave Frequency Assignment and Verification Model [Haseltine, 1974]. This model is an automated procedure to either determine or verify proposed frequency assignments considering all existing transmitter/receiver combinations in the proposed environment. Although this model is useful for verification of proposed frequency assignments for a large number of possible transmitter/receiver interactions, a number of limitations have been identified. An improved frequency assignment and verification model that uses a more comprehensive operational program is proposed.

4. RSMS Measurements

Measurements were made by the NTIA RSMS Van at selected sites in the Pacific Northwest. Transmitted emission spectrums were recorded for the entire 7125-8500 MHz band, as well as for selected-transmitter center frequencies. A comparison of these measurement results with data obtained from the GMF and necessary bandwidth calculation procedures given in the NTIA Manual was made. The necessary bandwidth calculation procedure compared favorably with the measurement results. However, necessary bandwidths given in the GMF were generally greater than those measured.

5. DOE Reaccommodation

Alternate frequencies were identified for those BPA systems in the 7900-8025 MHz band which were identified by the DOE as requiring primary status. This reaccommodation is necessary because the Fixed Service was downgraded to secondary status in the 7900-7975 MHz subband by the current U.S. National Allocation Table that resulted from the U.S. implementation of the WARC-79 results. Due to the number of frequency assignments to be relocated and the congested environment in the Pacific Northwest, the DOE requested technical assistance from NTIA in identifying alternate spectrum. The NTIA effort was part of this spectrum resource assessment, and the analysis procedure and results are presented in APPENDIX B of this report.

6. Sharing Potential Among Allocated Services

Most all potential interactions involving the various stations and services have been examined for peacetime applications. Where potential problems are anticipated, procedures were developed to eliminate or minimize this interference potential. However, the possible use of nongeostationary satellites by the Meteorological-Satellite Service (METSAT) has not been addressed and the effect of radars in the upper adjacent band on the fixed systems in the 7125-8500 band has not been studied. Also, the potential conflict between military earth stations and terrestrial fixed stations in emergency situations, as applicable to the 7125-8500 MHz band, has not been studied in detail.

RECOMMENDATIONS

The following are NTIA staff recommendations based on the technical findings contained in this report. Any action to implement these recommendations will be accomplished under separate correspondence by modification of established rules, regulations, or procedures.

1. If, in the future, nongeostationary satellites in the METSAT Service employ this band, the IRAC should consider reversing the direction of currently allocated up-path and down-paths for such use.

2. NTIA should develop an automated frequency assignment and verification model for fixed systems to assist in the various aspects of spectrum analysis and frequency assignment processes.

3. Federal agencies, when reviewing their frequency assignments, should obtain link plots of their fixed systems and put more emphasis on detecting erroneous data in the GMF.

4. Federal agencies that employ channeling plans in this band should jointly develop a common local channeling plan for their use to ensure compatible and more spectrum-efficient band operation.

5. The use of the 8400-8500 MHz subband by stations in the Fixed Service should be further investigated.

6. The issue of national security and emergency preparedness (NS/EP) telecommunications, as it pertains to the services allocated to the 7125-8500 MHz band, should be further investigated to specifically consider the matter of responsibility for radio-spectrum priorities during emergencies.

SECTION 3

RULES AND REGULATIONS

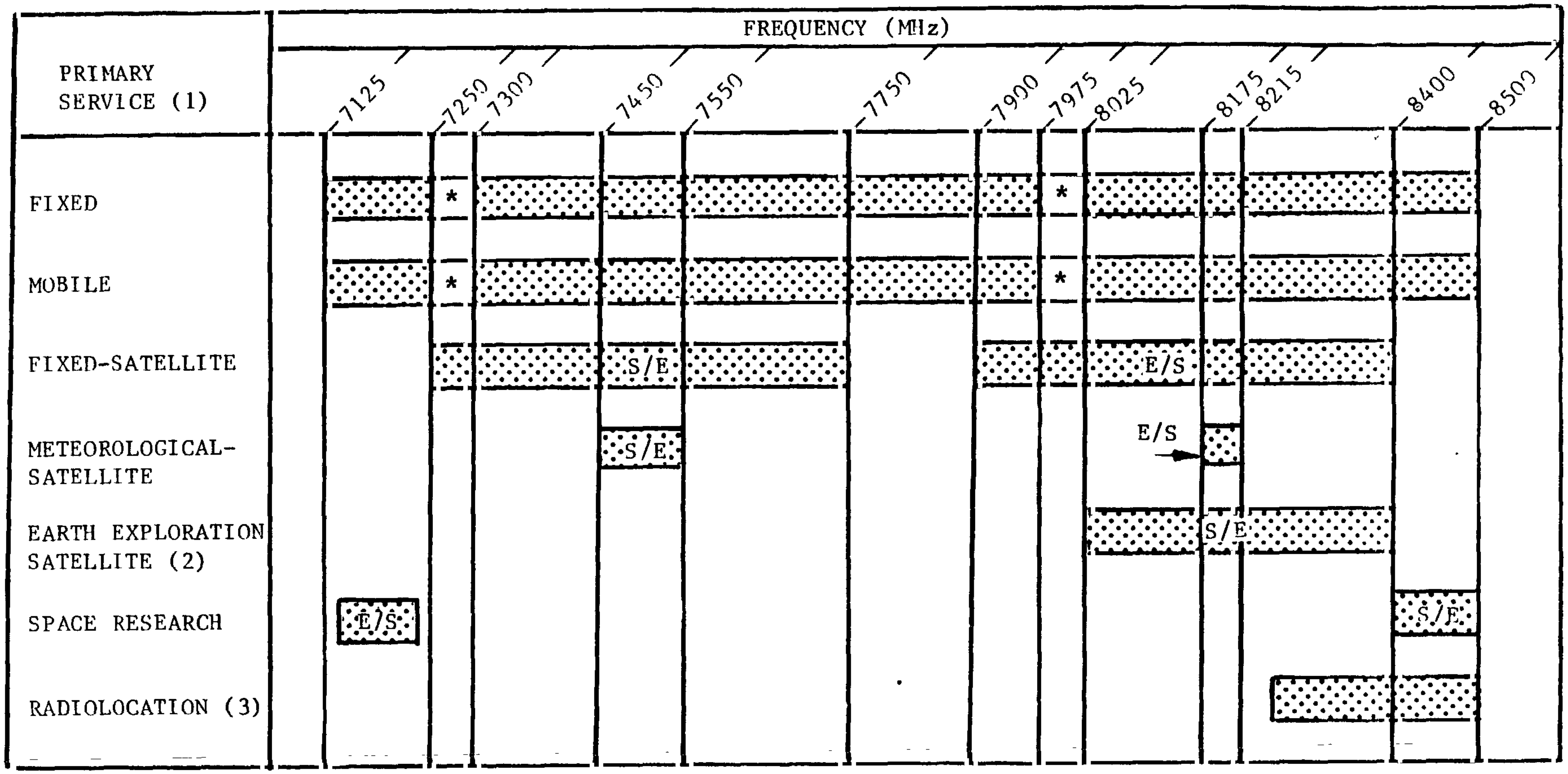
ALLOCATION TABLES

The 7125-8500 MHz frequency range is allocated for the Fixed, Mobile, and various space Services on a primary basis. The particular sharing arrangement among these services is provided for in several frequency bands in the allocation tables. These bands and the corresponding allocated services are summarized for three allocation tables: the allocation table in effect before WARC-79, the current ITU Table of Frequency Allocations, and the current U.S. National Table of Frequency Allocations (see Figures 1 through 3, respectively). The services shown on these summaries include those provided for by footnotes to these allocation tables. The allocation tables with applicable footnotes, from which the summaries were compiled, are presented in APPENDIX D.

A summary of the U.S. National and International Table of Frequency Allocations applicable to the 7125-8500 MHz frequency range before WARC-79 is given in Figure 1 and applicable pre-WARC-79 allocation table footnotes are listed in TABLE 1. In these allocation tables, the 7125-8500 MHz frequency range comprises 12 frequency bands; however, the lowest international band extends from 6425-7250 MHz. Nationally, the 7125-8500 MHz band is a Government band for the Fixed, Mobile and Space Services on a primary basis. The band 8400-8500 MHz is also allocated as a non-Government band for the Space Research Service (space-to-Earth) on a primary basis. Internationally, the pre-WARC-79 table allocated these bands to the same services, except the Radiolocation Service that is also allocated in the 8250-8400 MHz band in Australia and the United Kingdom by international footnote 394, and in the 8400-8500 MHz band in the United Kingdom by international footnote 394A. Additionally, the Fixed and Mobile Services are allocated in the 7250-7300 and 7975-8025 MHz bands in certain countries by international footnotes 392G and 392H.

Significant changes regarding these bands are included in the current ITU Table of Frequency Allocations (see TABLE 2 for applicable footnotes) as adopted in the Final Acts of the WARC-79. These include the addition of the Fixed and Mobile Services to the previously exclusive Fixed-Satellite Service (FSS) portions of the band (7250-7300 and 7975-8025 MHz) and the accommodation of the Mobile-Satellite Service (MSS) in the bands 7250-7375 and 7900-8025 MHz by international footnote 812. In addition, the Space Operations Service (SOS) (Earth-to-space) is allocated to the 7125-7155 MHz band by international footnote 810, and the allocation of the Radiolocation Service in the 8250-8400 MHz band in Australia and the United Kingdom is deleted. The services internationally allocated to this band are summarized in Figure 2.

In the current National Table of Frequency Allocations (see TABLE 2 for applicable footnotes), some of the frequency bands are reconfigured such that the entire range is comprised of 14 bands as shown on Figure 3. The bands 7250-7300 and 7900-8025 MHz are allocated to the Fixed-Satellite and Mobile-Satellite Services on a primary basis. By footnote, the Fixed-Satellite and Mobile-Satellite Services are limited to military systems. The allocation for the Mobile Service has been deleted in the 7125-8500 MHz band. Non-Government



NOTES: S/E - Space-to-Earth E/S - Earth-to-space

* - The Fixed and Mobile Services also allocated in certain countries (international footnotes 392G and 392H).

(1) - Services allocated by footnote are included in this figure.

(2) - EES is secondary internationally in Regions 1 and 3.

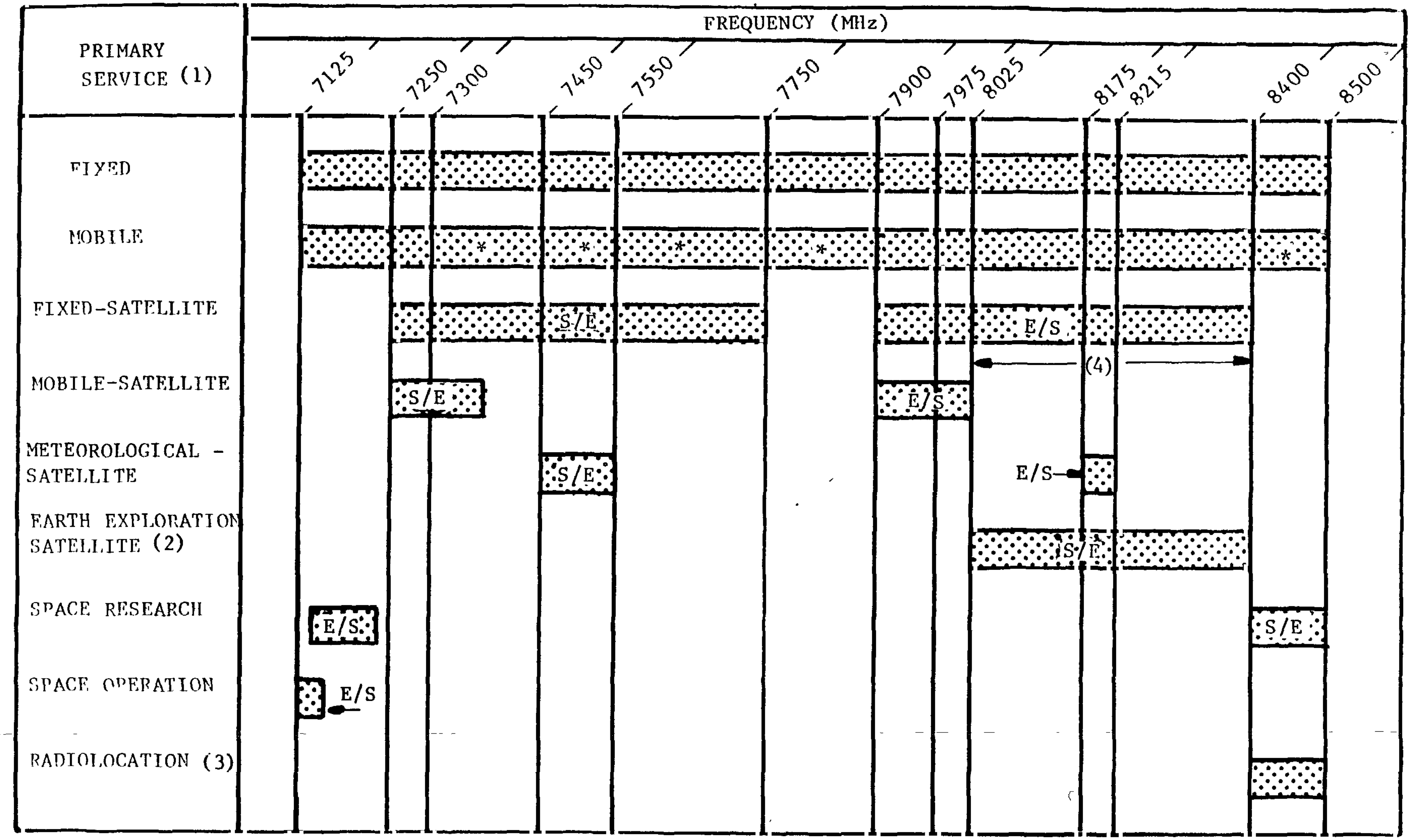
(3) - Allocated in Australia and the United Kingdom only (international footnotes 394 and 394A).

Figure 1. Summary of National and International Allocated Primary Services in the 7125-8500 Frequency Range before WARC-79.

TABLE 1

FOOTNOTES TO THE ALLOCATION TABLES BEFORE THE WARC-79
APPLICABLE TO THE 7125-8500 MHz BAND

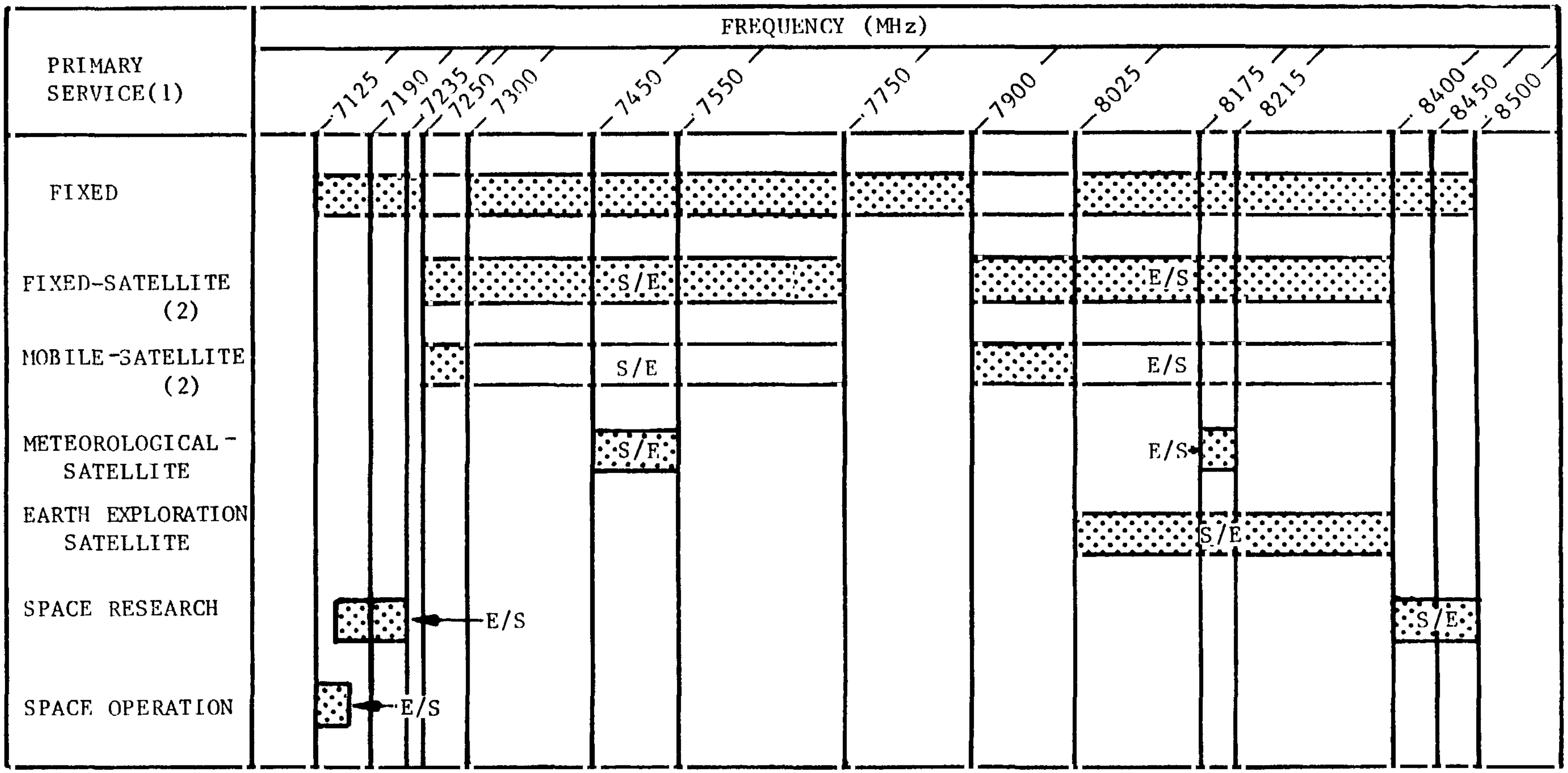
INTERNATIONAL	U.S. NATIONAL
392B—The band 7 145-7 235 MHz may be used for Earth-to-space transmissions in the space research service, subject to agreement between the administrations concerned and those having services operating in accordance with the Table, which may be affected. 392D—As an exception, passive fixed-satellite systems also may be accommodated in the band 7 250-7 750 MHz subject to: (a) agreement between the administrations concerned and those having services, operating in accordance with the Table, which may be affected; (b) the co-ordination procedures laid down in Articles 9 and 9A. Such systems shall not cause any more interference at active earth station receivers than would be caused by the fixed or mobile services. Power flux density limitations at the Earth's surface after reflection from the passive fixed-satellites shall not exceed those prescribed in the present Regulations for active fixed-satellite systems. 392G—In Algeria, Austria, Bulgaria, Cyprus, Cuba, Ethiopia, Finland, Hungary, Japan, Kuwait, Lebanon, Liberia, Malaysia, Morocco, the Philippines, Poland, the United Arab Republic, Yugoslavia, Roumania, Sweden, Switzerland, Czechoslovakia and the U.S.S.R., the band 7 250-7 300 MHz is also allocated to the fixed and mobile services. 392H—In Algeria, Bulgaria, Cuba, Ethiopia, Finland, Hungary, Japan, Kuwait, Lebanon, Morocco, Poland, the United Arab Republic, Yugoslavia, Roumania, Sweden, Switzerland, Czechoslovakia and the U.S.S.R., the band 7 975-8 025 MHz is also allocated to the fixed and mobile services. 394—In Australia and the United Kingdom, the band 8 250-8 400 MHz is allocated to the radiolocation and fixed-satellite services. 394A—In the United Kingdom, the band 8 400-8 500 MHz is allocated to the radiolocation and space research services. 394B—In Israel, the band 8 025-8 400 MHz is allocated, on a primary basis, to the fixed and mobile services and, on a secondary basis, to the fixed-satellite service. 394D—In Austria, Belgium, France, Israel, Luxembourg and Malaysia, the allocation to the space research service in the band 8 400-8 500 MHz is on a secondary basis.	US100—In the Additional Protocol to the Final Acts of the Space EARC, Geneva, 1963, a declaration on behalf of the USA states that the USA cannot accept any obligation to observe the exception claimed by Cuba in those footnotes to the Table of Frequency Allocations which were adopted by the EARC and which specifically named Cuba. **U.S. GOVERNMENT** G102—In the band 8025-8400 MHz, Earth Resources Satellite (ERS) System earth stations (receiving) within the US&P will be limited in number. It may be necessary to operate fixed-satellite service earth stations (transmitting) within the coordination area of an ERS earth station. Such operations will be coordinated in accordance with established procedures. G103—In the band 8175-8215 MHz, it may be necessary to operate meteorological-satellite earth stations (transmitting) within the coordination area of an Earth Resources Satellite (ERS) earth station (receiving). Such operations will be coordinated in accordance with established procedures. G104—In the bands 7450-7550 and 8175-8215 MHz, it is agreed that although the military space radio communication systems, which include earth stations near the proposed meteorological-satellite installations will precede the meteorological-satellite installations, engineering adjustments to either the military or the meteorological-satellite systems or both will be made as mutually required to assure compatible operations of the systems concerned. G107—Military earth stations in the band 7250-7750 and 7900-8400 MHz and 20.2-21.2, 30-31, 92-93, 102-103, 140-141 and 150-151 GHz may be fixed, transportable or located on board a ship or aircraft. G108—Planning and use of the bands 7300-7750, 7900-7975 and 8025-8400 MHz by mobile earth stations and the band 8025-8400 MHz by stations of earth resources satellite systems, necessitate the development of technical and/or operational sharing criteria to ensure the maximum degree of electromagnetic compatibility with existing and planned systems within these bands.



KEY: S/E - Space-to-Earth E/S - Earth-to-space
* - except Aeronautical Mobile

NOTES: (1) Services allocated by footnote are included in this figure.
(2) EES is secondary in Regions 1 and 3.
(3) Allocated only in the United Kingdom (see international footnote 818).
(4) In Region 2, aircraft stations are not permitted to transmit in the band 8025-8400 MHz.

Figure 2. Summary of Primary Services in the 7125-8400 MHz Band Provided for in the ITU Table of Frequency Allocations as Adopted at the WARC-79.



KEY: PRIMARY ALLOCATION SECONDARY ALLOCATION

S/E - SPACE-TO-EARTH E/S - EARTH-TO-SPACE

NOTES: (1) Services allocated by footnote are included in this figure.
(2) Limited to military systems.

Figure 3. Summary of Allocated Primary Services in the current U.S. National Table of Frequency Allocations in the 7125-8500 MHz Band.

TABLE 2

FOOTNOTES APPLICABLE TO THE U.S. NATIONAL AND THE ITU TABLES OF FREQUENCY ALLOCATIONS FOR THE 7125-8500 MHz BAND

INTERNATIONAL

809 In the band 6 425-7 075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7 075-7 250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the earth exploration-satellite (passive) and space research (passive) services in their future planning of this band.

810 Subject to agreement obtained under the procedure set forth in Article 14, in Region 2, the band 7 125-7 155 MHz may be used for Earth-to-space transmissions in the space operation service.

811 Subject to agreement obtained under the procedures set forth in Article 14, the band 7 145-7 235 MHz may be used for Earth-to-space transmissions in the space research service. The use of the band 7 145-7 190 MHz is restricted to deep space; no emissions to deep space shall be effected in the band 7 190- 7 235 MHz.

812 The bands 7 250-7 375 MHz (space-to-Earth) and 7 900-8 025 MHz (Earth-to-space) may also be used by the mobile-satellite service. The use of these bands by this service shall be subject to agreement obtained under the procedure set forth in Article 14.

813 In the band 8 025-8 400 MHz, the power flux-density limits specified in No. 2570 shall apply in Regions 1 and 3 to the earth exploration-satellite service.

814 In Region 2, aircraft stations are not permitted to transmit in the band 8 025-8 400 MHz.

815 Subject to agreement obtained under the procedure set forth in Article 14, the band 8 025-8 400 MHz may be used for the earth exploration-satellite service (space-to-Earth) in Bangladesh, Benin, Cameroon, China, the Central African Republic, the Ivory Coast, Egypt, France, Guinea, Upper Volta, India, Iran, Israel, Italy, Japan, Kenya, Libya, Mali, Niger, Pakistan, Senegal, Somalia, Sudan, Sweden, Tanzania, Zaire and Zambia, on a primary basis.

816 In the space research service, the use of the band 8 400-8 450 MHz is limited to deep space.

817 Different category of service: in Belgium, Israel, Luxembourg, Malaysia, Singapore and Sri Lanka, the allocation of the band 8 400-8 500 MHz to the space research service is on a secondary basis (see No. 424).

818 Alternative allocation: in the United Kingdom, the band 8 400-8500 MHz is allocated to the radiolocation and space research services on a primary basis.

U.S. NATIONAL

US252-The bands 2110-2120, 7145-7190 MHz, 34.2-34.7 GHz are also allocated for Earth-to-space transmissions in the Space Research Service, limited to deep space communications at Goldstone, California.

US258-In the band 8025-8400 MHz, the non-Government earth exploration- satellite service (space-to-Earth) is allocated on a primary basis. Authorizations are subject to a case-by-case electromagnetic compatibility analysis.

U.S. GOVERNMENT

G104-In the bands 7450-7550 and 8175-8215 MHz, it is agreed that although the military space radio communication systems, which include earth stations near the proposed meteorological-satellite installations will precede the meteorological-satellite installations, engineering adjustments to either the military or the meteorological-satellite systems or both will be made as mutually required to assure compatible operations of the systems concerend.

G116-The band 7125-7155 MHz is also allocated for Earth-to-space transmission in the Space Operations Service at a limited number of sites (not to exceed two), subject to established coordination procedures.

G117-In the bands 7250-7750 and 7900-8400 MHz and 20.2-21.2, 30-31, 39.5-40.5, 45.3-45.5 and 50.4-51.4 GHz the Government fixed-satellite and mobile-satellite services are limited to military systems.

use of this band is allocated on a shared primary basis with Government use for the Earth Exploration-Satellite (EES) Service (space-to-Earth) and the Space Research Service (space-to-Earth) in the 8450-8500 MHz band. The Government Space Research Service (Earth-to-space) in the 7145-7190 MHz band is limited to deep space communications at Goldstone, California, the Space Research Service (space-to-Earth) allocated to the 8400-8450 MHz band is limited to deep space, and the Space Operations Service (Earth-to-space) is allocated to the 7125-7155 MHz band. The significant change is that, nationally, existing Government fixed systems operating in the 7900-7975 MHz band have been downgraded to secondary status and those Fixed Service systems requiring primary status must be relocated to alternate frequencies in the 7/8 GHz band.

TECHNICAL STANDARDS

National

The general technical standards given in Chapter 5 of the NTIA Manual specify limits of frequency tolerance and spurious emissions for all transmitting stations by frequency band. The frequency tolerance limitations applicable to the transmitting stations in the 7125-8500 MHz band are given in the Table of Spurious Emissions and Frequency Tolerances (Section 5.2.3) as follows:

(1)	Fixed Stations	$\leq$ 100 W	50 ppm(parts per million)
		$\geq$ 100 W	10 ppm
(2)	Earth Stations		20 ppm
(3)	Space Stations		20 ppm

The standards for spurious signals for systems in terrestrial radiocommunication services limit the mean power of any emission supplied to the antenna transmission line, as compared with the mean power of the fundamental, in accordance with the following:

1. On any frequency removed from the assigned frequency by more than 75 percent, up to and including 150 percent, of the authorized bandwidth, at least 25 decibels attenuation;

2. On any frequency removed from the assigned frequency by more than 150 percent, up to and including 300 percent, of the authorized bandwidth, at least 35 decibels attenuation; and

3. On any frequency removed from the assigned frequency by more than 300 percent of the authorized bandwidth, for transmitters with mean power of 5 kilowatts or greater, at least 80 decibels attenuation; and for transmitters with mean power less than 5 kilowatts, at least 43 plus 10 log (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

The spurious tolerances for systems in space radiocommunications for incorporation into this table are in the process of being developed. However, maximum radiated unwanted emission levels applicable to space and Earth stations are given in Section 5.11.4 of the NTIA Manual.

In addition to these general rules, technical standards applicable to groups of services and specific services and stations used in the 7125-8500 MHz band are given in the NTIA Manual. Spectrum related standards are specified for Government Fixed Services operating between 1710 MHz and 15.35 GHz (Part 5.10). A summary of these standards is given in TABLE 3. Necessary bandwidth equations and examples are given in Table A of Annex J of the NTIA Manual. Limitations on power and direction of maximum radiation of stations in the Fixed and Mobile Services in the band 8025-8400 MHz are further specified in Section 8.2.34 of the NTIA Manual.

For the space services, minimum performance requirements (MPR) for spectral power density and frequency tolerance are specified in Part 5.11. These MPRs become effective January 1, 1985. Additional standards applicable to earth and space stations are given in Chapter 8 of the NTIA Manual. These standards are summarized in TABLE 4. The technical standards given in the current NTIA Manual are identical to pre-WARC-79 standards except the requirements for space station keeping and pointing accuracy of antennas on geostationary satellites are more stringent.

International

Internationally, in the ITU Radio Regulations [1982], the standards specified and the specific limitations are similar to those specified in the NTIA Manual. Compared with the current national standards, the present transmitter frequency tolerances (Appendix 7 of the ITU Radio Regulations) are less stringent for all stations used in the 7125-8500 MHz band, as are those limits to take effect after January 1, 1990. The international spurious emission limits are given in Appendix 8 and presently no level is specified for transmitters operating in the 7125-8500 MHz band. There are limits specified, however, applicable to transmitters installed after January 1, 1985, and to all transmitters after January 1, 1994. The international spurious emission limits do not apply to digital modulations or to stations in the space services. The spurious emission limits specified nationally and internationally are compared graphically in Figure 4. However, the international limit applies to all spurious emissions; whereas nationally, the general limit specified in Section 5.2.3 applies to frequency separations greater than 300 percent of the authorized bandwidth and the limit for fixed nondigital systems (given in Section 5.10.1) to frequency separations greater than 250 percent of the authorized bandwidth. Provisions relating to groups of services and specific services and stations are similar to those given nationally. For the most part, these provisions are equal to, or less stringent than, the current national requirements.

POLICIES AND PROCEDURES

There are several policies and coordination procedures in the NTIA Manual which have specific applicability to the 7125-8500 MHz band. The titles of these are provided in TABLE 5. Included in this list is Annex B to the NTIA Manual, in which criteria and procedures are given for the spectrum sharing limits for terrestrial and/or space radiocommunication services specified in Chapter 8 of the NTIA Manual. Included in this Annex are coordination contours (calculated in accordance with Appendix 28, 1982 ITU Radio Regulations) for previously coordinated earth stations. There are, of course, many additional policies and procedures of a more general nature which apply to the RF spectrum as a whole.

TABLE 3

SUMMARY OF U.S. GOVERNMENT TECHNICAL STANDARDS APPLICABLE TO THE FIXED SERVICE IN THE 7125-8500 MHz BAND (PART 5.10)

TRANSMITTING EQUIPMENT

A. Emission Spectrum:	Attenuation (dB)	Condition
1. Nondigital	25	$0.5\ B_n < \Delta F \leq B_n$
	35	$B_n < \Delta F \leq 2.5\ B_n$
	$43 \leq X \leq 80$	$2.5\ B_n < \Delta F$
2. Digital *	$50 \leq Y \leq 80$	$0.5\ B_n < \Delta F \leq 2.5\ B_n$

where: $X = 43 + 10 \log$ (mean power, in watts)
$Y = 35 + 0.8\ (P-50) + 10 \log B_n$
B_n = necessary bandwidth, in MHz
$P = \Delta F$ expressed as percent of B_n

B. Frequency Tolerance (FT): 50 ppm for power $\leq$ 100 W
10 ppm for power $>$100 W

*Power in 4 kHz band relative to mean output power.

RECEIVING EQUIPMENT

A. Noise Figure: $\leq$ 12 dB

B. Selectivity: -3 dB bandwidth (BW_3) $\leq B_n + 2$ FT
-60 dB bandwidth $\leq 5\ BW_3$

C. Spurious Response: -60 dB

D. Frequency Stability: $\leq 0.02\ BW_3$

E. Conducted Spurious Emissions: $\leq$ - 85 dBW

ANTENNAS

A. Antenna Pattern:

1. Angle from beam axis	2.5°	5—10°	10—15°	15—20°	20—30°	30—100°	100—140°	140—180°
2. Minimum dB down	3	19	23	28	30	34	35	43

B. Cross Polarization Discrimination: 20 dB

C. Antenna Mechanical Stability: $\pm$ 1.9° maximum deviation

SYSTEM LIMITATIONS

A. Power: Minimum Amount Required

B. Equivalent Isotropically Radiated Power (EIRP): $\leq$ 55 dBW

TABLE 4

SUMMARY OF U.S. GOVERNMENT TECHNICAL STANDARDS APPLICABLE
TO THE SPACE SERVICES IN THE 7125-8500 MHz BAND

EARTH STATIONS (Section 8.2.35)

A. Equivalent Isotropically Radiated Power (EIRP)

+40 dBW/4 kHz	for	$\theta \leq 0°$
+40 + 3θ dBW/4 kHz	for	$0° < \theta \leq 5°$
No Limit	for	$\theta > 5°$

B. Minimum θ

$\geq 3°$	for other than Space Research Stations
$\geq 5°$	for Space Research Stations (Near-Earth)
$\geq 10°$	for Space Research Stations (Deep-Space)

SPACE STATIONS

A. Power Flux Density ($dBW/m^2/4$ kHz) Limit at Earth's Surface
(Section 8.2.36)

Angle of Arrival	$0° \leq \delta \leq 5°$	$5° \leq \delta \leq 25°$	$25° \leq \delta \leq 90°$
1. FSS and METSAT	-152	-152 + 0.5(δ-5)	-142
2. EES and Space Research	-150	-150 + 0.5(δ-5)	-140

B. Power Flux Density at Geostationary Orbit from EES: -174 $dBW/m^2/4$ kHz
(Section 8.2.36)

C. Station Keeping: Position Within ±0.1° of Longitude
(Section 8.2.38)

D. Pointing Accuracy of Antenna on Geostationary Satellites:
(Section 8.2.39)

Within 10% of Half Power Beamwidth
or ± 0.3° Whichever is Greater

SPACE AND EARTH STATIONS (Part 5.11)

A. Spectral Power Density Falloff: 12 dB/octave
(outside necessary bandwidth to at least 60 dB down)

B. Frequency Tolerance: 20 ppm after 11/24/70
50 ppm before 11/24/70

KEY: θ = Earth station antenna elevation angle above horizontal plane
δ = Space station antenna angle of arrival above horizontal plane

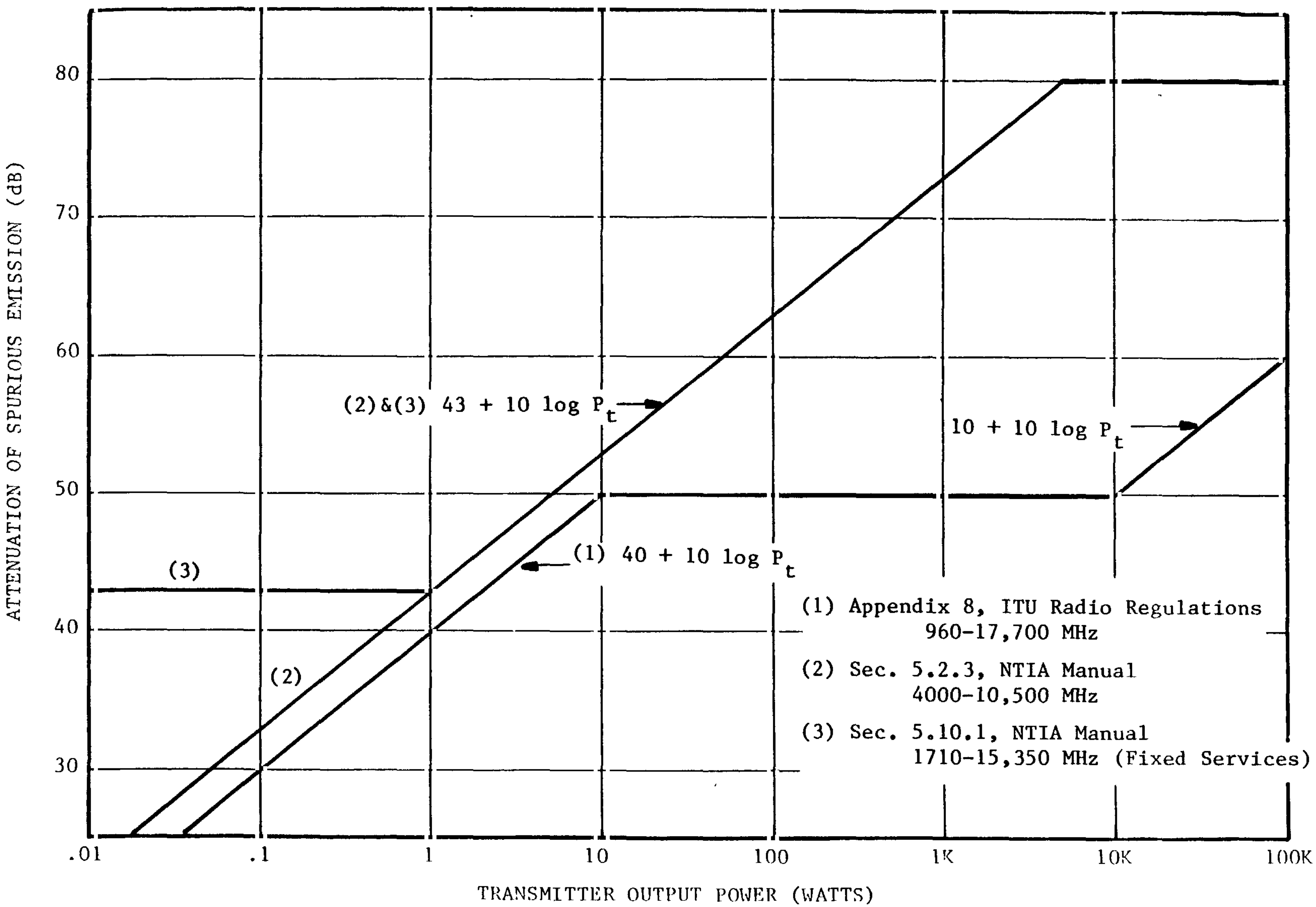


Figure 4. Comparison of the Spurious Emission Limits Specified Internationally and Nationally for Terrestrial Systems in the 7125-8500 MHz Band.

TABLE 5

POLICIES AND PROCEDURES SPECIFICALLY APPLICABLE TO THE 7125-8500 MHz BAND IN THE NTIA MANUAL

NUMBER	TITLE
Sec. 8.2.25	"Use of Frequency Diversity for LOS Transmissions in the Bands Allocated to the Fixed Service Above 1710 MHz"
Sec. 8.2.32	"Control of Emissions from Space Stations"
Sec. 8.2.33	"Selection of Sites and Frequencies for Earth and Terrestrial Stations" in the Bands Above 1 GHz Shared with Equal Rights by Terrestrial Radiocommunication and Space Radiocommunication Services"
Sec. 8.2.37	"Control of Interference between Geostationary-Satellite Systems and Non-Synchronous Inclined Orbit-Satellite Systems"
Sec. 8.2.43	"Frequency Assignments to Transportable Earth Stations in the 7250-7750 and 7900-8400 MHz Bands"
Sec. 8.2.44	"Frequency Assignments for Fixed Service Stations 7900-7975 MHz"
Sec. 8.4.12	"Coordination of Assignments for Transmissions by Terrestrial Stations Located Within the Coordination Area of Receiving Earth Stations"
Sec. 8.4.13	"Coordination of Assignments for Transmission or Reception by Earth Stations"
Sec. 8.4.14	"Coordination of Assignments to Earth and Space Stations which Utilize Geostationary Satellites"
Sec. 8.4.15	"List of Coordinated Earth Stations"
Sec. 9.2.4	"Use of Data Plots and Coordination Contour Maps"
ANNEX B	"Data and Procedures for Assessing Interactions Among Stations in the Space and Terrestrial Services"

INTERNATIONAL AGREEMENTS

United States/Canada Coordination Agreement

The United States/Canada Agreement relating to the coordination and use of frequencies above 30 MHz is presented in Part 3.4 of the NTIA Manual. Arrangement D of the Technical Annex of this agreement provides for the exchange of frequency assignment and engineering comments on proposed use of the 7125-8400 MHz band within common border areas. Coordination of existing and proposed use of the 8400-8500 MHz band is not required. Experimental use is also excluded from required coordination in the 7125-8400 MHz band as are military tactical and training operations in the bands 7125-7250 and 7750-7900 MHz. Coordination areas are defined for proposed stations of a terrestrial service as follows:

(1) The area in each country which lies within 35 miles of the border where a proposed station's antenna looks toward the border within the 200 degree sector.

(2) The area in each country which lies within five miles of the border where a proposed station's antenna looks away from the border within the 160 degree sector.

(3) The area in either country within the coordination distance (ITU Recommendation Spa 1) of a receiving earth station in the other country for stations that will use the same frequency band. ITU Recommendation Spa 1 has since been abrogated, and coordination contours determined by the methods in Appendix 28 of the ITU Radio Regulations are being used.

Coordination of earth stations is required if any portion of the United States/Canada border lies within the coordination contour (Appendix 28, ITU Radio Regulations) of the proposed earth station. Basic data required for coordination of these stations are given in Appendices 2 and 3 to Arrangement D.

Final Acts of the WARC-79

The WARC-79 was convened by the ITU in an effort to reach agreement on the revised international arrangements necessitated by changing world requirements for the radio spectrum and technological developments of telecommunication systems that have come about over the last 20 years. The previous general WARC was convened in 1959. The Final Acts of the WARC-79 constitute the ITU Radio Regulations, 1982, that took effect January 1, 1982. The Final Acts were submitted to the U.S. Senate by the President for consent to ratification as a treaty and consent was given in December 1982. In general, the essential U.S. objectives were satisfied at the WARC-79 [Robinson, 1979]. The U.S. proposals to this conference pertaining to the 7125-8500 MHz band, however, were not entirely accommodated by the decisions negotiated at WARC-79. The U.S. proposed allocating the Space Research Service (deep space) to bands 7145-7235 MHz (Earth-to-space) and 8400-8500 MHz (space-to-Earth). Allocation of the Space Operations Service to the band 7125-7155 MHz and the Space Research

Service to the band 7125-7145 MHz were also U.S. proposals. These proposals were partially accommodated by the conference. The U.S. proposal to add the Space Research Service (space-to-Earth) to the 7750-7850 MHz band was not adopted. More importantly, it was the U.S. objective to add allocation for the MSS in the 7250-7750 MHz and 7900-8400 MHz bands, retain two exclusive subbands for the FSS and the MSS, and to expand the exclusive up-path band for these space services to 8025 MHz. The exclusive subbands were not maintained and the Fixed and Mobile Services were added to the International Table of Frequency Allocation on a primary basis. Also, the MSS was added to the table by footnote and only in the bands 7250-7375 and 7900-8025 MHz. However, these objectives were accommodated in the U.S. National Table of Allocations in the U.S. implementation of the WARC-79 results. This accommodation, without being in direct conflict with the international rules, demonstrates that the U.S. objectives pertaining to this band, at the WARC-79, were essentially achieved.

<u>Space WARC-85/88</u>

In its Resolution No. 3, the WARC-79 resolved that a future WARC be convened to deal with the issue of access to the geostationary-satellite orbit and the frequency bands allocated to the Space Services. In the 1981 session, the ITU Administrative Council tentatively scheduled two sessions for this conference (referred to herein as Space WARC-85/88) to begin in July 1985 and September 1987, respectively. (Subsequently, the date of the second session was changed to September 1988 by the Plenipotentiary Conference in Nairobi, 1982.) The issue of the geostationary-satellite orbit concerns existing regulatory procedures and principles in the use (i.e., frequencies, service, and orbital position) of this limited orbital space. However, there is concern on the part of some countries (particularly the developing nations) that congestion of the orbit capacity will occur before they have the economic and technical capability to establish space systems. And as demonstrated at the WARC-79, the developing nations have increasing influence in shaping communications policy in the international forums and nontechnical factors, such as cultural and political interests, are becoming more of a consideration in the deliberations of these forums.

Space WARC-85/88 will be the most comprehensive conference ever to affect space telecommunications using the geostationary-satellite orbit; therefore, the U.S. preparation for this conference is important. Part of this preparation is to decide which frequency bands and space services should be addressed by this conference. The majority of the space systems, nationally, in the 7125-8500 MHz band use geostationary satellites and are in the FSS and MSS. Additionally, most major international space systems in the 7/8 GHz band are military systems. Both this band and the Space Services using this band are candidates for consideration by this upcoming conference. These issues are currently being studied in the U.S. preparatory program. The central forums in the U.S. preparatory process are the Ad Hoc 178 of the Interdepartment Radio Advisory Committee and the Federal Communications Commission's Advisory Committee for the Space WARC-85/88.

SECTION 4

SPECTRUM STATISTICS AND MAJOR SYSTEMS

GENERAL

The 7125-8500 MHz band is used to support high capacity Government fixed microwave links (typically 600 voice channels or several video links). A large portion of this band is also used for military space radiocommunications in the Fixed-Satellite and Mobile-Satellite Services. Nationally, two frequency subbands are primarily allocated to, and used for, the FSS and MSS, and one of these subbands has been expanded in the U.S. implementation of the WARC-79 results. To determine the impact of the allocation changes, as well as potential problem areas ensuing from current use of this band, assignment trends, future plans, and other spectrum usage information were collected and are summarized in this section. The spectrum usage information was based on frequency assignment statistics from the GMF, system review documentation, and discussions with Government personnel involved in frequency management. The records taken from the GMF are current as of August 1982.

FREQUENCY ASSIGNMENT STATISTICS

As of August 1982, there were 7432 frequency assignments listed in the GMF for the 7125-8500 MHz band. Of these assignments, 6694 are for systems in the Fixed Service. The geographical distribution of these fixed assignments is shown in Figure 5. Over half of the assignments to stations in the Fixed Service are for the Federal Aviation Administration (FAA) Radar Microwave Links (RML) and major concentrations of assignments occur where systems of other agencies are in the same areas. The FAA has 3631 frequency assignments in the Fixed Service and the geographic distribution of these assignments is shown in Figure 6. Other major users of this band include the DOE, military agencies, the Tennessee Valley Authority (TVA), and the U.S. Coast Guard (CG) for their Vessel Traffic System (VTS). There are 554 assignments in the GMF for stations in the space radiocommunication services in this band. The associated earth station locations are shown in Figure 7. The total number of assignments for the 7125-8500 MHz band has remained relatively constant over the last ten years. This can be seen in Figure 8 that is a plot of the number of assignments per year since 1972 for three subbands of the 7125-8500 MHz band. The three subbands include the 7250-8400 MHz band and two adjacent bands: 7125-7250 and 8400-8500 MHz. As shown in Figure 8, the 8400-8500 MHz band is used less than the other two bands. Presently, there are 45 assignments per 100 MHz of spectrum in the 8400-8500 MHz band. This compares to 565 and 709 assignments per 100 MHz of spectrum for the 7250-8400 MHz and 7125-7250 MHz bands, respectively. Figure 9 shows the actual number of assignments for each assigned frequency in the 7125-8500 MHz band. As can be seen, there are certain discrete frequencies that have a larger number of assignments (i.e., 80 to 100 assignments per frequency). This is due to the use of channeling plans by the larger users of this band for their fixed point-to-point microwave systems.

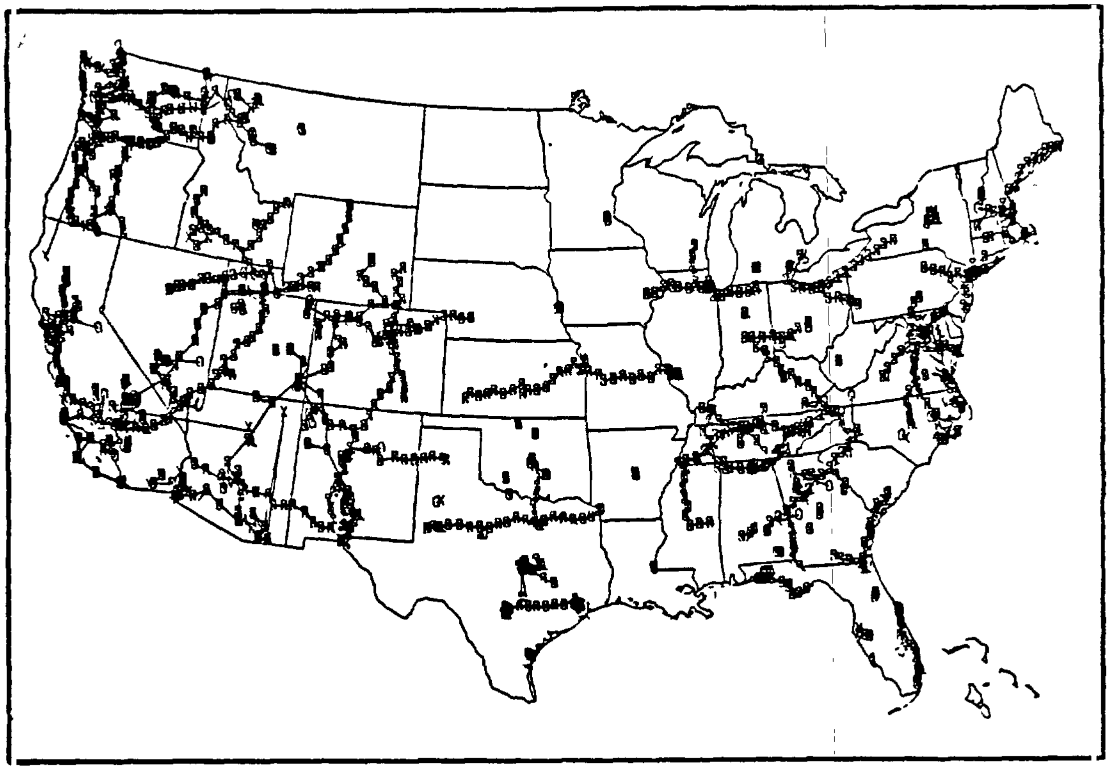


Figure 5. Geographic Distribution of Assignments to Stations in the Fixed Service in the 7125-8500 MHz Band.

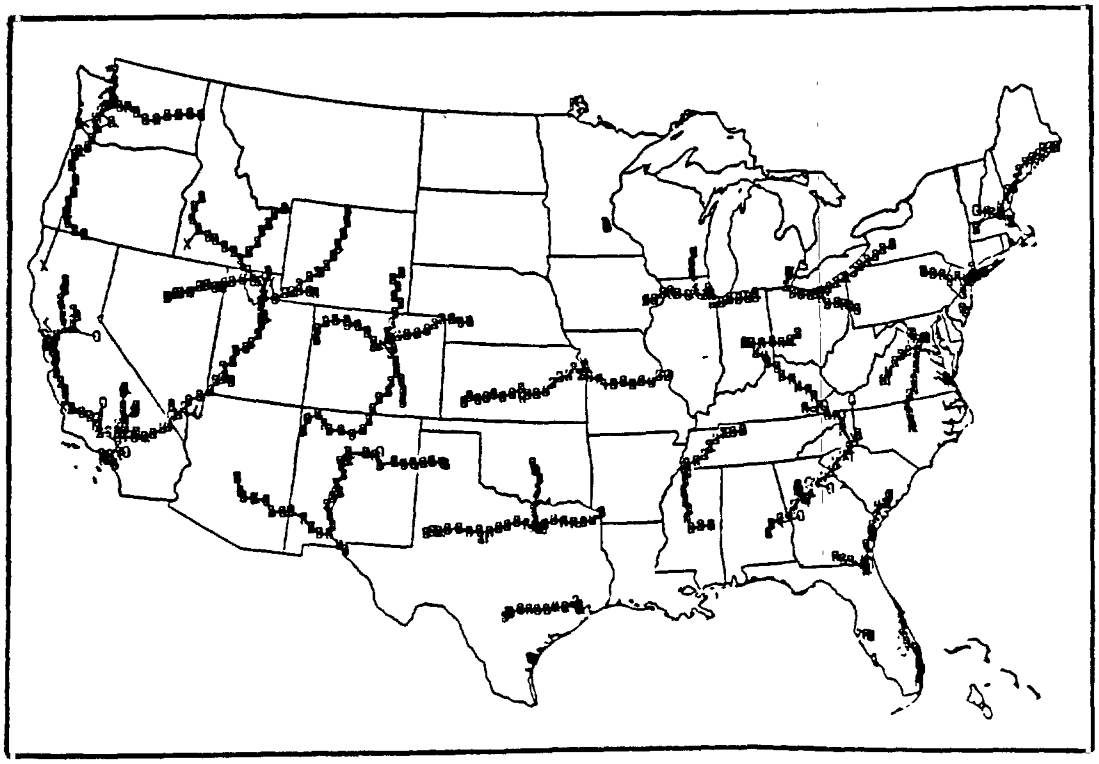


Figure 6. Geographic Distribution of FAA Assignments to Stations in the Fixed Service in the 7125-8500 MHz Band.

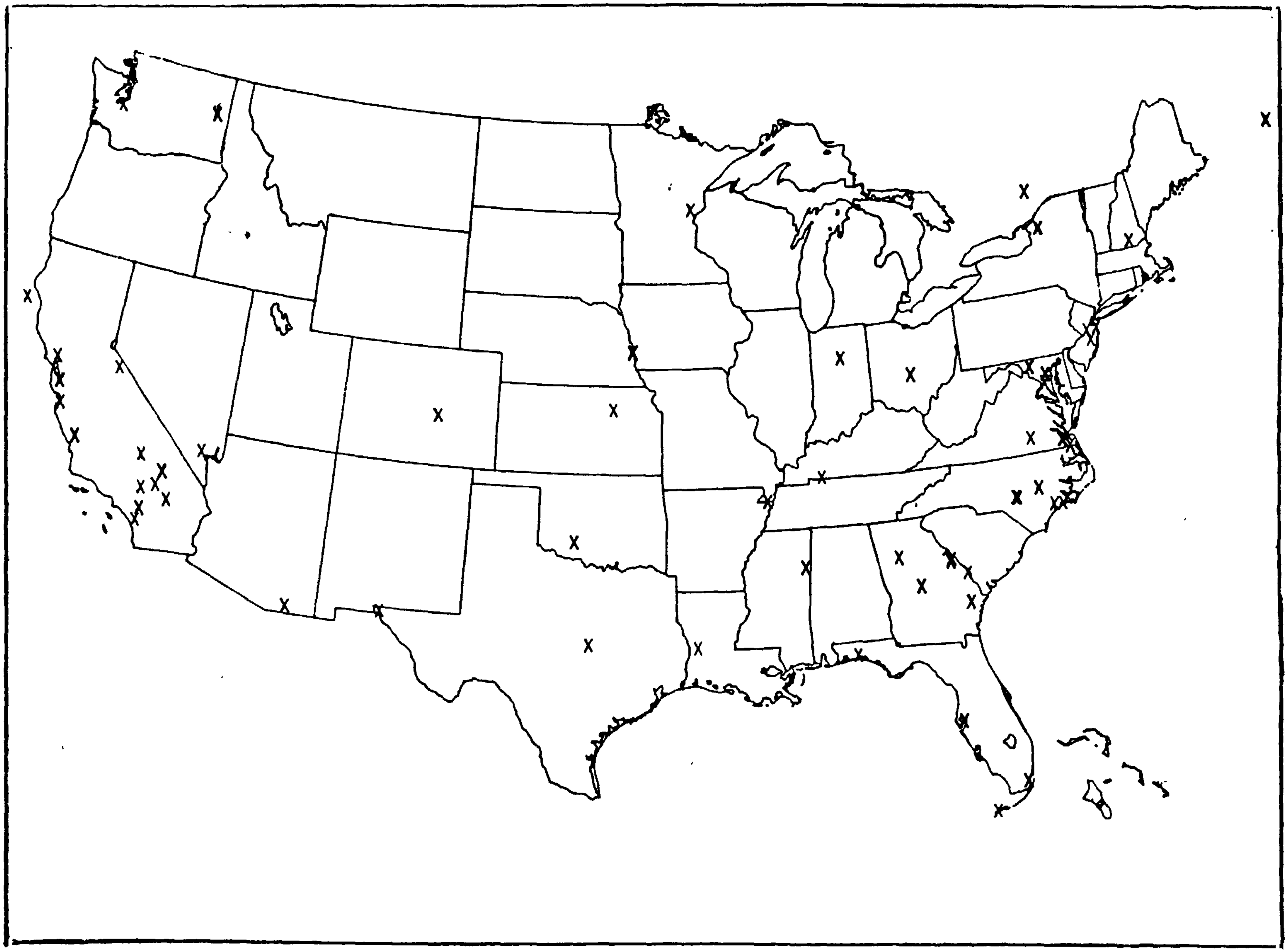
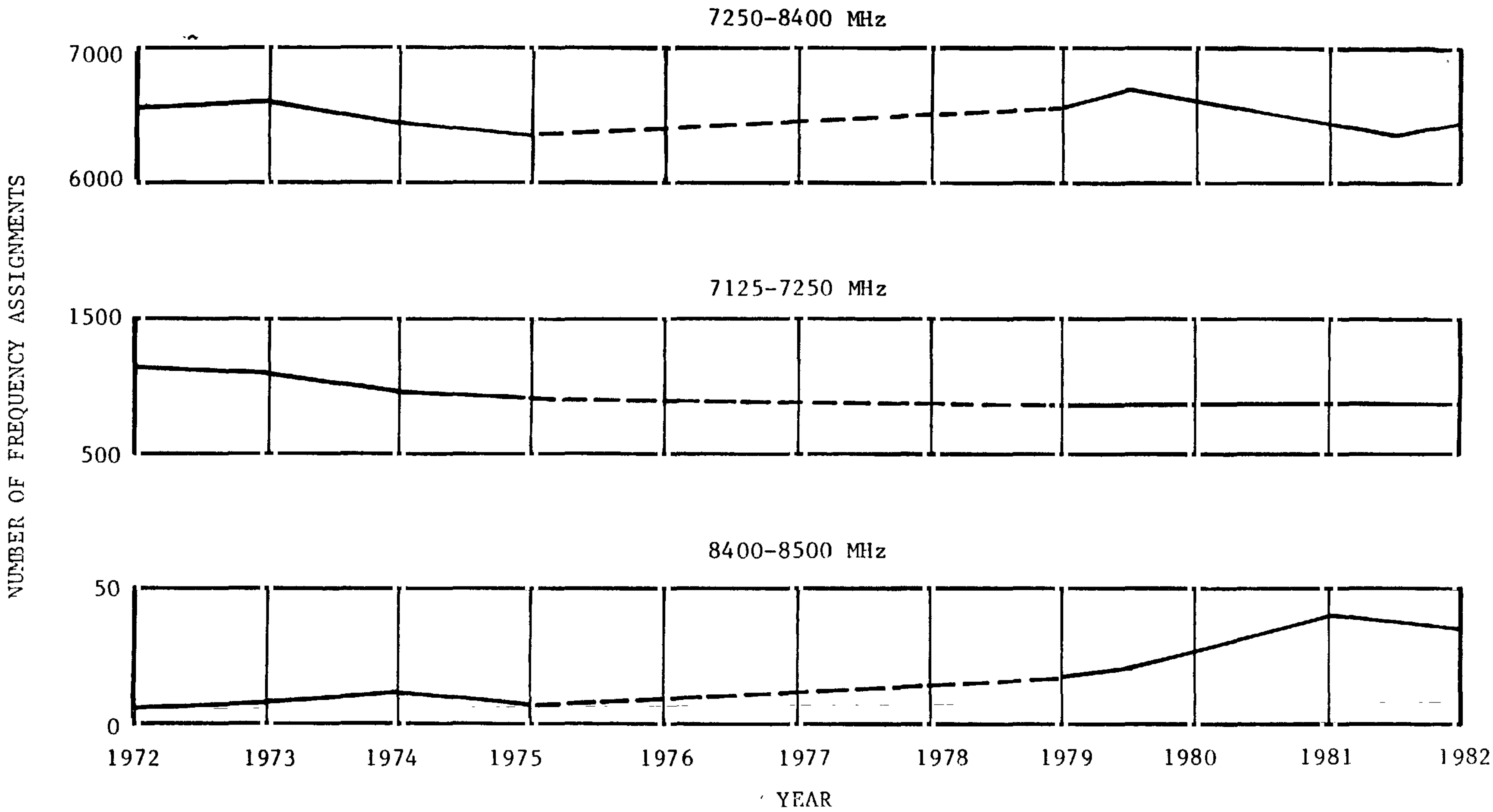


Figure 7. Earth Station Locations for Space Radiocommunication Systems in the 7125-8500 MHz Band.



Note: Dashed line is extrapolation of missing data.

Figure 8. Number of Frequency Assignments in the 7125-8500 MHz Band Per Year

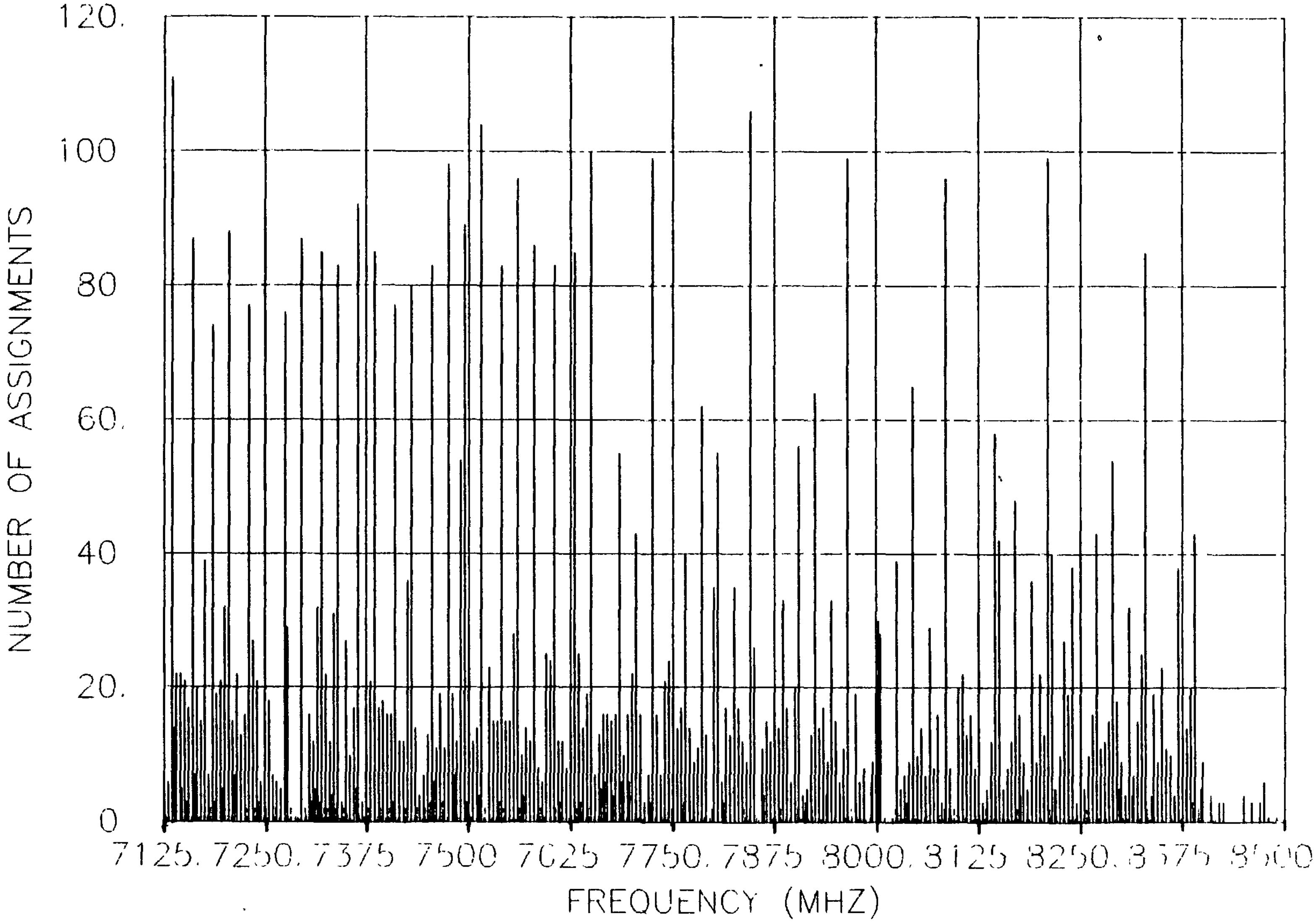


Figure 9. Number of Assignments Per Frequency in the 7125-8500 MHz Band.

Agency Use

There are 20 agencies with assignments in the 7125-8500 MHz band. The agencies, their number of assignments, and the respective percentage of the total number of assignments are listed in TABLE 6. As can be seen, over 90 percent of the total number of assignments belongs to five Government agencies: the FAA, the DOE, and the three military agencies, with the FAA assignments alone accounting for almost half of the total number. Also given in TABLE 6 is the number of assignments per agency for three subbands of the 7125-8500 MHz band. As previously illustrated, the 8400-8500 MHz band is less used than the other two subbands.

To identify how these assignments are used, a list of the services and various stations and the respective number of occurrences found in the GMF for this band is given in TABLE 7. The total number of occurrences is greater than the total number of assignments due to the multiple listing of station class symbols per assignment. There are 169 more station (STC) designator occurrences than there are frequency assignments. Most of the multiple station class listings occur in the U.S. Air Force assignments for experimental testing stations (with 74 more STC occurrences than assignments) and in the NASA assignments for stations in the Fixed Service (with 64 more STC occurrences than assignments). Taking this into account, the number of assignments for the Fixed Service still predominates by accounting for over 88 percent of the total number of assignments. The second largest group of assignments is for space radiocommunications that account for seven percent of the total. The only other significant group of assignments is for experimental stations that make up 4.5 percent of the total number, and most of these are in support of existing or future space radiocommunication systems. The services listed in TABLE 7 are used nationally as of August 1982. There are no assignments for the METSAT and EES Services (i.e., there are two services allocated, but not listed as used in this band). The distribution of STCs per agency is given in TABLE 8. The STCs are grouped into six general categories: fixed, mobile, FSS, MSS, miscellaneous space stations, and miscellaneous stations. All of the 20 Government users have assignments in the Fixed Service. Six agencies have assignments for space radiocommunications service and eight agencies have assignments for experimental stations. The distribution of the fixed STC per agency for three subbands of the 7125-8500 MHz is shown in TABLE 9 that illustrates the fact that there are relatively few fixed assignments in the 8400-8500 MHz subband. This is shown at the bottom of TABLE 9 where the number of assignments is referenced to a common 100 MHz of spectrum. The distribution of the assignments for experimental stations, shown in TABLE 10, is heavier in the 7250-8400 MHz subband because most of the experimental stations are in support of space radiocommunications. All of the assignments for the space services (except four) are in the 7250-8400 MHz band as allocated. The four assignments for the Space Research Service are in the 8400-8500 MHz subband as allocated.

MAJOR SYSTEMS

In the United States, the 7125-8500 MHz band is used extensively by the terrestrial line-of-sight (LOS) microwave systems in the Fixed Service. The use of the band by systems in the Mobile Service is minimal (i.e., only seven assignments). Also, the Mobile Service in the 7125-8500 MHz band is no longer allocated in the U.S. National Table of Frequency Allocations. A considerable

TABLE 6

DISTRIBUTION OF ASSIGNMENTS BY AGENCY
IN THE 7125-8500 MHz BAND

AGENCY(1)	NUMBER OF FREQUENCY ASSIGNMENTS(2)				
	7125-7250 MHz	7250-8400 MHz	8400-8500 MHz	7125-8500 MHz	
				NUMBER	PERCENTILE
FAA	467	3164		3631	48.9
DOE	102	753	4	859	11.6
N	74	731	5	810	10.9
AF	104	680	4	788	10.6
AR	44	587	1	632	8.5
TVA	23	221		244	3.3
CG	9	82	4	95	1.3
NASA	11	57	9	77	1.0
C	10	47	0	57	0.8
ICA	14	38	0	52	0.7
NS	0	43	0	43	0.6
CIA	7	25	0	32	0.4
NG	3	26	3	32	0.4
VA	9	19	0	28	0.4
I	5	15	0	20	0.3
J	0	3	11	14	0.2
HHS	3	3	0	6	<0.1
FEMA	1	4	0	5	<0.1
T	0	0	4	4	<0.1
NSF	0	3	0	3	<0.1
TOTALS	886	6501	45	7432	100

(1) Agency abbreviations are those identified in Annex G of the NTIA Manual.
(2) Current as of August 1982.

TABLE 7

SERVICES AND STATIONS USING THE 7125-8500 MHz BAND

SERVICE	STATION CLASS SYMBOL	STATION(1)	NUMBER OF OCCURRENCES IN GMF (2)
Fixed	FX FXE	Fixed Telemetering Fixed	6666 28
Mobile	FL FLE MO	Land Telemetering Land Mobile	2 4 1
Fixed-Satellite	EC TC TCS	Space Earth Earth on board a ship	230 205 2
Aeronautical Mobile-Satellite	EJ TB TJ	Space Earth Mobile Earth	26 56 15
Land Mobile-Satellite	EU TY	Space Earth	3 3
Maritime Mobile-Satellite	EG TG	Space Mobile Earth	2 6
Space Research	EHER	Space Telemetering Space	4
Aeronautical Radionavigation	RLS	Surveillance Radar	1
None Specified	EK XC XD XM XR XT	Space Tracking Space Experimental Contract Developmental Experimental Developmental Experimental Composite Experimental Research Experimental Testing	2 25 8 1 24 287

(1) See Section 6.1.4 of NTIA Manual for definitions of stations.
(2) Number of occurrences does not necessarily equal number of assignments.

TABLE 8

DISTRIBUTION OF STATION CLASSES BY AGENCY

AGENCY[1]	FIXED FX,FXE	MOBILE FL,FLE,MO	FSS EC,TC,TCS	MSS EJ,TB,TJ EU,TY,EG,TG	MISC. SPACE EHER,EK	MISC. XC,XD,XM XR,XT,RLS
FAA	3631					
DOE	852					8
N	544		169	8	2	89
AF	535	1	91	97		138
AR	425	4	140	6		65
TVA	244					
CG	95					
NASA	121	2			4	14
C	55					2
ICA	52					
NS	4		35			4
CIA	30		2			
NG	8					26
VA	28					
I	20					
J	28					
HHS	6					
FEMA	5					
T	8					
NSF	3					
TOTALS	6694	7	437	111	6	346

[1] Agency abbreviations are the same as those in Annex G of the NTIA Manual.

TABLE 9

DISTRIBUTION OF FIXED STATIONS IN THREE SUBBANDS

AGENCY[1]	NUMBER OF OCCURRENCES IN GMF			
	7125-7250 MHz	7250-8400 MHz	8400-8500 MHz	7125-8500 MHz
FAA	467	3164		3631
DOE	102	746	4	852
N	70	472	2	544
AF	95	438	2	535
AR	51	373	1	425
TVA	23	221		244
CG	9	82	4	95
NASA	8	113		121
C	10	45		55
ICA	14	38		52
NS		4		4
CIA	7	23		30
NG	3	5		8
VA	9	19		28
I	5	15		20
J		6	22	28
HHS	3	3		6
FEMA	1	4		5
T			8	8
NSF		3		3
TOTAL	877	5774	43	6694
PER 100 MHz	701.6	502.1	43	486.8

[1] Abbreviations are the same as those in Annex G of the NTIA Manual.

TABLE 10

DISTRIBUTION OF EXPERIMENTAL STATIONS BY AGENCY

AGENCY[1]	NUMBER OF OCCURRENCES IN THE GMF																			
	7125-7250 MHz					7250-8400 MHz					8400-8500 MHz					7125-8500 MHz				
	XC	XD	XM	XR	XT	XC	XD	XM	XR	XT	XC	XD	XM	XR	XT	XC	XD	XM	XR	XT
DOE										8										8
N					4					81		1			3		1			88
AF			1		9	14	1			110					2	14	1	1		121
AR										65										65
NASA				2	1					2				8	1				10	4
C									1	1									1	1
NS									4										4	
NG						7	6		8		4			1		11	6		9	
SUB-TOTAL			1	2	14	21	7		13	267	4	1		9	6	25	8	1	24	287
TOTAL	17					308					20					345				
PERCENTAGE	4.9					89.3					5.8					100				
PER 100MHz	13.6					26.8					20					25				

[1] Abbreviations are the same as those in Annex G of the NTIA Manual.

variety of fixed systems exists and these systems are operated by numerous Government agencies in this band, nationally. The military agencies, however, are the predominant users of the Space Services. The DSCS-II and FLTSATCOM systems are the main systems in use in this band, nationally. Assignment statistics given in the previous section provide some information on how this band is used. The following paragraphs provide a brief summary of the major systems, both operating and planned, in this band.

Terrestrial Radiocommunications

The FAA is by far the predominant user of this band with respect to number of frequency assignments. These assignments are for the FAA Radar Microwave Link (RML) networks that provide communications between remote radar sites and associated air traffic control (ATC) sites. Other major users of the Fixed Service include the military agencies, the DOE, TVA, and the U.S. Coast Guard for their VTS. The terrestrial systems used by these agencies differ with respect to purpose, information carried, spectrum requirements, and configuration. Most of the equipments used, however, are commercial off-the-shelf multichannel (typically 600 channel) FDM/FM radios. Recent years have seen the development of new technology in the form of digital microwave systems that may find increased applications in the 7125-8500 MHz band. Such systems can be configured to relay computer data as well as voice channels. Brief descriptions of the major terrestrial systems are as follows.

FAA RML Systems

The purpose of the RML is to provide information of en-route airborne traffic to Air Route Traffic Control Centers (ARTCC). A number of RML systems also provide radar data transmission between terminal radars and associated ATC towers. There are several types of equipments used on these networks. The RML-1A, RML-2, and RML-3 systems operate in the 7125-7650 MHz band, while the RML-4 operates over the 7125-8400 MHz range. A few of the pertinent system parameters for the RML-4 system are listed in TABLE 11. (The RML-6 system parameters are listed in TABLE 12, and the characteristics for the LOS microwave equipmerts using the 7/8 GHz band are listed in TABLE 13.) These networks normally use six separate RF channels, 16 MHz wide, per hop. Four channels (three active and one spare) are used to transmit radar, beacon, and control information from the remote radar site to the indicator site. Two channels (one active and one spare) are used in the reverse direction for control and monitoring. The transmission is LOS and often requires six or more relays along the path to redirect and amplify the signal. The antennas are sometimes used with passive reflectors or are periscope-types of systems. The RF power is typically 100 milliwatts. Frequencies used for the RML systems are selected from FAA-developed frequency assignment plans. Several of the older plans included frequencies that are now allocated primarily to the Fixed-Satellite and Mobile-Satellite Services, nationally; and many RML systems are operating on frequencies from these prior plans. There is a newer plan, however, in which frequencies in two 50 MHz slots are avoided. This newer plan is considered standard for new assignments and provides for a maximum of eight radar systems to be remoted to any one location. The older plans are still to be used in the expansion planning of existing RML systems since no combination of the different plans in use is compatible. A representative frequency plan is presented as

Figure 10. Center frequencies for a complete network have 20 MHz and 25 MHz separations.

The FAA also uses a few RML-6 systems at a number of locations which provide for a multichannel interconnect between control stations and large remote air/ground facilities. These systems differ in a number of aspects from the other RML systems. The major difference is that the RML-6 transmits all radar-to-indicator information in one wideband channel as opposed to three in the other systems. The radar locations are in close proximity to the airports as opposed to the remote radar sites in the other RML networks; therefore, typically, these systems utilize only one hop. From the GMF records, these systems have necessary bandwidths of 45 MHz and utilize two wideband RF channels in both directions. The RML-6 system parameters are given in TABLE 12.

Other Terrestrial Systems

The Navy, Air Force, and Army comprise the next largest group of users of terrestrial fixed systems. Two administrations: the BPA and TVA, are next in the number of assignments for fixed systems. The equipment used and configuration for these systems are similar; therefore, they will be discussed together. The military agencies use their fixed systems to relay radar, video, and voice data for operations and control support, land-line backup, and satellite support and interconnect. Locations of these fixed networks are around military bases and test ranges. The equipments used are typically commercial off-the-shelf analog FDM/FM radios. Digital radios are also used and some existing analog radio links are being upgraded to digital. Frequency and space diversity are utilized in these systems; however, most of these systems are in remote areas, and general practice is that frequency diversity will not be used. There is no formal channeling plan in use by the military agencies.

The BPA and TVA use their fixed communication systems to interconnect the various generators, substations, and users for monitoring and control of their respective power transmission systems. The systems consist of predominantly 600-channel FDM/FM commercial off-the-shelf equipment. These systems require high reliability due to the critical function they serve. This is accomplished by the design of fade margins on the order of 30 to 40 dB with the use of diversity schemes. BPA uses frequency diversity with typical diversity spacings on the order of five percent (with a minimum of three percent). These frequency separations are incorporated in a frequency plan used by the BPA. The BPA has used this plan since 1975 for all modifications to existing systems as well as new links. This plan consists of six diversity pairings with center frequencies separated by 25 MHz. TVA utilizes both frequency and space diversity in their systems. TVA uses no standard frequency plan but selects frequencies on a case-by-case basis. Both administrations also employ loop diversity. Both networks are unique to an area; the BPA system is located in the Pacific Northwest and the TVA is located in the Southeast, as outlined in Annex G of the NTIA Manual. No great expansion of either system is planned; however, small extensions and equipment updates are anticipated.

Typical equipment characteristics for these commercially available equipments using the 7125-8500 MHz band are given in TABLE 13.

TABLE 11

SYSTEM PARAMETERS FOR THE RML-4
MICROWAVE LINK (RADAR TERMINAL)

Frequency Range	7.125-8.4 GHz
Modulation	FM
Power Output per Channel	-10 dBW
Bandwidth per Channel	16 MHz
Number of RF Channels	4
Receiver Noise Figure	14 dB
Receiver IF	70 MHz
Antenna Type	Periscope
Antenna Polarization	Horizontal or Vertical
Antenna Gain	39.4-45.3 dBi

TABLE 12

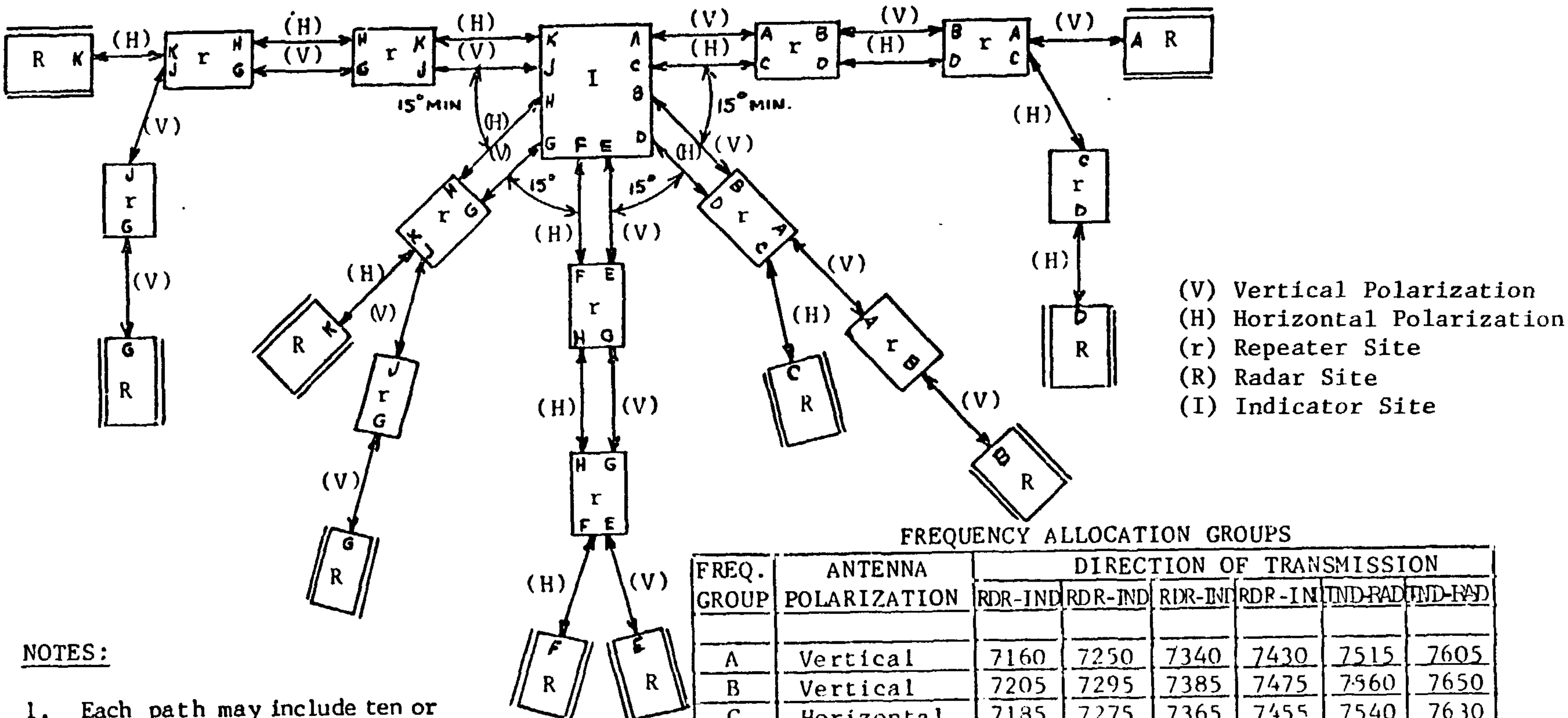
SYSTEM PARAMETERS FOR THE RML-6 MICROWAVE LINK

Frequency Range	7.125-8.4 GHz
Modulation	FM
Power Output	8 dBW
RF Bandwidth	45 MHz
Deviation Ratio	0.25
Peak Frequency Deviation	± 4 MHz
Baseband Bandwidth	16 MHz
Receiver Noise Figure	10 dB
Antenna Type	Parabolic Dish Direct
Antenna Polarization	Horizontal or Vertical
Antenna Gain	40 dBi
Antenna Diameter	1.9 meters (6 ft)

TABLE 13

TYPICAL CHARACTERISTICS FOR LOS MIRCROWAVE
EQUIPMENTS USING THE 7125-8500 MHz BAND

Modulation	FDM FM or Video
Power Output	-10 to +10 dBW
RF Bandwidth	10-45 MHz
Number of Channels	600 Voice or up to 7 Video
Deviation	200 kHz/channel for FDM, 4 MHz for Video
Receiver Sensitivity	-90 dBm
Antenna Type	Parabolic or Periscope
Antenna Polarization	Horizontal or Vertical
Antenna Gain	40-48 dBi



NOTES:

1. Each path may include ten or more repeaters.
2. 15 degree minimum angular path bearing separation between adjacent parallel path groups.
3. For three or four parallel paths, frequency groups A-C or B-D combine with frequency groups E-F, G-H or J-K.
4. Maintain 15 ft. center-to-center separation between antennas.
5. Maintain minimum skew angles between antennas and associated tower mounted reflectors.

FREQUENCY ALLOCATION GROUPS

FREQ. GROUP	ANTENNA POLARIZATION	DIRECTION OF TRANSMISSION					
		RDR-IND	RDR-IND	RDR-IND	RDR-IN	IND-RAD	IND-RAD
A	Vertical	7160	7250	7340	7430	7515	7605
B	Vertical	7205	7295	7385	7475	7560	7650
C	Horizontal	7185	7275	7365	7455	7540	7630
D	Horizontal	7230	7320	7410	7580	7135	7495
E	Vertical	7685	7805	7925	8045	8170	8290
H	Horizontal	7785	7905	8025	8145	8270	8390
G	Vertical	7725	7845	7965	8085	8210	8330
K	Horizontal	7705	7825	7945	8065	8190	8310
J	Vertical	7765	7885	8005	8125	8250	8370
F	Horizontal	7745	7865	7985	8105	8230	8350
	(ALL ABOVE FREQUENCIES IN MEGAHERTZ)						

FREQUENCY PLAN E

Figure 10. FAA Frequency Plan Used in the Pacific Northwest.

Space Radiocommunications

The current national use of the 7125-8500 MHz band for space radiocommunications is for military FSS and MSS applications by DSCS and FLTSATCOM. These two military satellite systems provide unique and complementary communications capability to the U.S. Armed Forces within the United States and around the world. In addition to the U.S. systems, this band continues to be used extensively for military purposes around the world by various countries. These systems, the nominal orbital position for the satellites and the countries, are summarized in TABLE 14. These orbital positions are also shown in Figure 11.

Defense Satellite Communications System (DSCS)

The DSCS is an evolutionary DOD satellite communications system providing worldwide coverage. The system satisfies U.S. communication requirements for command and control, crisis management, intelligence, early warning detection, data relay, treaty monitoring and surveillance information, and diplomatic traffic. The system provides secure voice and high-data-rate communications. The system includes the space segment, fixed earth stations, transportable earth stations, and mobile earth stations on board ships and aircraft.

The space segment, as it exists, began in 1969 with the launch of the DSCS-II satellites. Fourteen DSCS-II satellites have been launched since 1971. Six DSCS-II satellites are currently in synchronous orbit with four of these being operational and two in-orbit spares. The four DSCS-II satellites are deployed over the Indian, Pacific (one eastern and one western), and Atlantic Oceans. The first DSCS-III satellite was launched in October 1982. The eventual orbital locations of the DSCS-III are expected to be the same as the DSCS-II locations.

The DSCS-III is the system planned for future use. Therefore, this discussion will be on the DSCS-III rather than on the DSCS-II. The third-generation DSCS satellites have a 10-year lifespan. The system operates in the 7250-8400 MHz band using multiple-beam antennas and a six-channel transponder designed for Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), and Spread Spectrum Multiple Access (SSMA). As presented in Figure 12, the DSCS-III space station's receive band is 7900-8400 MHz with channels 1 through 5 translated 725 MHz and channel 6 translated 200 MHz resulting in a space station transmit band of 7250-7750 MHz. The receive channels 1 through 4 may be switched to receive on either the waveguide lens multibeam antenna (MBA) or the earth coverage antenna in any combination. This provides the capability to simultaneously provide receive coverage worldwide on some channels while concentrating high-gain across a specified area for other channels.

The transmit (i.e., downlink) channels 1 and 2 are switchable to the MBAs or the high-gain narrow-coverage gimballed reflector. Channel 3 has access to either an MBA or an earth coverage horn. Channel 4 can be switched between the MBA, the earth coverage horn, or the narrow-beam reflector. Channels 5 and 6 are always connected to the earth coverage transmit horns. Each of the two transmit MBAs have 19 beams that are turned on or off to produce various beam shapes for selective coverage. The receive MBA has 61 beams for nulling and interference

TABLE 14

EXISTING AND PLANNED GEOSTATIONARY SATELLITES
UTILIZING THE 7250-7750 MHz AND
7900-8400 MHz BANDS

SATELLITE LONGITUDE	NOMENCLATURE	ADMINISTRATION
170°W	GALS-4	USSR
135°W	DSCS II, III E PAC	USA
108°W	MUSAT-A	Canada
100°W	FLTSATCOM E PAC	USA
52.5°W	DSCS III W ATL	USA
42.5°W	DSCS III MID ATL	USA
26.5°W	GALS-1	USSR
23°W	FLTSATCOM ATL	USA
18°W	SATCOM III ATL	Belgium
12°W	DSCS II, III ATL	USA
8.0°W	TELECOM-1A	France
6.0°W	SKYNET-A	UK
5.0°W	TELECOM-1C	France
0.0°E	SICRAL-1A	UK
4.0°E	SICRAL-1B	France
16.0°E	GALS-6	Italy
22.0°E	GALS-2	Italy
35°E	SKYNET-4C	USSR
45°E	GALS-2	USSR
53°E	SKYNET	UK
60°E	DSCS II, III IN) N	USA
75°E	FLTSATCOM INT N	USA
85°E	GALS-3	USSR
130°E	GALS-5	USSR
172°E	FLTSATCOM W PAC	USA
175°E	DSCS II, III W PAC	USA

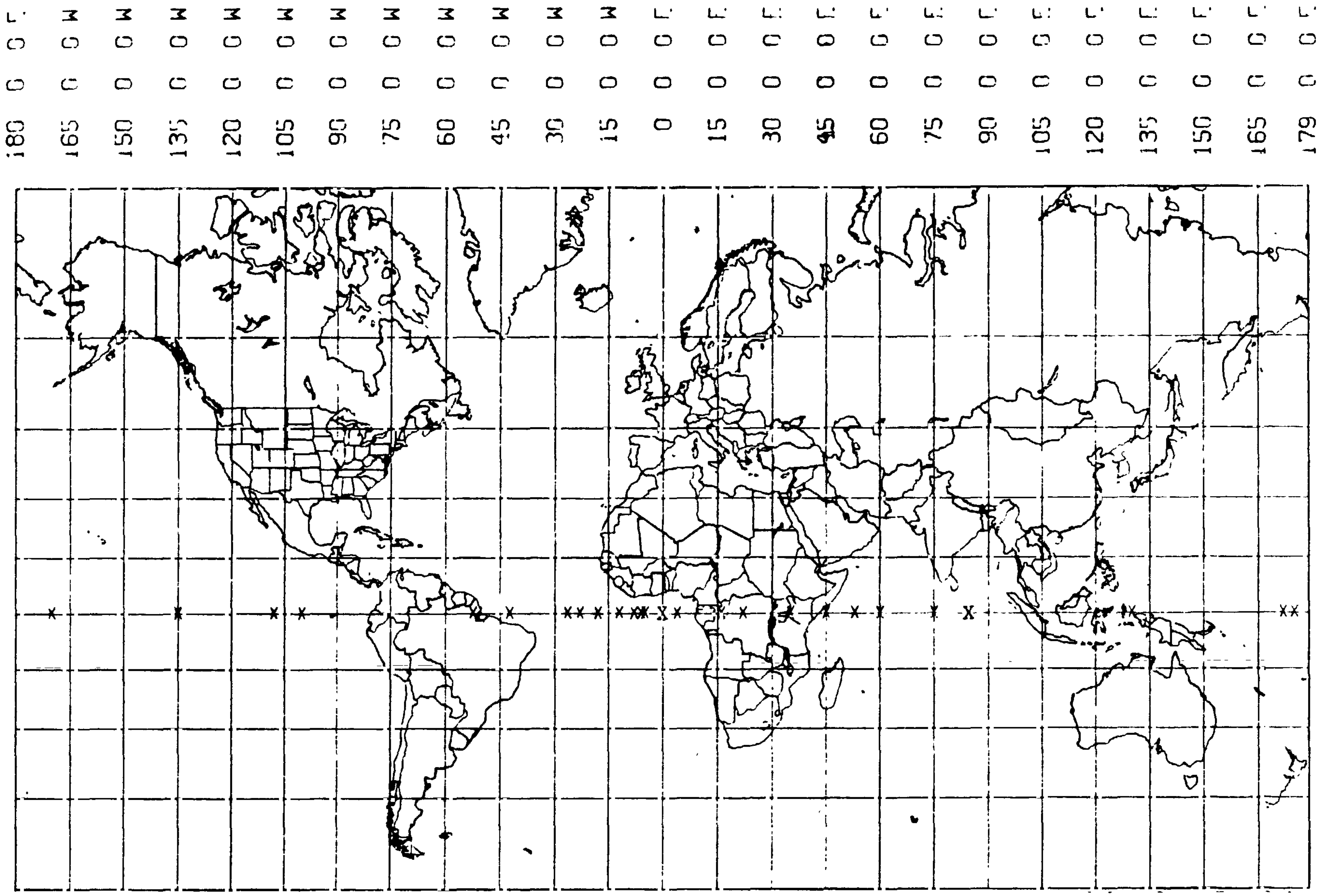


Figure 11. Orbital Positions of Existing and Planned Geostationary Satellites in the 7125-8500 MHz Band.

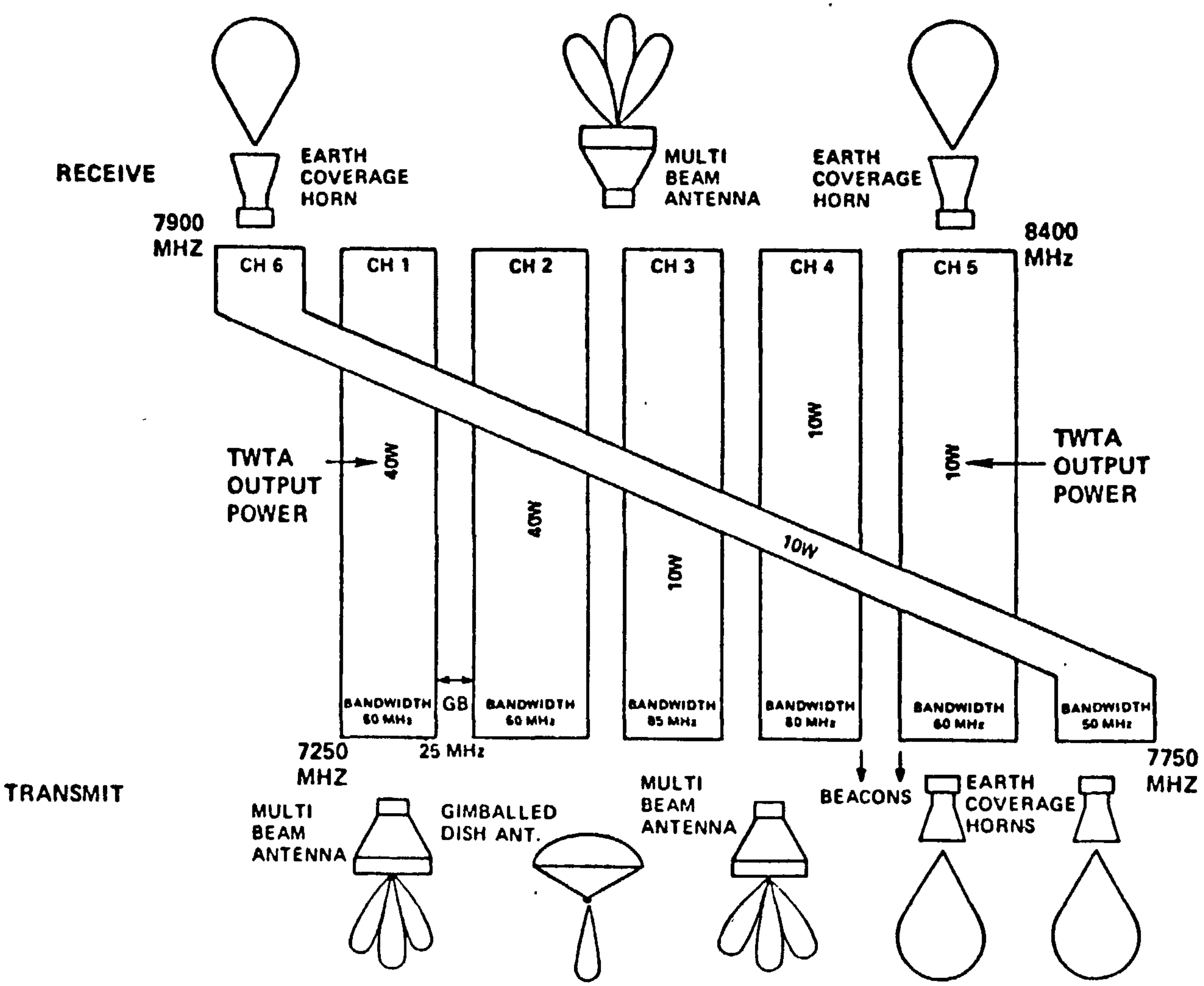


Figure 12. DSCS-III Space Station Frequency Plan.

rejection. The MBA selective coverage feature also allows the allocation of antenna gain and consequently EIRP to ground locations according to terminal size and traffic requirements.

The DSCS-III system operates with fixed and transportable earth stations and with mobile terminals on board aircraft and ships. Thus the DSCS-III can operate with either large or small terminals. A number of earth terminals are available or are being developed for use in the DSCS system. A listing of the most typical earth terminals is presented in TABLE 15. The terminals range from the small airborne AN/ASC-24 to the large fixed type AN/FSC-78. Discussions of four representative earth terminals follow.

AN/ASC-24 Airborne Terminal

The AN/ASC-24 airborne earth terminal is deployed on board the E-4B Advanced Airborne Command Post (AABNCP) and the National Emergency Airborne Command Post (NEACP). The AN/ASC-24 provides one or two full-duplex channels. Normally, the satellite deployed over the eastern Pacific is used. Others can be used as determined by the location of the aircraft. The satellites are acquired by manual or computer-directed antenna pointing. Tracking of the acquired satellites is accomplished either by beacon or computer based on inputs from the E-4B Inertial Navigation System (INS) and Air Data Computer (ADC) and satellite ephemeris inputs.

The AN/ASC-24 transmits in the 7.9-8.4 GHz band and receives in the 7.25-7.75 GHz band in six discrete preselected transponders. The bandwidth is 100 or 125 MHz. Binary phase-shift-keying (BPSK) consists of 75-bps teletype, 1200- or 2400-bps AUTODIN, 9600-bps secure voice and 75-bps link order wires. The RF portion utilizes pseudonoise, direct-sequence spread-spectrum modulation that has quadrature PSK (QPSK) with a selectable chip rate varying from 10 MHz to 40 MHz. The data rate is variable from 5 Hz to 5 MHz. Two-carrier operation is possible with a nominal frequency separation of 90 MHz.

AN/FSC-78(V) Fixed Terminal

The AN/FSC-78(V) is a fixed-station earth terminal fulfilling a role as a heavy-route communications terminal for the DSCS. The terminal can accommodate a variety of baseband modulation, multiplex, and code techniques including FDM, TDMA, and SSMA via external modems. The terminal provides simultaneous transmit and receive carrier operation with configuration of up to 9-uplink and 15-downlink carriers.

The antenna system is an 18-meter diameter Cassegrain-feed parabolic reflector. An automatic tracking system is employed to optimize the antenna gain in the direction of the satellite. The feed system consists of a 5-horn monopulse array.

The antenna-mounted parametric amplifiers are cryogenically cooled units having a noise temperature of 30 Kelvins and a gain of 30 dBi with a 1 dB bandwidth of 500 MHz. Down-converters employ dual conversion with low-side local oscillator injection to provide IF outputs of 70 and 700 MHz.

TABLE 15

SELECTED DSCS EARTH TERMINALS

NOMENCLATURE	TYPE OF TERMINAL	NO. DEPLOYED OR PLANNED	ANTENNA DIAMETER (METERS)	TRANSMIT ANTENNA GAIN (dBi)	PREAMPLIFIER TYPE	G/T (dB)	POWER AMPLIFIER TYPE	MAXIMUM POWER AMPLIFIER OUTPUT (kW)	EIRP (dBm)
1. AN/ASC-24	Airborne	4	1	32	UCP	10	KLY	11	102
2. AN/FSC-78(V)	Fixed	18	18.3	61	CP	39	TWT	3.7	127
3. AN/FSC-79	Fixed	5	18.3	61	FET	26	KLY	8	130
4. AN/GSC-39	Fixed and Transport-able	21	11.6	57	CP	34	TWT	5	124
5. AN/MSC-46	Ground Mobile	13	12.2	58	CP	34	KLY	10	128
6. AN/SSC-6	Shipborne		1.8	41	UCP	14	KLY	11	111
7. AN/TSC-54	Transport-able	12	5.5	51	UCP	26	KLY	8	120
8. AN/TSC-86	Transport-able	6	6.1	52	UCP	26	KLY	1	120
9. AN/WSC-2	Shipborne		2.4	44	UCP	18	KLY	6	112
10. S-A MT*		39 Planned	11.6	57	FET	33	TWT	0.9	117

*State-of-the-art medium terminal

CP = Cooled Parametric Amplifier
UCP = Uncooled Parametric Amplifier
FET = Field Effect Transistor
TWT = Traveling Wave Tube
KLY = Klystron
G/T = Gain-to-noise temperature ratio

The transmitter employs up-converters translating 700 MHz IF signals with a 125 MHz bandwidth in a single conversion step, up to the 7.9-8.4 GHz band. A second conversion step is used to translate 70 MHz IF signals with a 40 MHz bandwidth. The terminal may be equipped with up to nine up-converters. The power amplifier is a liquid-cooled traveling wave tube (TWT). Each power amplifier has a 500 MHz instantaneous bandwidth and covers the full 7.9-8.4 GHz range to provide multicarrier operation.

AN/TSC-86 Transportable Earth Terminal

The AN/TSC-86 ground transportable earth terminal is the replacement for the older AN/TSC-54 earth terminal that is considered obsolete as a mobile terminal. The AN/TSC-86 is capable of providing simultaneous communications with up to four other terminals. Included in the terminal is the modulation, demodulation, multiplexing, and signal conditioning equipment necessary for the processing of voice, data, and teletype signals. The terminal also consists of two antenna groups: one quick reaction, 2.4 m (8-foot) parabolic, and one 6 meter (20-foot) parabolic capable of transmitting multiple carriers. The set-up time is approximately 1 hour to satellite acquisition with the small antenna and within 12 hours for the large dish antenna.

The communications subsystem accepts voice frequency (VF), teletypewriter, and baseband digital signals from external cable transmission networks and combines them with on-board teletype and voice orderwire signals to form a composite, multiplexed, digital signal called the mission bit stream. This bit stream is applied to a bulk encryption device before routing to the digital data modem by the modulated 70-MHz panel for conversion to super high frequency (SHF) and transmission. Received signals are processed in a similar manner, except in the reverse order.

AN/WSC-2 Shipboard Terminal

The AN/WSC-2 shipboard terminal is built in either of two configurations, medium or large. The medium set employs a 1.2-meter diameter antenna, while the large set employs a 2.4-meter antenna. All other nonantenna parameters of the medium and large sets are identical.

The antenna system on board ship consists of two Cassegrain-feed antennas with two-axis drives providing full hemispherical coverage under conditions stipulated for sea-states 1 through 5. Processor controlled automatic handover causes switching of RF signals when the prime antenna approaches a predesignated boundary limit. The sets employ a pseudonoise monopulse type of automatic tracking system.

Gyro-stabilized reference signals are used by a solid-state processor to generate servocommand signals that operate the antenna drive motors, thereby correcting antenna errors. The effects of roll, pitch, yaw, heave, and heading are continuously corrected, while an antenna pointing accuracy within 0.10 degree is maintained.

FLTSATCOM

The FLTSATCOM system provides unique and complementary communications capability to the U.S. Armed Forces within the United States and around the world. The FLTSATCOM system provides communications capability to link command centers ashore (using the 7/8 GHz bands) with commanders afloat (using the UHF bands) and the commanders afloat to fleet elements (using the VHF bands) for tactical purposes. This system is also used by the ground Armed Forces. The "leased satellite" (LEASAT) series is intended as the future replacement for FLTSATCOM. The LEASAT represents a different approach to the procurement of satellite services for the military. Rather than outright purchase and operation, the military will lease the satellites from Hughes Communications Services, Inc. Four satellites are planned with the first launch scheduled for this year. The satellites will be deployed over the United States and the Atlantic, Pacific, and Indian Oceans.

The main UHF operating band of the LEASAT is around 300 MHz. An uplink is planned in the 8 GHz band.

Earth-Exploration Satellites (EESs) and Meteorological-Satellites (METSATs)

There are no EESs or METSATs operating in the 7.25-8.40 MHz band. However, the EES Service (space-to-Earth) is allocated to the 8025-8400 MHz band. As of January 1984, there were two experimental assignments in the GMF for the Landsat-D system at 8212.5 MHz. One assignment is for collimation tower use for checkout and maintenance of the Landsat-D receive only earth station at Greenbelt, Maryland, and the other is for space-to-Earth transmission of high-rate data to Greenbelt and foreign stations not yet defined. Also, in IRAC Doc. 23377, reference is made to a Landsat-D frequency in use at 8215.5 MHz but there is no record of this assignment in the GMF.

The METSAT Service that is an EES used for meteorological purposes is allocated to the 7450-7550 MHz (space-to-Earth) and 8175-8215 MHz (Earth-to-space) bands. Originally, the METSAT Service was allocated to this band for a follow-on system to the GOES. In general, METSATs collect a wide spectrum of data from on-board sensors and through the use of remote data collection platforms. The on-board sensors provide high resolution imagery and quantitative data on temperature, humidity, and other atmospheric and ocean functions. The spacecraft collects data from various remote platforms and relays it to the central ground station. Bands other than the 7/8 GHz band are presently used by the METSATs; however, these bands are becoming bandwidth limited, creating a need to move to other areas.

The 7/8 GHz band will most likely be used by METSATs for data transmissions requiring a wide bandwidth. For example, high-resolution video data may require 100 MHz of bandwidth for transmission of raw data.

RSMS VAN MEASURMENT DATA

As part of the NTIA Spectrum Analysis Program, measurements of selected Federal frequency bands have been taken to supply basic information on spectrum utilization to Federal frequency managers. This effort is a continuation of band usage measurements in various areas of the United States since 1973. Measurements were taken using the RSMS operated by NTIA. All measurement activities were carried out in accordance with established Department of Commerce policy and administrative procedure as defined in the RSMS Operations Manual [RSMS, 1975]. The procedures relate especially to constraints on release of measurement data and prohibition of aural monitoring on frequencies that may have non-Government assignments.

Measurements were made of emission spectra of fixed systems utilizing the 7125-8500 MHz band in the Seattle, Washington, area from June through August, 1982. The objective was to determine emission spectra of the various fixed systems in the Seattle area, as well as relative band occupancy of the 7125-8500 MHz band at specific sites where the fixed systems are located. The information gained was to be used in comparison with theoretical necessary bandwidth calculations, frequency assignment data in the GMF, and verification of frequency reassignments identified for the reaccommodation of certain BPA fixed systems. All measurements were made using the Wideband Search Program that steps through a predetermined band of frequencies and records relative power levels at each step. In general, a scan was made of the 7125-8500 MHz band with the RSMS parabolic dish aimed at the antennas located on the fixed system's antenna tower. Typically, these measurements consisted of seven scans of 200 MHz which took approximately six minutes per scan. Additionally, smaller scans of 20 and 25 MHz wide were made, centered on a transmitter frequency, with the RSMS antenna aimed at the respective dish (i.e., radiated or open field measurement). At some sites, the RSMS was connected directly to the output waveguide of the respective transmitter (i.e., hard-line or closed system measurement). The hard-line connection was made at the waveguide following the isolator and filter of each transmitter. Hard-line measurements were made to determine the relative accuracy of radiated measurements since the RSMS antenna was pointed at the sidelobe of a fixed system antenna on a tower. At the BPA site of Squak Mountain, emission spectra were also determined (both hard-line and radiated) with the baseband of the respective fixed system loaded with white noise. Measurements were also made of one diversity channel with normal loading with the other diversity channel noise loaded to determine what relationship, if any. The purpose of these measurements was to determine the measured bandwidth relationship with channel loading.

The emission spectra of four different fixed systems in the Seattle area operating in the 7125-8500 MHz band were measured. The measurement locations and dates, the transmitter frequencies and necessary bandwidths are given in TABLE 16. Except for the U.S. Coast Guard VTS, which is a one-way communication system, measurements were made at both ends of at least one link in each system. The emission spectra of five different equipments (from radiated measurements) utilized in these four systems are shown in Figures 13 through 17. Complete measurement results are given in APPENDIX A. These results include comparisons between necessary bandwidths, channel loading, and GMF entries. The conclusions, based on this measurement data, include the following.

1) There is essentially no difference in measured bandwidths of the emission spectra determined by radiated or hard-line connections. Even though the receiving RSMS antenna was pointed at the sidelobe of a transmitting antenna, the relative transmission spectra were identical to those measured connected to the transmitter output. This finding allows the van to measure emission spectra of similar fixed

TABLE 16

RSMS MEASUREMENT LOCATIONS IN THE SEATTLE, WASHINGTON, AREA

SITE	ALTITUDE IN METERS	AGENCY[1]	MEASUREMENT DATES	EMISSION SPECTRUM IN MHz	TRANSMIT FREQUENCIES IN MHz	EQUIPMENT NOMENCLATURE
BLYN MOUNTAIN	646	N CG	6/21/82 8/10 - 8/12/82	12 40	7375, 7610 7145, 7195, 7505 8230, 8280 8330, 8380	MOTOROLA MR300 FARINON ELECTRIC FV8F
TACOMA	131	BPA	8/16/82	25	7710, 7880, 7915 8065, 8260, 8385	GENERAL ELECTRIC TRS696C COLLINS MW508D
SQUAK MOUNTAIN	617	BPA	8/18/82 - 8/19/82	25	7340, 7380 7685, 7740 9 OTHERS	GENERAL ELECTRIC TRS696C COLLINS MW508C
AUBURN	89	FAA	8/23/82	20	7135, 7495, 7515 7540, 7605, 7630 8170, 8290	COLLINS 552A-5
MADRONA	134	FAA	8/24/82	20	7135, 7160, 7185 7250, 7275, 7340 7365, 7430, 7455 7495, 7560, 7650	COLLINS 552A-5
BANGOR	95	N	8/26/82	12	7415	MOTOROLA MR300

[1] Agency abbreviations are the same as those in Annex G of the NTIA Manual.

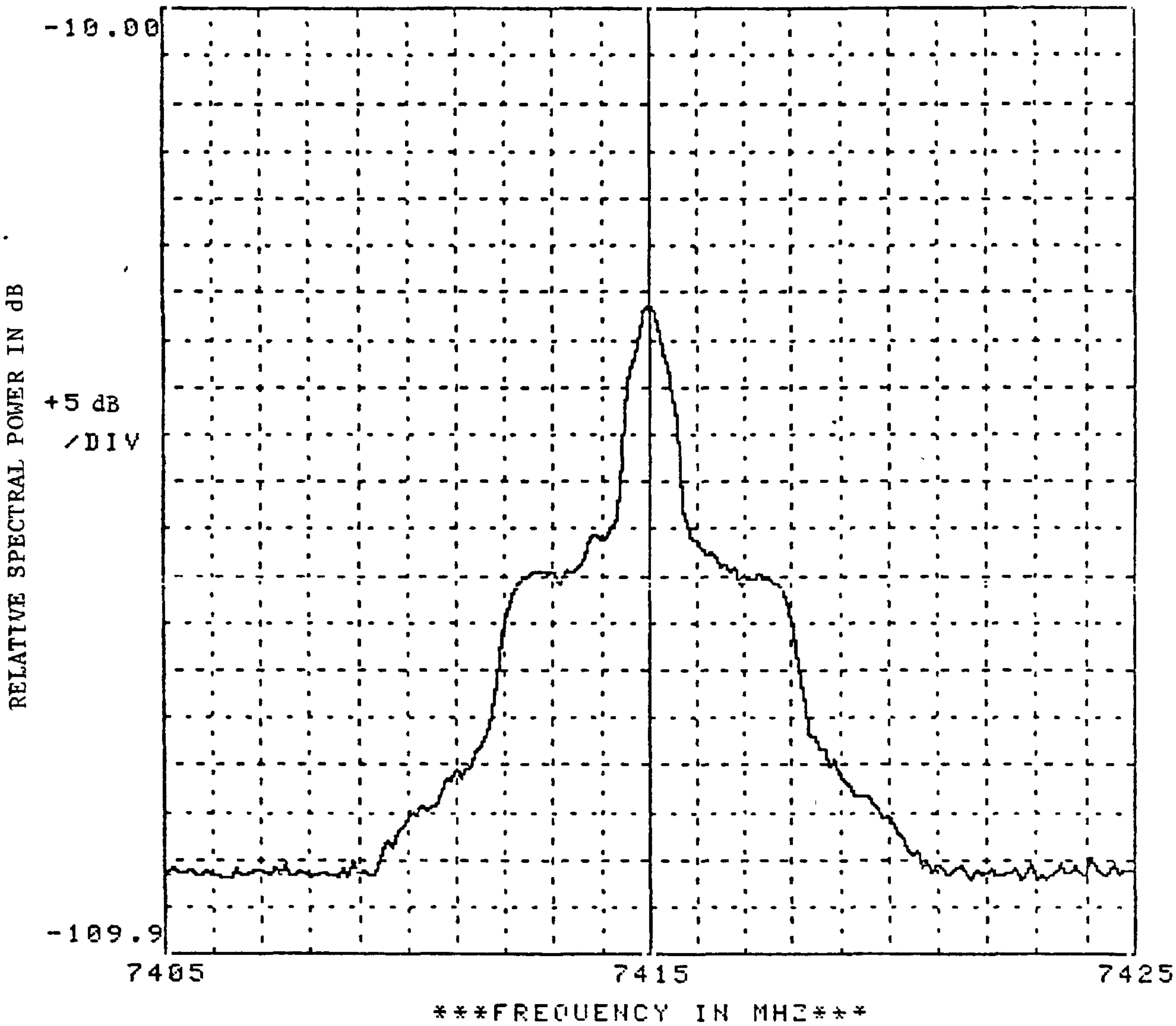


Figure 13. Transmitter Emission Spectrum of a Motorola MR300

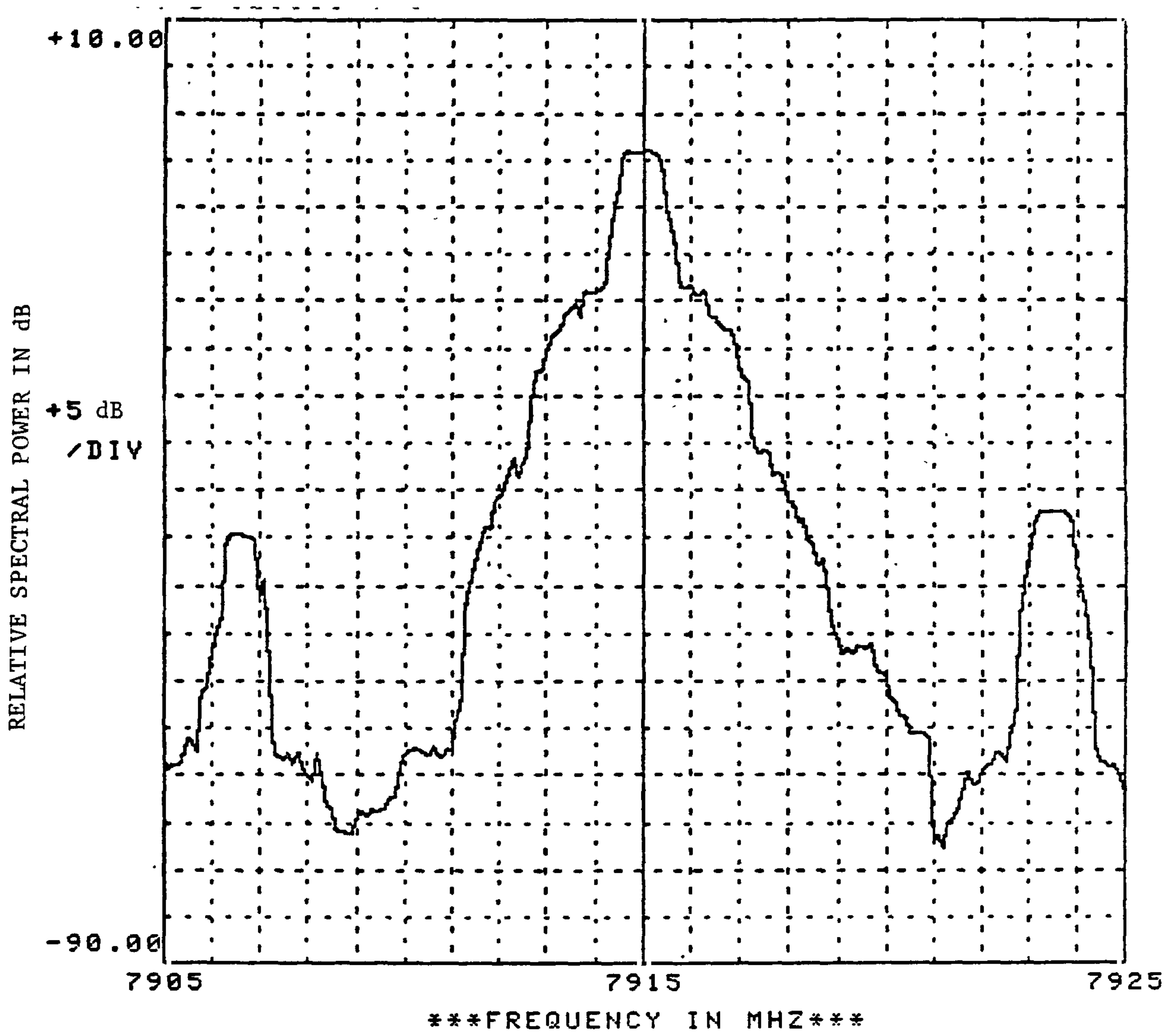


Figure 14. Transmitter Emission Spectrum of a General Electric TRS696C.

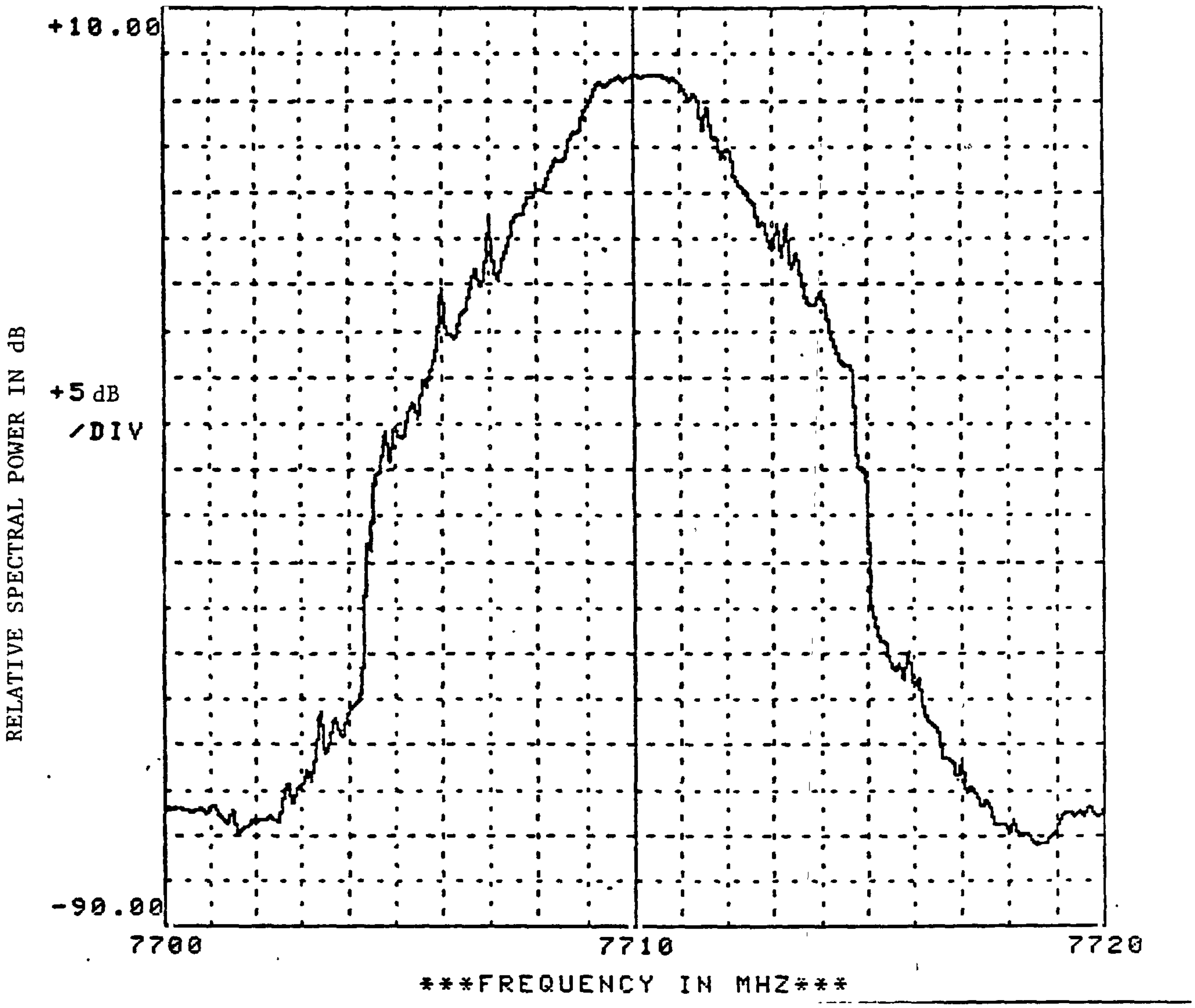


Figure 15. Transmitter Emission Spectrum of a Collins MW508C.

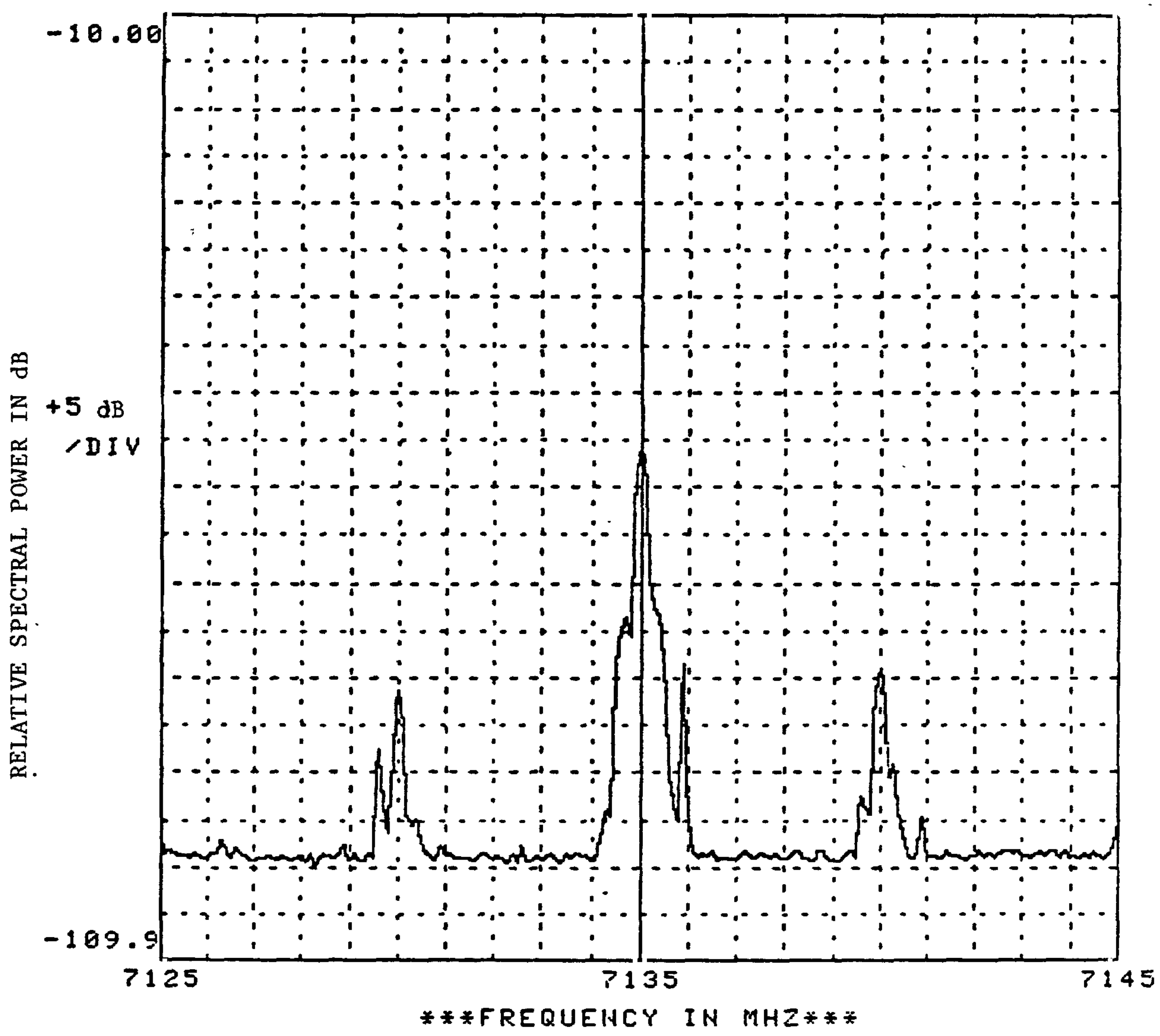


Figure 16. Transmitter Emission Spectrum of a Collins 552A-5.

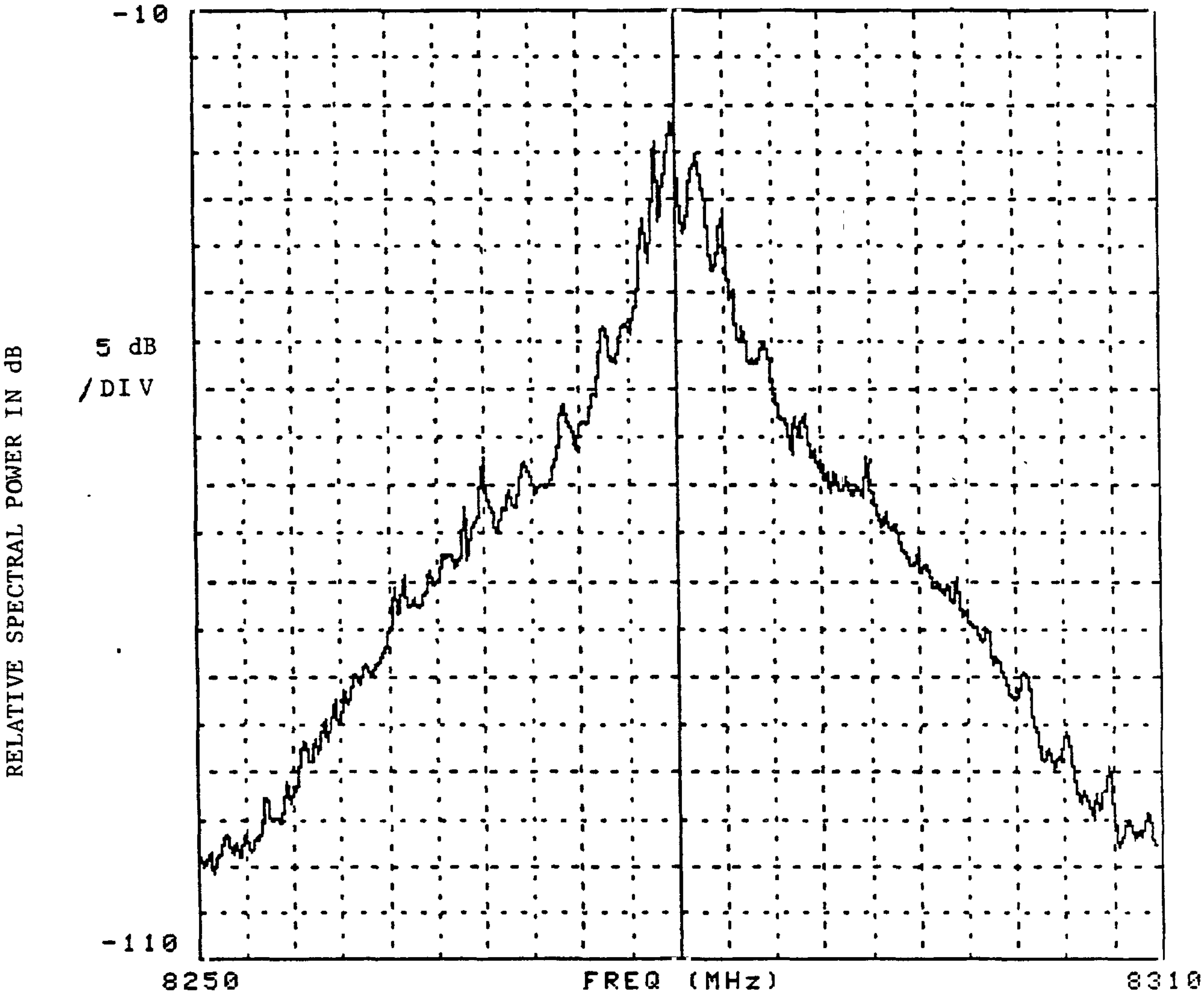


Figure 17. Transmitter Emission Spectrum of a Farinon Electric FV8F.

systems with a greater degree of confidence without having to tap into the transmitter waveguide. Subsequent emission spectra measurements can be made without having to be collocated with the transmitter, and factors such as siting access, space, security, and time are now not as restrictive.

2) Comparing measurements of equipment under normal loading with those under a fully loaded condition, yields no bandwidth difference at the measurement noise floor. The bandwidth of the mainlobe is greater at the 3 dB points and the falloff is sharper, but the occupied bandwidth at the noise floor is essentially the same.

3) Experience gained from the BPA reaccommodation project and this measurement effort proved the RSMS measurements useful in identifying vacant frequencies at a site, but they cannot, by themselves, determine the whole scenario necessary for frequency assignment. The occupied spectrum at a site can be determined, but the effect of a proposed transmitter on the environment cannot be readily determined.

4) Examination of equipment, along with conversations with various field personnel, revealed that it is standard practice to use waveguide filters and isolators between the transmit and receive equipment. Certain frequency assignment rules are used by frequency managers regarding intermodulation and spurious responses. One of these is to never assign a transmit-receive frequency separation equal to the equipment IF. With the use of these filters and isolators, this problem is significantly reduced. Therefore, these rules should be investigated for the cases where isolators and filters are used.

5) The emission bandwidth of transmitters utilizing 8.5 MHz pilot carriers consumes more spectrum (i.e., 25 MHz necessary bandwidth) than those utilizing 3.2 MHz pilot carriers (i.e., 17-20 MHz necessary bandwidth) although both systems carry the same amount of information.

6) Most systems occupy less spectrum than the required bandwidth listed in the GMF. It is realized that the necessary bandwidth determination is based more on system capacity and future plans rather than present use, but it appears that some of these listings exceed system capacity. It is recommended that the agencies concerned investigate this matter and correct erroneous listings as well as apply for correct required bandwidth listings for future assignments.

SECTION 5

PROBLEM ASSESSMENT

This section presents a problem assessment matrix for the 7125-8500 MHz band. Using the data in the preceding sections, the relative degree of compatibility between services using the band is identified. The intent here is not to develop preliminary solutions to the problems, but rather, to identify problem magnitude and degree of importance. The issues thus identified are examined in more detail in Section 6.

PROBLEM ASSESSMENT MATRIX

Figure 18 is the problem assessment matrix for the 7125-8500 MHz band. It is based on the data presented in this report and reflects the major U.S. Government concerns and needs. The rows and columns of the matrix represent the class of transmitter and receiver stations operating in the identified service. Interactions between stations fall into three categories: no problems, manageable problems, and serious problems.

1) No Problems - implies that the systems involved are sufficiently separated in frequency or distance to preclude interference even under worst-case conditions. Also included are interactions involving only one Federal agency. In the latter case, potential problems are resolved within that agency.

2) Manageable Problems - those interactions where interference is possible under worst-case conditions, but which can be avoided using conventional frequency management techniques.

3) Serious Problems - those where potential interference may exist which is not easily resolved using existing spectrum management procedures. None were identified in this study.

SUMMARY OF INTERACTIONS

An examination was made of the interactions among the major systems identified in this band. For purposes of discussion, these are ordered in a matrix by the various receiver types interacting with the representative environment. The rationale for these interactions is discussed in the following paragraphs.

Fixed Service Receivers

The Fixed Service is the dominant service in the band from the standpoint of the number of assignments. Sharing of the band among fixed systems has been accomplished effectively through the actions of the Frequency Assignment Subcommittee of the IRAC. Verification of the compatibility of proposed assignments, however, is largely a case-by-case process engaging the member agency frequency managers. An automated method of verifying assignments among fixed stations would reduce the workload of agency frequency managers and ensure

TRANSMITTERS Service	Direction	RECEIVERS: FIXED SERVICE (--)	RADIOLOCATION (--)	FIXED-SATELLITE (E/S)	FIXED-SATELLITE (S/E)	MOBILE-SATELLITE (E/S)	MOBILE-SATELLITE (S/E)	SPACE RESEARCH (E/S)	SPACE RESEARCH (S/E)	METEOROLOGICAL SATELLITE (E/S)	METEOROLOGICAL SATELLITE (S/E)	(EES) (S/E)	SPACE Op. (E/S)
FIXED	--	M (1)			M (2)				M (2)		M (2)	M (2)	
RADIOLOCATION	--	M (5)							M (5)				
FIXED-SATELLITE	S/E			7	7	7	7				M (4)		
	E/S	M (2)		7	7	7	7			M (4)		M (3)	
MOBILE-SATELLITE	S/E			7	7	7	7				M (4)		
	E/S	M (6)		7	7	7	7		M (5)	M (4)		M (6)	
SPACE RESEARCH	S/E												
	E/S	M (2)											M (4)
METEOROLOGICAL-SATELLITE	S/E				M (4)								
	E/S	M (2)		M (4)								M (3)	
EARTH EXPLORATION-SATELLITE (EES)	S/E								M (5)				
SPACE OPERATIONS	E/S	M (2)						M (4)					

KEY

- No Problems Anticipated (See Text)
- M = Manageable Problems
- Serious Problems (None Identified)

Footnotes

1. Requires coordinations between terrestrial (fixed) stations.
2. Requires coordination between terrestrial and earth stations.
3. Requires coordination between earth stations.
4. Requires coordination between space stations.
5. Potential adjacent band interactions.
6. Requires close coordination for any use of secondary allocated service.
7. Subject to be considered for alternative spectrum management mechanism - Space WARC-85/87.

Figure 18. Interaction Matrix for the 7.125-8.5 GHz and Adjacent Bands.

that effective assignment methods were used. This is further examined in Section 6.

Sharing of Fixed Service receivers with the various earth stations used in the band for peacetime applications can be accomplished in a relatively straightforward manner through established procedures given in Section 8.4.12 of the NTIA Manual. Specific interference calculations have also been discussed by Parlow, et al. [1973] and an automated computer model was developed to specifically address coordination between the Fixed Service and earth stations in this band [Moran, 1976].

Sharing of Fixed Service receivers and space stations has been managed effectively through the adoption of power flux density (PFD) limits identified in Section 8.2.36 of the NTIA Manual. These PFD limits were established to ensure compatibility with the Fixed Service. Some minimal precautionary limits on the pointing angle of the fixed stations, however, may be required.

Use of mobile-satellite earth stations in the band 8025-8400 MHz is on a secondary basis to the Fixed Service and any such use must be closely coordinated.

Sharing of Fixed Service receivers with radiolocation does not involve cochannel operation; however, the high power and wide spectrum of typical radars in the bands above 8.5 GHz suggest the possibility of adjacent band interference. Currently, little use is being made of the 8.4-8.5 GHz band by the Fixed Service, thus avoiding significant adjacent band problems with radars. This may be due, in part, to the uncertainty concerning possible radar interference. Further study would be desirable to explore the possibility of expanded use of the Fixed Service in this band.

Radiolocation Service Receivers (Adjacent Band)

No potential problems were identified as a result of adjacent band interference to radiolocation systems.

Fixed-Satellite Service (FSS) Receivers

For the space segment of the FSS, few, if any, sources of potential interference can be identified. Protection from fixed stations is afforded by EIRP and pointing angle restrictions identified in Section 8.2.34 of the NTIA Manual. A method of calculation for determining if coordination is required between geostationary-satellite networks sharing the same frequency bands is given in Appendix 29 of the ITU Radio Regulations.

Coordination of FSS earth stations with the Fixed Service for peacetime applications can be accomplished in a relatively straightforward manner using procedures given in Section 8.4.12 of the NTIA Manual.

Potential interference between the FSS receivers and geostationary METSAT systems has been examined in detail [Mayher and Parlow, 1973] and found to be manageable within existing procedures. Not examined in that study was the possible use of nongeostationary METSATs, for example, a polar-orbiting satellite such as the TIROS-N series currently operated by the National Oceanic and Atmospheric Administration. Operation of such a system in the same band with the FSS could pose potentially difficult coordination problems. Since current allocations do not preclude such possible use, a need exists to examine this interaction in more detail. Such possible use is examined in Section 6.

The most significant issue involving the FSS (and MSS as well) is not a national issue but, rather, an international issue. In 1985, a WARC of the ITU will be convened in Geneva, Switzerland, addressing planning of space radiocommunication services that use the geostationary orbit. The major emphasis of this conference will be on the FSS bands. There is the possibility that the lesser-developed countries will pressure for some form of planning of the FSS in the 7/8 GHz band. NTIA and the Federal Government agencies must be prepared to protect U.S. interests in this matter. This subject is being examined by the IRAC Ad Hoc 178 and is not addressed further in this report.

Mobile-Satellite Service (MSS) Receivers

The MSS is allocated on a primary basis only in the bands 7250-7300 MHz and 7900-8025 MHz that are shared with the FSS (primary basis) and the Fixed Service (secondary basis). Since the MSS and FSS systems are operated in this band as an integral system, the MSS receivers are not further considered here.

Space Research Service Receivers

The Space Research Service in the Earth-to-space direction is shared with the Fixed and the Space Operation (Earth-to-space) Services. Existing EIRP limitation on the Fixed Service, given in Section 5.10.4 of the NTIA Manual, should preclude any significant interference. The limitation of two sites for the Space Operations Service (U.S. Government Footnote G116) and the limitation of Space Research to Goldstone, California, (U.S. National Footnote US252) should limit possible interactions to a manageable level.

In the space-to-Earth direction, both cochannel and adjacent band interactions are possible. Within the band 8.4-8.5 GHz, the Space Research Service shares on a primary basis with the Fixed Service. Due to the typical high sensitivity and tracking antennas used in the Space Research Service, coordination can become difficult. The limited number of sites used by this service, however, makes the interaction manageable. Although very little use is being made of the band 8.4-8.5 GHz by the Fixed Service, further study could be undertaken to address expanded use of the band and potential coordination difficulties with the Space Research Service. Adjacent band interactions may involve radiolocation (especially airborne) in the bands above 8.5 GHz and any secondary use of the MSS in the bands below 8.4 GHz. These interactions appear manageable because of the high level of coordination currently practiced at the Goldstone, California site.

Meteorological-Satellite (METSAT) Service Receivers

Interactions involving the METSAT Service using geostationary satellites have been examined and found to be manageable [Mayher and Parlow, 1973].

However, the possible use of nongeostationary satellites by this service has not been addressed and should be examined as previously indicated.

<u>Earth Exploration-Satellite (EES) Service Receivers</u>

All potential interactions involving the EES Service have been examined and found manageable using existing frequency management procedures [Mayher and Parlow, 1973].

<u>Space Operations Receivers</u>

The space operations allocation in this band is limited to the band 7125-7155 MHz in the Earth-to-space direction by U.S. Government Footnote G116. The use of this service is limited to two sites and shares spectrum allocation only with the Fixed and Space Research Services. No significant problems are anticipated.

SECTION 6

SPECTRUM MANAGEMENT ISSUES

In the evaluation of the various interactions discussed in this assessment, no serious interference problems, among the services allocated for this band, are identified. Procedures are provided in the NTIA Manual, or elsewhere, to mitigate any such serious interference problems. However, several spectrum-management issues did emerge where further study is necessary to make the most effective use of the band and/or to assist in protecting U.S. Federal Government interests. These are summarized as follows:

1. review of existing standards and procedures (including GMF assignment practices) to identify improvements

2. develop additional frequency assignment aids, both manual and automated, for more efficient sharing among fixed stations

3. investigate possible accommodation of METSAT space stations of other than geostationary satellites

4. develop necessary analysis and subsequent proposals and positions to ensure that the U.S. objectives are achieved during the Space WARC-85/88 with regard to the FSS and MSS in this band.

RULES, REGULATIONS, AND PROCEDURES

Detailed technical standards have been adopted for both the terrestrial fixed and space radiocommunication services used in this band. These technical standards are summarized in Section 3 of this report. They have been updated periodically and there are some improvements to the standards applicable to space stations in the Final Acts of the WARC-79. These improvements are incorporated in the current NTIA Manual. In general, these technical standards are adequate to ensure compatible operations among the various services using this band according to state-of-the-art developments and other spectrum management procedures. Other spectrum management procedures include those policies and coordination procedures presented in the NTIA Manual (also outlined in Section 3 of this report) as well as recommended procedures presented in previous studies concerning this band and the various services used in this band (see bibliography). Overall, these policies and procedures provide for compatible operations among the various services used in this band. However, certain improvements to the present standards and procedures have been identified as discussed in Section 4 of this report. The following are spectrum-management issues involving rules, regulations, and procedures: emission standards for digital modulation techniques, channeling plans for Fixed Service operations, and GMF data accuracy.

Emission Limits for Digital Modulation Transmissions

Limits of emission outside the necessary bandwidth for Government fixed operations are specified in Paragraph 5.10.1.6 of the NTIA Manual. Limits are specified for both digital and analog modulation schemes and are summarized in TABLE 3 in this report. For modulation schemes other than digital, the emission limit specified depends on the frequency separation, and for frequency separations greater than 250 percent of the necessary bandwidth, the emission limit depends on the mean output power of the transmitter. The latter is graphically illustrated in a comparison of limits shown in Figure 4. For transmissions employing digital modulation techniques, however, the emission limit is dependent upon the necessary bandwidth as well as the frequency separation outside the necessary bandwidth. Additionally, the limit is bounded by a minimum attenuation of 50 dB with an 80 dB maximum independent of necessary bandwidth or frequency separation. The specified emission limit (summarized in TABLE 3) results, for most applications, (i.e., for necessary bandwidths between 5 and 40 MHz) in a 50 dB attenuation immediately outside the necessary band and 80 dB attenuation before a frequency separation of 100 percent of the necessary bandwidth. There is a footnote to this standard that states this limit may be unduly restrictive to narrowband digital radio systems. Since the limit requires greater attenuation with greater necessary bandwidths, it appears the standard is more restrictive on wideband systems. Additionally, an analog system with a necessary bandwidth of 25 MHz is required to have an attenuation of 25 dB at a frequency separation of 100 percent of the necessary bandwidth. For a digital system with the same necessary bandwidth, an attenuation of 80 dB is required at the same frequency separation. It is recommended that the limit for emissions outside the necessary bandwidth for digital radio systems be investigated for possible improvements based on state-of-the-art developments and present deployments.

Channeling Plans

For most of the frequency assignments in the GMF, channeling plans were used in determining the specific frequencies. The FAA and the BPA utilize established channeling plans for their fixed point-to-point networks. Most other agencies engineer the specific frequencies on a case-by-case basis. The two channeling plans use different center frequencies and channel spacings, and their use in the Pacific Northwest results in inefficient spectrum utilization. The current BPA channeling plan consists of six frequency diversity pairings with center frequencies separated by 30 MHz and a frequency range of 7545-8385 MHz. The FAA plans, however, are designed for the RML configuration of six frequencies (i.e., four in one direction and two in the other) per link with center frequency separations of 25 MHz. These FAA plans have frequency ranges of 7125-7725 and 7750-8400 MHz. The present BPA frequency plan excludes frequencies in the two satellite subbands, whereas this is not necessarily the case for the older FAA frequency plans.

A potential problem area is where these two plans are used in the same area. Since these two plans have different center frequency spacings, frequency separations of 5 MHz between the two systems are possible. This condition can be more of an electomagnetic compatibility problem than when the two systems are operating on the same frequency [Hurt and Crandall, 1980]. Additionally, the utilization of a different frequency plan, developed uniquely for one system and not the other, leads to inefficient use of the radio spectrum. The frequency plan used on an FAA link may use frequencies that would deny the use of any standard frequency diversity pairings on the BPA plan. In the study to reaccommodate certain BPA links, which was part of this overall study and is presented as APPENDIX B of this report, this was found in several instances.

Whereas the use of channeling plans can be advantageous in many respects, it is not necessarily the most efficient method. A goal in the spectrum management process is to develop procedures that are simple to administer, while at the same time efficient and economical to accommodate the various requirements of band users. The use of a channeling plan can serve as an aid in achieving this goal. Conversely, the use of channeling plans that are not compatible with each other can make the spectrum management process harder than necessary and the result is even less efficient use of the spectrum. Therefore, it is recommended that the development of a uniform channeling plan be investigated for the various fixed systems using this band. This channeling plan would be used by all agencies and would incorporate requirements for frequency diversity and one-way radar information, as well as providing standard transmit/receive separations.

GMF Data Accuracy

Spectrum management processes can be only as good as the information used. One main source of data for many coordination procedures, both manual and automated, is the GMF. During this investigation, and in the BPA reaccommodation study in particular, many GMF data fields were found to be inaccurate. These inaccuracies ranged from site location parameters (e.g., site name, latitude, longitude, etc.) to equipment parameters (e.g., necessary bandwidth, equipment nomenclature, etc.). The site coordinate errors were the most prevalent. This is most probably due to the number of data fields in this parameter and the fact that an error is not obvious unless a geographic plot is made using the GMF data information. Since the site location is a very important parameter (it is used in all coordination procedures, especially those automated coordination procedures where erroneous input data would be less likely to be detected), it is highly recommended that each agency obtain geographic plots of their frequency assignments during the normal five-year review to ensure their proper location is listed in the GMF and to correct obvious errors in the GMF as soon as possible.

Frequency Assignment Aids

New assignments proposed by a Federal agency are reviewed and coordinated within the FAS of the IRAC to identify potential frequency conflicts with existing stations. Several aids, both automated and manual, are available to frequency managers and analysts to assist in this process. Two of the most widely recognized techniques for choosing and/or verifying frequencies for fixed LOS networks are briefly discussed here.

EIA Bulletin 10-C. For coordination among fixed microwave systems employing FDM/FM, the EIA in its Bulletin 10-C [EIA, 1976] has developed a detailed coordination procedure that provides techniques for calculating the C/I for acceptable performance of a link based on a given level of interference power in a single voice channel. This procedure is recognized and is used throughout much of the microwave industry. The results produced using this procedure are somewhat conservative; therefore, the systems designed using this method will have a high probability of no interference problems.

Microwave Frequency Assignment Model. An automated assignment aid called the Point-to-Point Microwave Frequency Assignment and Verification Model [Haseltine, 1974] was developed for the Defense Communications Agency (DCA) for their continuing requirement to recommend frequencies for new fixed networks or modifications to existing ones. The model is an automated method of assigning and verifying microwave link frequencies for a point-to-point fixed network. It is capable of handling large numbers of transmitter/receiver interactions using a large environment file such as the GMF as input. For each possible transmitter/receiver interaction, the model calculates an INR and compares this with a predetermined threshold. Only those interactions exceeding this threshold will be printed as output. Required inputs from an interface file include site locations, link descriptions, bandwidths, transmitter power, and antenna size. User inputs include equipment characteristics, interference threshold criteria, and receiver noise thresholds. In the frequency assignment mode, a list of available frequencies, or a frequency band, is required. In the model development, certain assumptions were made regarding the antenna sidelobes, and the cosite, intersite, and adjacent-channel couplings. These assumptions were on the conservative side and, along with the propagation loss, tend to calculate very conservative INR values. The propagation loss used in INR calculations is based on free-space propagation with no consideration of terrain blockage.

The limitations of this model include, in addition to the propagation loss used, time-consuming calculations of the antenna patterns, overly complicated and time-consuming off-frequency rejection calculations, and inaccessibility to required selected inputs for modifications. Two of the most severe limitations of this program are not really part of the model, but rather part of the environment file used (i.e., the GMF) and the program's susceptibility to inaccurate entries. In particular, an erroneous site location affects the antenna coupling calculation, the propagation loss, and possibly the cross-polarization mismatch calculations. A cosite problem could be considered an intersite interaction and vice versa. Since these calculations are automated, error detection is not readily available. Effective spectrum management requires that the data used be complete and accurate and its use in automated procedures illustrates another example of its importance. In spite of the limitations, however, this model was used in the BPA reaccommodation study and proved to be very useful in culling those transmitter/receiver interactions that did not need further consideration. It is recommended that this model be used as a core for further study to develop an improved frequency assignment and verification model for NTIA. See APPENDIX C for an examination of overall NTIA needs for automated assignment aids.

SHARING BETWEEN THE METEOROLOGICAL-SATELLITE AND FIXED-SATELLITE SERVICES

Geostationary Systems

The frequency allocation in the 7/8 GHz region for the METSAT Service was originally adopted to provide for a follow-on system to the present Geostationary Operational Environmental Satellite (GOES) System. This GOES-II was expected to require greater bandwidth than was available in the 1670-1710 MHz band. The sharing of the proposed GOES-II with the FSS was examined in detail by Parlow, et al. [1974]. Although the GOES-II is yet to be implemented, that analysis, which showed the interaction to be manageable using existing procedures, is still valid.

Nongeostationary Systems

The allocation to the METSAT Service in this band makes no limitation as to whether the system is to be geostationary or nongeostationary. An example of the latter system would be the TIROS-N series operated in polar orbit using frequencies in the 1670-1710 MHz band. The possible use of a nongeostationary METSAT in this band has not been examined.

In a typical low orbit METSAT, the orbit inclination will be approximately 90 degrees (near polar orbiting) and sun synchronous. A sun synchronous orbit is one in which the orbit rotates eastward about the polar axis by approximately one degree per day; this, in effect, being the Earth's annual revolution about the sun which provides for consistent illumination throughout the year. The satellite crosses the equator at the same local solar time each day.

With this type of orbit, the satellite will eventually pass over all points of the Earth. Similarly, the satellite will eventually pass within the mainbeam of all earth stations pointing towards the geostationary orbit. The percentage of time a given polar orbiting satellite will pass within the earth station's mainbeam, on a long-term basis, can be estimated given the specific orbital parameters.

When the polar satellite does intercept the mainbeam of an earth station, a clearly unacceptable interference situation will exist. Since both the METSAT and FSS are governed by the same PFD limits, the signal at the Earth's surface will be of the same order of magnitude. The resulting C/I will be on the order of 0 dB that will likely result in some loss of signal.

- Given the above factors, it is unlikely that sharing between the FSS and nongeostationary METSAT system using present allocations would be successful.

However, consider reversing of the allocation for the METSAT up-path and down-path. In this case, the only interactions possible with the FSS are between space stations and between earth stations. The former interaction between geostationary and orbiting satellites has been examined in detail by Parlow and Mayher [1973] and found to present no interference problems even under worst-case assumptions. Interactions between earth stations of the FSS and METSAT Services can be coordinated adequately using existing procedures in Section 8.4.13 of the NTIA Manual. Additionally, it should be noted that an up-path for polar orbiting satellites in the METSAT Service in the 7125-8500 MHz band is not required. This capability will remain at S-band because an up-path high volume link for polar orbital satellites is not needed.

In providing for reversal of the allocated up-path and down-path of the METSAT Service, the existing allocation in the 8025-8400 MHz band for the EES space-to-Earth Service is noted. Since the METSAT Service is a subcategory of the EES, the METSAT Service in the space-to-Earth direction could be authorized and operated under the EES allocation. For the up-path, two options appear feasible, if needed. One would require a reversal of direction on the existing METSAT allocation at 7450-7550 MHz. The other would be to seek a new allocation for the up-path in, for example, the 7750-7900 MHz band where no space systems are allocated. Both options require further study before implementation is considered.

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APPENDIX A

RESULTS OF RSMS MEASUREMENTS OF THE 7125-8500 MHz BAND IN THE SEATTLE, WASHINGTON, AREA

Presented in this appendix are the results of the measurement effort concerning the 7125-8500 MHz band in the Seattle, Washington, area in the summer of 1982. The measurement results are presented in the form of curves of the transmitter emission spectra measured by the RSMS, using the Wideband Search Program. As shown in TABLE 13, measurements were made of four different fixed point-to-point microwave systems: a Navy communication system, a CG VTS, the BPA system, and an FAA RML. Numerous measurements were made of these systems at six sites, which involved specific measurements of the emission spectrum of six different off-the-shelf commercial transmitters. The following is a general discussion of the measurement effort for each of the fixed systems which details the measurement setup, procedure, and results as outlined in the RSMS operations log.

Navy Communication System

The first measurements were made June 21, 1982, at Blyn Mountain (elevation 646 m), located approximately 45 miles northwest of Seattle, Washington. This site is used by both the Navy and the Coast Guard as part of their communication networks. The Navy communication network operating in the 7125-8500 MHz band is a three-link, two-way network connecting Bangor (near Seattle) to Cape Flatterey at the mouth of the Strait of Juan de Fuca. Communications at Blyn Mountain are linked to Bangor and the Navy site of Ramapo. At this site, adjacent to the Navy antenna towers, measurements were made of transmitter emissions in the band 7000 to 8400 MHz using an omnidirectional antenna. These measured spectra are shown in Figure A-1. As experience was gained in this measurement effort, the frequency limits were changed to include the entire 7100-8500 MHz band, and the RSMS parabolic dish antenna was used in all subsequent radiated measurements. Shown in Figure A-1 are detected signals on 19 frequencies. The decrease in the noise floor at 8000 MHz in this figure and all subsequent wideband scans, is due to a switching circuit in the RSMS. Using an omnidirectional antenna, 14 Coast Guard frequencies (both transmitted to and from this site) were detected as well as the four transmit and receive frequencies of the Navy system at this site. One signal, detected at 7860 MHz, could not be found in the GMF for this area. Also absent from these measurements were three GMF frequencies that were expected to be detected. The three undetected frequencies (8155, 8199.1 and 8228.7 MHz) were expected from the Coast Guard frequency assignment serial numbers CG 750375, CG 750378, and CG 750377. Also suspect is CG 750374 because it is similar to the other three assignments, but its frequency of 8475 MHz exceeded the upper limit of this particular measurement effort.

From this site, the Navy transmits to Ramapo on 7375 MHz and receives on 7565 MHz. The transmitted frequency to Bangor is 7610 MHz and the received frequency is 7415 MHz. The necessary bandwidth listed in the GMF for these assignments is 12 MHz. Selected measurements were made with smaller scans (i.e., 40 MHz) to determine the emission spectrum of the transmitters at Blyn Mountain on June 21, 1982, and the transmitter at Bangor on August 26, 1982. The equipment used on both links is the Motorola MR300. The emission spectra of the transmitters at Blyn Mountain were determined by hard-line measurements (i.e., measured by connecting a coaxial cable directly between the transmitter output and the RSMS) using a 40 MHz scan starting 20 MHz below the two center frequencies, with the equipment under normal loading conditions. These emission spectra are shown in Figures A-2 and A-3. As can be seen in Figure A-2, which is representative of several scans, the transmitter under normal traffic has a measured bandwidth of 12 MHz at approximately 55 dB down from its peak amplitude and occupies a bandwidth of 20 MHz near the measurement noise floor. The emission spectrum illustrated in Figure A-3 shows a measured bandwidth of 12 MHz at approximately 65 dB down from its peak amplitude. At Bangor, a band scan was made with the RSMS parabolic dish aimed at the Bangor-Blyn Mountain antenna. This scan, shown in Figure A-4, shows the transmitted frequency at 7415 MHz. Also illustrated is an unidentified signal at a center frequency of 7694 MHz. The emission spectrum of the transmitter at Bangor over a scan of 20 MHz is shown in Figure A-5. This emission spectrum was determined by a radiated measurement (i.e., by aiming the RSMS dish at the transmitter antenna), and the measured bandwidth is approximately 12 MHz at the measurement noise floor (i.e., 60 dB down).

Coast Guard Vessel Traffic System

The next measurements made were of the Coast Guard VTS at Blyn Mountain. The VTS relays remote video data on surface vessel traffic on the Strait of Juan de Fuca to the vessel traffic center (VTC) in Seattle. There are seven remote radars feeding information to the VTC on seven separate one-way 40 MHz channels. The Coast Guard station at Blyn Mountain is at the point in the trunk which receives information from all seven of the remote radars and retransmits the seven channels to the site at Bremerton, which in turn retransmits to the VTC in Seattle.

Measurements were made on this system August 10 through August 12, 1982. Six band scans were made with the RSMS dish directed at a cluster of antennas on the CG tower. A representative band scan is shown in Figure A-6. With the RSMS antenna pointing at the middle cluster of antennas on the CG tower, 11 signals with significant amplitude were detected. Nine of these were on CG frequencies and the other two were the Navy transmitted frequencies adjacent to this site. There was one signal on the frequency of 7650 MHz which could not be identified. Smaller wideband scans were then made on the seven CG frequencies to Bremerton. The transmitters at this site are Farinon Electric FV8F. Figures A-7 through A-13 show measured 40 MHz wide scans of the emission spectra of this equipment with the RSMS aimed at the antenna used on this link (i.e., radiated measurements). These measurements were then repeated with RSMS directly connected to the outputs (i.e., hard-lined) of the respective transmitters. Larger 60 MHz scans were made due to the increase in the measurements dynamic range obtained by directly connecting the equipment. These hard-lined emission spectra are shown on Figures A-14 through A-20.

Comparisons between the radiated and hard-lined measurement results showed the same bandwidths for the same reference level (i.e., same number of dB down). The main difference in the two measurement techniques is the lower measurement noise floor of the hard-lined measurements. From the radiated measurements of this system, it was found that the emission bandwidth is about 22 MHz at the measurement noise floor (e.g., between 35 and 45 dB down). Whereas from the hard-lined measurements, the emission bandwidth is about 50 MHz at 80 dB down. All of these CG measurements were made under normal loading conditions.

BPA System

Measurements were made of the BPA system at two sites during the week of August 16, 1982. The BPA microwave point-to-point communication system is used to interconnect the various generators, substations, and users for monitoring and control of the BPA power transmission system. The system consists predominantly of 600-channel FDM/FM commercial equipment. At the two BPA measurement sites of Tacoma and Squak Mountain, General Electric TRS696C and Collins MW508C radios are used. To obtain high reliability in the system, frequency diversity is used throughout the system, in addition to using 40 dB design fade margins. Measurements of this system included noise loading the baseband (to simulate transmission under a fully loaded condition) in addition to the previous measurement procedures.

The first BPA measurement site was Tacoma. This site interconnects communications between the BPA sites of Squak Mountain (the other measurement site) and Capital Peak and has a spur link to the Tacoma substation. Band scans were made with the RSMS dish directed at two of the three Tacoma dishes. These band scans are shown in Figures A-21 and A-22. The band scan shown in Figure A-21 was done with the RSMS dish aimed at the Tacoma-Squak Mountain dish. Shown on this scan are signals centered on all six transmitted frequencies from the Tacoma station. As expected, the two signals transmitted on the frequencies to Squak Mountain have greater amplitudes. The scan shown in Figure A-22 was done with the RSMS dish aimed at the Tacoma-Tacoma Sub-station dish. All six transmitted signals are also shown to be present with the two signals on frequencies to the Tacoma substation having the greater amplitudes. Additionally, a signal at a receive frequency from the Tacoma substation was detected in this scan (i.e., at 8065 MHz). Smaller 20 MHz scans (both radiated and hard-lined) were made centered on the six transmitted frequencies. The radiated measurements of these signals are shown in Figure A-23 through A-28. Shown in Figures A-23 through A-26 are emission spectra of General Electric TRS696C transmitters that are used on the Tacoma-Squak Mountain and Tacoma-Capital Peak links. As can be seen in these figures, this equipment employs pilot carriers at ± 8.5 MHz and occupies typically 20 MHz of spectrum at the measurement noise floor. Figures A-27 and A-28 show the emission spectra of Collins MW508D transmitters that are used on the Tacoma-Tacoma substation link. Pilot carriers at ± 3.2 MHz are utilized by this equipment that is within the mainbeam of the transmitter emission and cannot readily be discerned by these curves.

Typically, these Collins equipments were found to use bandwidths less than 20 MHz. All six of these transmitters were then measured again with the RSMS tied directly to the output of the measured equipment. These resulting emission spectra are shown in Figures A-29 through A-34. The main difference between the two measurement techniques (i.e., hard-lined vs. radiated) was an increase in dynamic range and lower measurement noise floors in the hard-lined measurements.

The emission bandwidths at equal attenuations of the peak amplitude, however, are equal.

The next measurements made were determined at Squak Mountain that links with Tacoma and six other BPA sites. A similar procedure was followed at this site with the addition of measuring emission spectra with the baseband noise loaded to simulate traffic under a fully loaded condition (i.e., all available baseband channels used). At this site, two band scans were made, one with the RSMS dish aimed at the Squak Mountain-Tacoma dish and one with the RSMS dish aimed at the Squak Mountain-Covington dish. These scans are shown in Figures A-35 and A-36, respectively. Detected at the Squak Mountain-Tacoma dish were 16 signals with significant amplitudes. Thirteen were the transmit frequencies (one nondiversity link) used on Squak Mountain and three were receive frequencies. The two signals transmitted on frequencies to Tacoma were of greatest amplitudes and the amplitudes of the other transmitters, as well as the three receive signals, were dependent mainly upon the relative antenna orientation to the RSMS antenna mainbeam. Similarly, detected at the Squak Mountain-Covington dish were 12 signals with significant amplitudes. One expected transmitter signal at 7965 MHz was only 2 dB above the measurement noise floors, thus undetectable as shown in Figure A-36 that is composed of seven smaller (200 MHz wide) scans. Importantly, no signals were detected at the site on frequencies other than those listed in the GMF as BPA assignments for this site.

Smaller scans were then made of the four transmitters to Tacoma and Covington. Each transmitter was measured four times, twice radiated (with normal traffic and noise loaded) and twice hard-lined (normal and loaded). The radiated measurements were done over 40 MHz scans and the hard-lined measurements were done over 20-25 MHz scans. Figures A-37 through A-40 show the emission spectrum of the transmitter at Squak Mountain (GE TRS696C) to Tacoma at 7340 MHz determined under the four different measurement techniques. Figures A-41 through A-48 show the emission spectrum of the other diversity transmitter to Tacoma at 7685 MHz similarly determined. Figures A-45 through A-52 show the emission spectra of the two transmitters (both Collins MW508C's) to Covington.

The comparison between radiated and hard-lined measurement techniques shows the same results as before. The hard-lined technique yields greater dynamic range (i.e., the noise floor is lower and more of the emission spectrum can be determined) but the bandwith determinations are the same. Similarly, comparing the measurements of equipment under normal loading with those under a fully loaded condition, yielded no bandwidth difference at the measurement noise floor. With the baseband channels fully loaded, the bandwidth of the mainlobe at the 3 dB and 20 dB down points is greater, however.

The pilot carriers were not included in the noise loaded measurements of the GE TRS696C. This was done in order to prevent interfering with the diversity channel operations during the measurement effort. This was taken into account in the bandwidth comparisons previously discussed. Additionally, measurements were made on one channel with normal traffic with the other diversity channel loaded. The resulting emission spectrum was identical to the scan made with both channels normally loaded. Therefore, the loading of one channel does not affect the emission spectrum of the diversity channel. In general, these transmitters were found to occupy a bandwidth of 20-22 MHz at the measurement noise floor, and the GE TRS696 transmitter with the 8.5 MHz pilot carriers occupied greater bandwidths than the COL MW508C.

<u>FAA Radar Microwave Link (RML)</u>

The next system measured was the FAA RML at two sites near Seattle on August 23 and 24, 1982. The RML system provides information of en-route air traffic to control centers at major airports. These networks use six separate RF channels per hop. Four channels (three active and one spare) are used to transmit radar, beacon, and control information from remote radar sites to the indicator site located at the ATCC. Two channels (one active and one spare) are used in the reverse direction for control and monitoring. Measurements were made at the indicator site at Auburn, Washington, and a connecting site at Madrona. The equipments located at these sites are Collins 552A-5's that are also known as RML-4's. There are four remote radar links coming into Auburn (two of these use the same path in this portion of the system). Therefore, there are eight indicator-to-remote radar channels or eight transmitters at this indicator site. A band scan was made with the RSMS antenna aimed at the Auburn-Kent antenna. This scan is shown in Figure A-53. As can be seen, the frequencies used on this link are at 7135 and 7495 MHz. Smaller scans (20 MHz wide) were made of all eight transmitted signals at this site. All of these measurements were performed with the RSMS antenna directed toward the respective antenna reflectors. Periscope-type antennas are utilized on this system. Figures A-54 and A-56 show the two transmitted signals to Kent. As seen, these transmissions include pilot carriers at $\pm$ 5 MHz. The signal shown in Figure A-55 is a carrier only, since this channel is used as a spare. The emission spectrum shown in Figure A-56 was measured with the baseband of this spare channel noise loaded. As can be seen, the bandwidth at the measurement noise floor does not exceed the bandwidth necessary for the pilot carriers. Shown in Figures A-57 and A-60 are the four transmitters to the Madrona site, and the two transmitters to the Grass Mountain site are shown in Figures A-61 and A-62. All six of these transmitters, especially the Auburn-Madrona transmitter at 7515 MHz (Figure A-57), appear to exceed the frequency tolerance limit for fixed operations in this band. At 50 ppm, the transmitted frequency should not exceed a deviation of 0.356 to 0.425 MHz (depending upon the assigned frequency) from the assigned frequency. The transmitted frequency on Figure A-57 is 3.4 MHz higher than the assigned frequency. In general, though these emission spectra occupy an 11 MHz bandwidth at the measurement noise floor, the necessary bandwidth listed in the GMF is 20 MHz.

Measurements were then made at the FAA site at Madrona. Linked to Madrona are the indicator site at Auburn and the FAA site at Tenino. Since two remote radar links use the same path at this point in the network, four RF channels are used in the Madrona-Auburn link and eight RF channels are used in the Madrona-Tenino link. A band scan was made with the RSMS antenna aimed at the Madrona-Auburn antenna. This band scan is shown in Figure A-63, that illustrates all 12 transmitted signals from this site. Smaller 30 MHz scans were then made of these 12 signals. Figures A-64 through A-65 show the emission spectra of the four transmitters used in the Madrona-Tenino link. The emission spectra of the transmitters used in the Madrona-Auburn link are shown in Figures A-68 through

A-75. The bandwidth of the transmitters to Tenino at the measurement noise floor is shown to be approximately 11 MHz. Whereas, the bandwidth of the transmitters to Auburn at the noise floor (i.e., 60 dB from the peak amplitude) is about 20 MHz. This is due to the increase in the dynamic range the RSMS was able to obtain with different antenna orientations. The bandwidths of these transmitters are still on the order of 11 to 12 MHz at about 40 dB down. Again, the measurements of these transmitters show the transmitted frequencies exceeding the allowed frequency tolerance from the assigned frequency in most cases.

Summary

In general, the measurement results on these fixed systems agreed favorably with listings in the GMF. Information was gained on the actual occupied bandwidth of these transmitters, as well as shapes and falloffs of the mainlobes of their emission spectrum. Additionally, measurement techniques were tested, and experience gained in this measurement effort will assist future measurement efforts in time and improved results both in the actual testing and the presentation of data. In particular, the following conclusions were drawn from the results of this measurement effort.

1. There is essentially no difference in measured bandwidths of the emission spectra determined by radiated or hard-line connections.

2. Comparing measurements of equipment under normal loading with those under a fully loaded condition, yields no bandwidth difference at the measurement noise floor. The bandwidth of the mainlobe is greater at the 3 dB points and the falloff is sharper, but the occupied bandwidth at the noise floor is essentially the same.

3. Experience gained from the BPA reaccommodation project and this measurement effort proved RSMS measurements are useful in identifying vacant frequencies at a site, but cannot, by itself, determine the whole scenario necessary for frequency assignment. The occupied spectrum at a site can be determined, but the effect of a proposed transmitter on the environment cannot be readily determined.

4. Examination of equipment and conversation with various field personnel revealed that it is standard practice to use waveguide filters and isolators between the transmit and receive equipment and the waveguides. There exists certain frequency assignment rules used by frequency managers regarding intermodulation and spurious responses. One of these is to never assign a transmit-receive separation equal to the equipment IF. With the use of these filters and isolators, this problem is significantly reduced. Therefore, these rules should be investigated for the cases where isolators and filters are used.

5. Transmissions of equipment utilizing 8.5 MHz pilot carriers consume more spectrum than those utilizing 3.2 MHz pilot carriers, although both systems have the same information capacity.

6. Most systems occupy less spectrum than the listed necessary bandwidth in the GMF. Although the necessary bandwidth listings may be based more on system capacity and future plans rather than present use, it appears that some of these listings exceed system capacity. The agencies concerned should investigate this matter to correct erroneous listings as well as apply for correct necessary bandwidth listings for future assignments.

7. Several erroneous transmitter and receiver locations and location names exist in the FAA assignments in the Seattle area.

8. Some FAA transmitters appear to operate on frequencies that exceed the frequency tolerance limit for fixed operations in the part of the system measured in the Seattle area.

9. Coast Guard frequency assignments CG 750374, CG 750375, CG 750377, and CG 750378 are listed in the GMF, but no signals were detected on these frequencies at the designated location by the RSMS during this measurement effort.

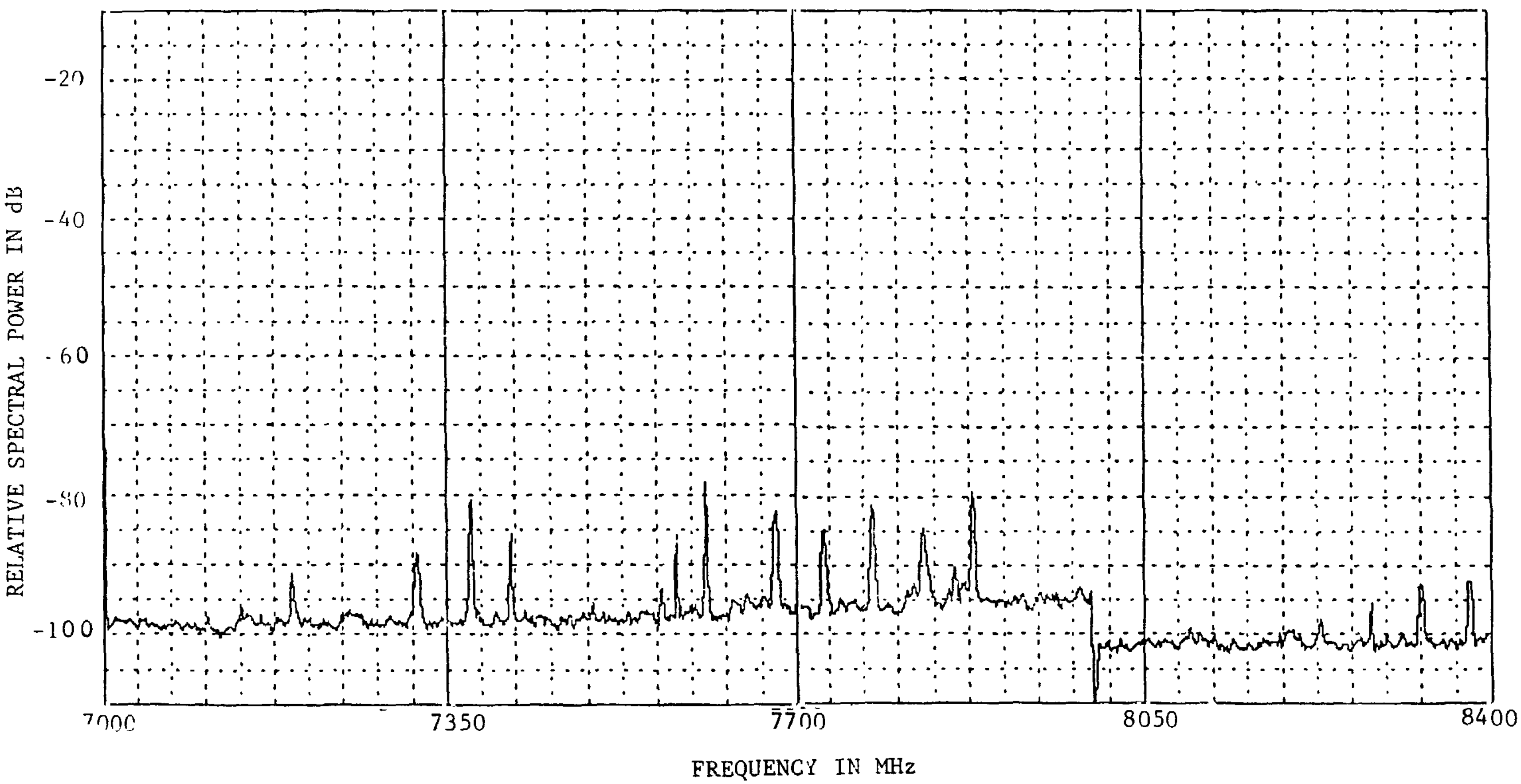


Figure A-1. Band Scan at Blyn Mountain - 7000 to 8400 kHz.

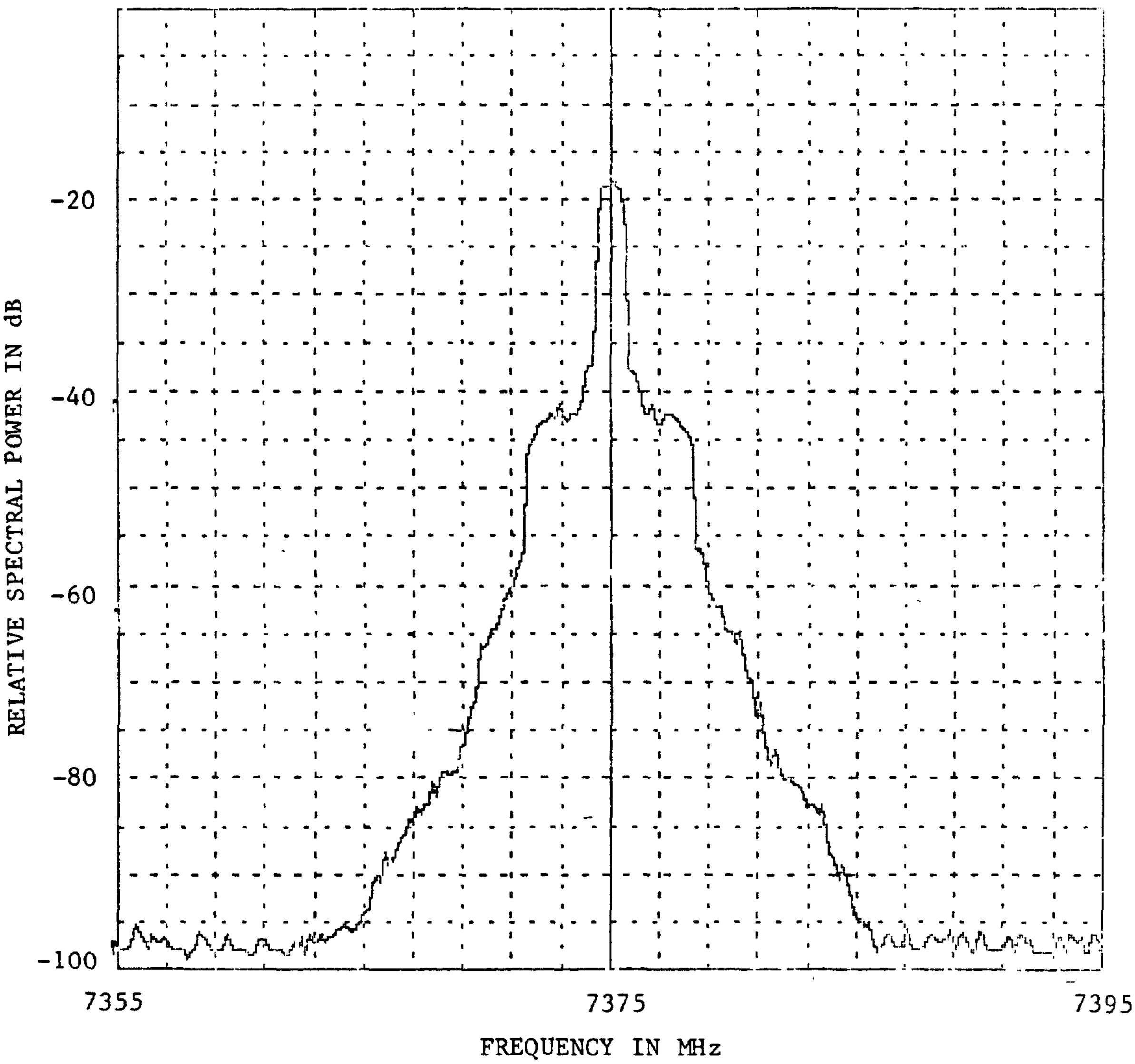


Figure A-2. Emission Spectrum of a Motorola MR300 Transmitter at Blyn Mountain (f_o = 7375 MHz).

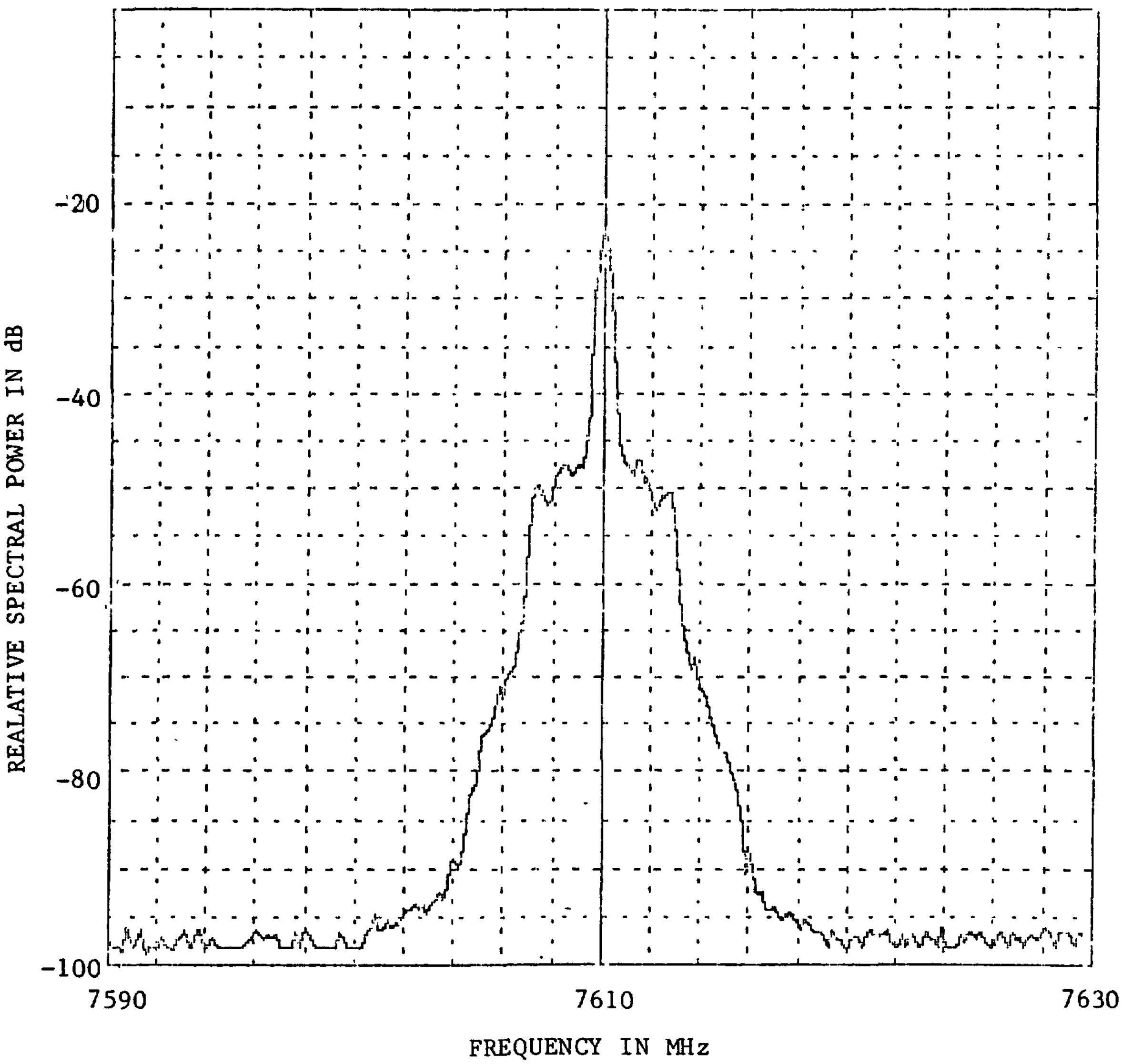


Figure A-3. Emission Spectrum of a Motorola MR300 Transmitter at Blyn Mountain (f_o = 7610 MHz).

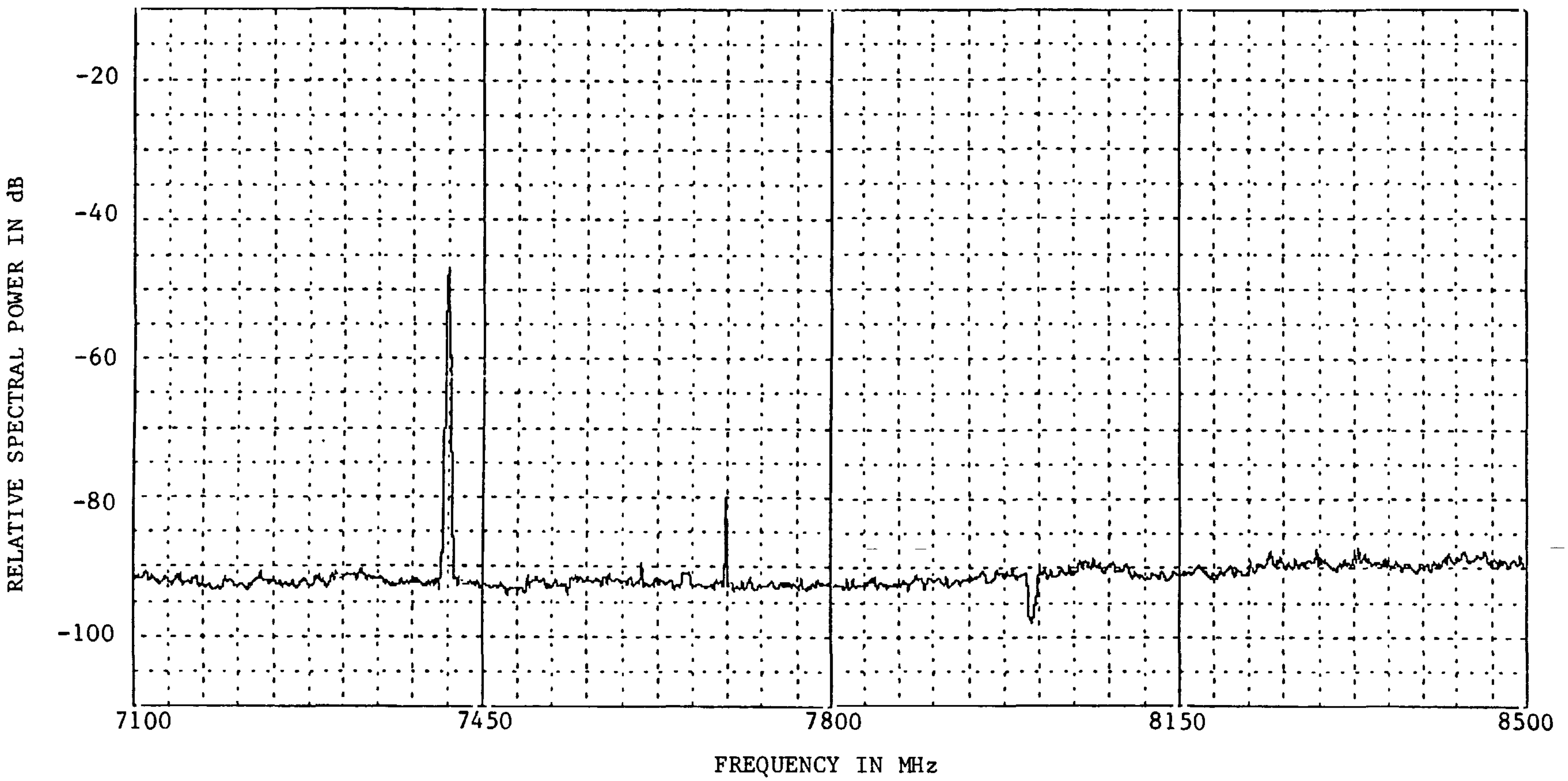


Figure A-4. Band Scan at Bangor - 7100-8500 MHz.

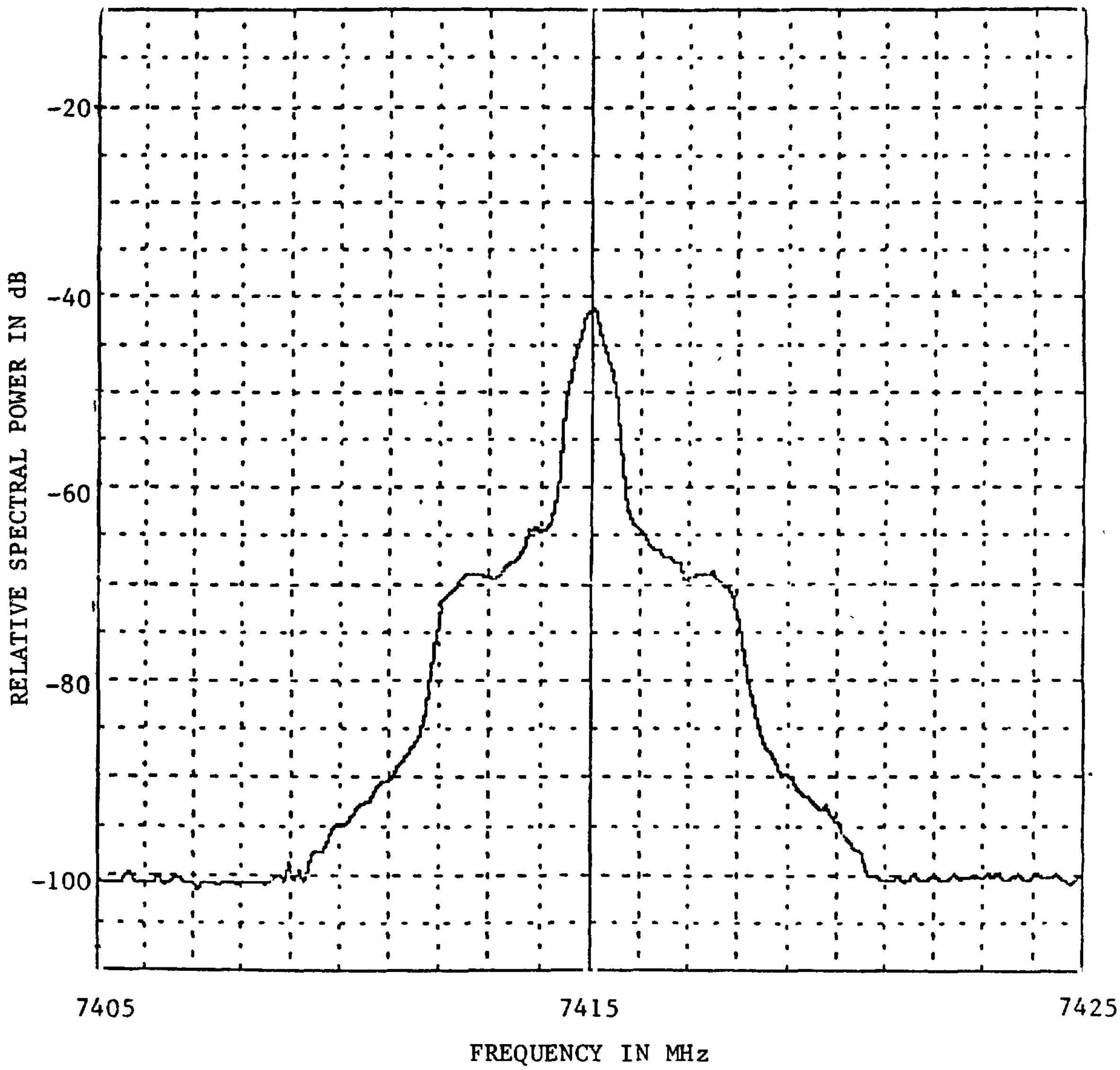


Figure A-5. Emission Spectrum of a Motorola MR300 Transmitter at Bangor, Washington (f_o = 7415 MHz).

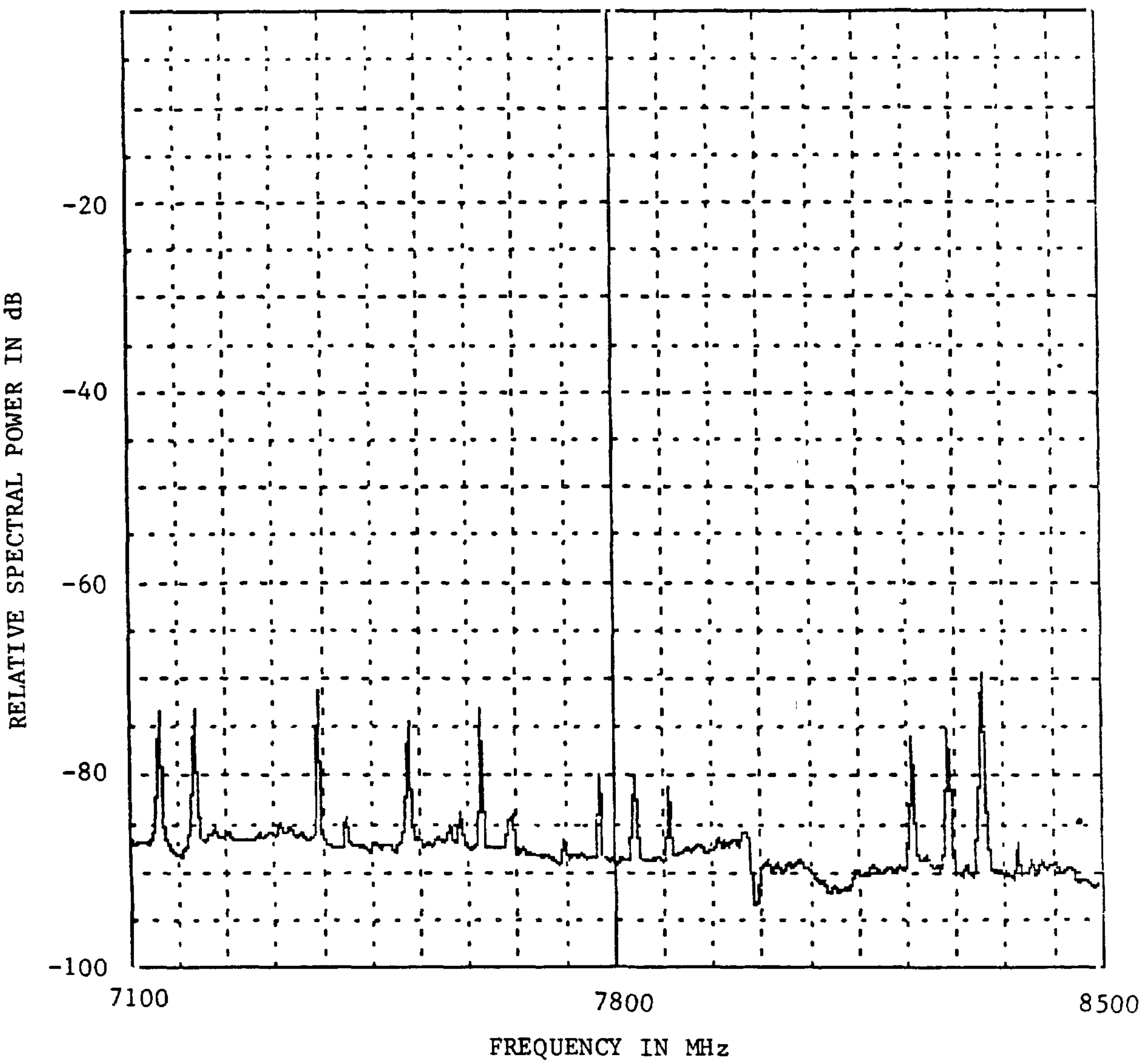


Figure A-6. Band Scan of the CG Station at Blyn Mountain-
7100-8500 MHz.

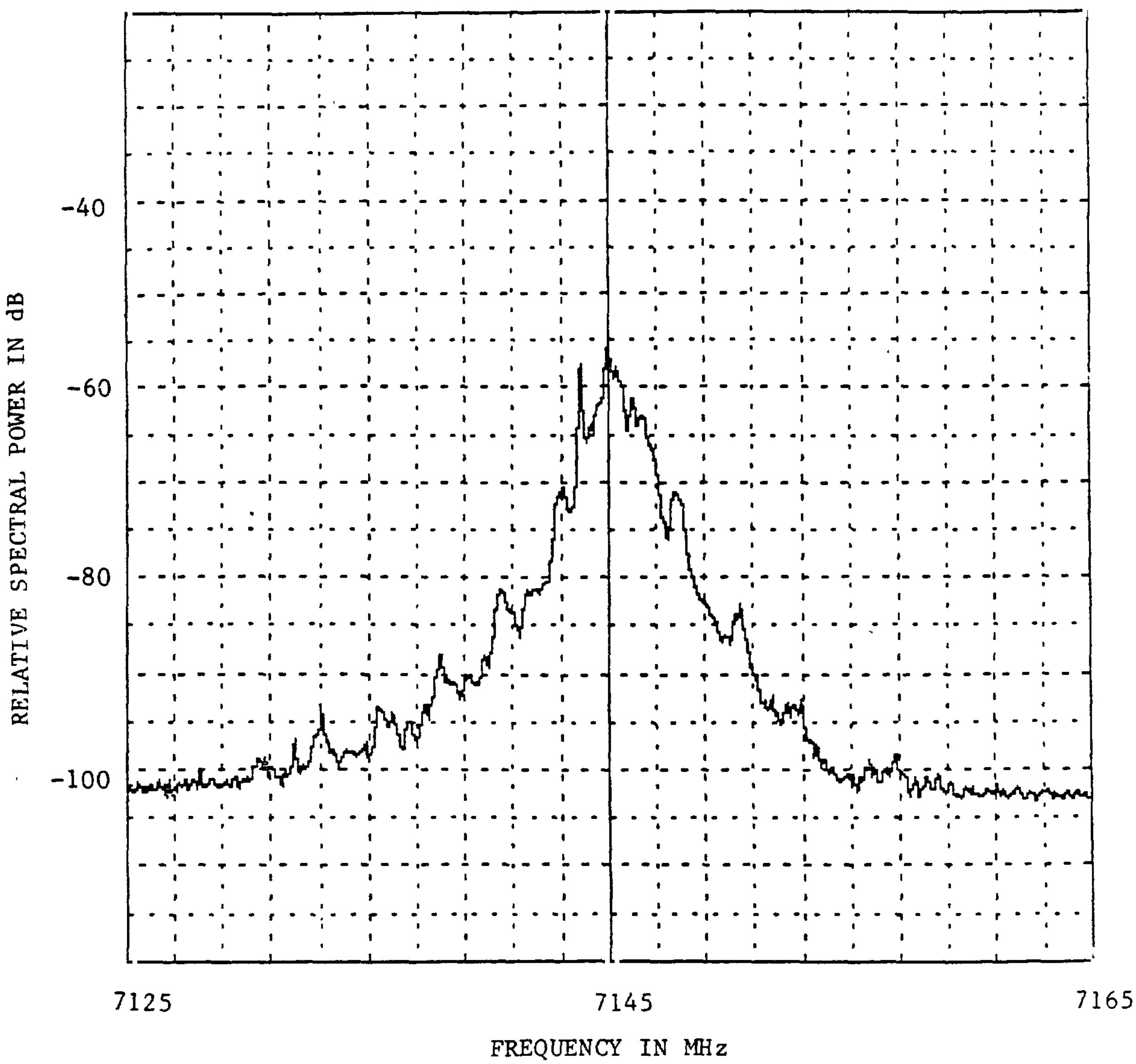


Figure A-7. Emission Spectrum of a Farinon Electric FV8F (f_o = 7145 MHz, Radiated).

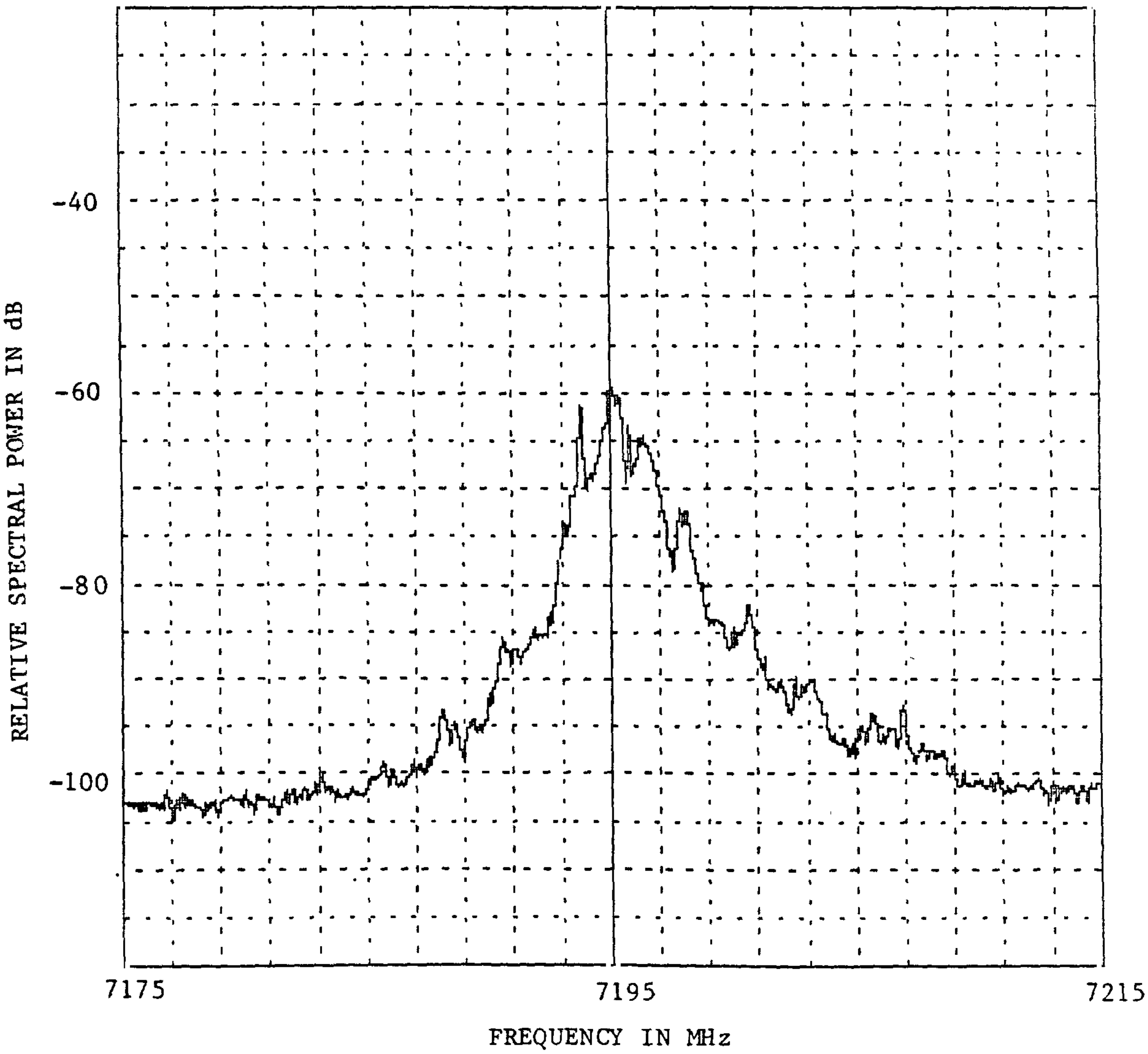


Figure A-8. Emission Spectrum of a Farinon Electric FV8F (f_o = 7195 MHz, Radiated).

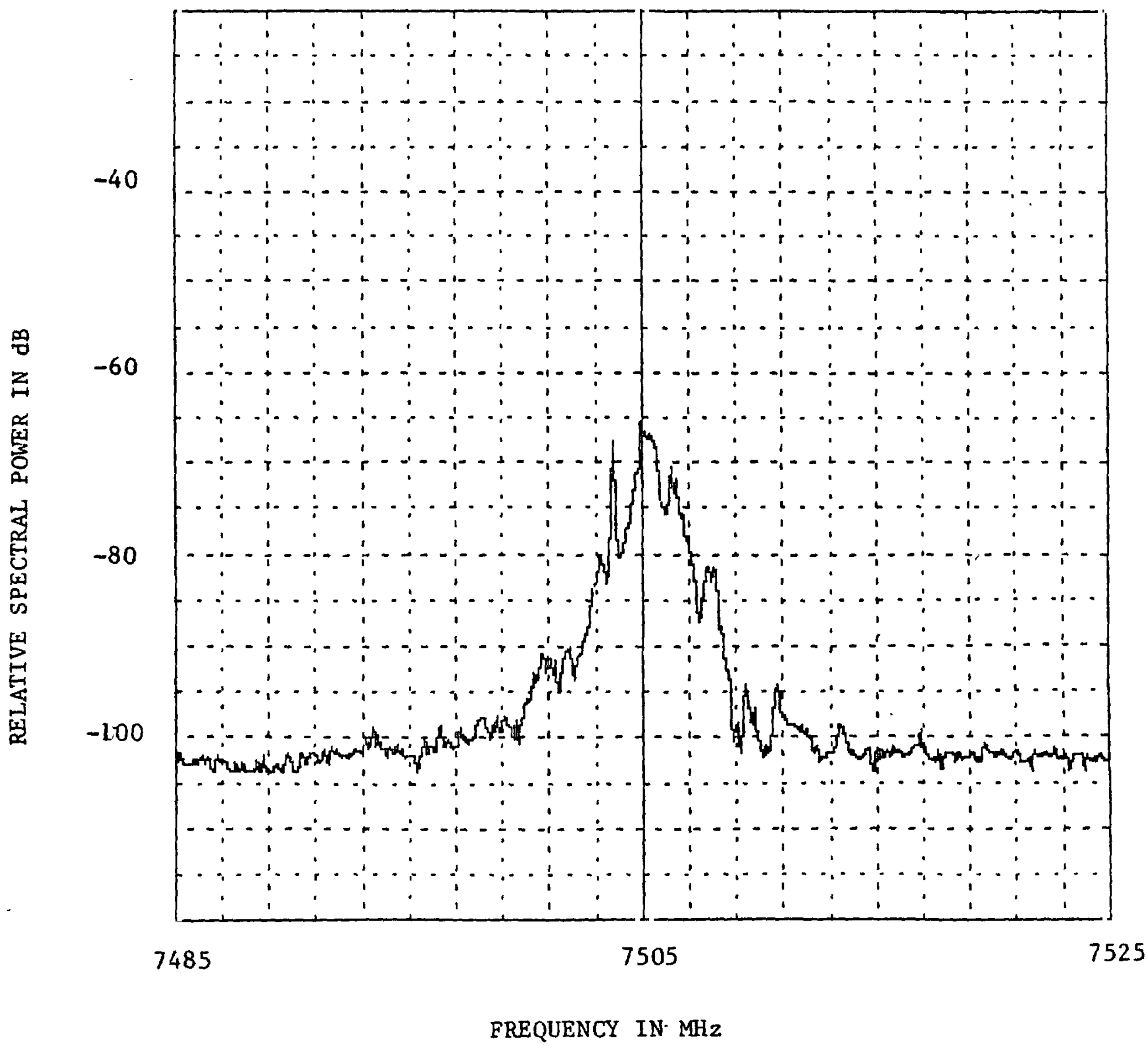


Figure A-9. Emission Spectrum of a Farinon Electric FV8F, (f_o=7505 MHz, Radiated).

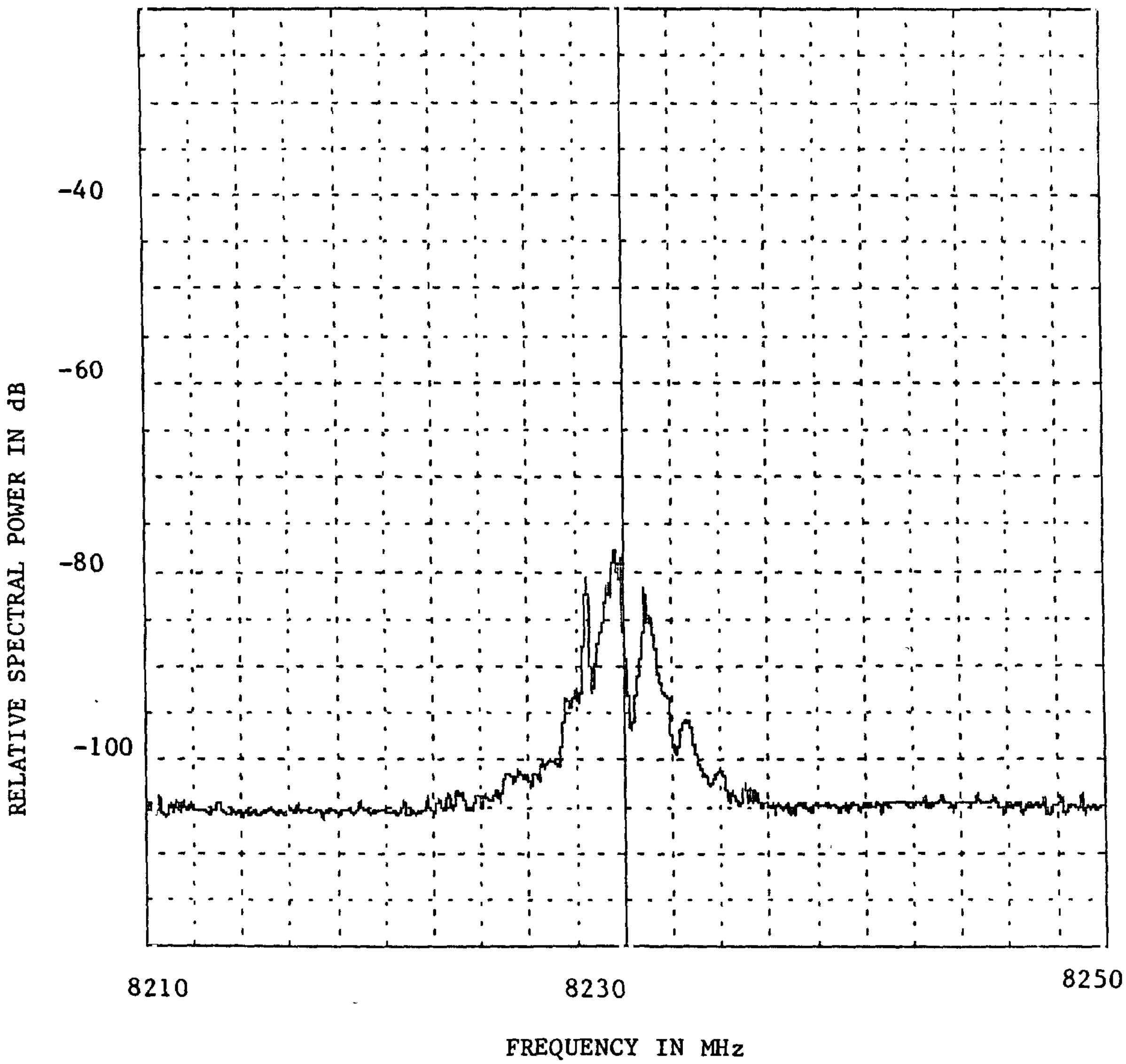


Figure A-10. Emission Spectrum of a Farinon Electric FV8F, (f_o=8230 MHz, Radiated).

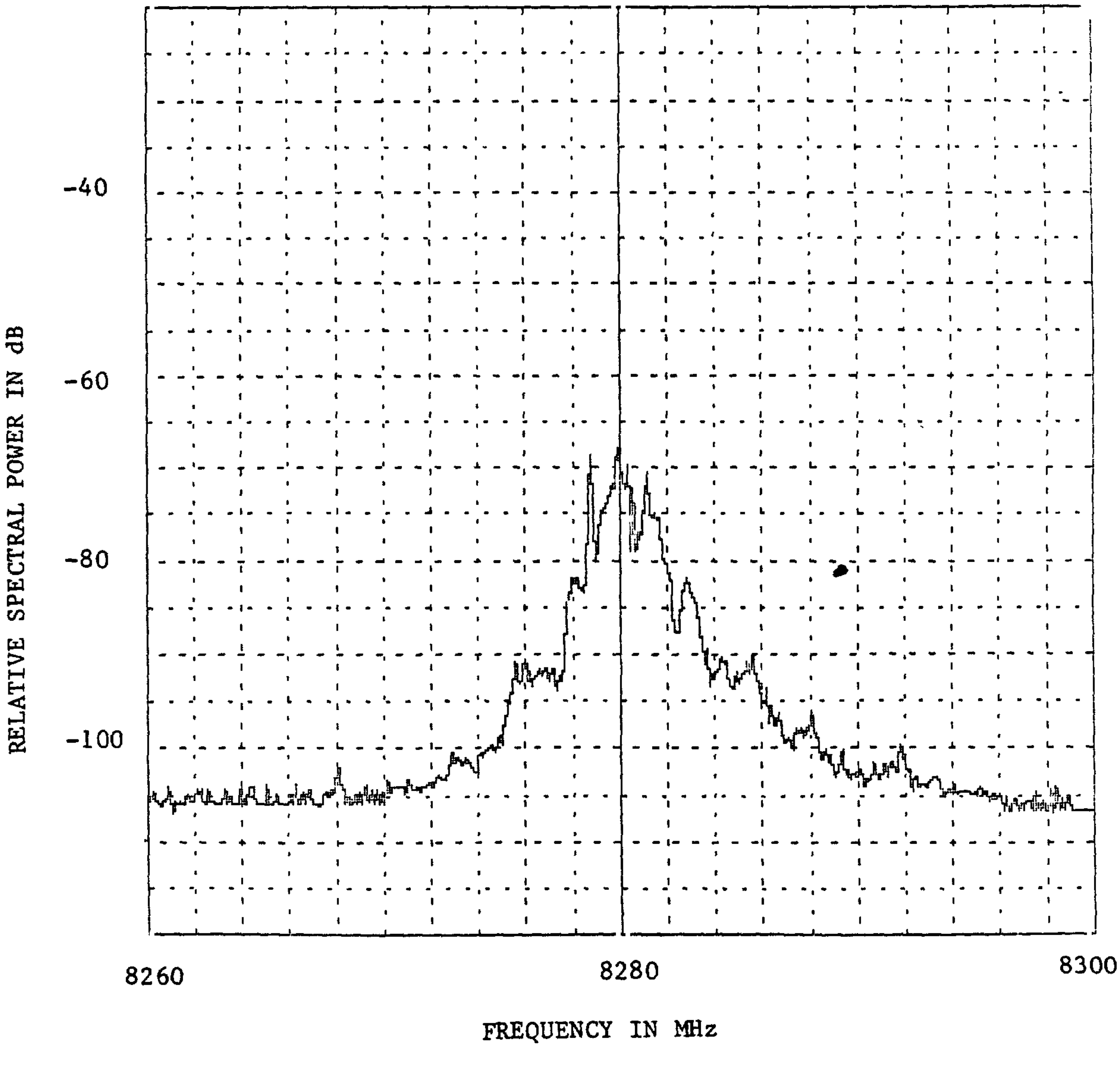
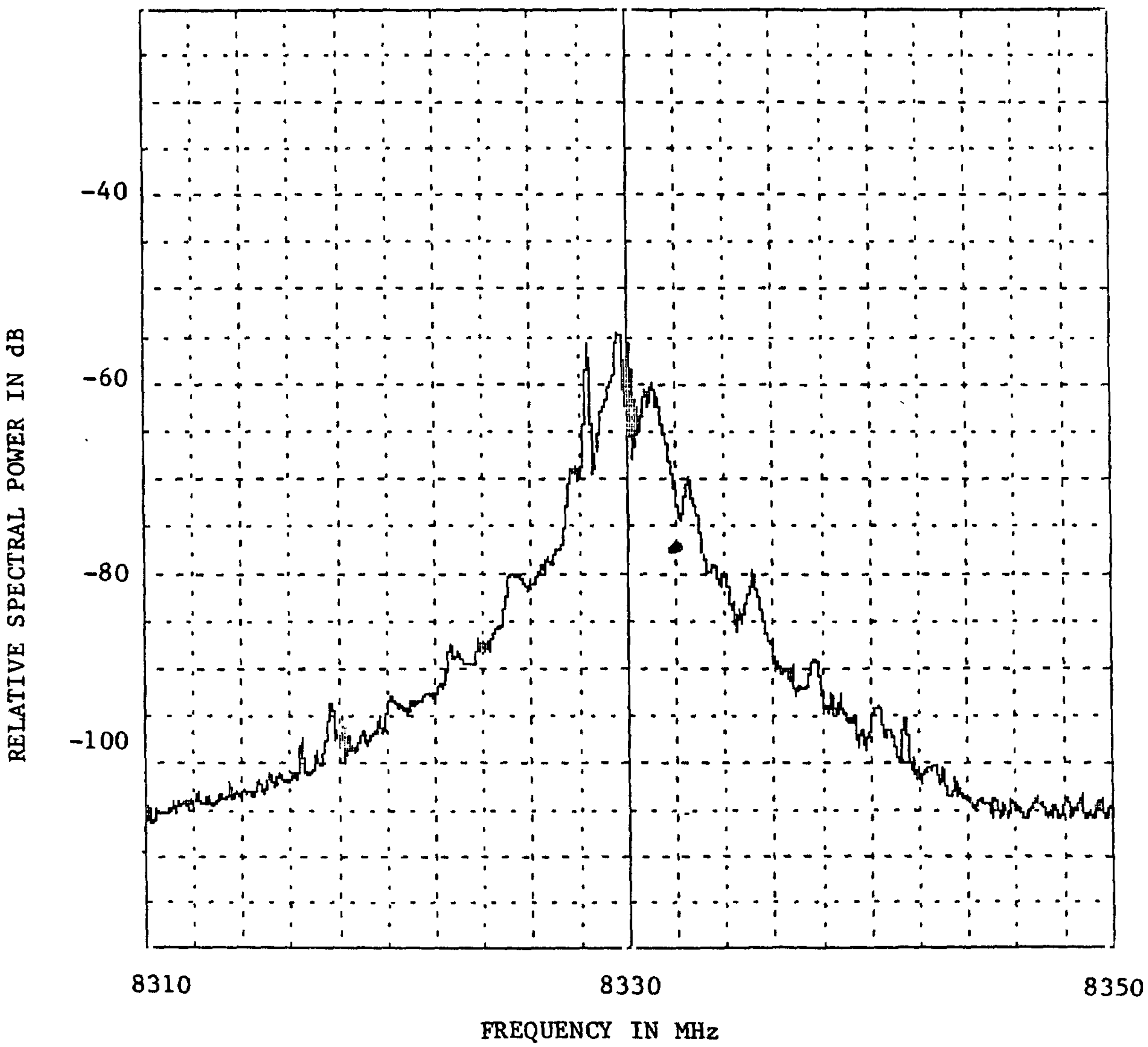


Figure A-11. Emission Spectrum of a Farinon Electric FV8F, (f_o = 8280 MHz, Radiated).



A-12. Emission Spectrum of a Farinon Electric FV8F, (f_o = 8330 MHz, Radiated).

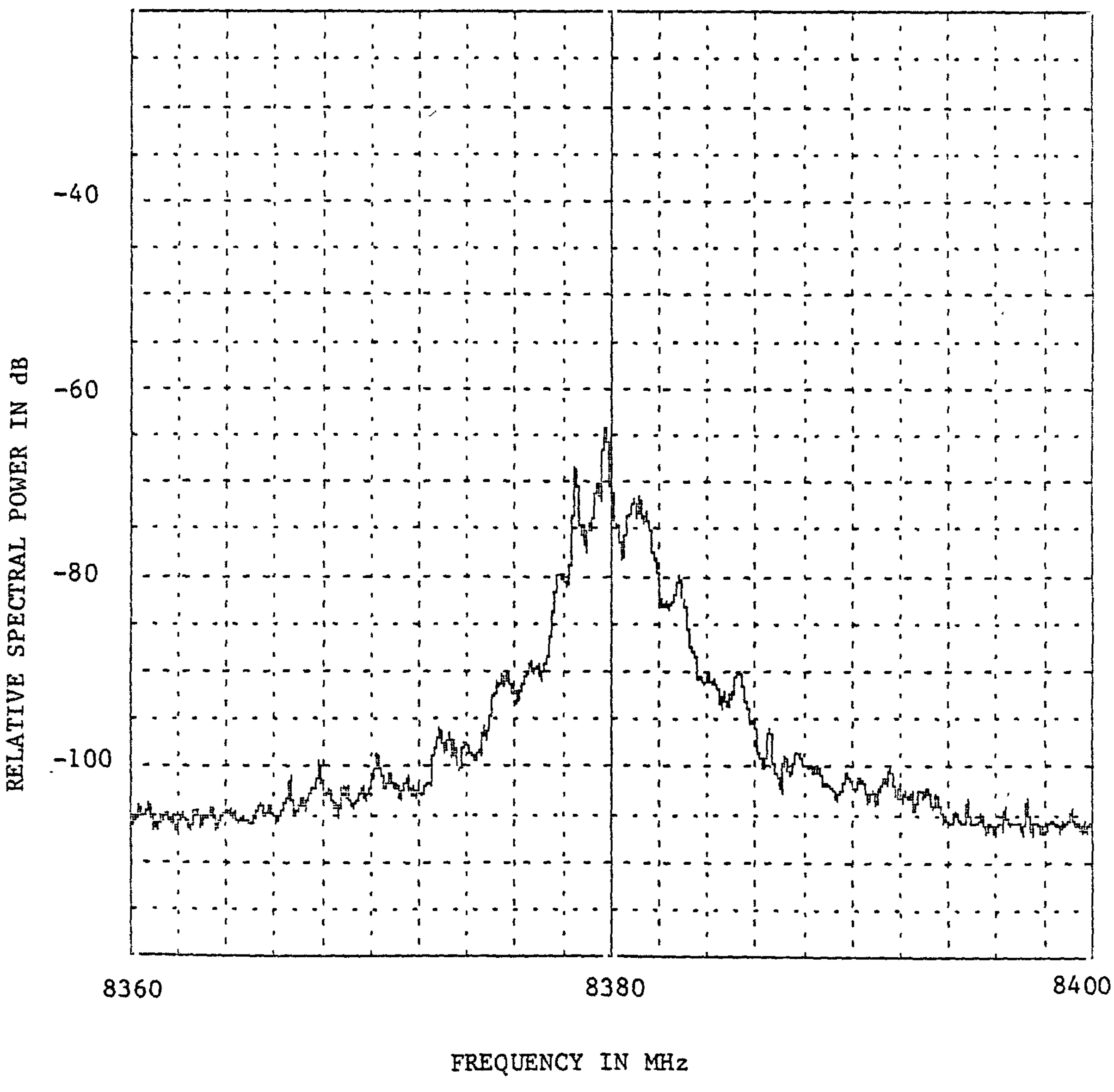


Figure A-13. Emission Spectrum of a Farinon Electric FV8F (f_o = 8380 MHz, Radiated).

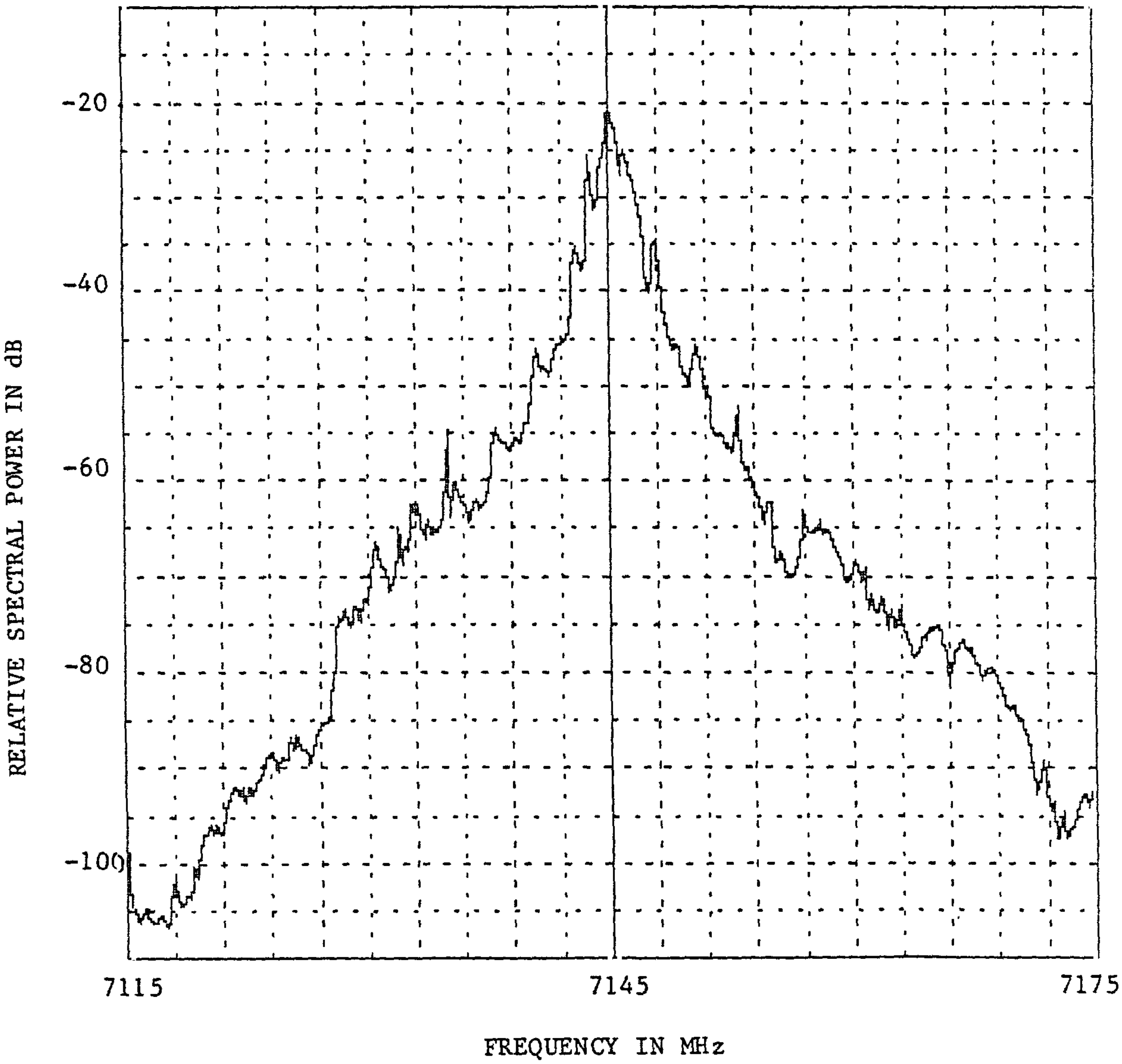


Figure A-14. Emission Spectrum of a Farinon Electric FV8F (f_o = 7145 MHz Hard-lined).

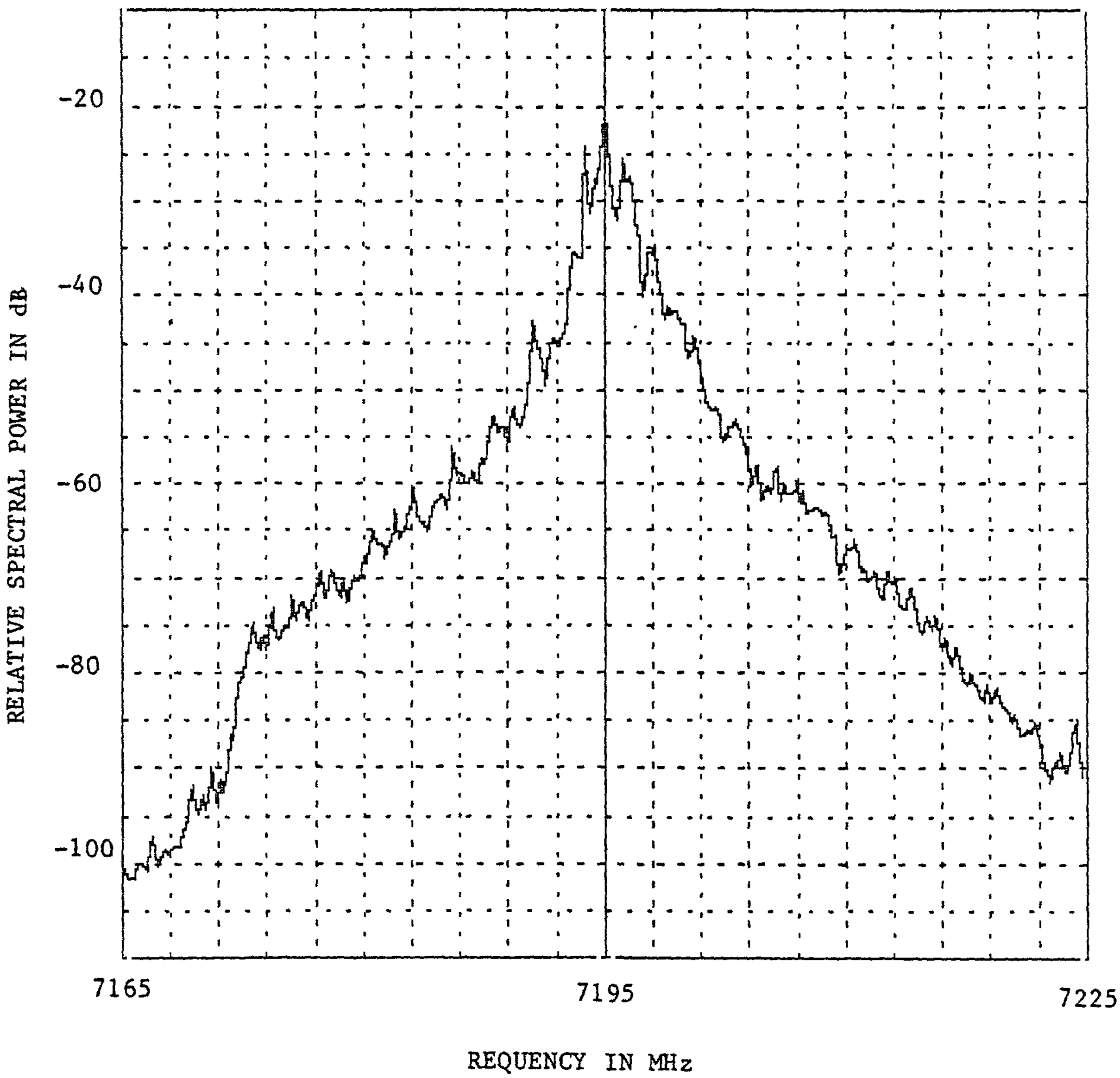


Figure A-15. Emission Spectrum of a Farinon Electric FV8F (f_o=7195 MHz, Hard-lined).

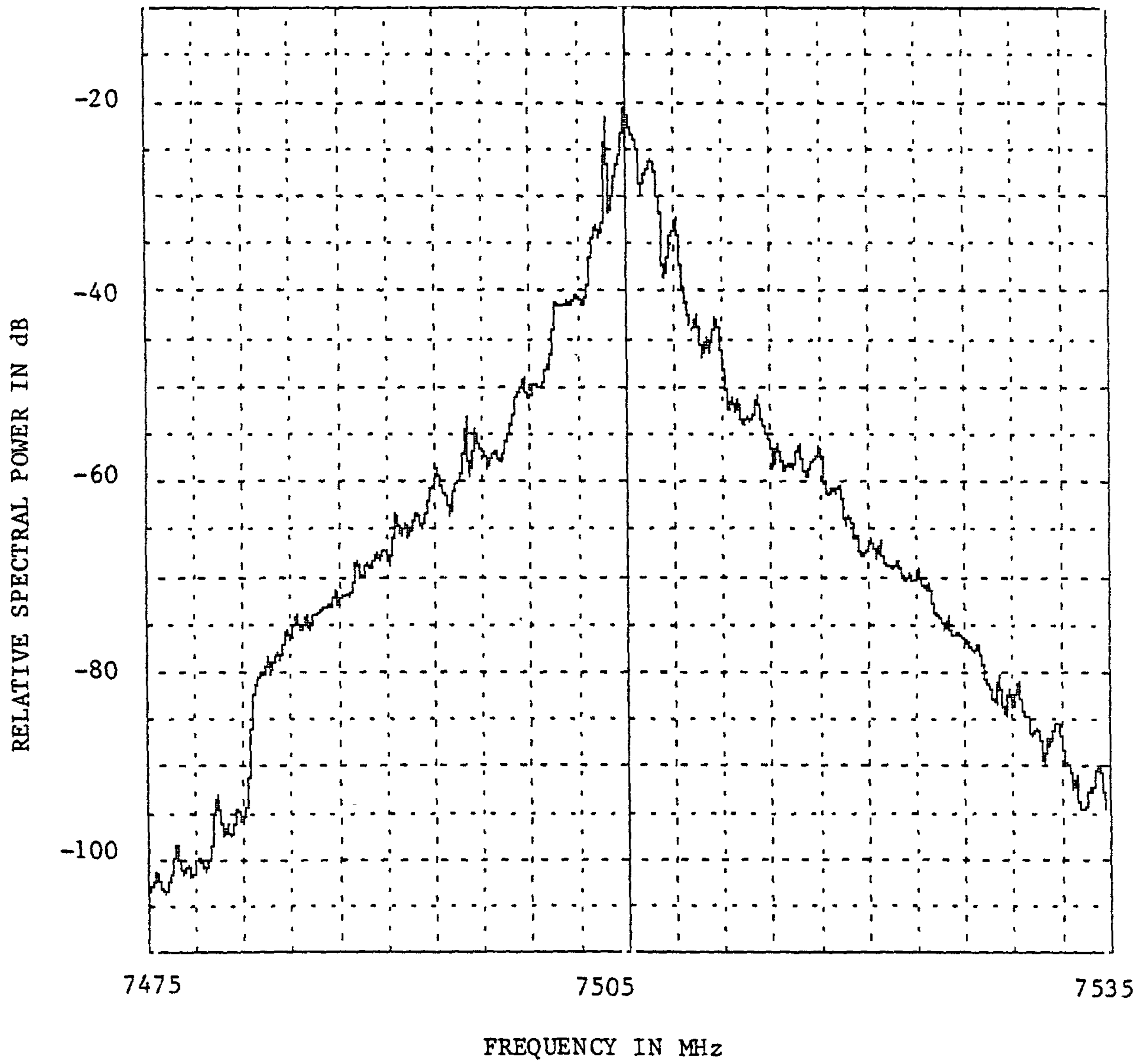


Figure A-16. Emission Spectrum of a Farinon Electric FV8F (f_o = 7505 MHz, Hard-lined).

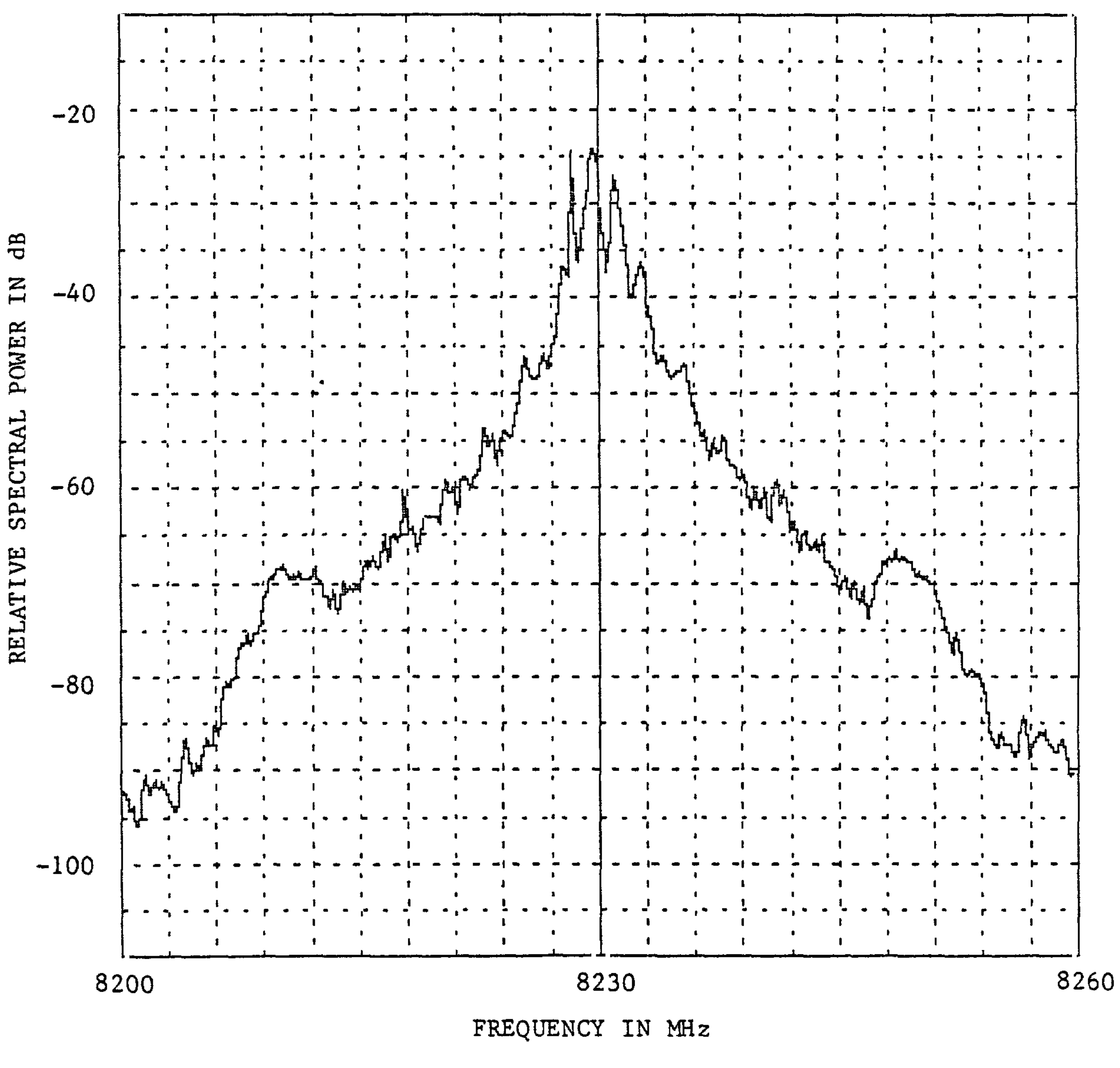


Figure A-17. Emission Spectrum of a Farinon Electric FV8F (f_o = 8230 MHz, Hard-lined).

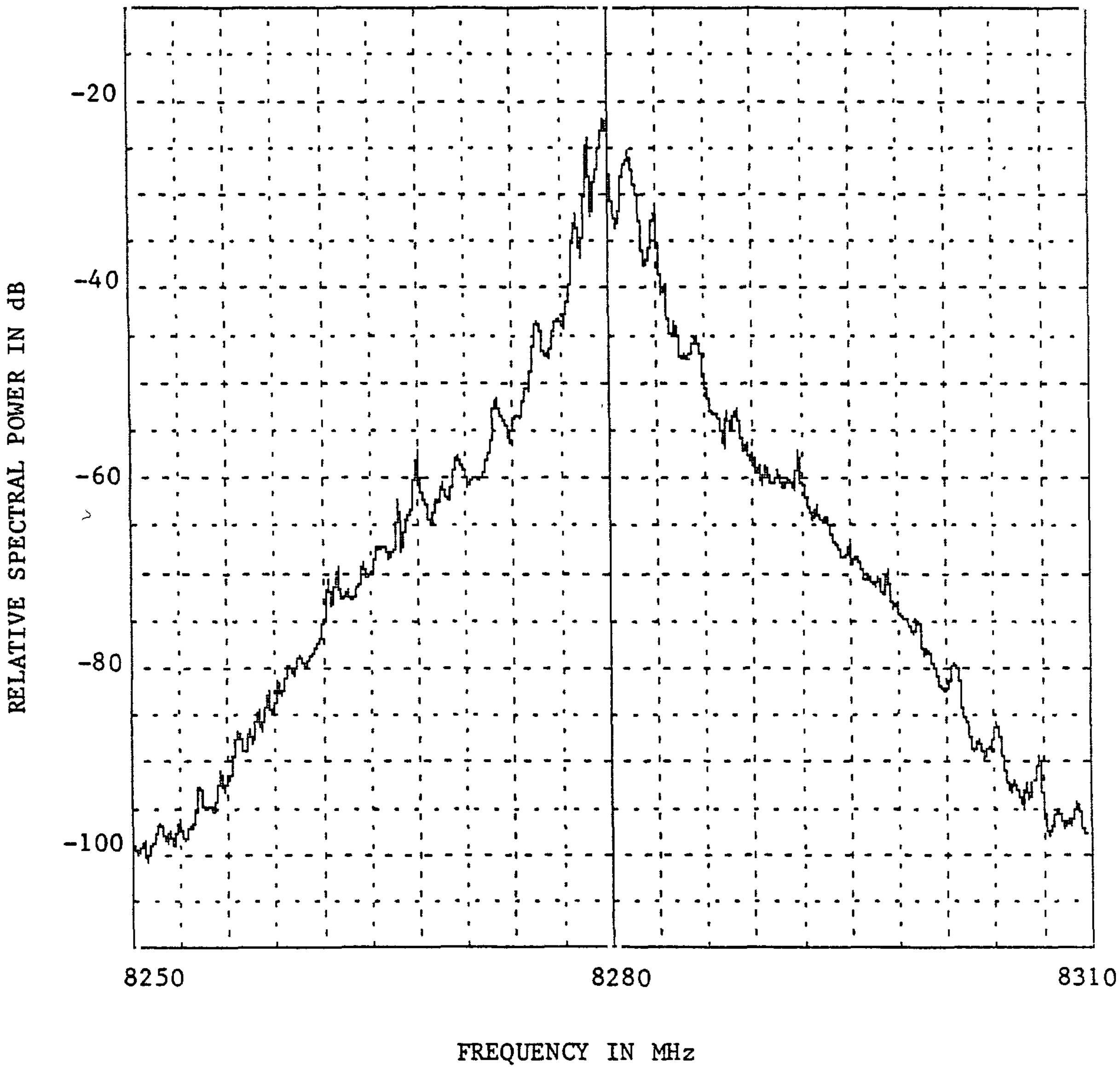


Figure A-18. Emission Spectrum of a Farinon Electric FV8F (f_o = 8280 MHz, Hard-lined).

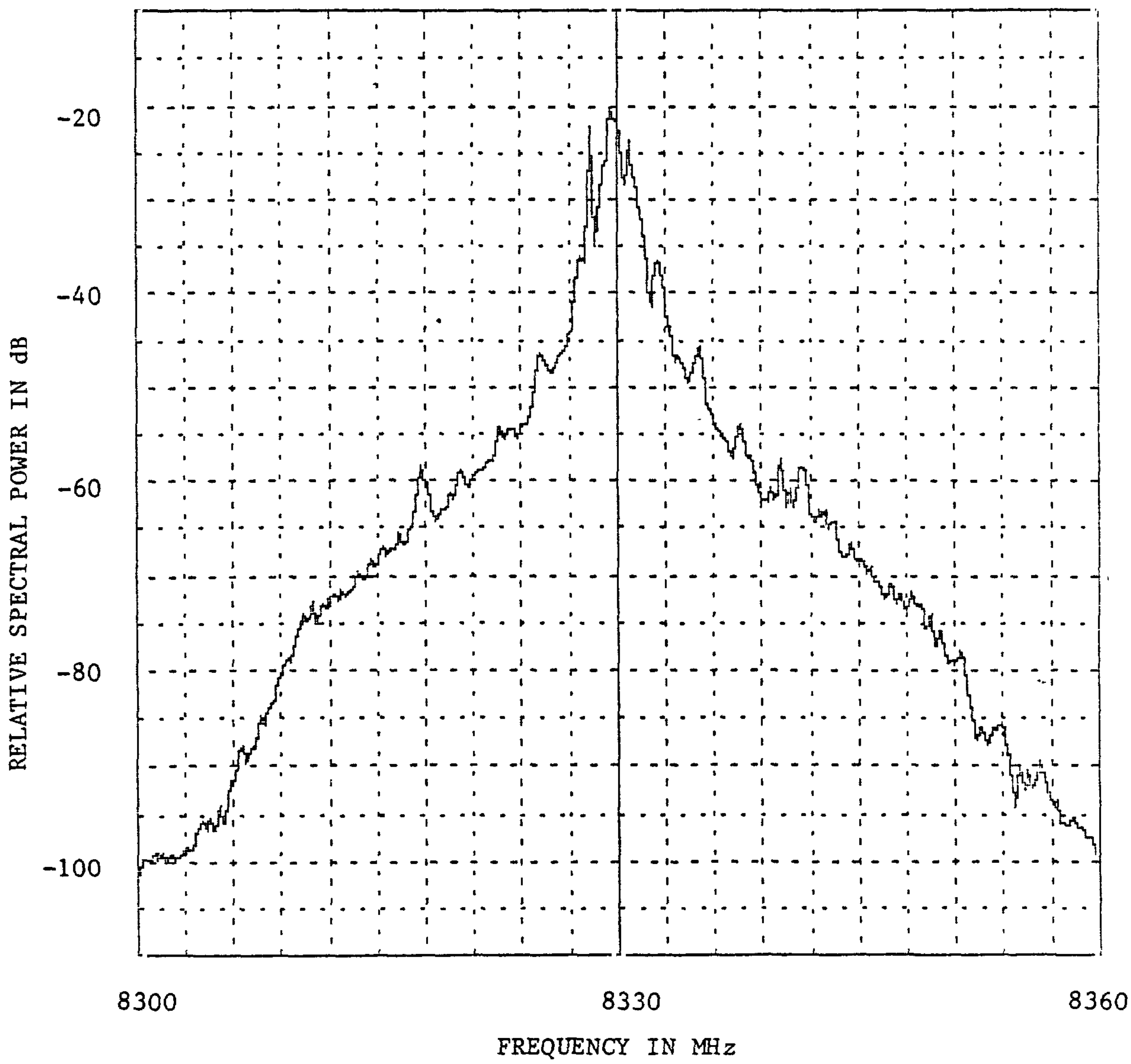


Figure A-19. Emission Spectrum of a Farinon Electric FV8F (f_o = 8330 MHz, Hard-lined).

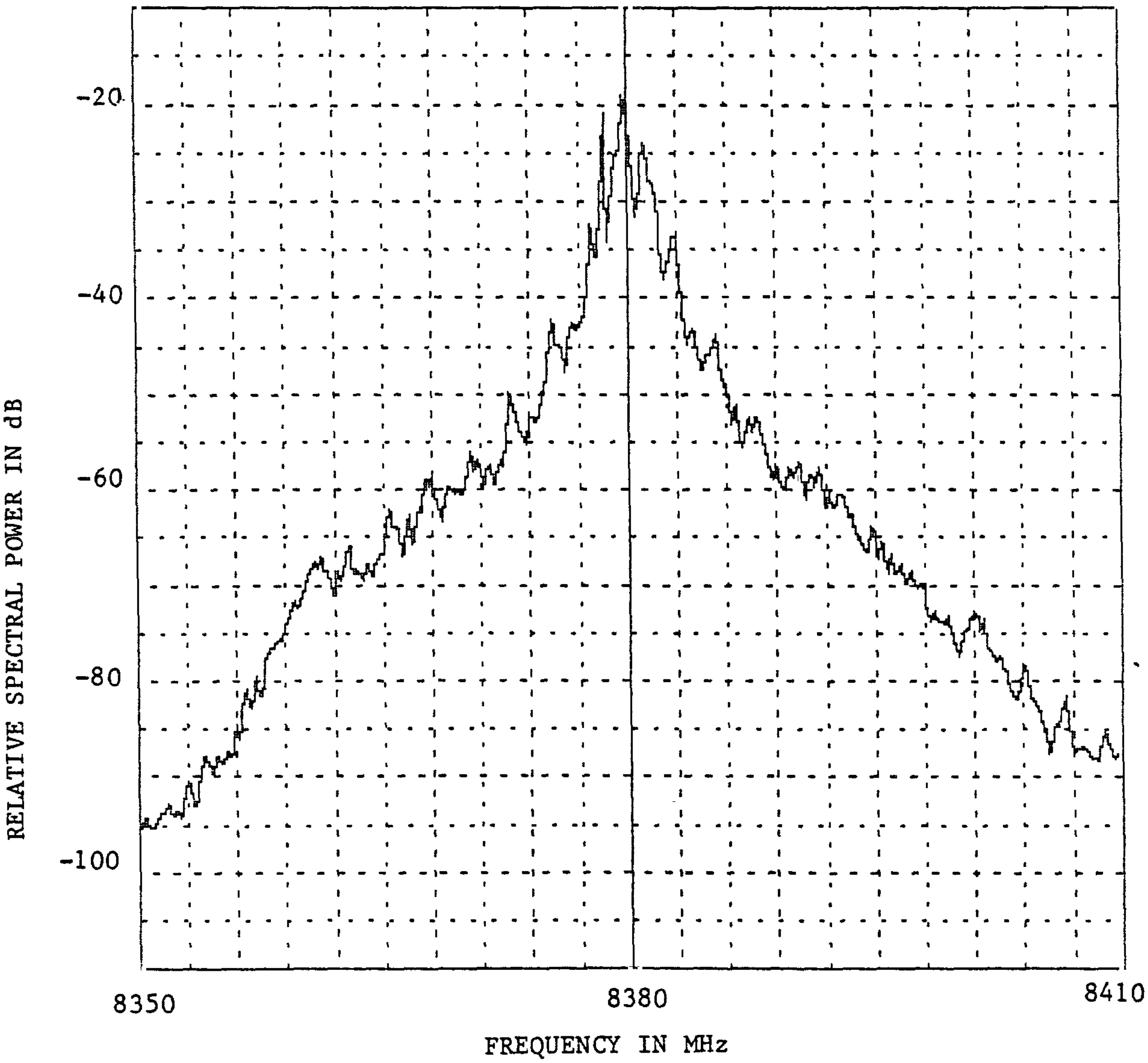


Figure A-20, Emission Spectrum of a Farinon Electric FV8F (f_o = 8380 MHz, Hard-lined).

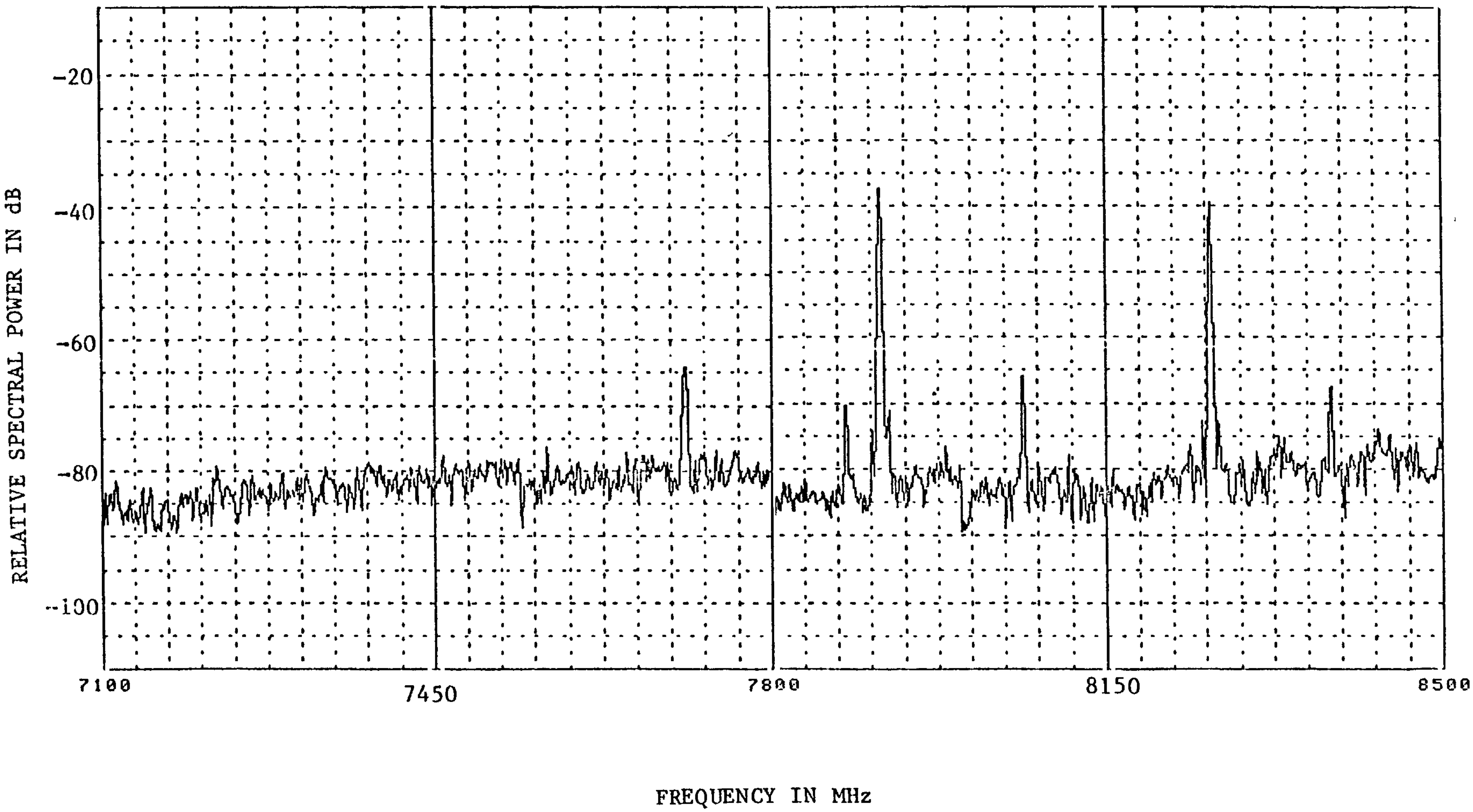


Figure A-21. Band Scan of the Tacoma - Squak Mountain Antenna

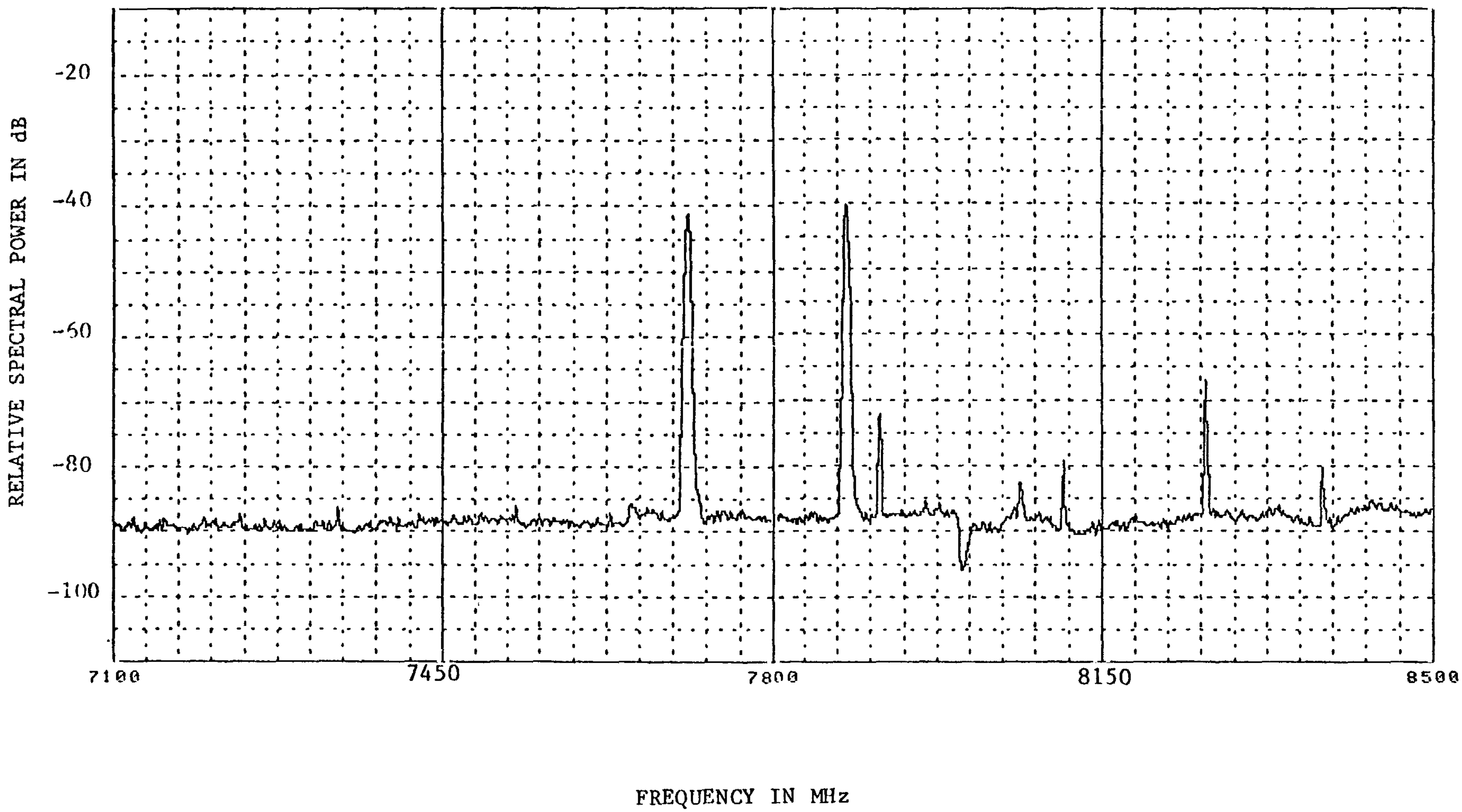


Figure A-22. Band Scan of the Tacoma - Tacoma Substation Antenna.

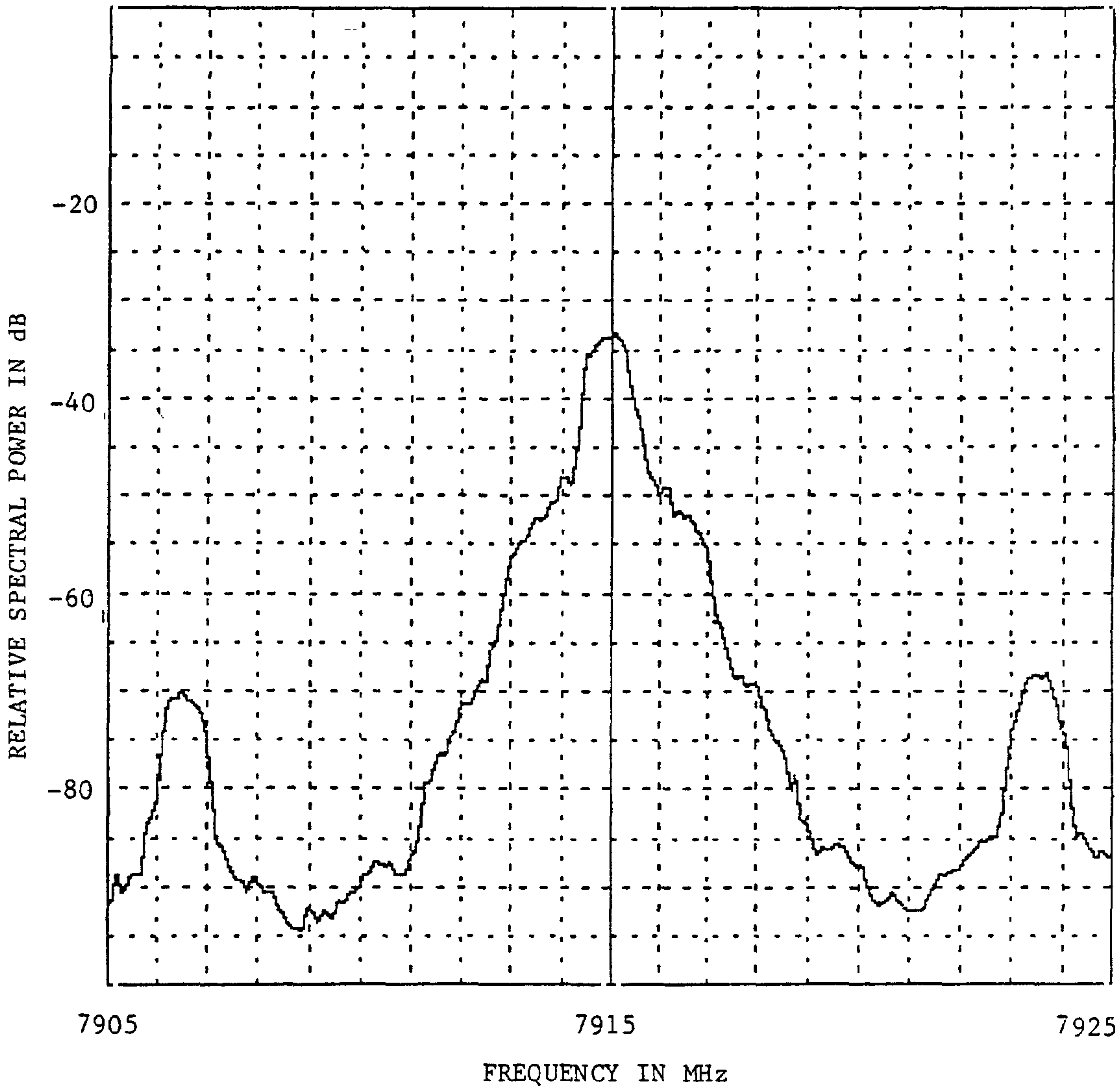


Figure A-23. Emission Spectrum of a General Electric TRS696C (f_o = 7915 MHz, Radiated).

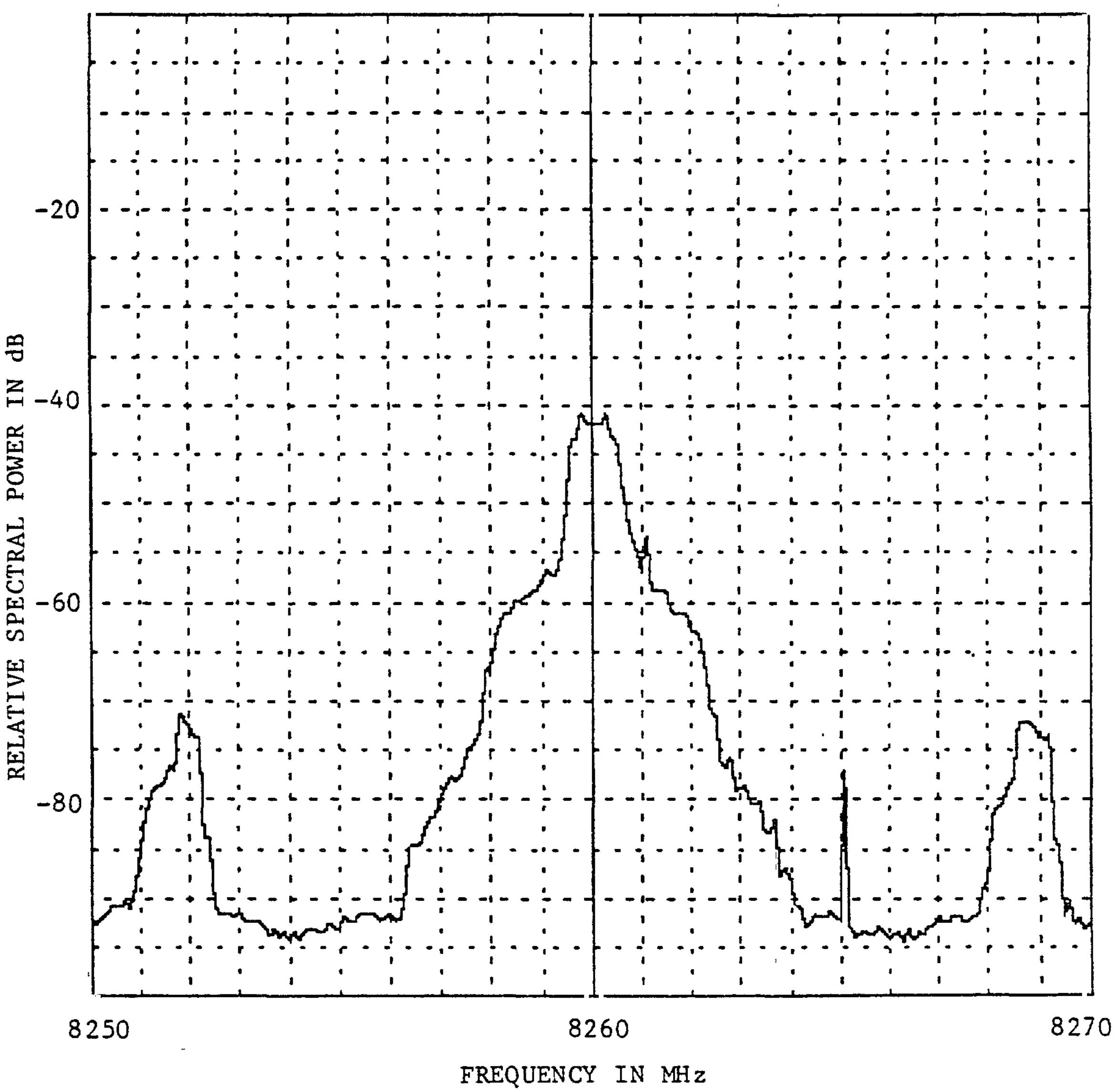


Figure A-24. Emission Spectrum of a General Electric TRS 696C (f_o = 8260 MHz, Radiated).

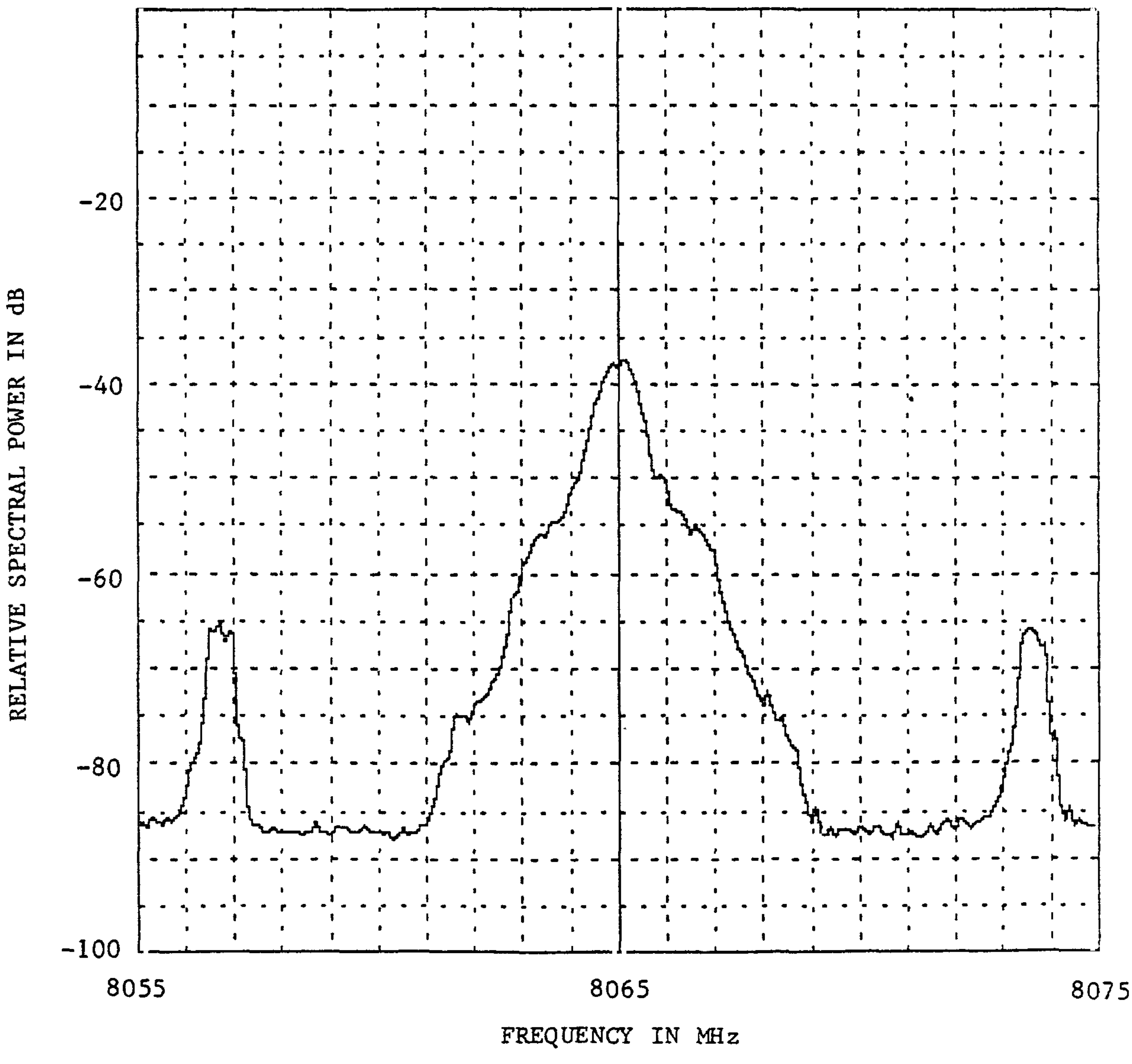


Figure A-25. Emission Spectrum of a General Electric TRS 696C (f_o = 8065 MHz, Radiated).

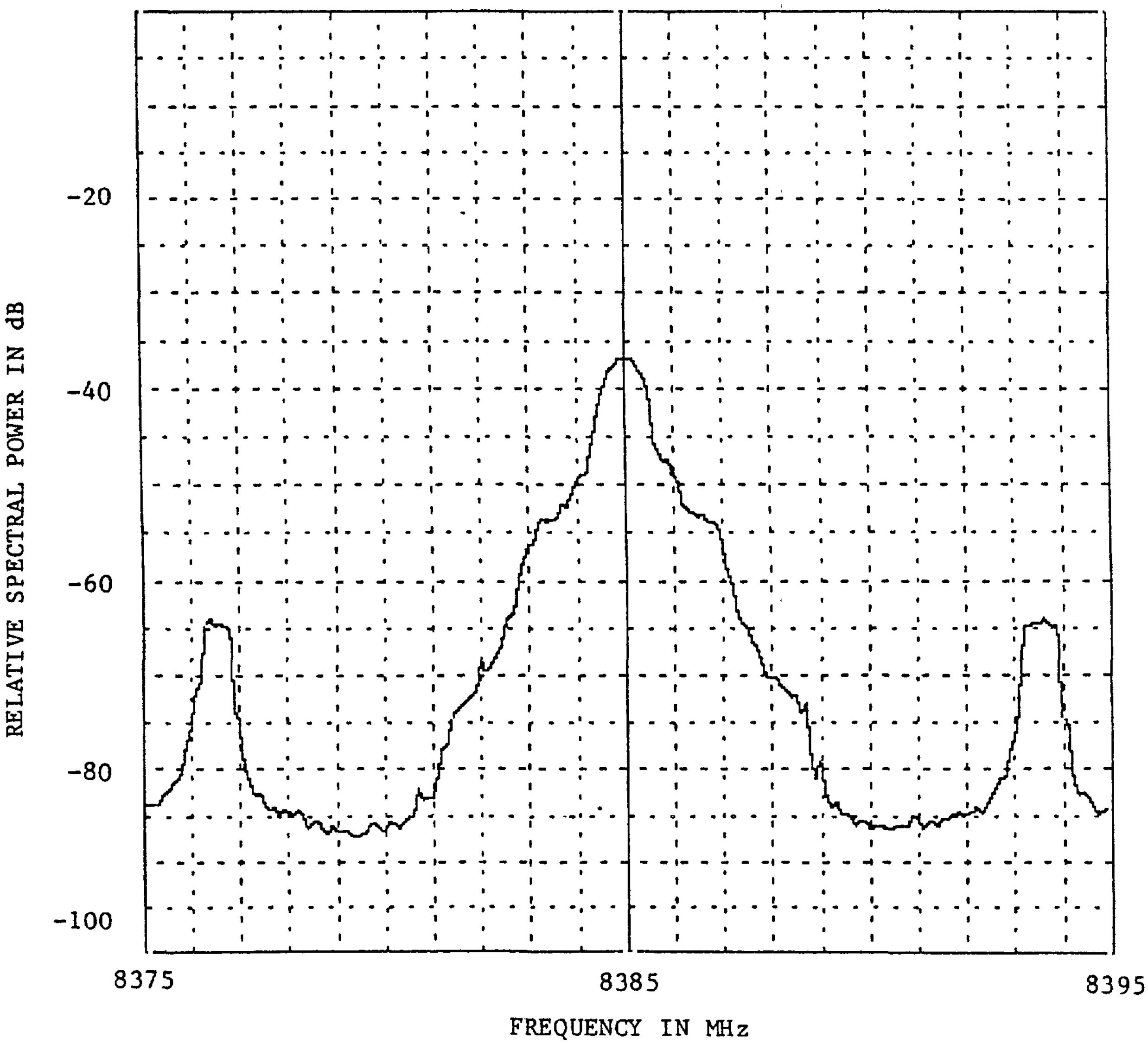


Figure A-26. Emission Spectrum of a General Electric TRS 696C (f_o = 8385 MHz, Radiated).

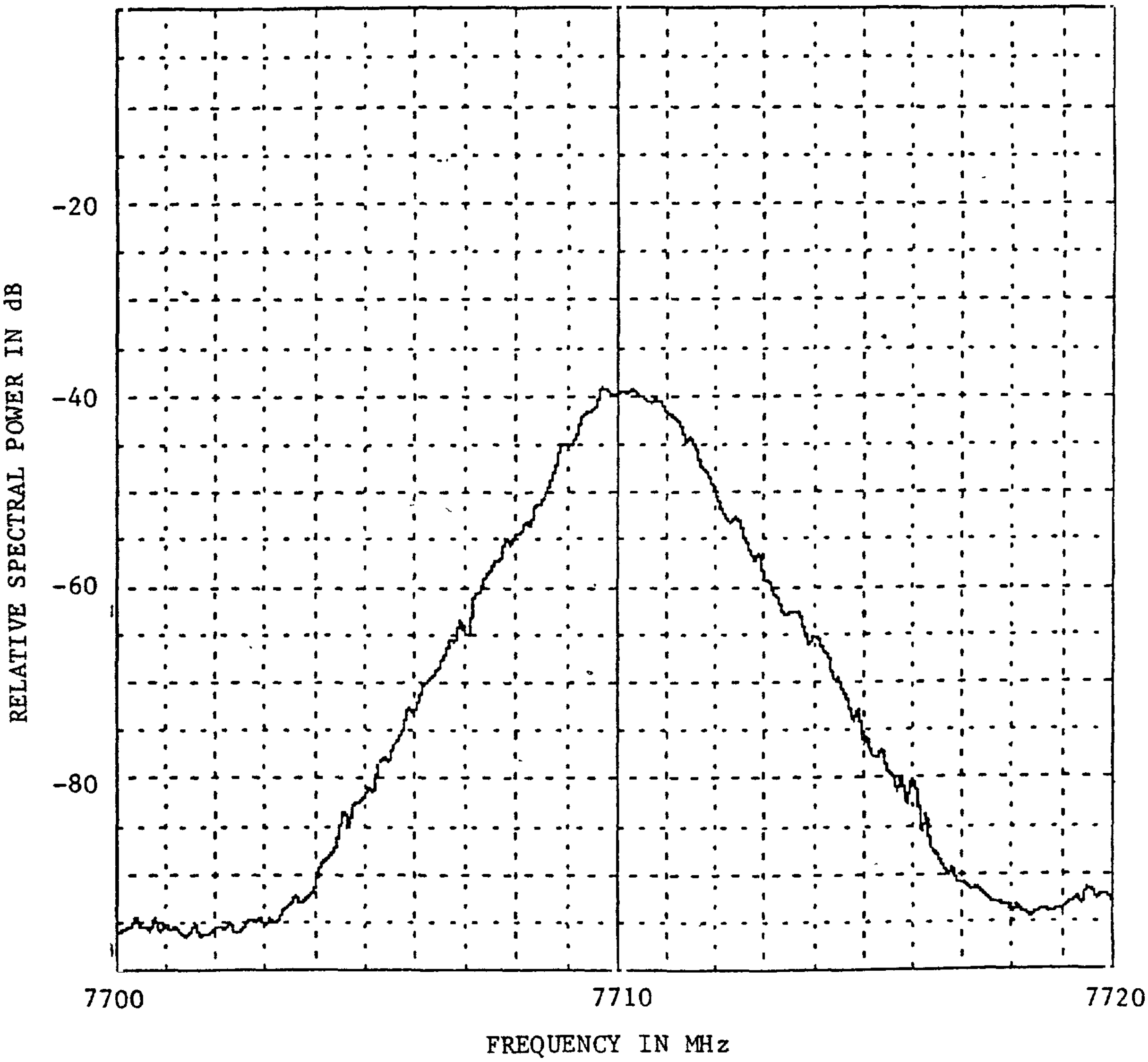


Figure A-27. Emission Spectrum of a Collins MW508D (f_o = 7710 MHz, Radiated).

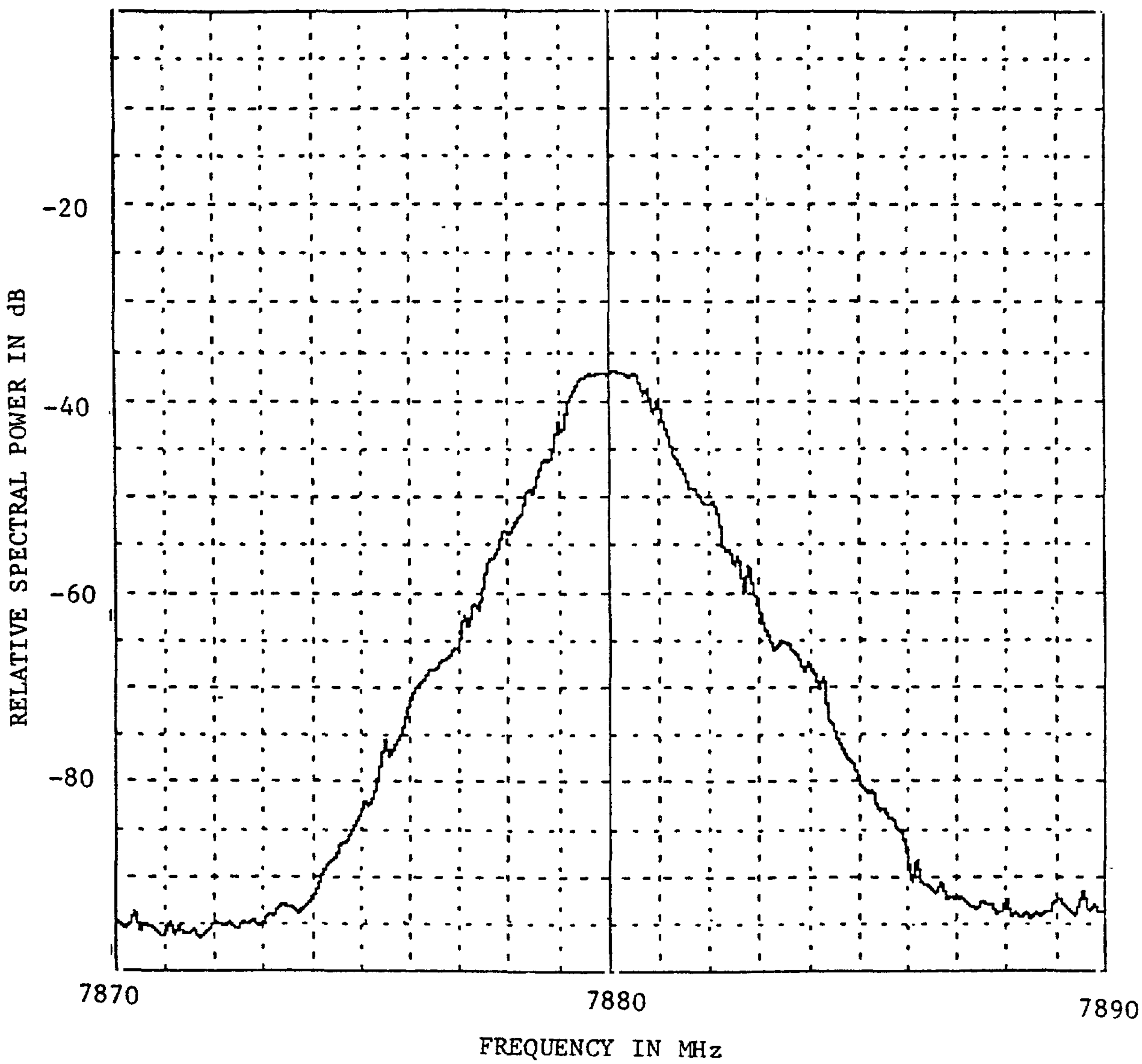


Figure A-28. Emission Spectrum of a Collins MW508D (f_o = 7880 MHz, Radiated)

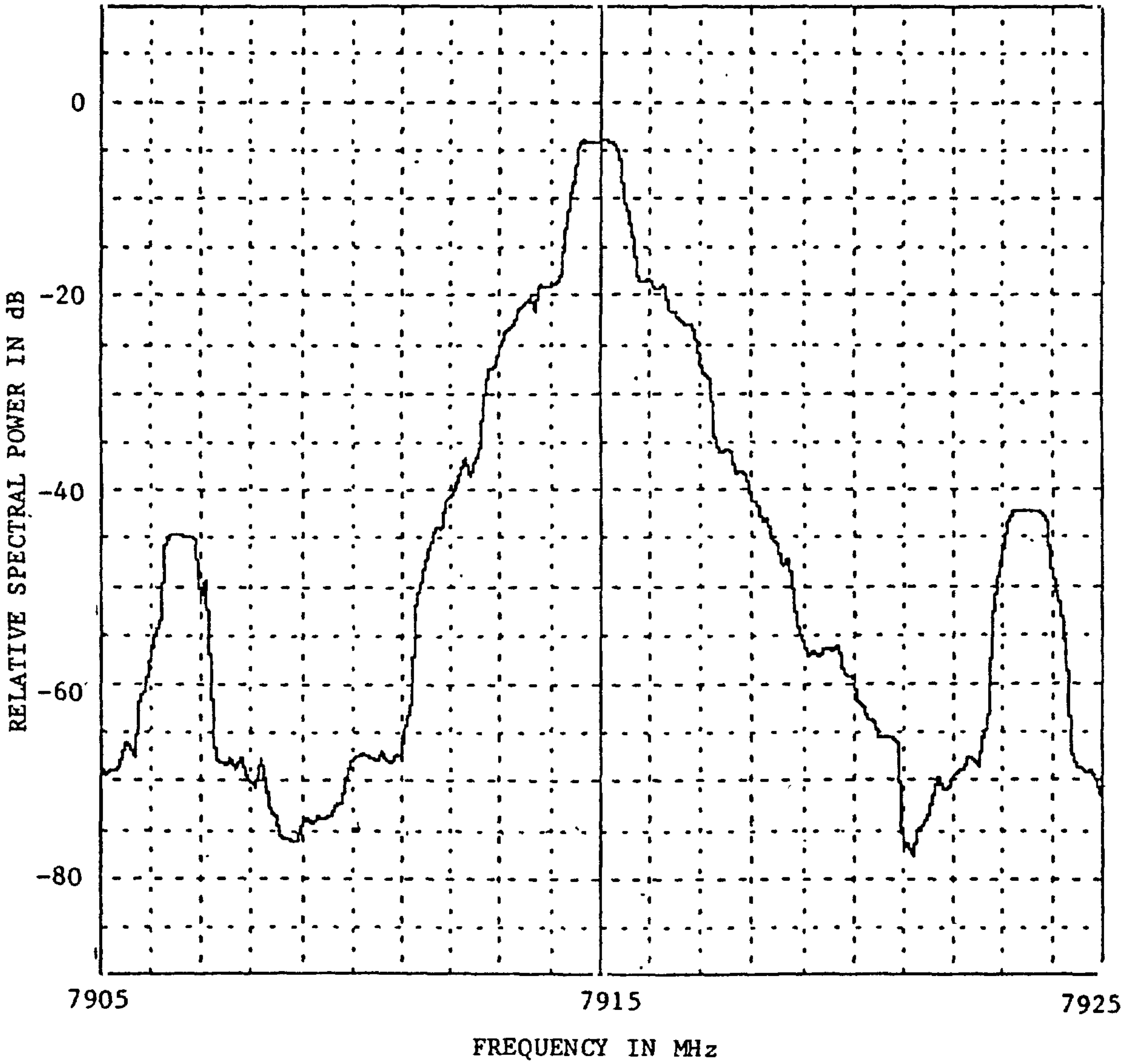


Figure A-29. Emission Spectrum of a General Electric TRS696C (f_o = 7915 MHz, Hard-lined).

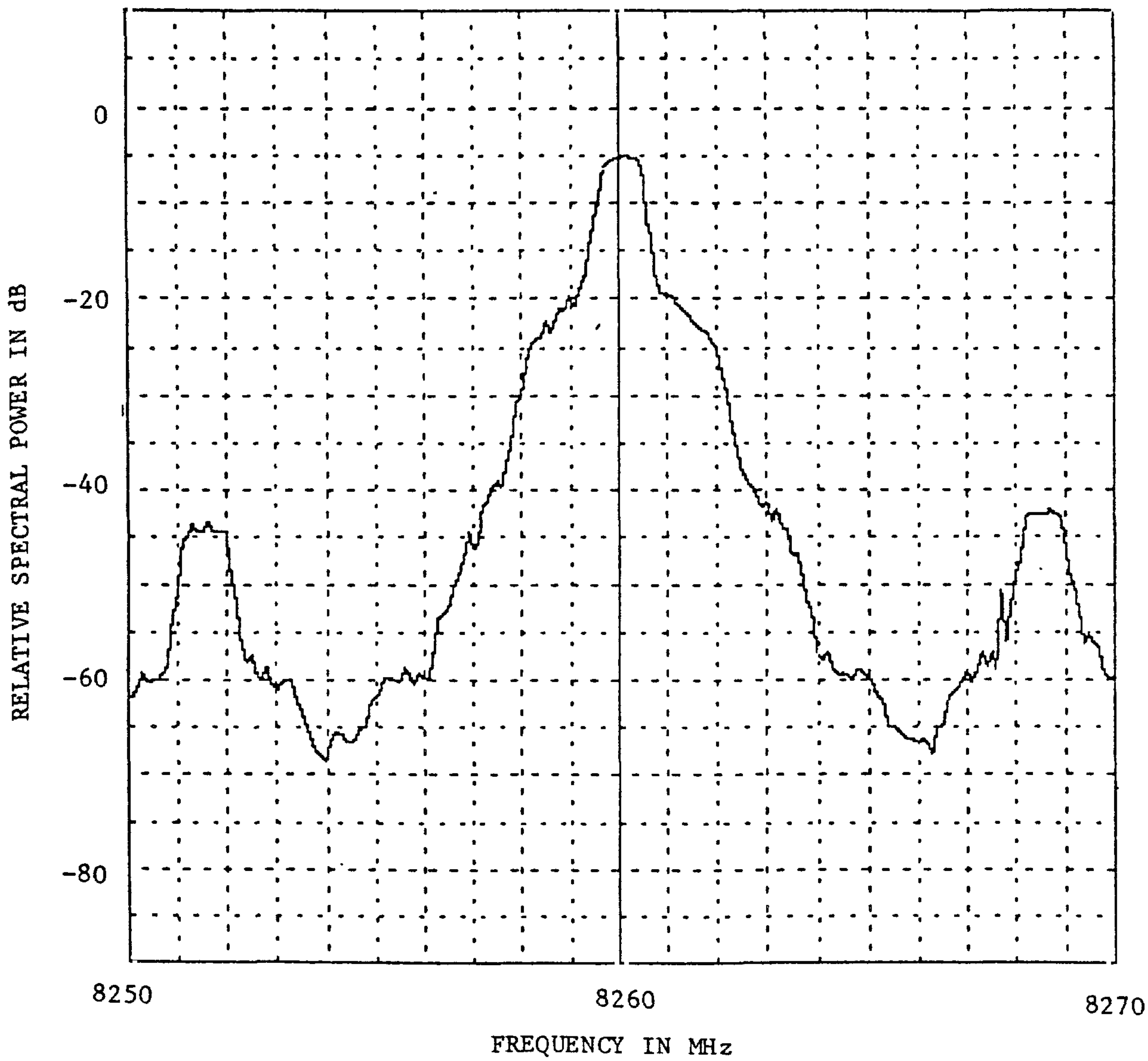


Figure A-30. Emission Spectrum of a General Electric TRS696C (f_o = 8260 MHz, Hard-lined).

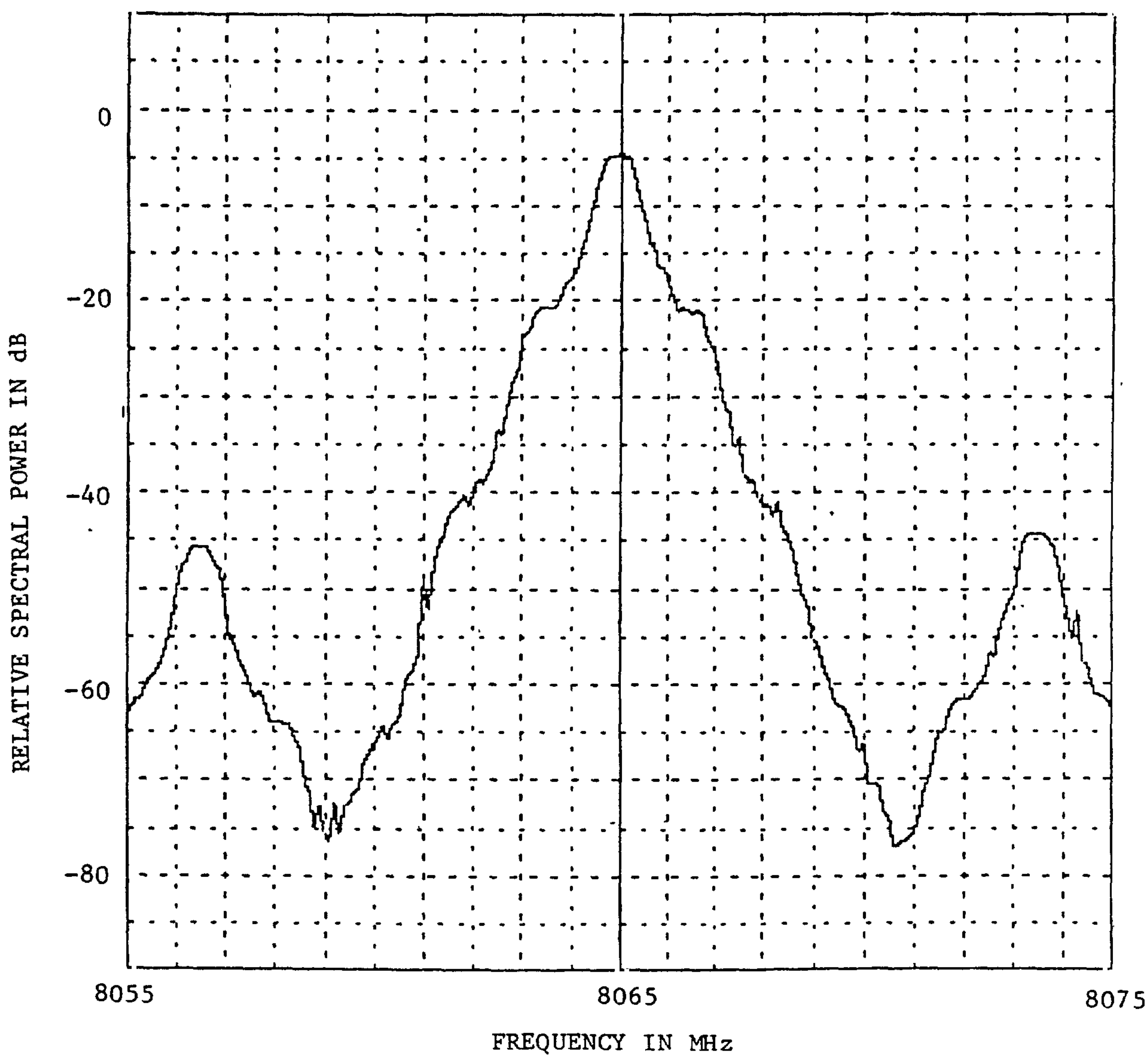


Figure A-31. Emission Spectrum of a General Electric TRS 696C (f_o = 8065 MHz, Hard-lined).

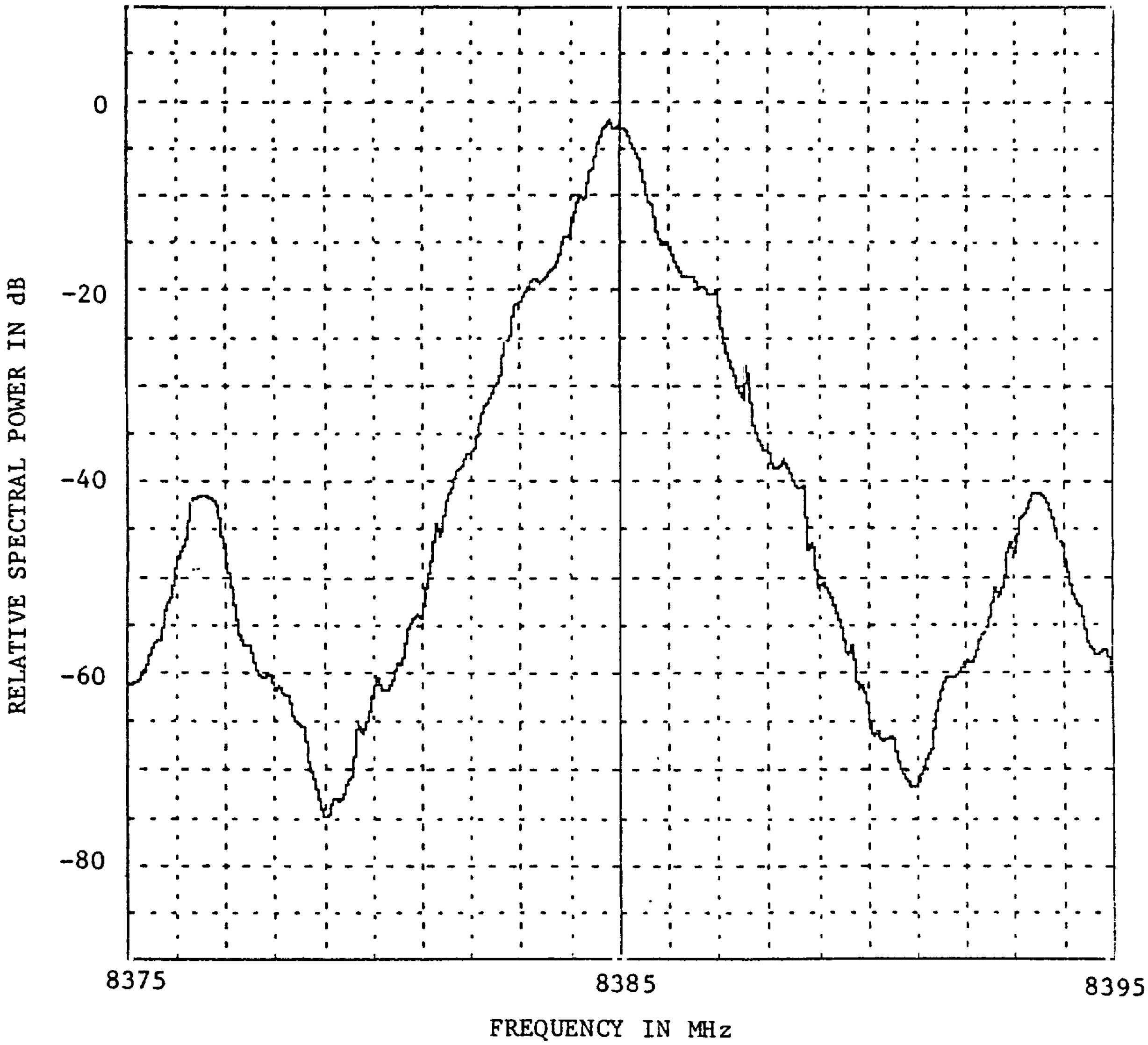


Figure A-32. Emission Spectrum of a General Electric TRS696C (f_o = 8385 MHz, Hard-lined).

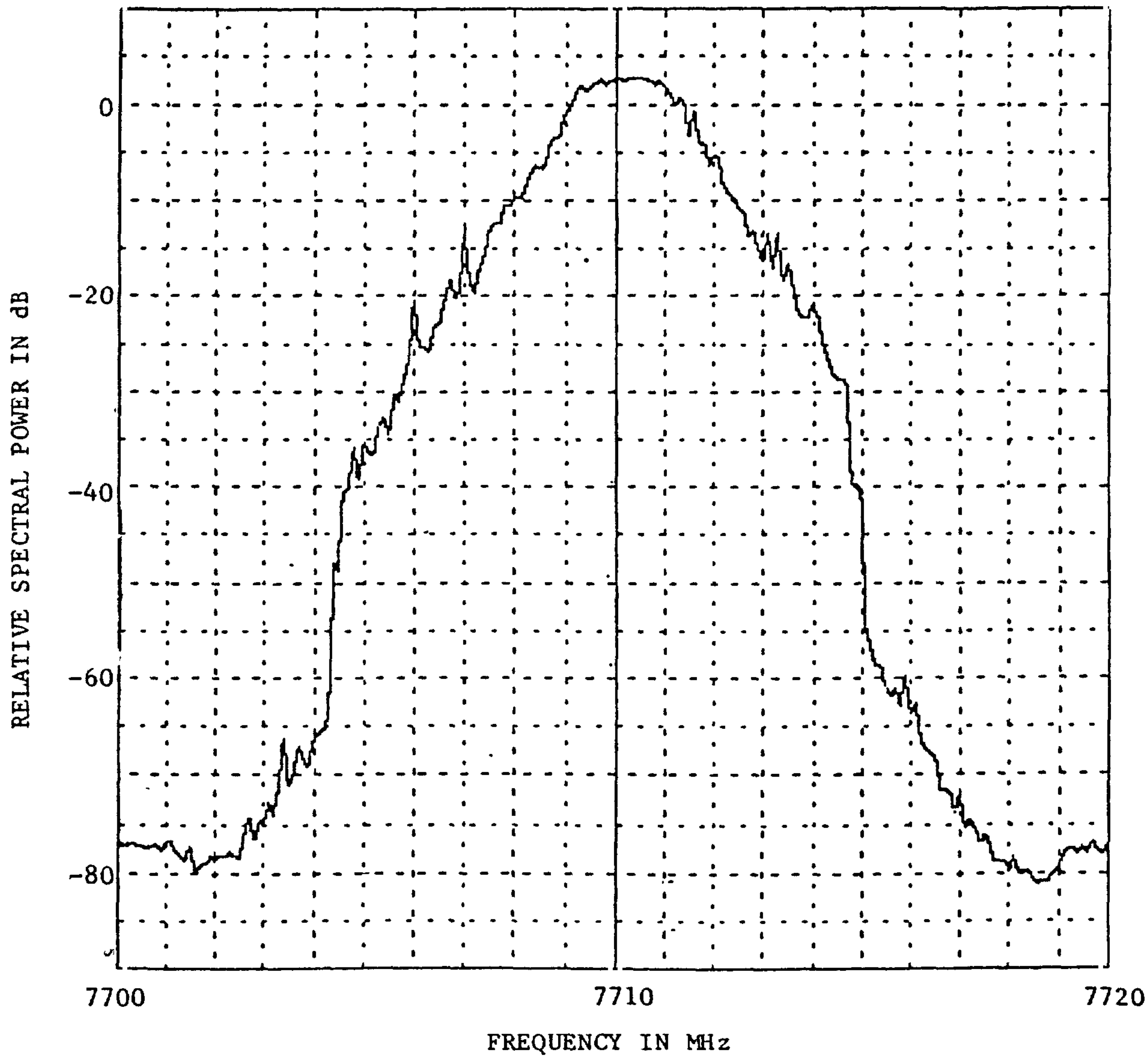


Figure A-33. Emission Spectrum of a Collins MW508D (f_o = 7710 MHz, Hard-lined).

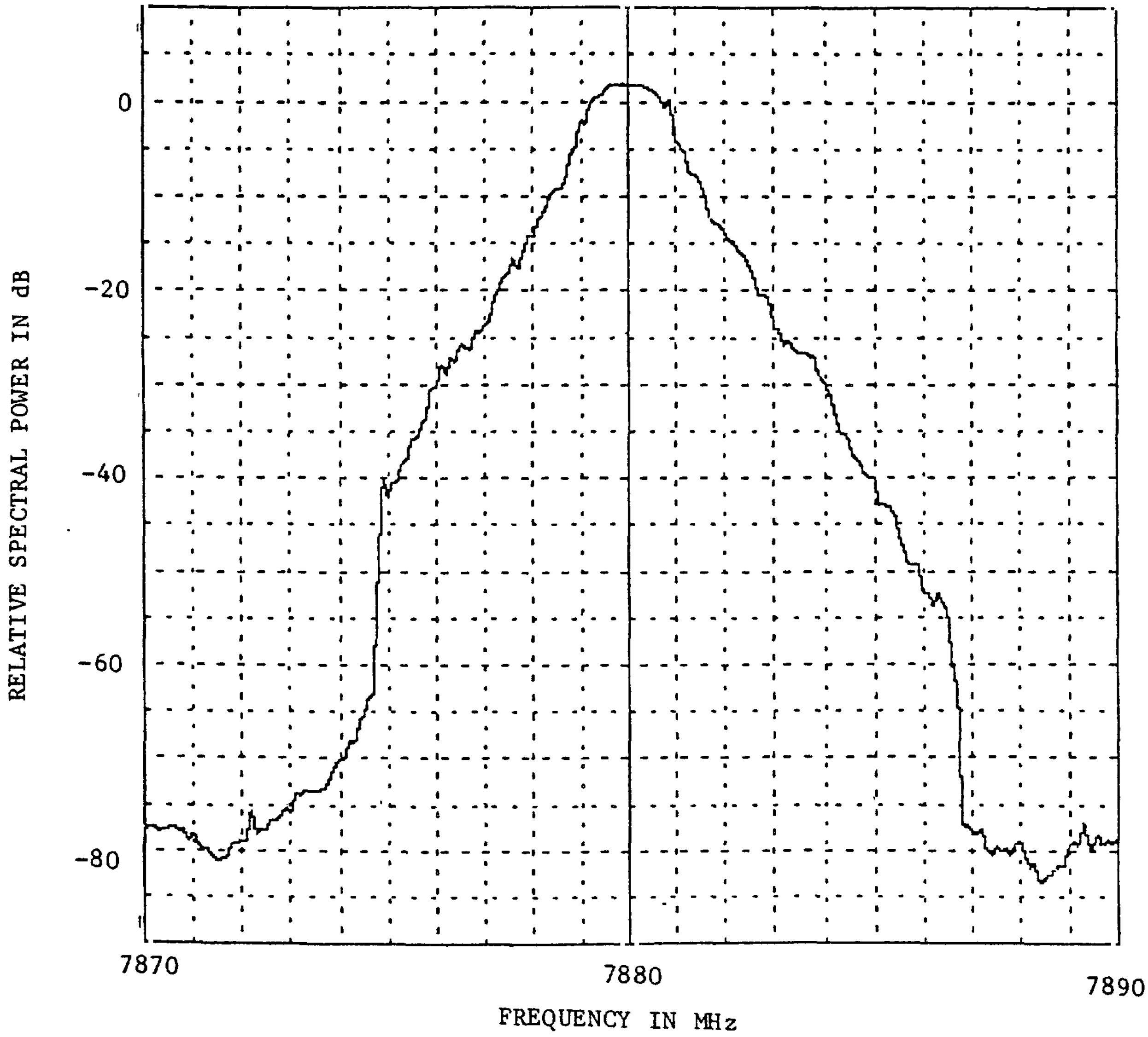


Figure A-34. Emission Spectrum of a Collins MW508D (f_o = 7880 MHz, Hard-lined).

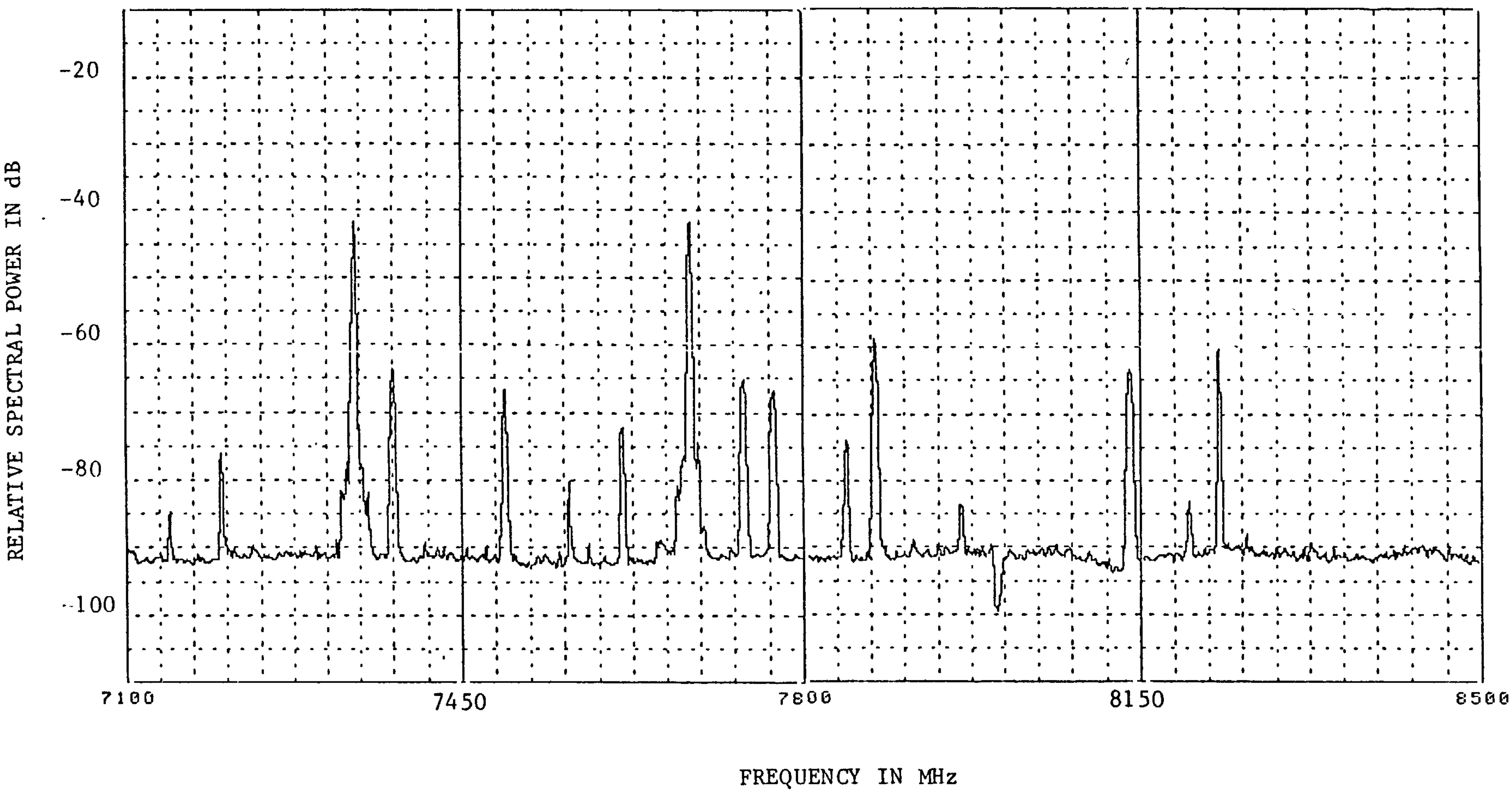


Figure A-35. Band Scan of the Squak Mountain - Tacoma Antenna.

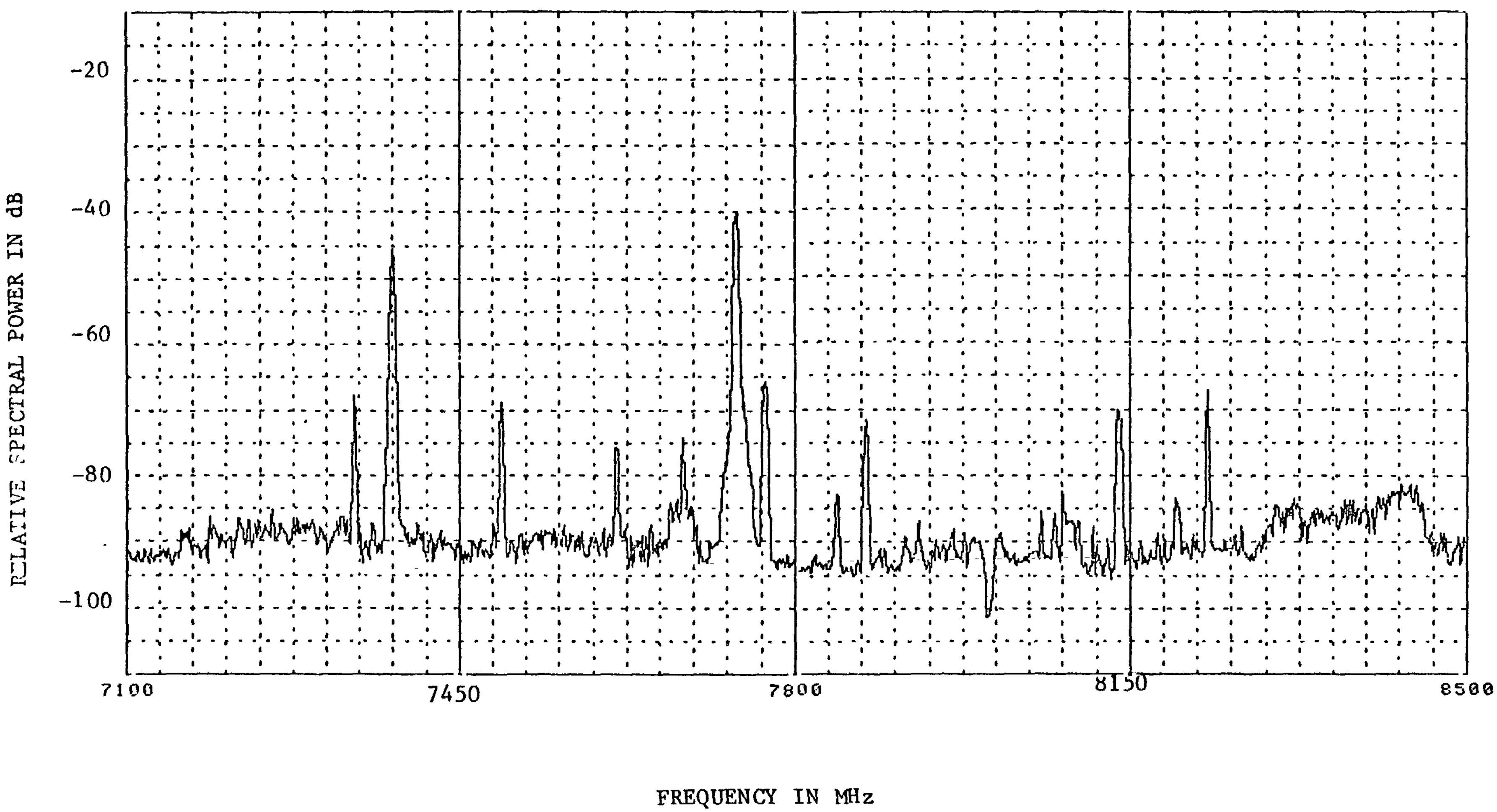


Figure A-36. Band Scan of the Squak Mountain-Covington Antenna.

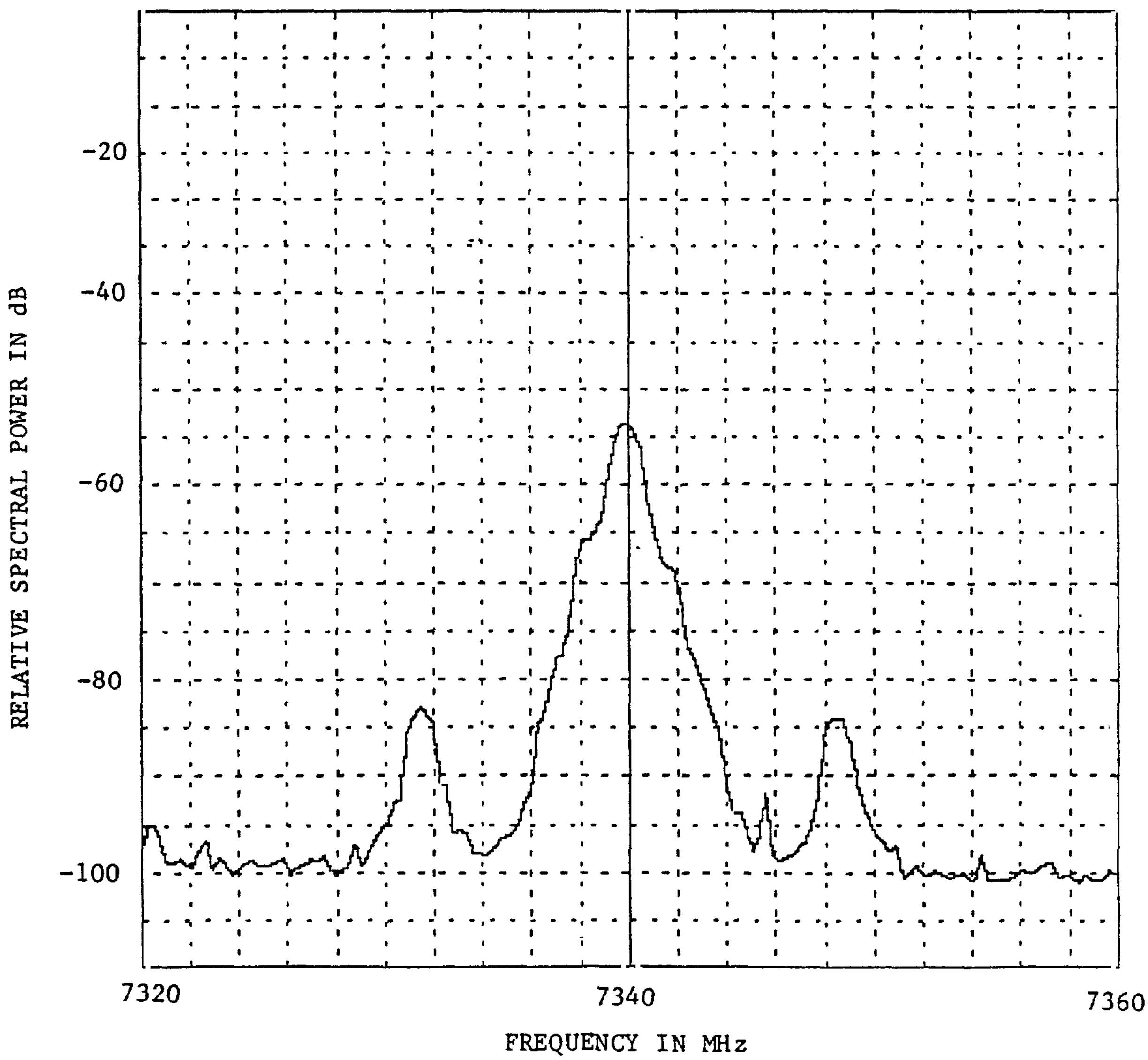


Figure A-37. Emission Spectrum of a GE TRS696C (f_o = 7340 MHz, Radiated, Normal Traffic).

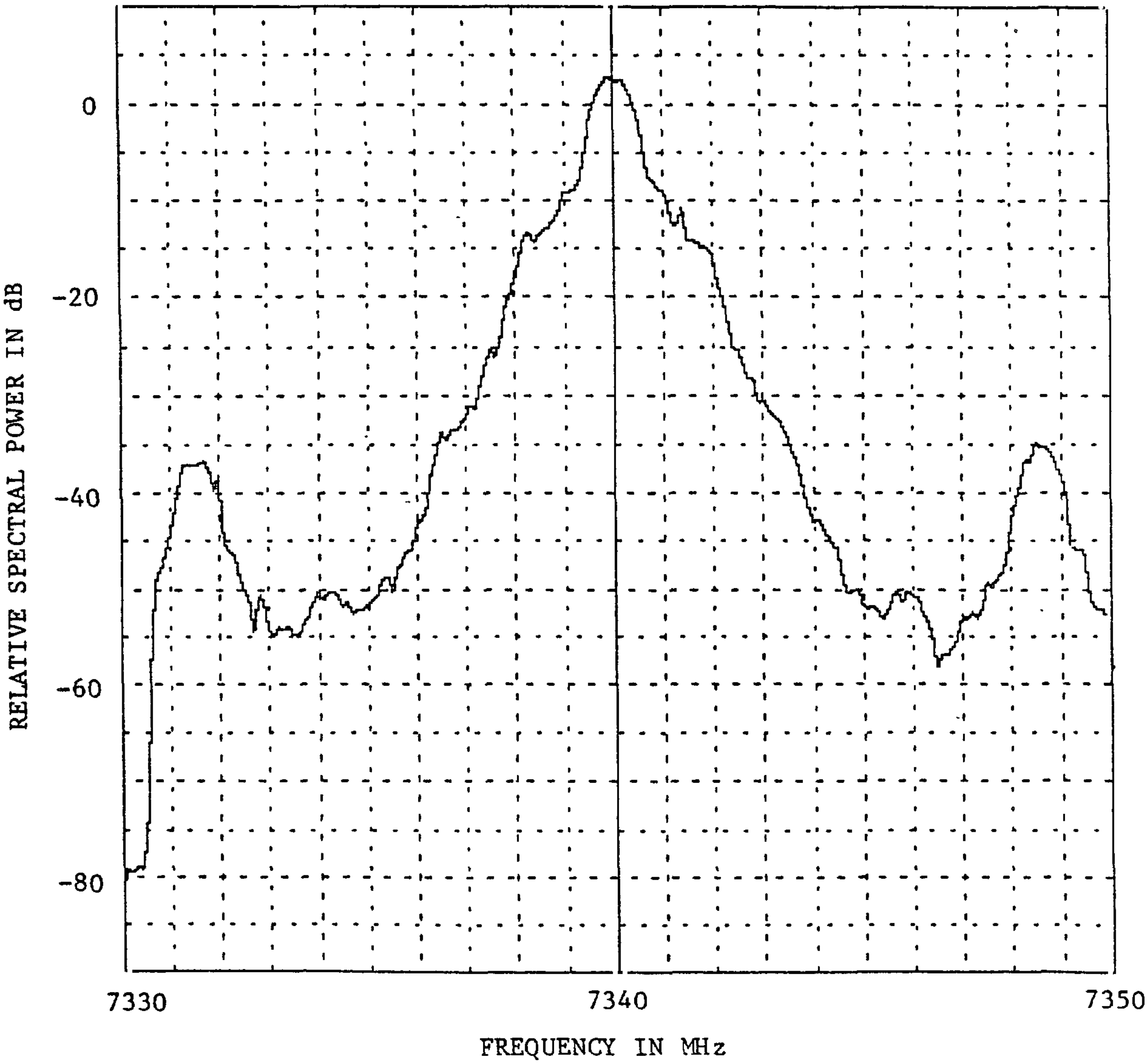


Figure A-38. Emission Spectrum of a GE TRS696C (f_o = 7340 MHz, Hard-lined, Normal Traffic).

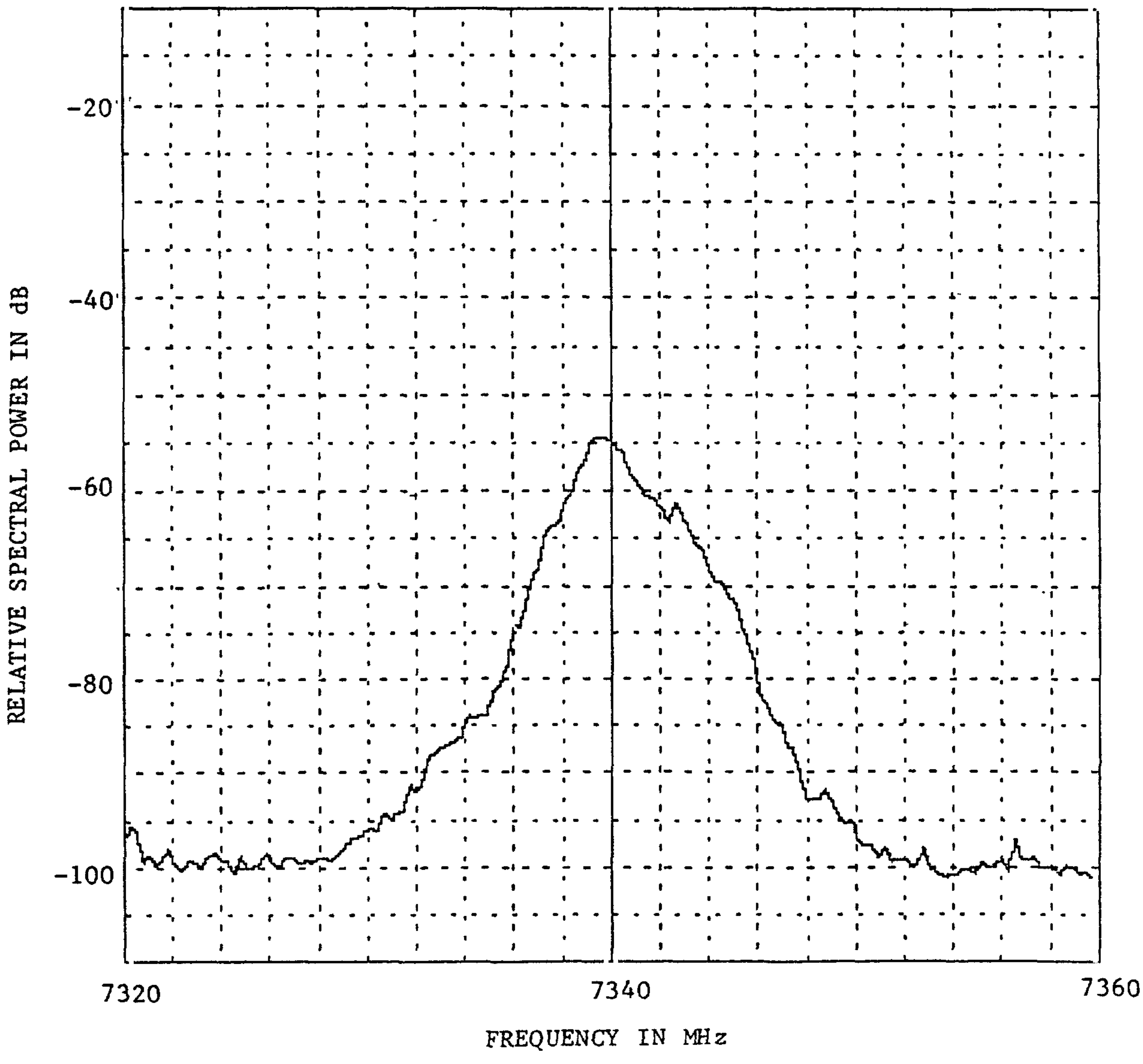


Figure A-39. Emission Spectrum of a GE TRS696C (f_o = 7340 MHz, Radiated, Loaded Condition).

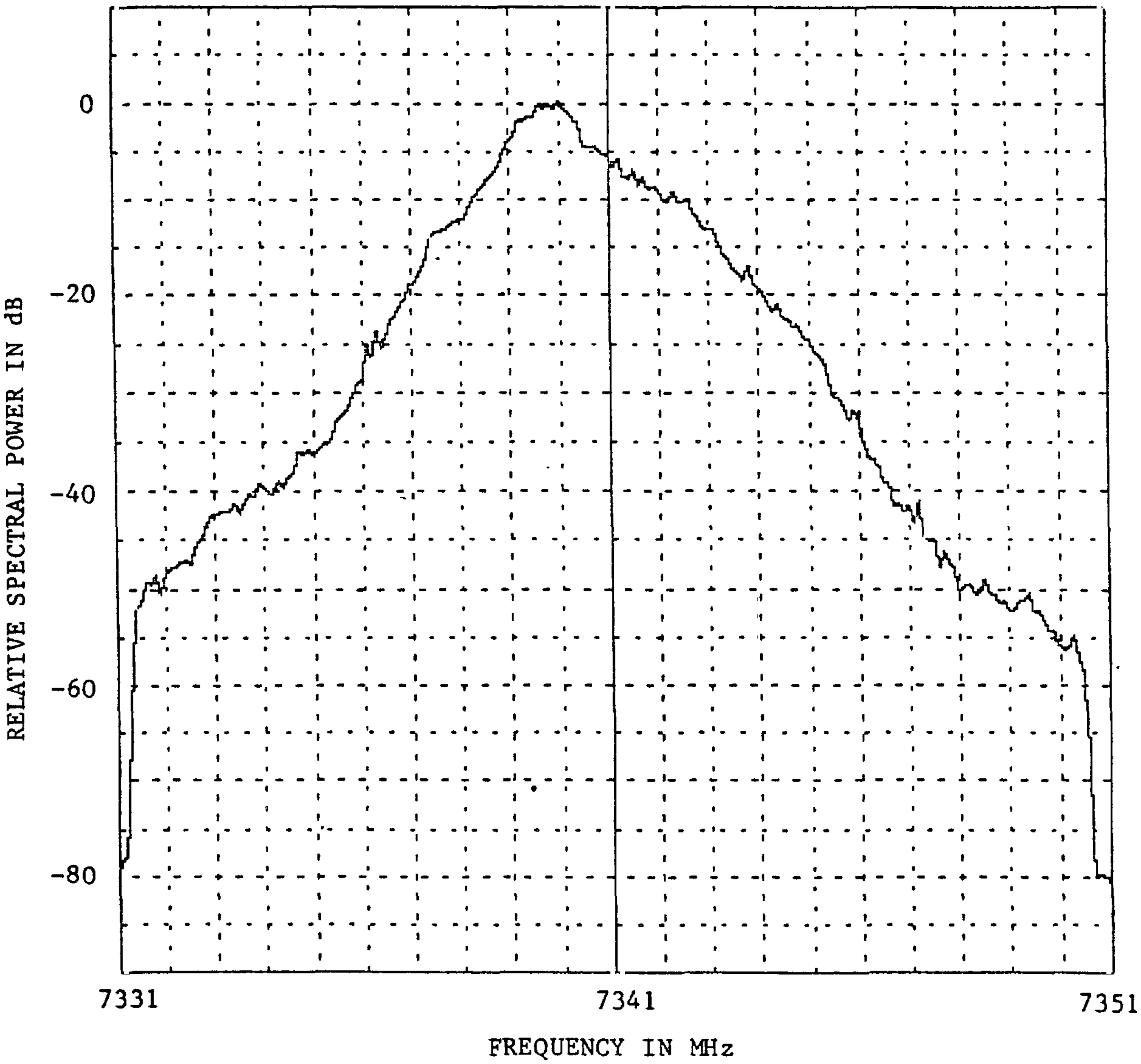


Figure A-40. Emission Spectrum of a GE TRS696C (f_o = 7340 MHz, Hard-lined, Loaded Condition).

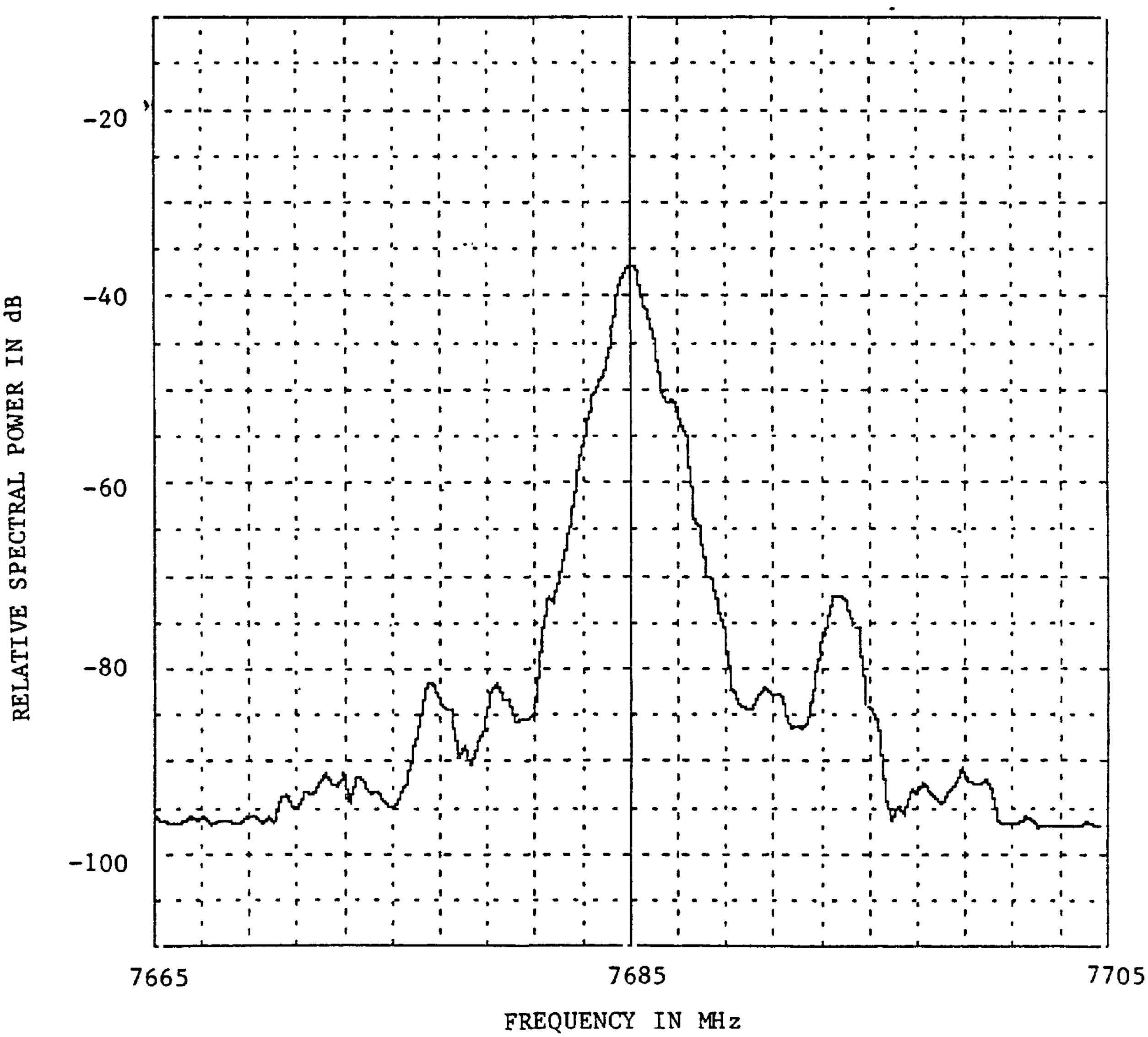


Figure A-41. Emission Spectrum of a GE TRS696C (f_o = 7685 MHz, Radiated, Normal Traffic).

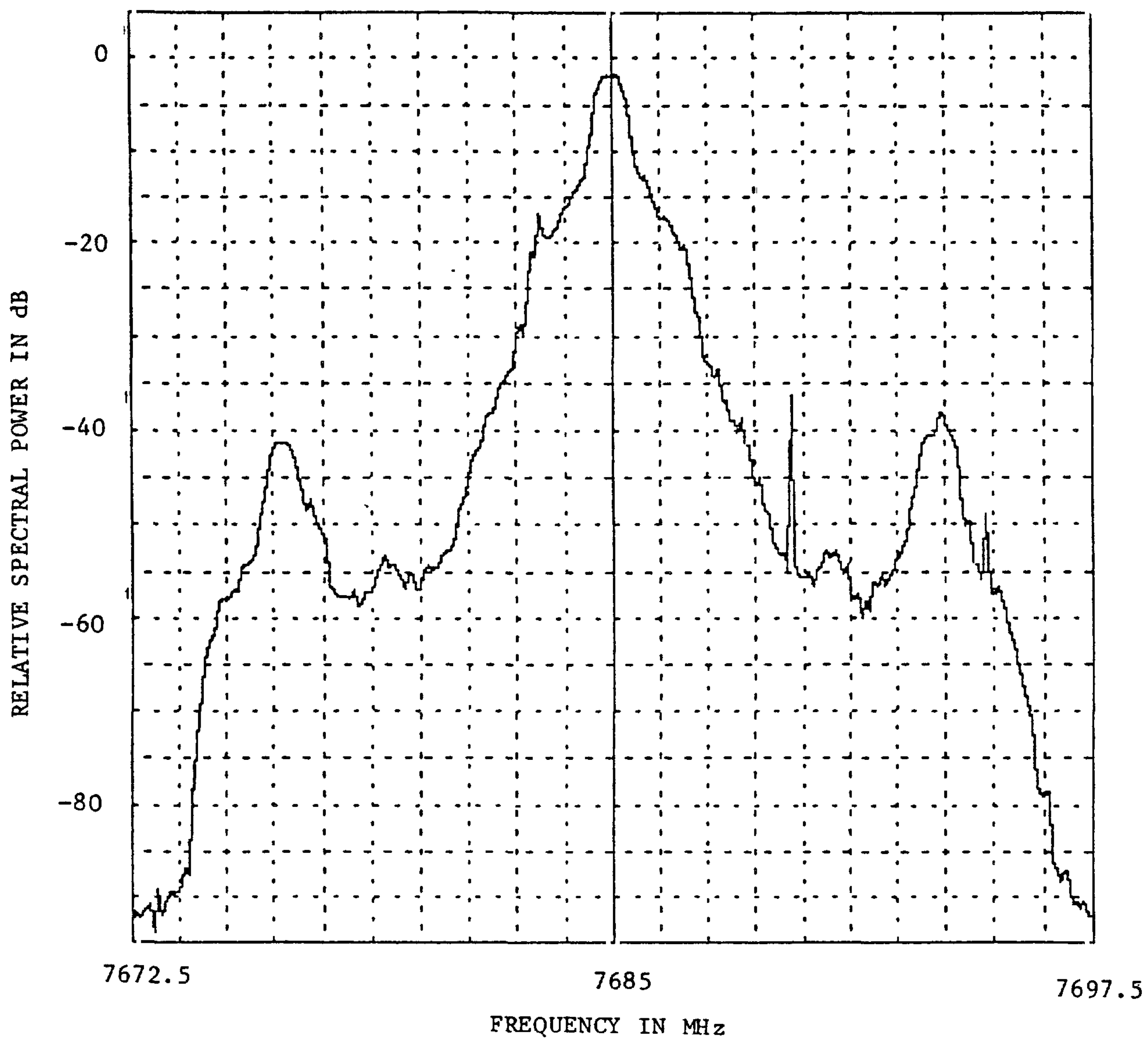


Figure A-42. Emission Spectrum of a GE TRS696C (f_o = 7685 MHz, Hard-lined, Normal Traffic).

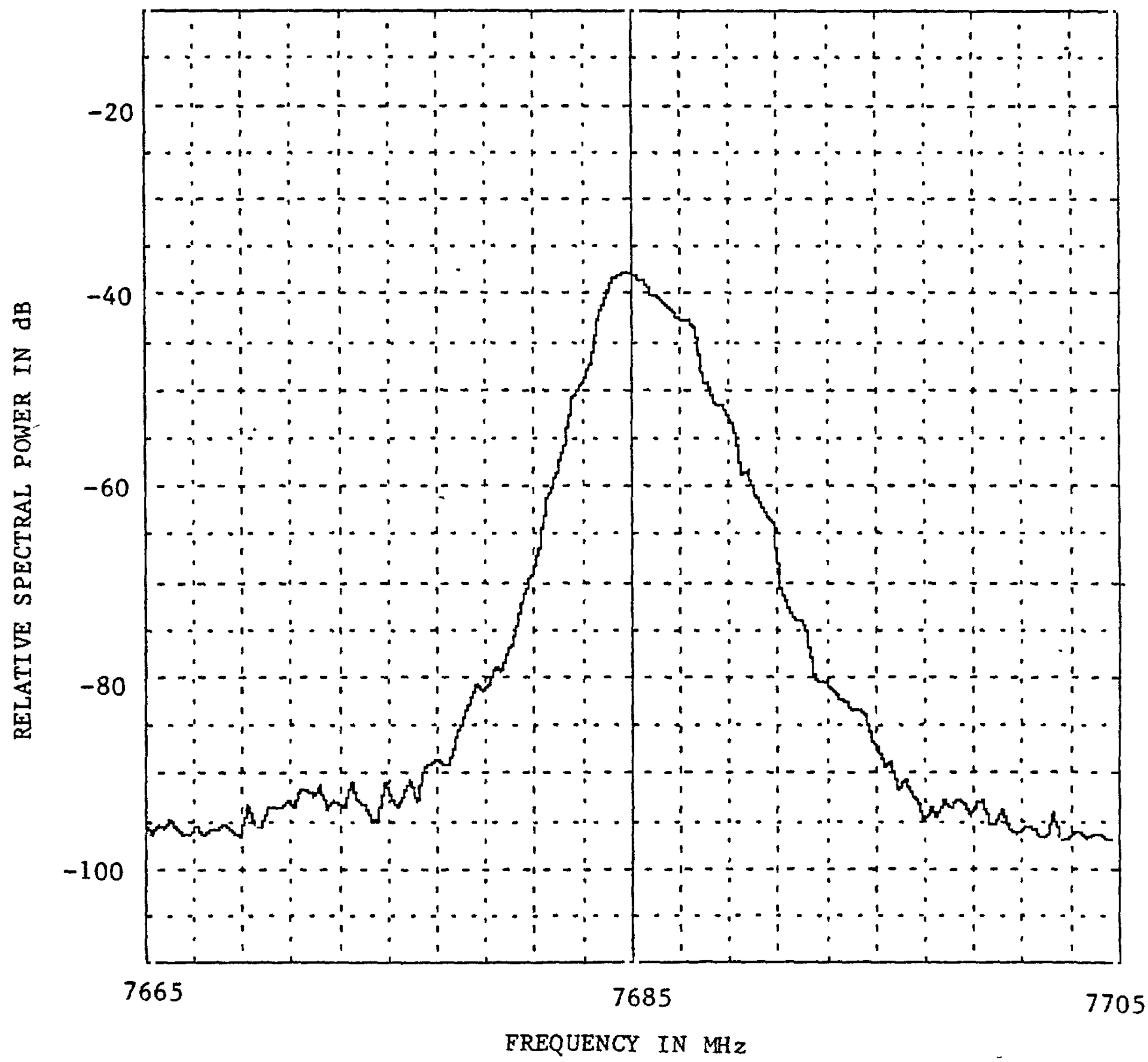


Figure A-43. Emission Spectrum of a GE TRS696C (f_o = 7685 MHz, Radiated, Loaded Condition).

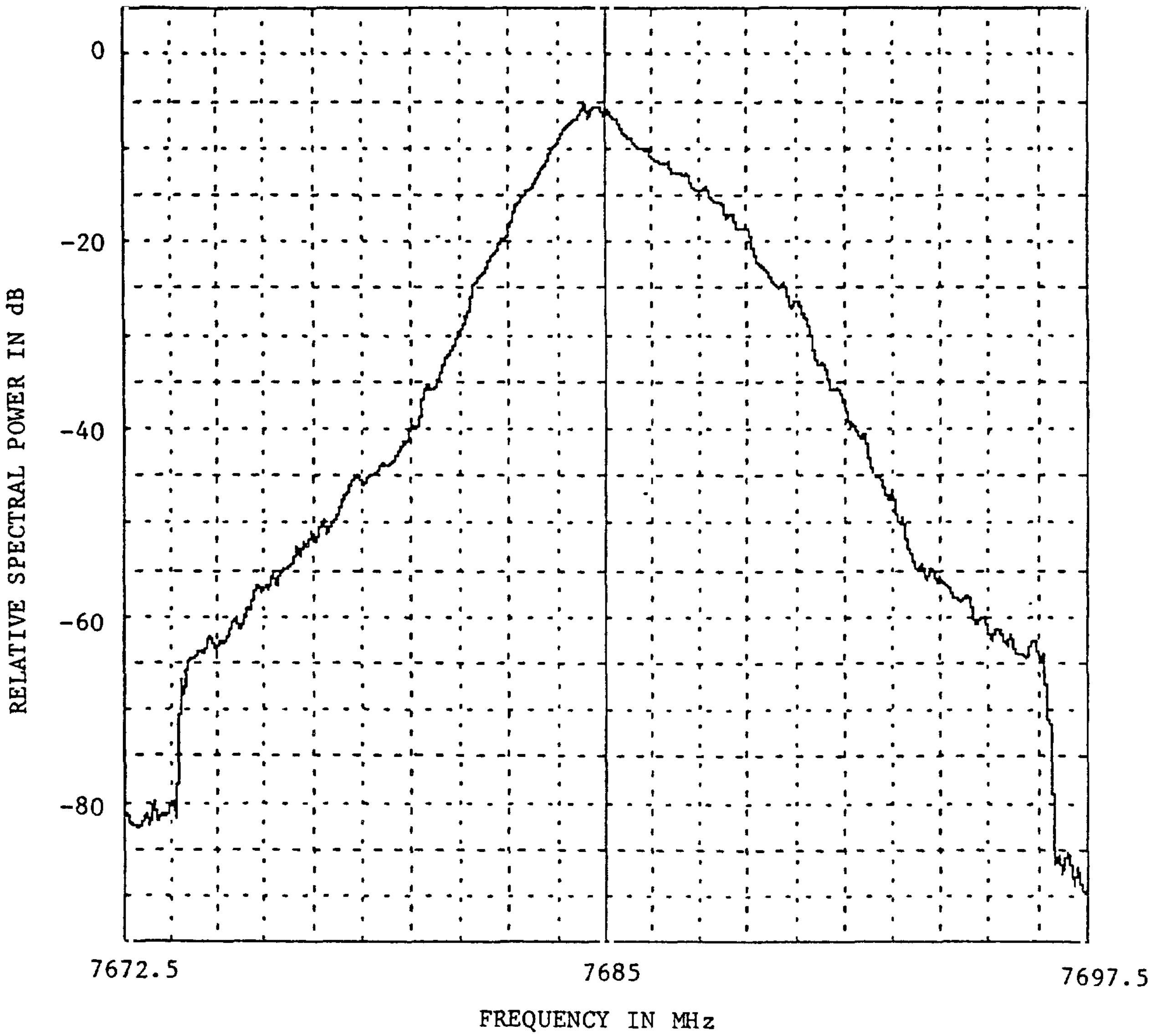


Figure A-44. Emission Spectrum of a GE TRS696C (f_o = 7685 MHz, Hardlined, Loaded Condition).

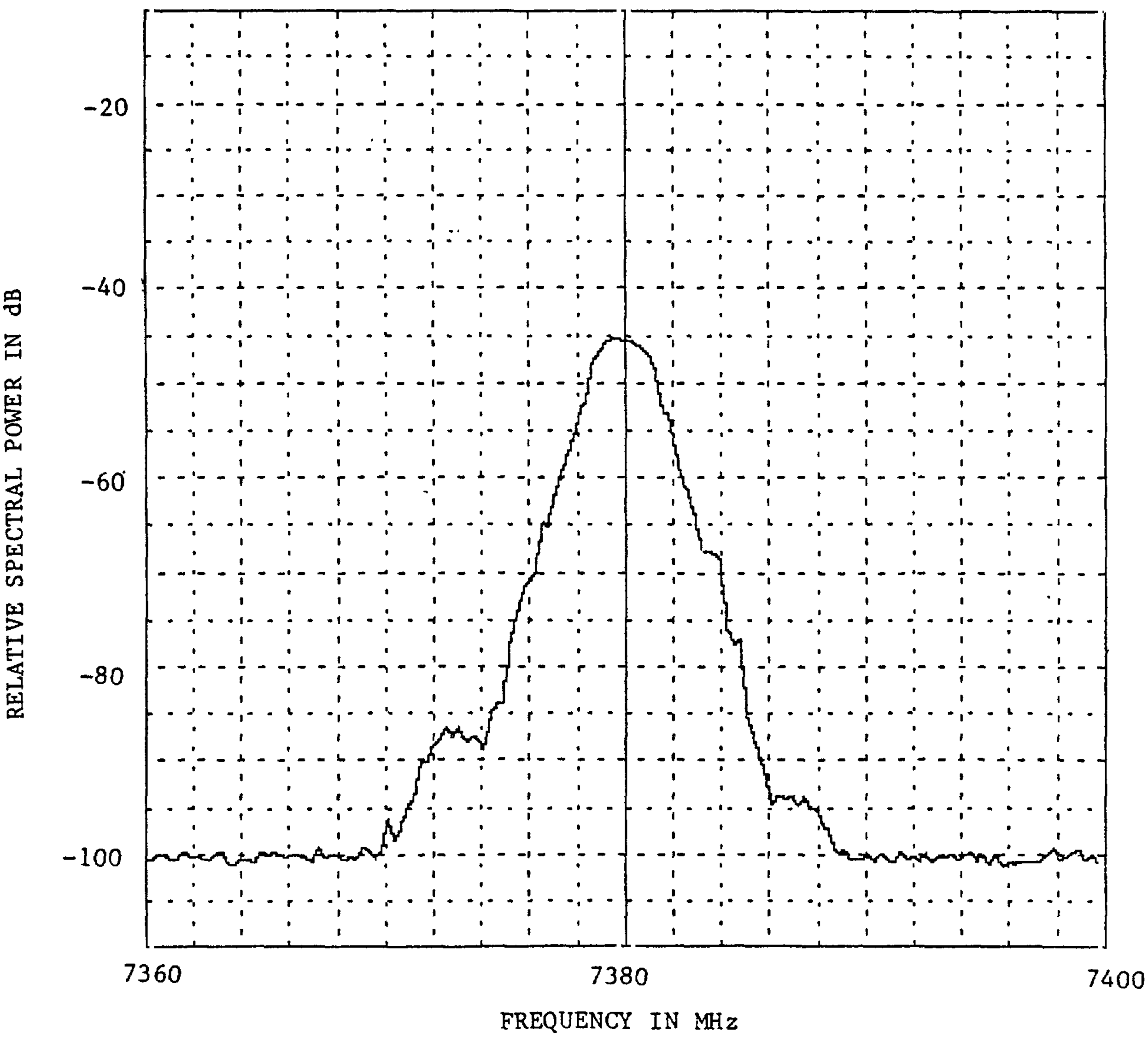


Figure A-45. Emission Spectrum of a COL MW508C (f_o = 7380 MHz, Radiated, Normal Traffic).

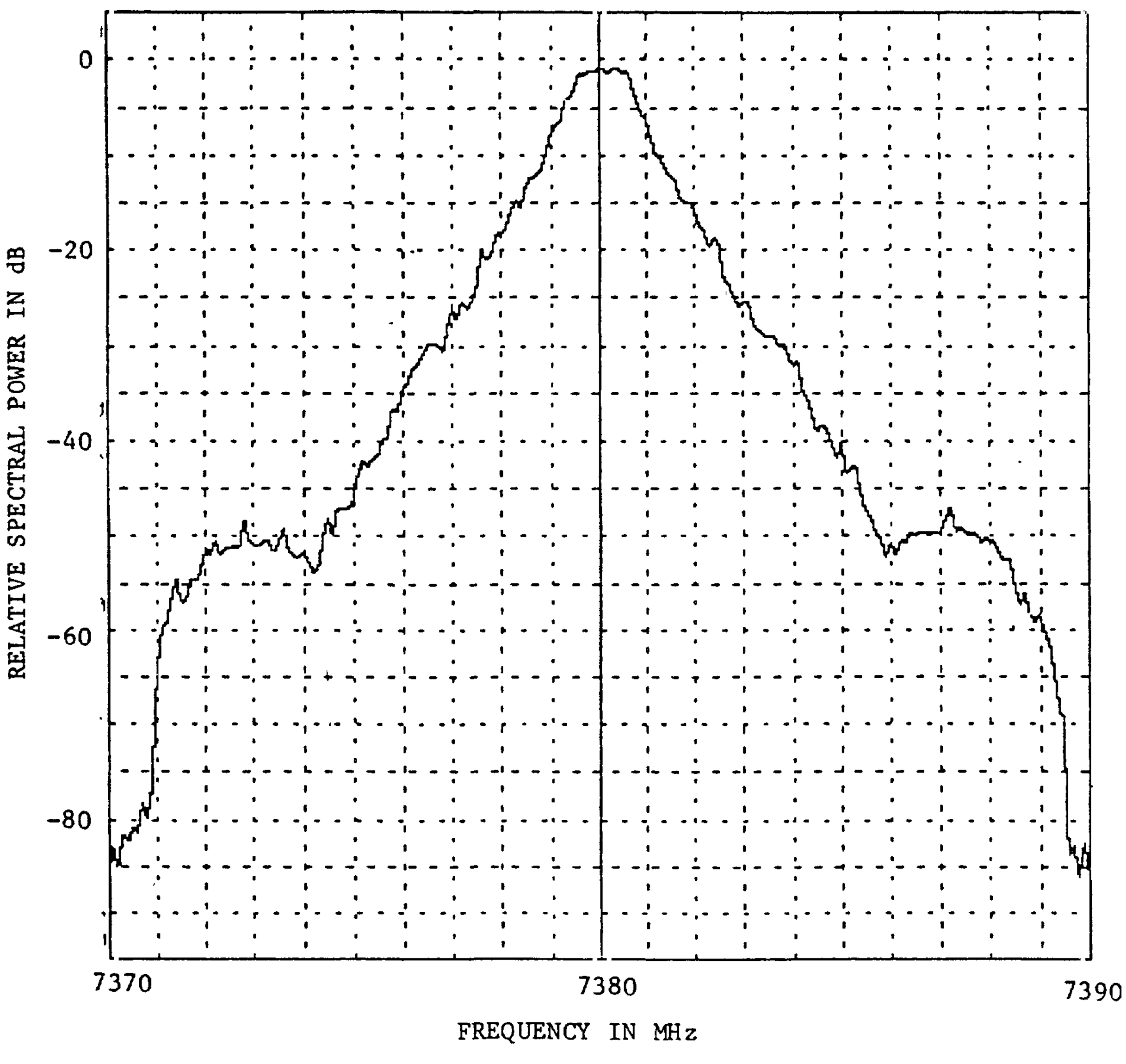


Figure A-46. Emission Spectrum of a COL MW508C (f_o = 7380 MHz, Hard-lined, Normal Traffic).

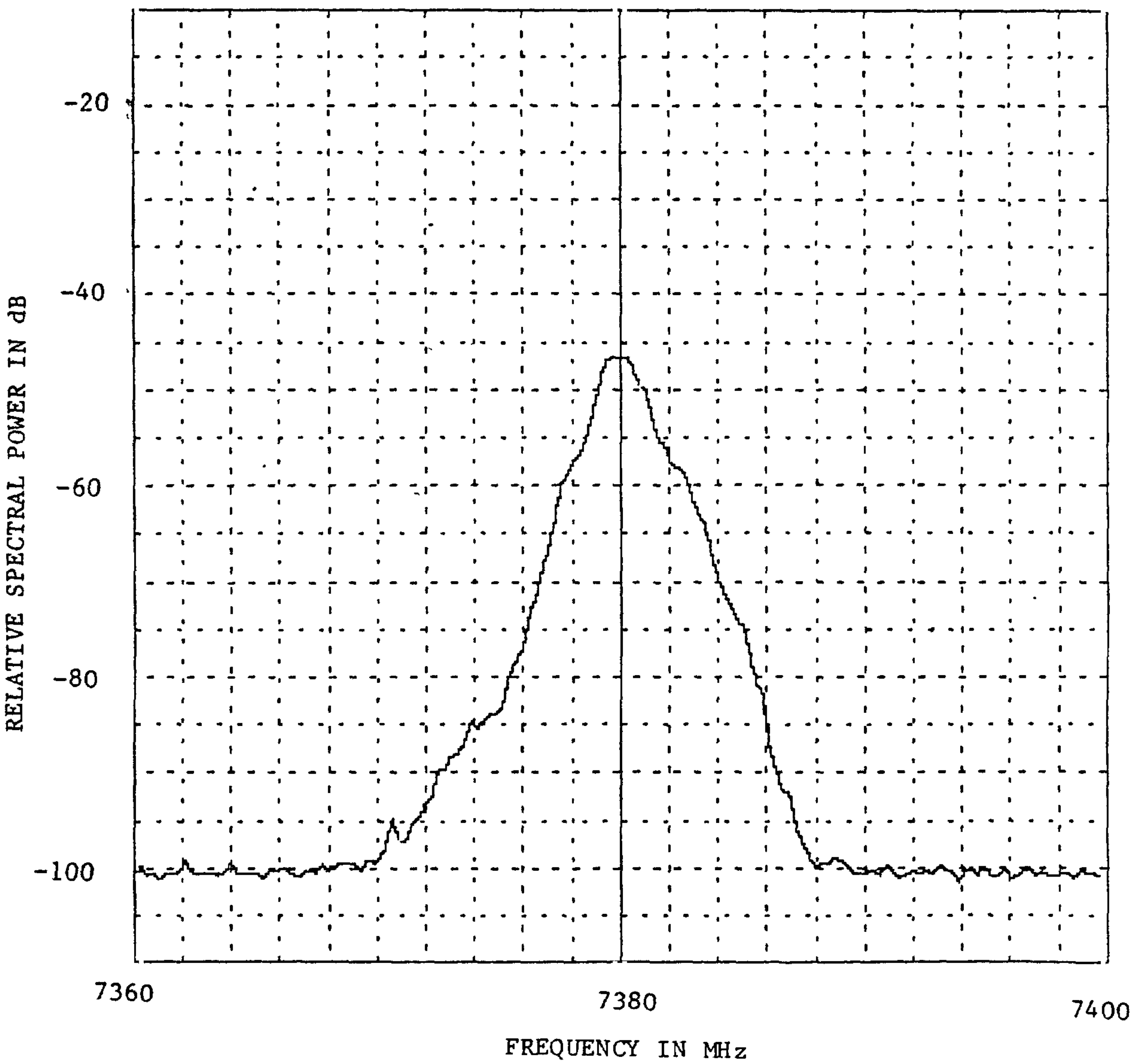


Figure A-47. Emission Spectrum of a COL MW508C (f_o = 7380 MHz, Radiated, Loaded Condition).

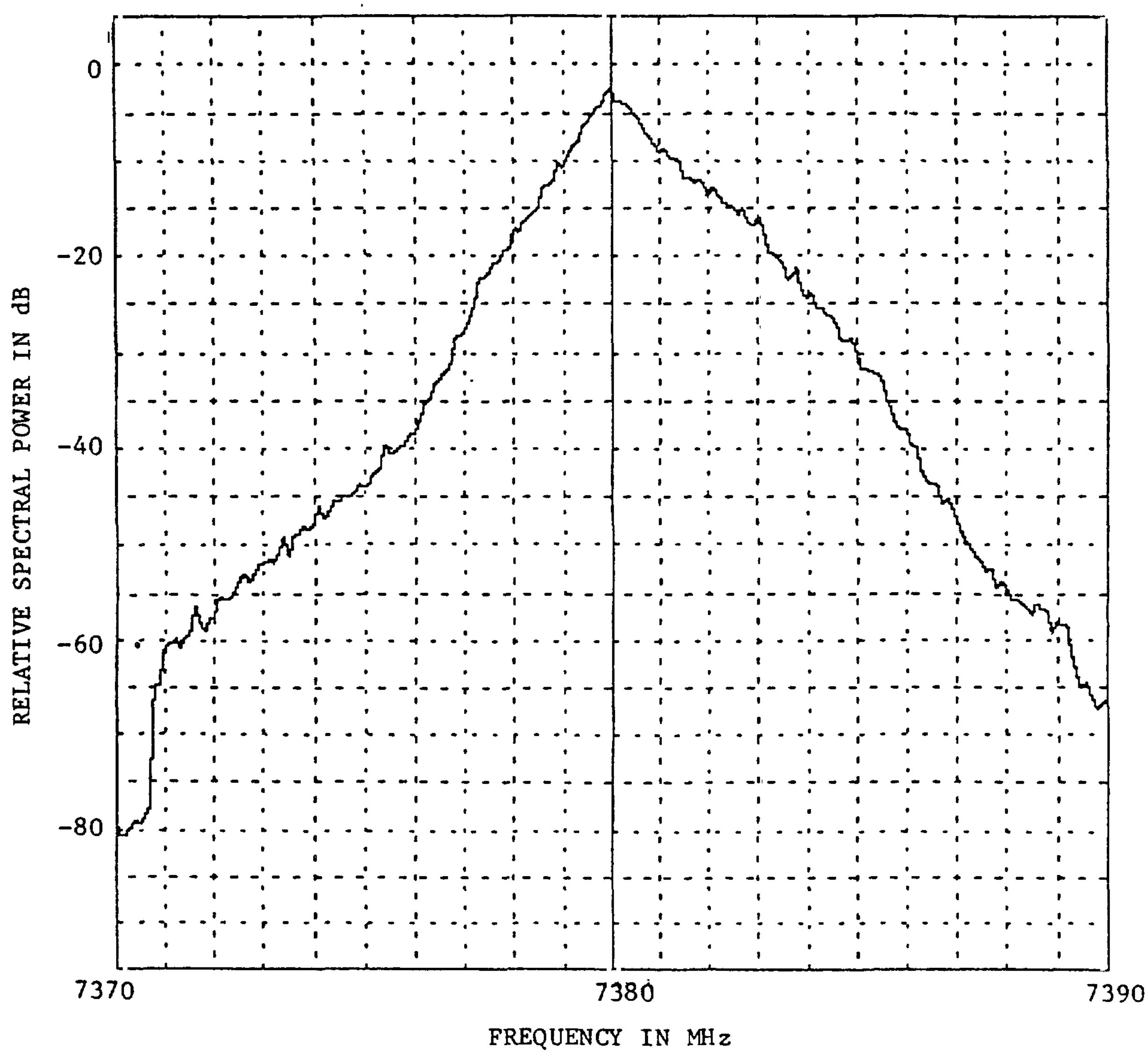


Figure A-48. Emission Spectrum of a COL MW508C (f_o = 7380 MHz, Hard-lined, Loaded Condition).

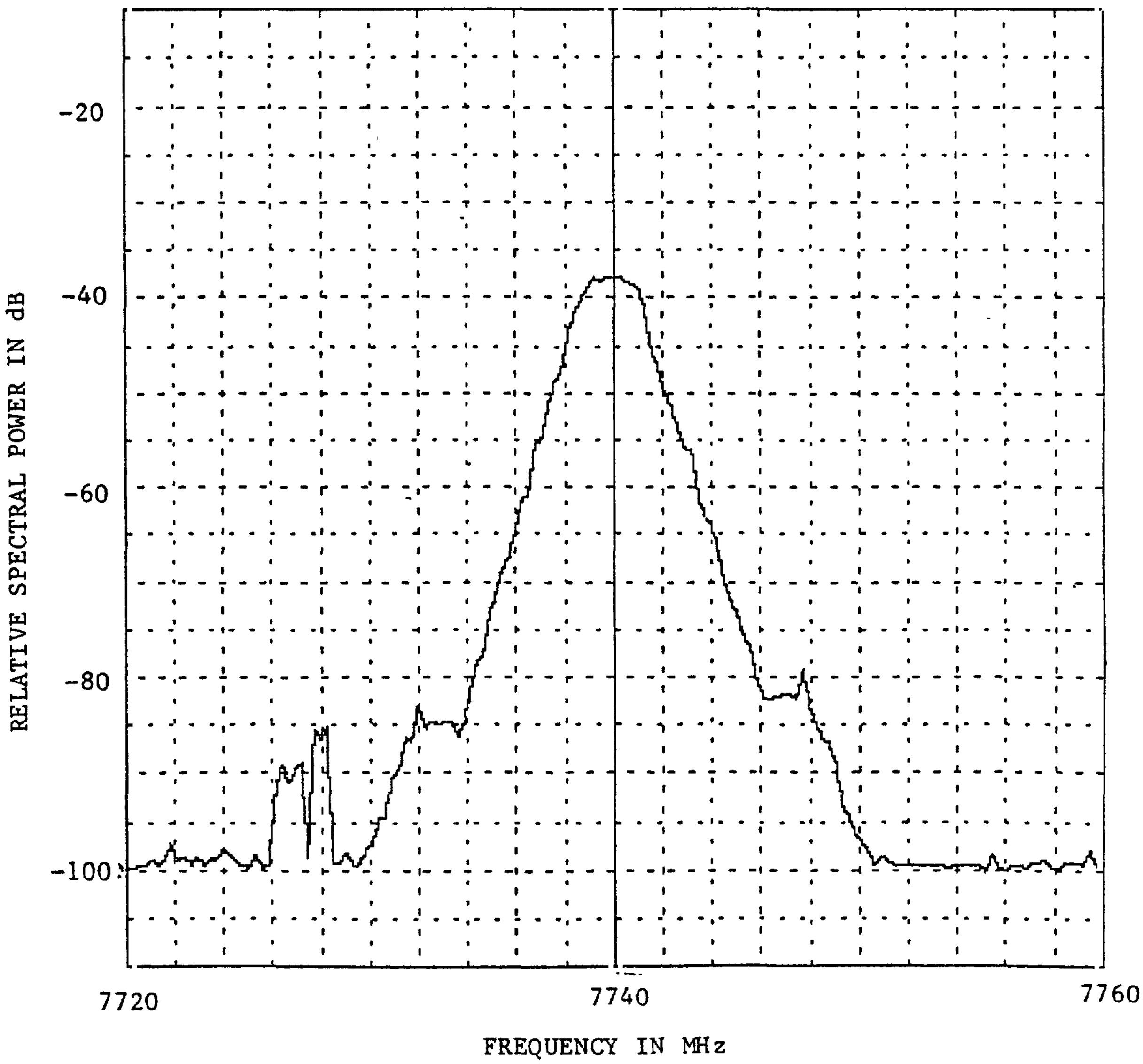


Figure A-49. Emission Spectrum of a COL MW508C (f_o = 7740 MHz, Radiated, Normal Traffic).

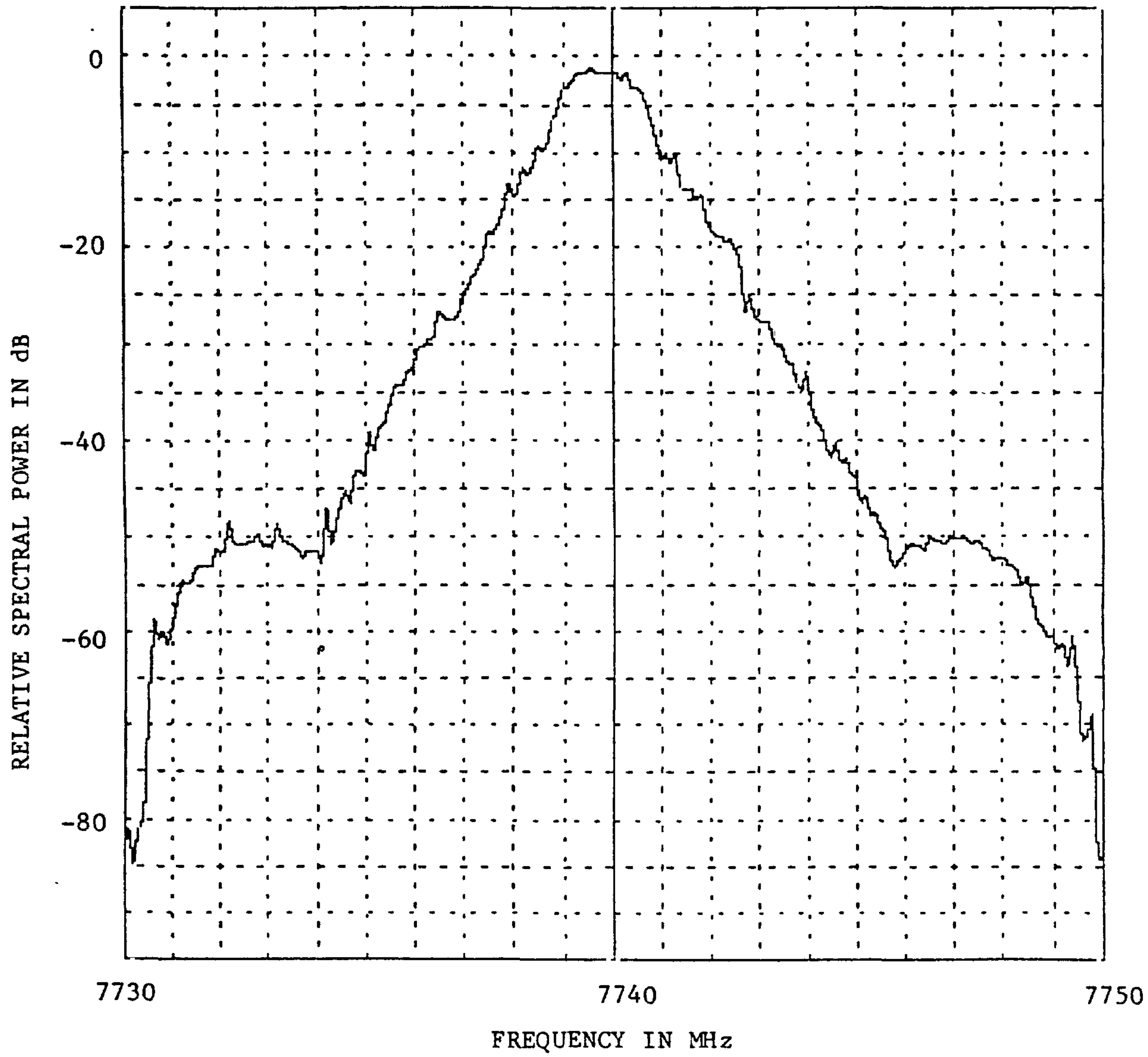


Figure A-50. Emission Spectrum of a COL MW508C (f_o = 7740 MHz, Hard-lined, Normal Traffic).

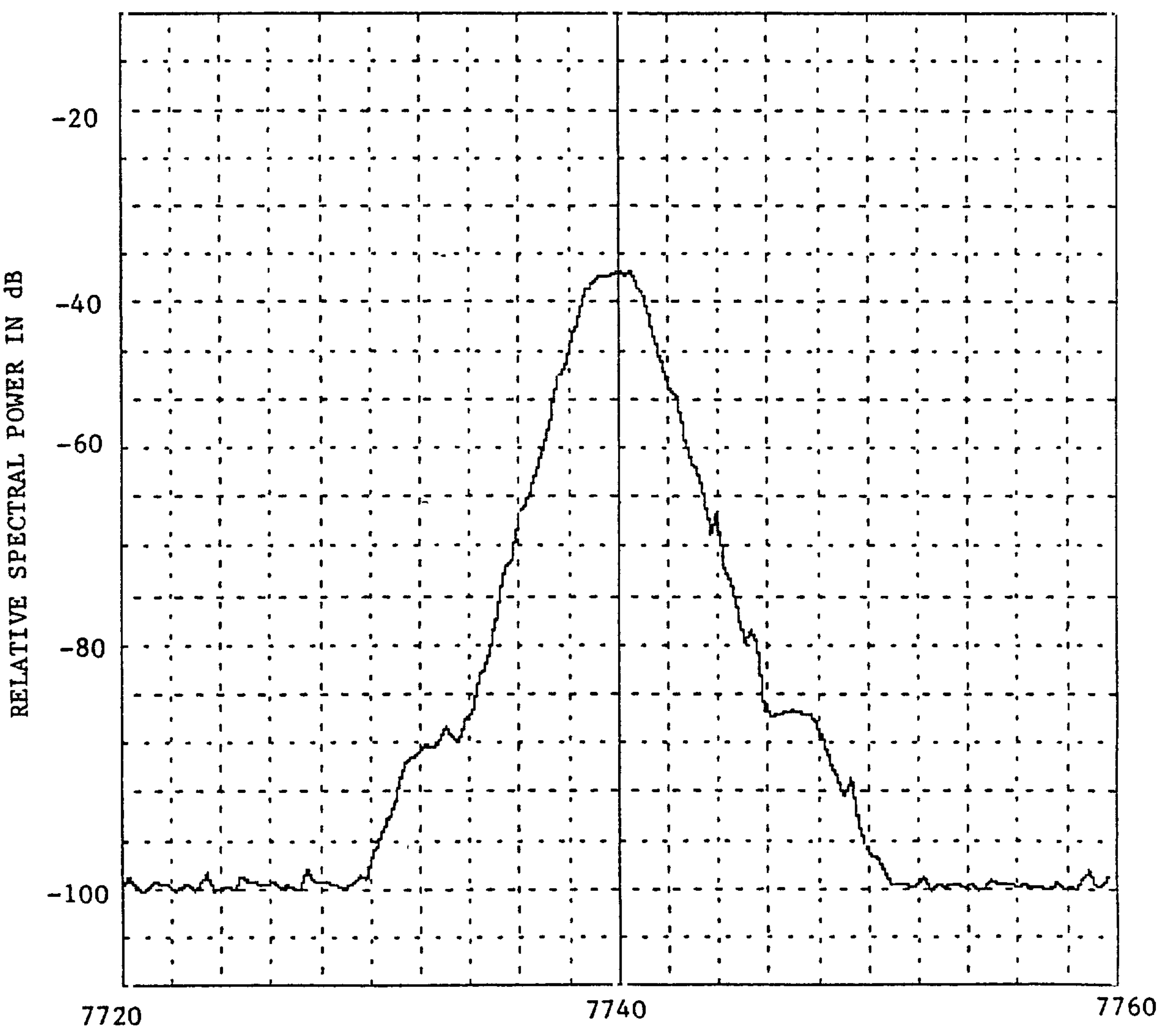


Figure A-51. Emission Spectrum of a COL MW508C (f_o = 7740 MHz, Radiated, Loaded Condition).

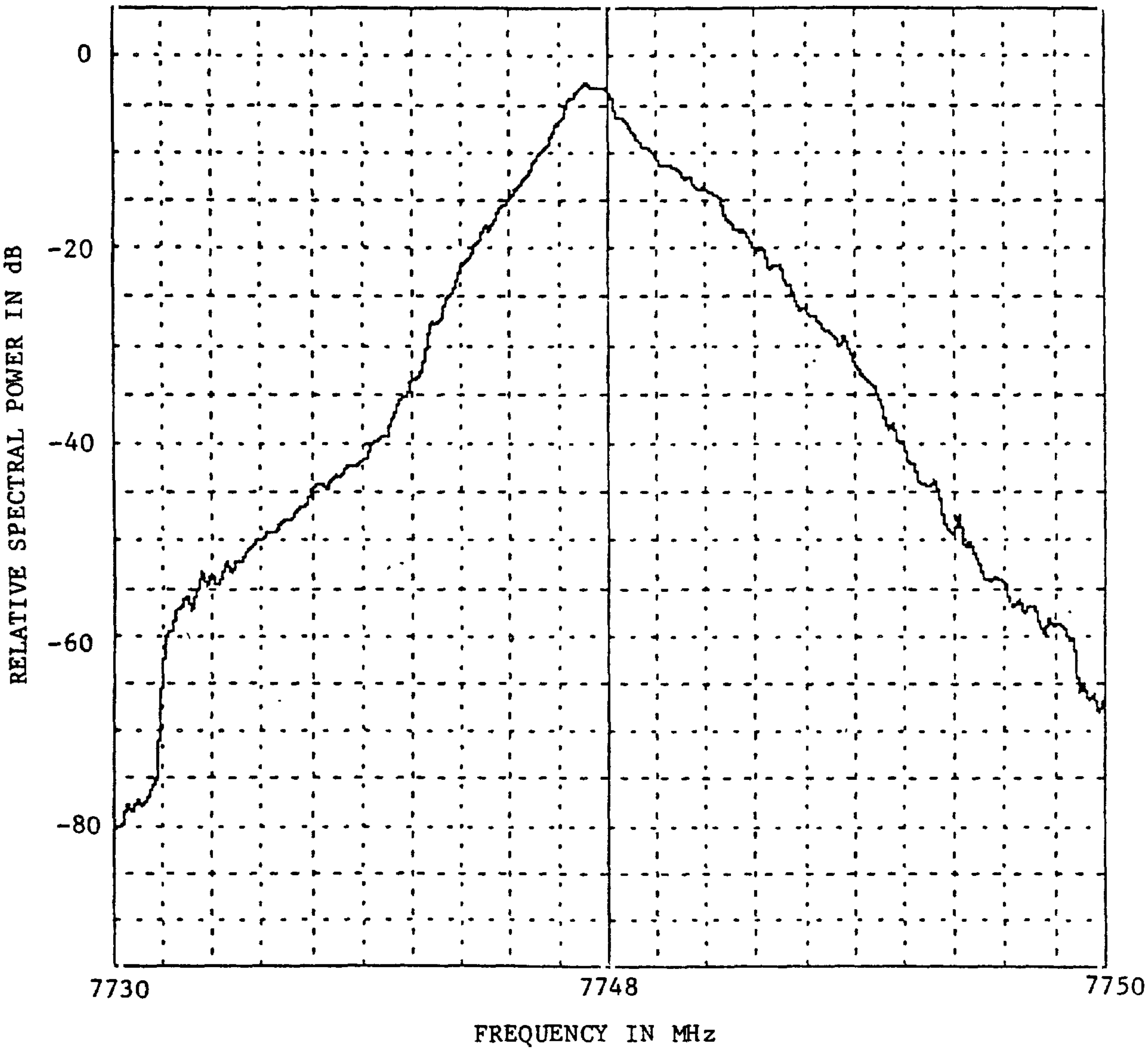


Figure A-52. Emission Spectrum of a COL MW508C (f_o = 7740 MHz, Hard-lined, Loaded Condition).

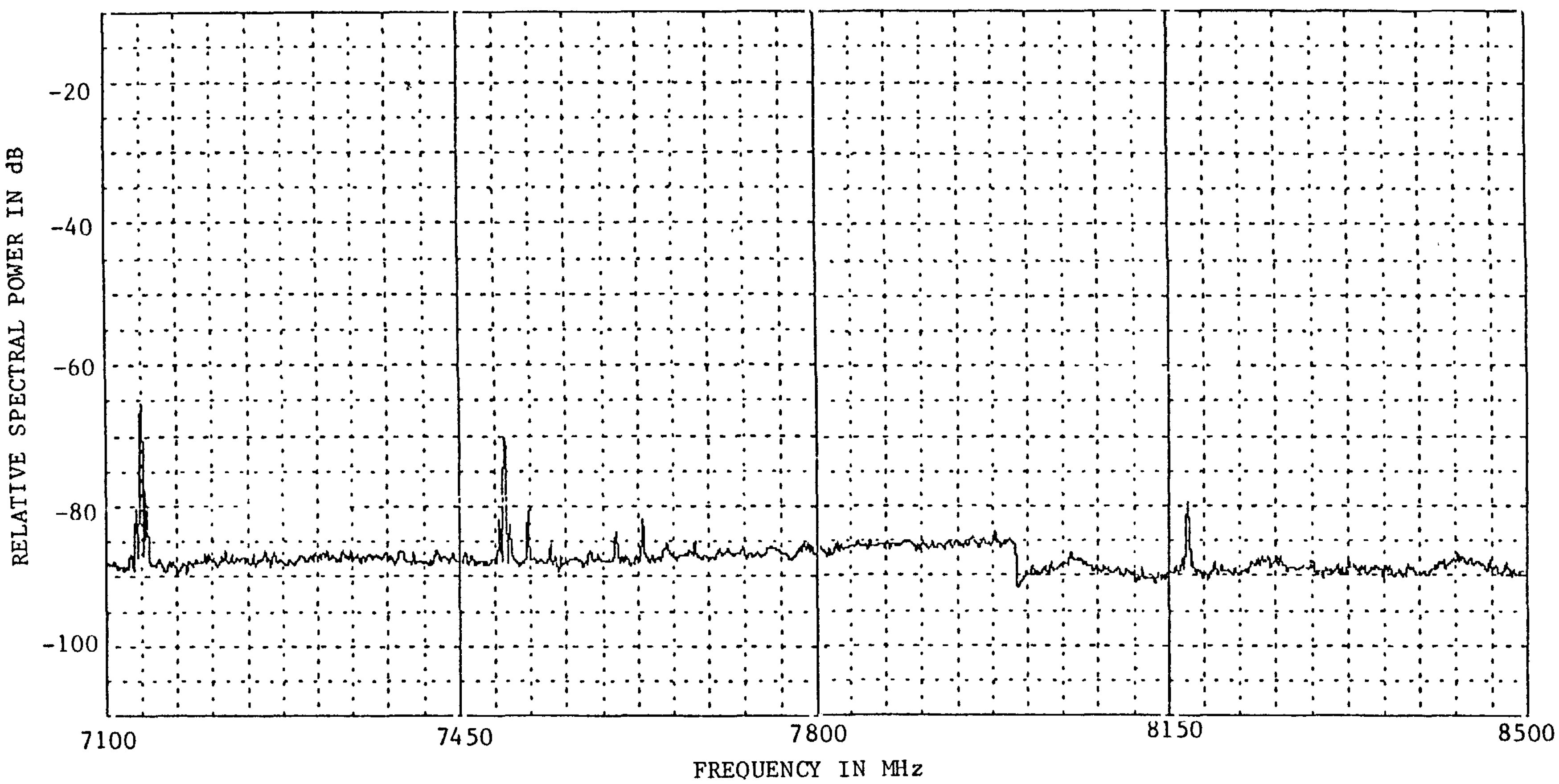


Figure A-53. Band Scan of the Auburn-Kent Antenna.

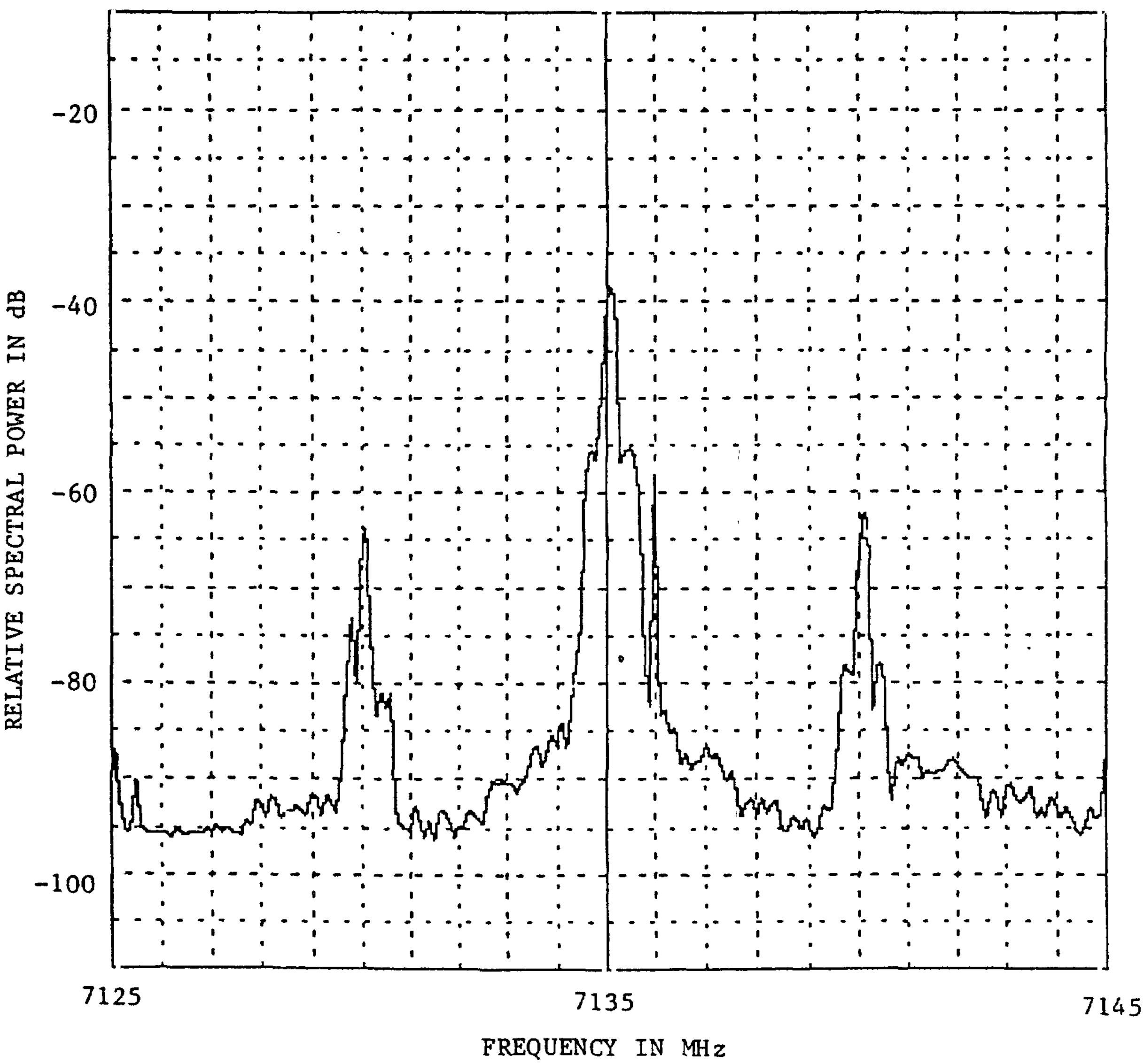


Figure A-54. Emission Spectrum of a Collins 552 A-5 (f_o = 7135 MHz, Radiated).

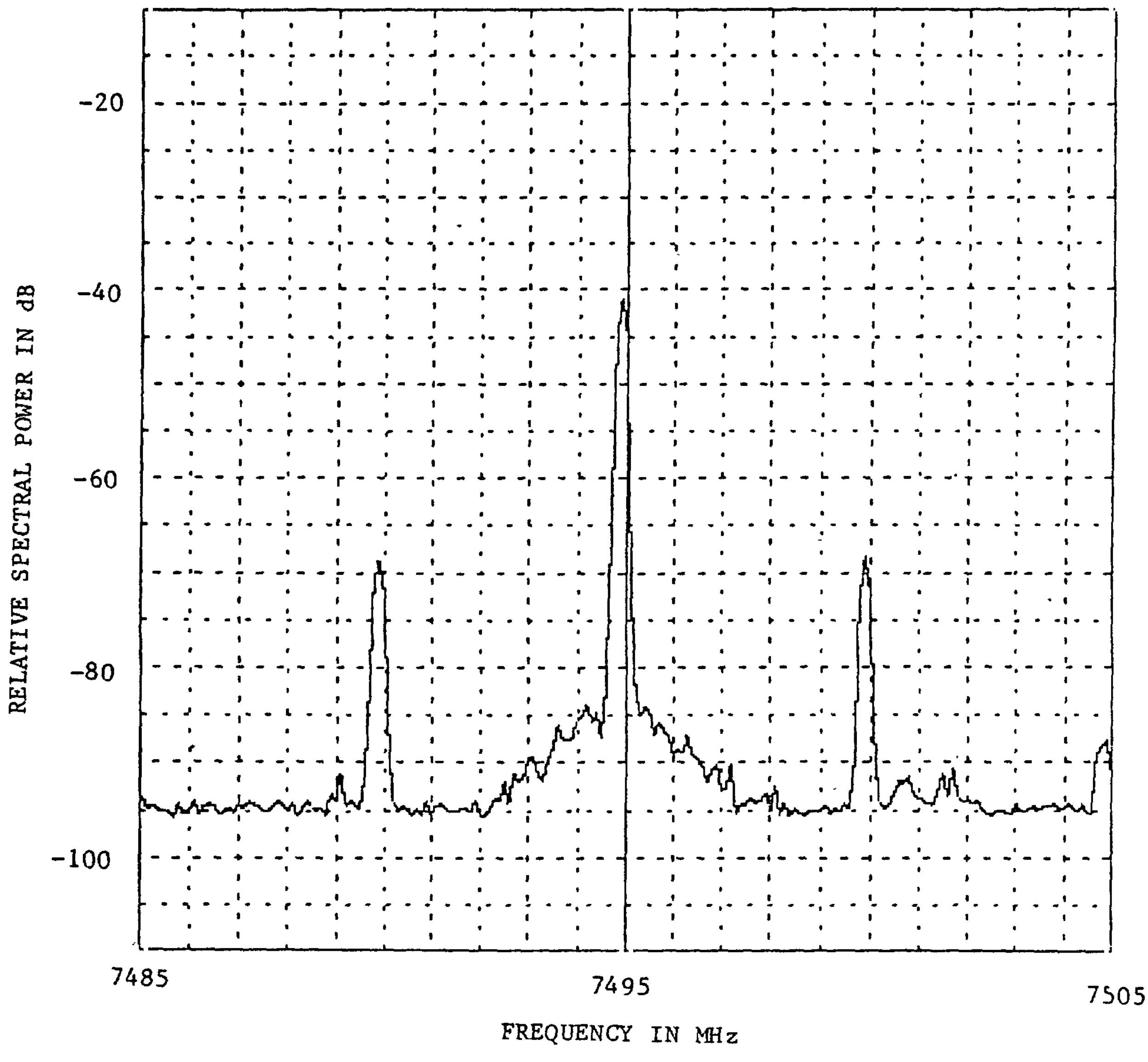


Figure A-55. Emission Spectrum of a Collins 552A-5 (f_o = 7495 MHz, Radiated).

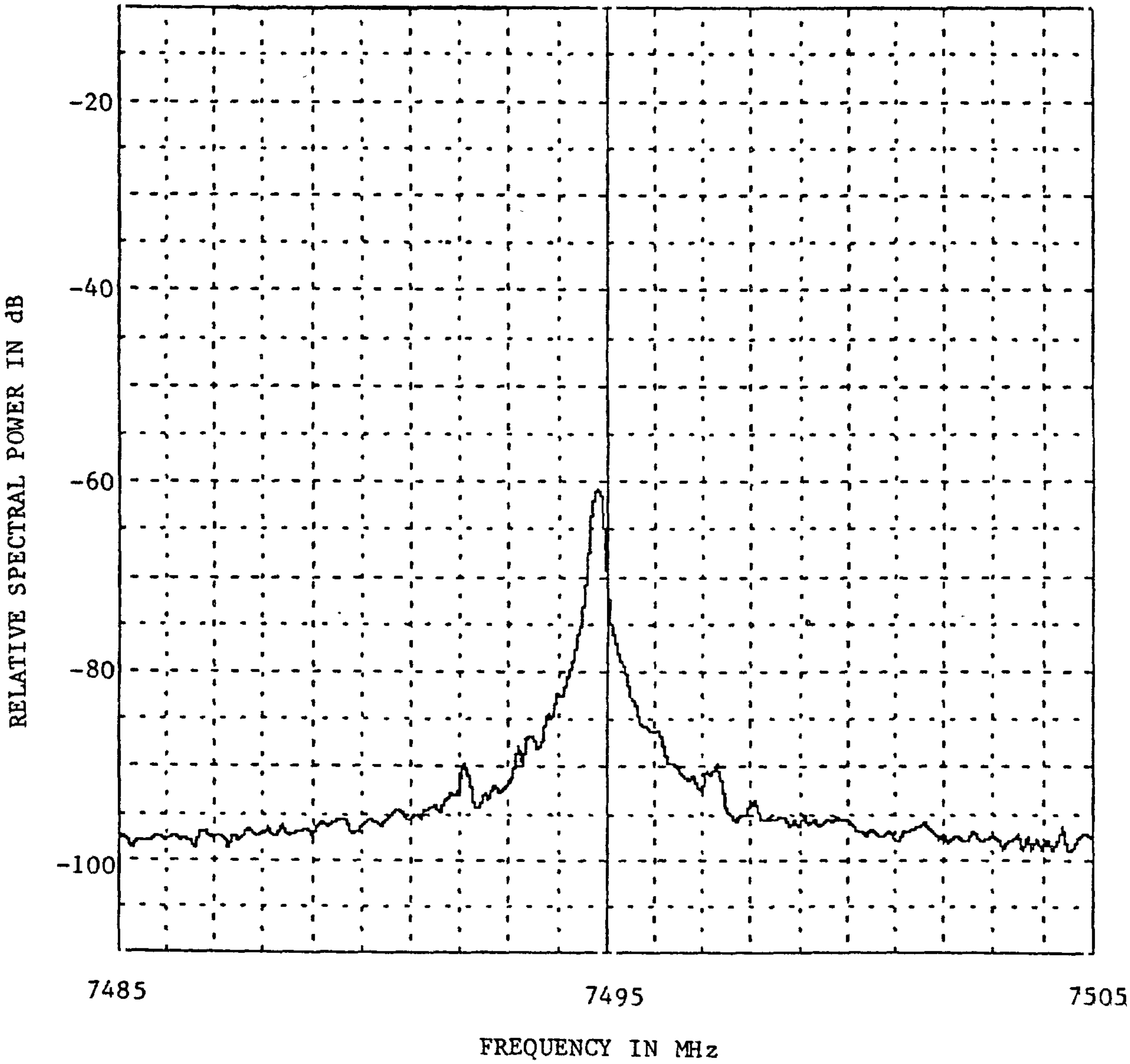


Figure A-56. Emission Spectrum of a Collins 552A-5 (f_o = 7495 MHz, Radiated, Loaded Condition).

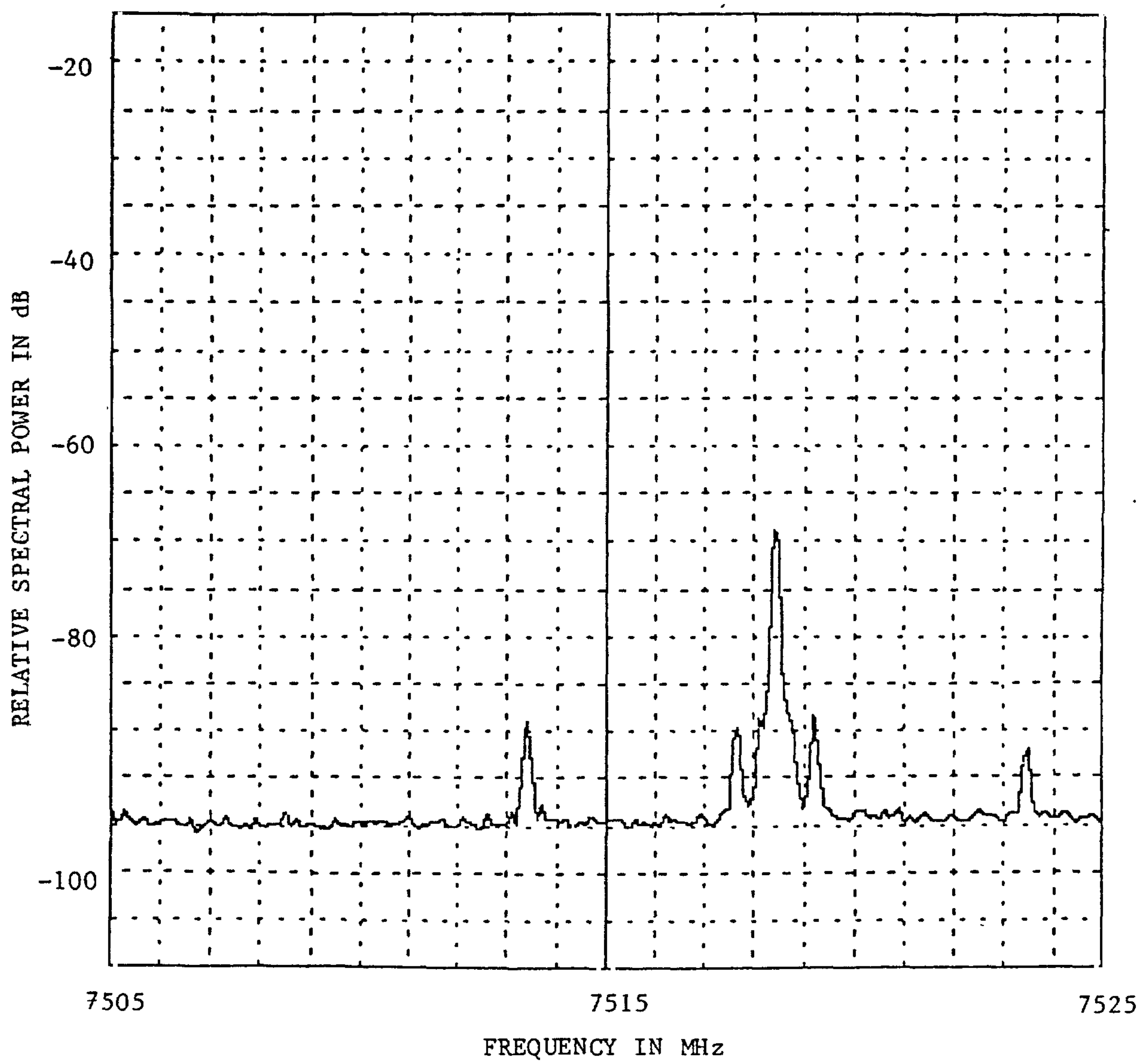


Figure A-57. Emission Spectrum of a Collins 552A-5 (f_o = 7515 MHz, Radiated).

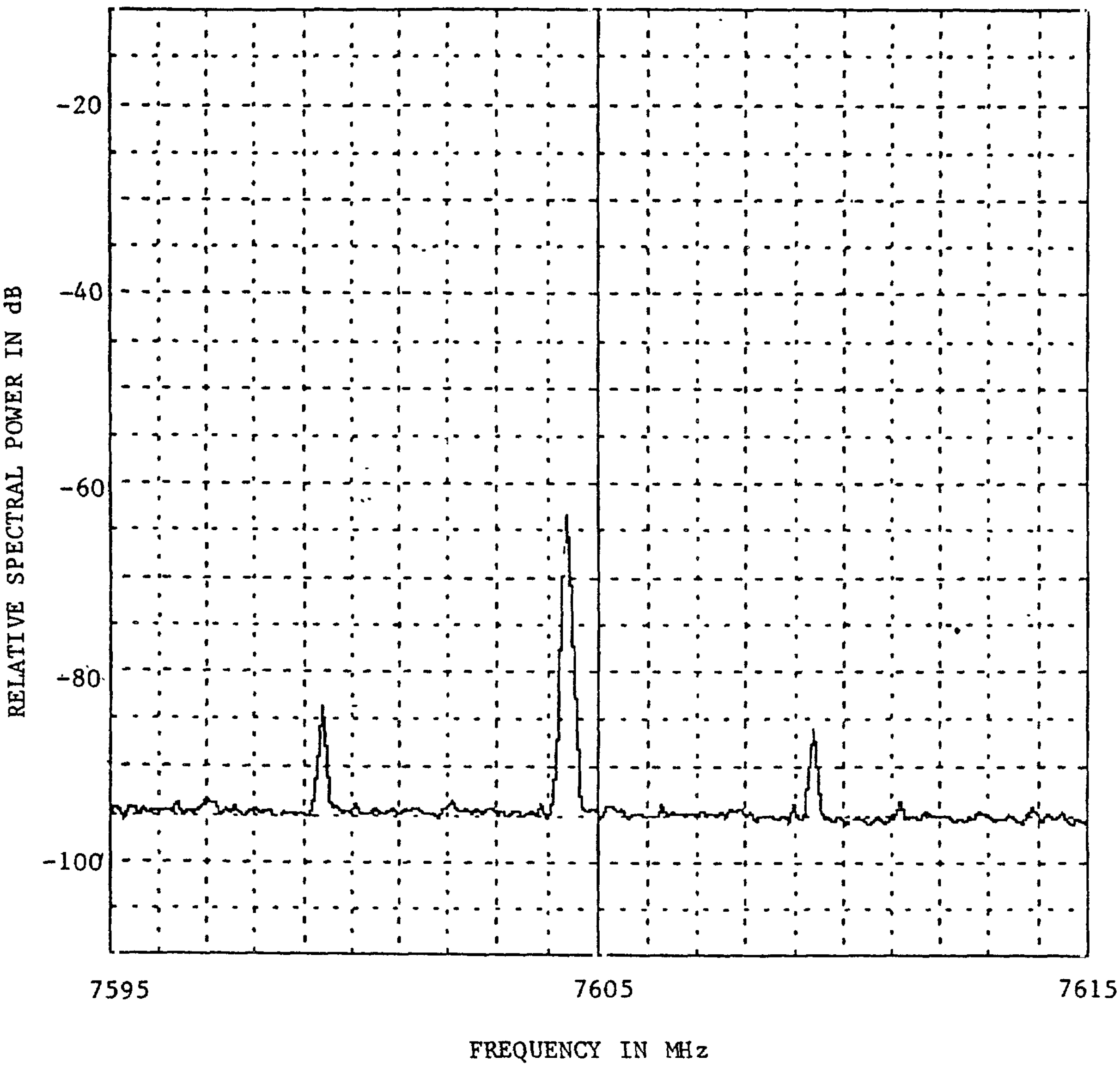


Figure A-58. Emission Spectrum of a Collins 552A-5 (f_o = 7605 MHz, Radiated).

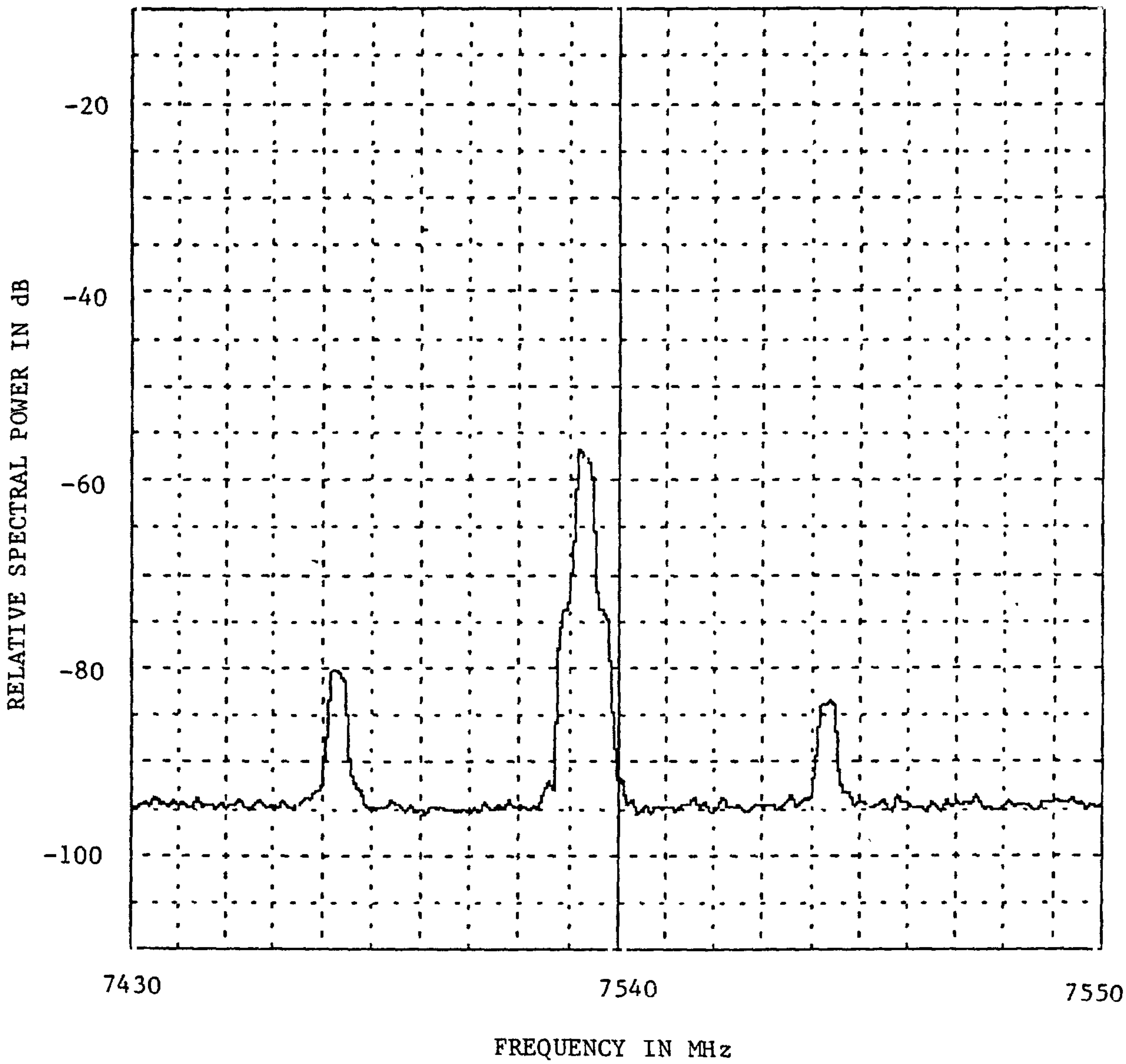


Figure A-59. Emission Spectrum of a Collins 552A-5 (f_o = 7540 MHz, Radiated).

Figure A-60. Emission Spectrum of a Collins 552A-5 (f_o = 7630 MHz, Radiated).

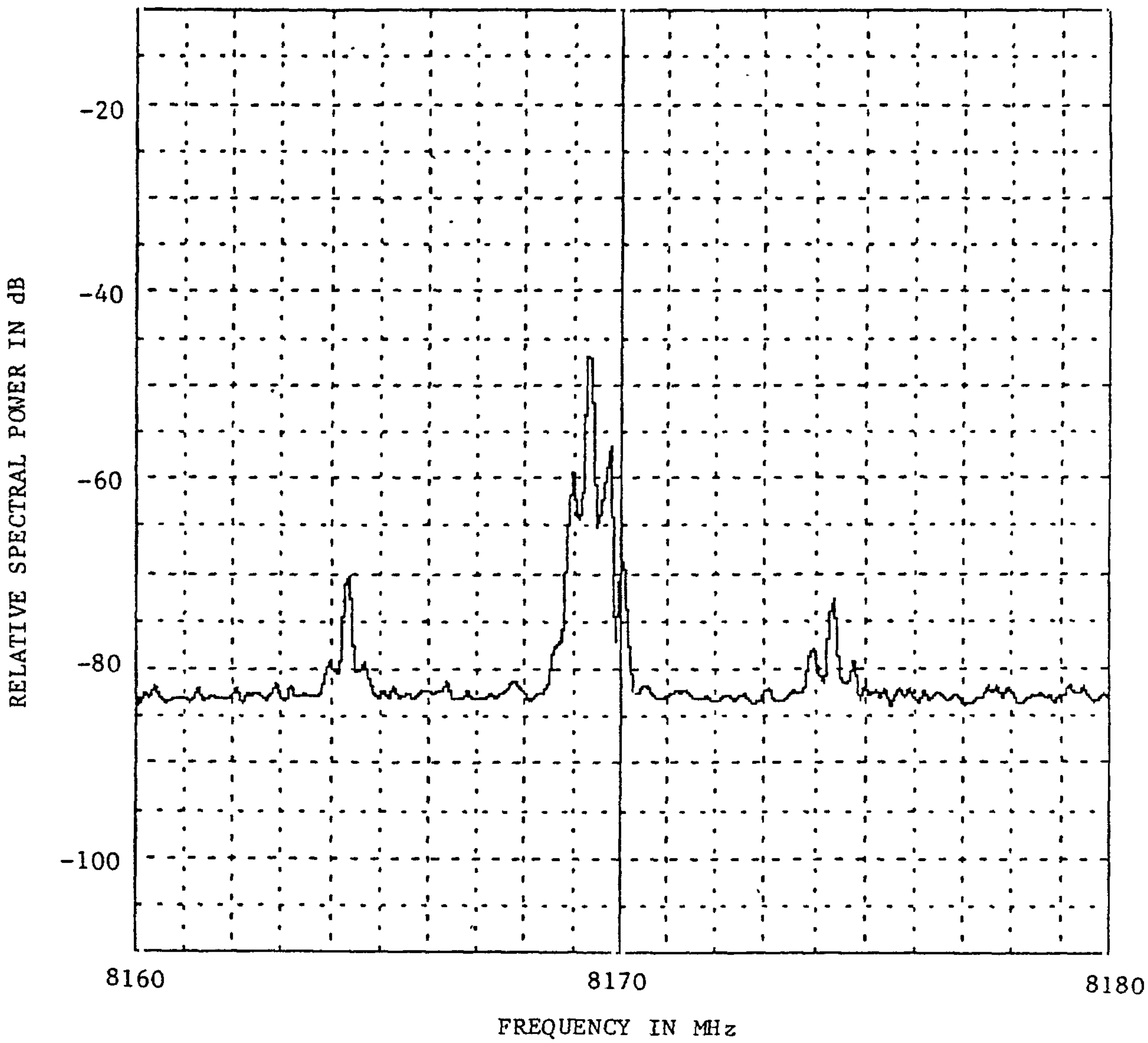


Figure A-61. Emission Spectrum of a Collins 552A-5 (f_o = 8170 MHz, Radiated).

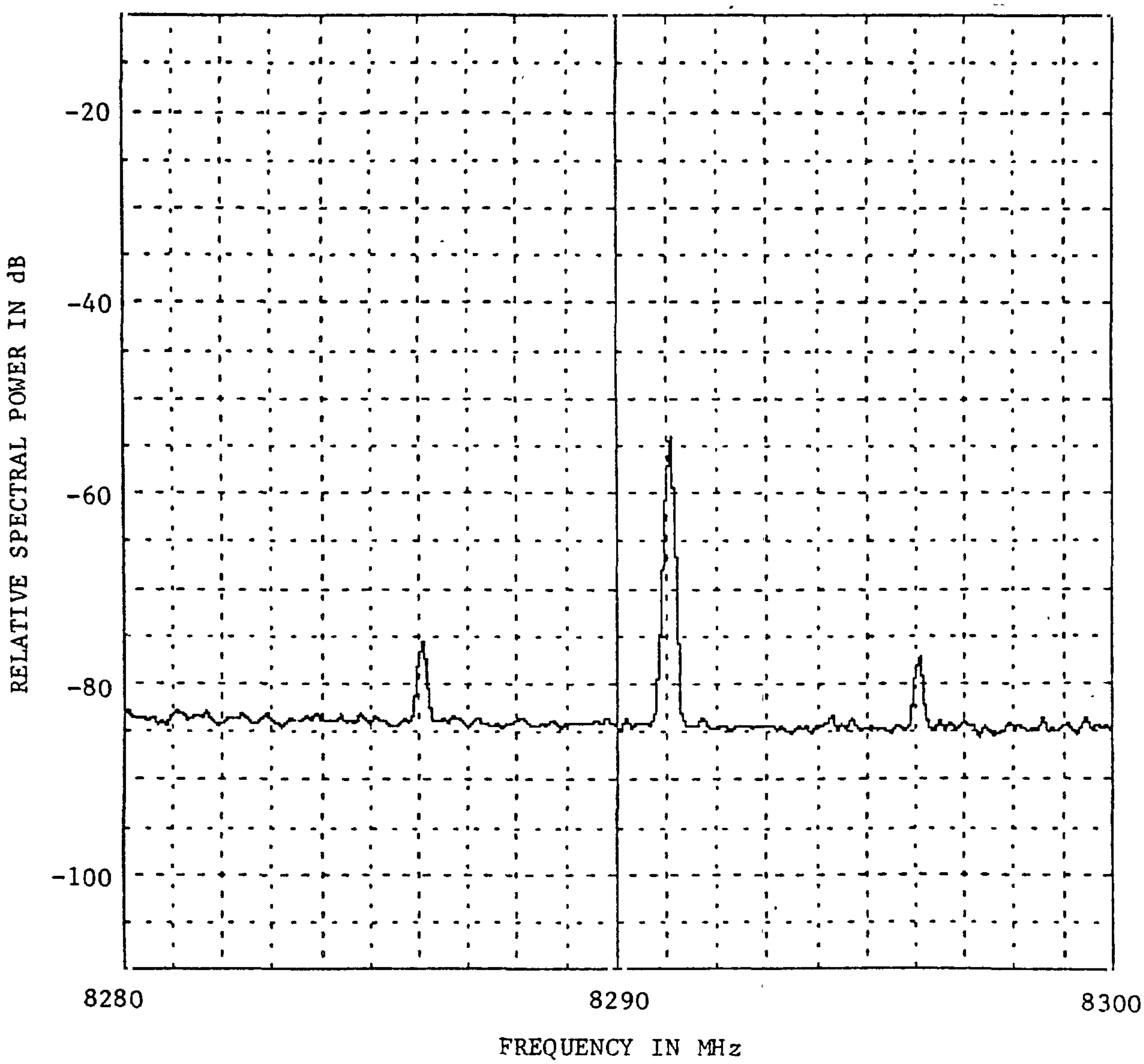


Figure A-62. Emission Spectrum of Collins 552A-5 (f_o = 8290 MHz, Radiated).

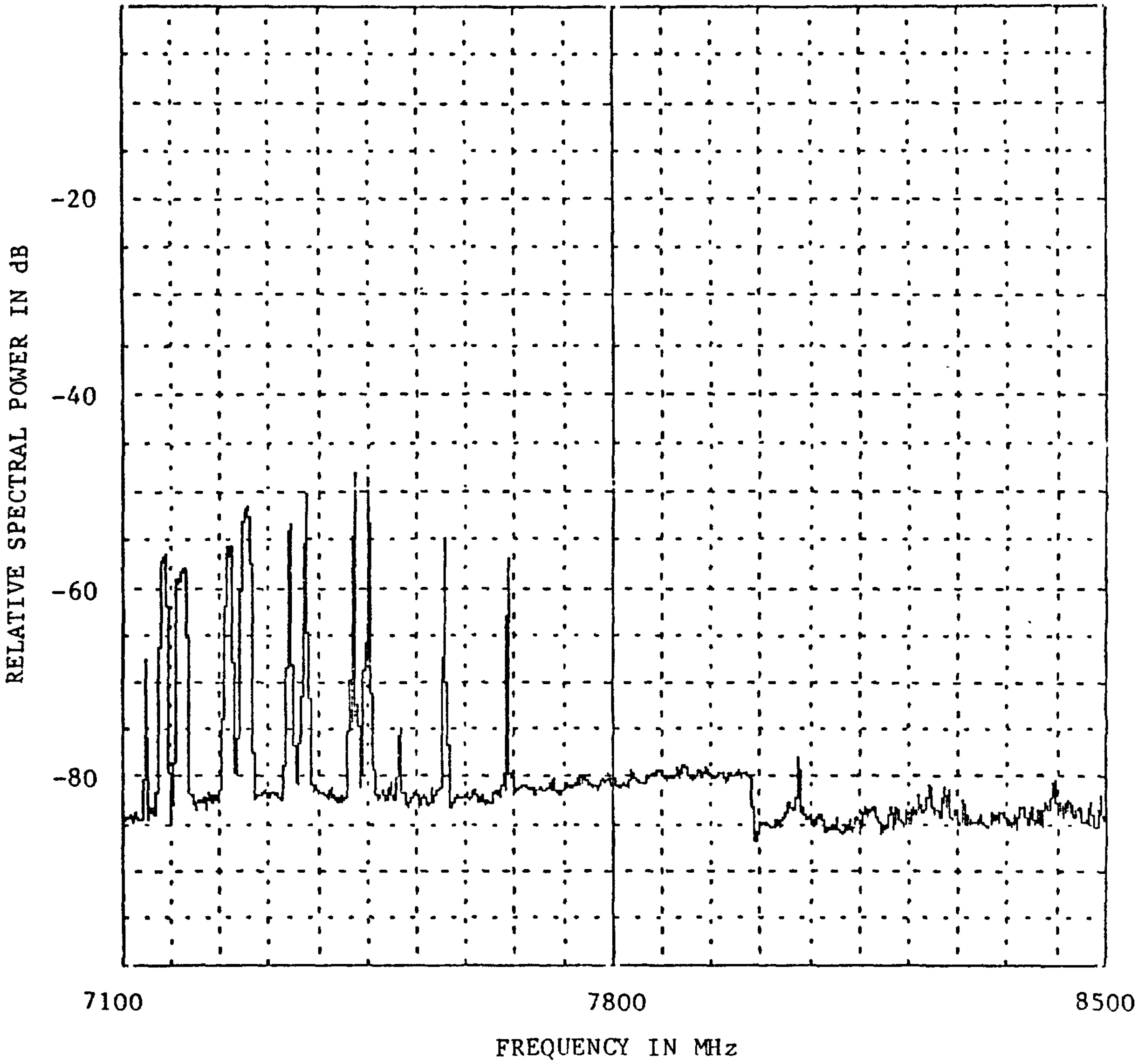


Figure A-63. Band Scan of the Madrona - Auburn Antenna.

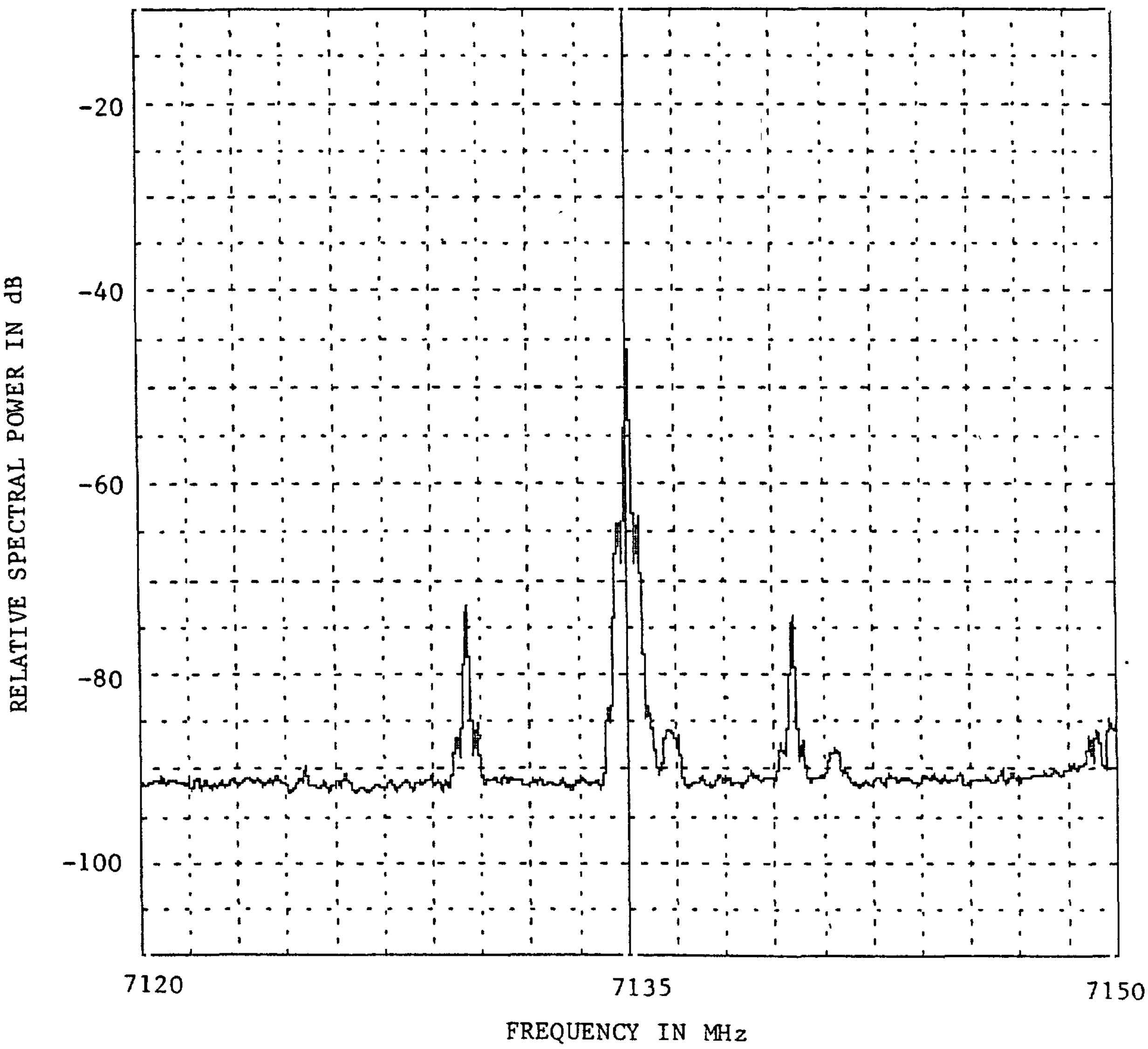


Figure A-64. Emission Spectrum of a Collins 552A-5 (f_o = 7135 MHz, Radiated).

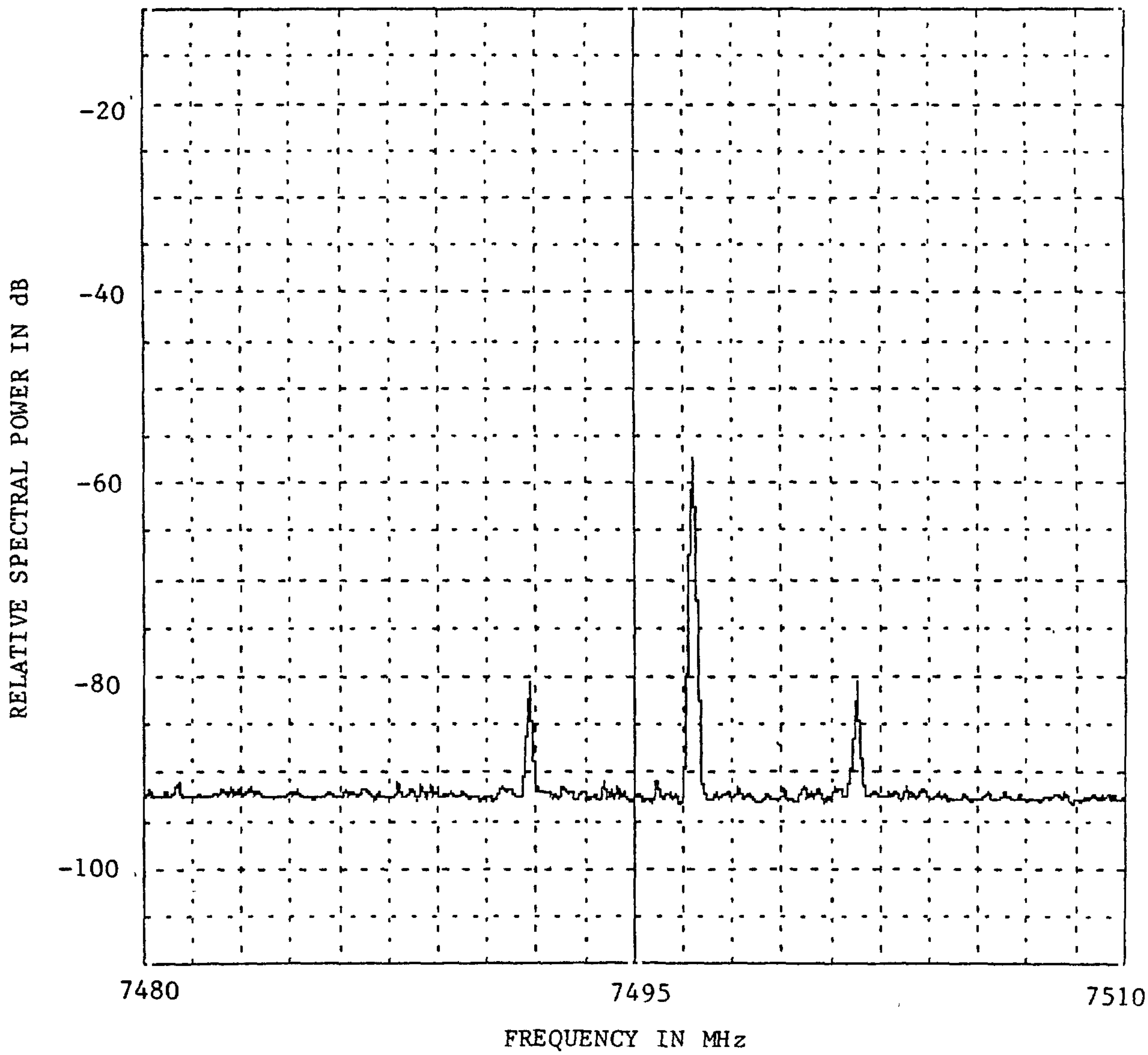


Figure A-65. Emission Spectrum of a Collins 552A-5 (f_o = 7495 MHz, Radiated).

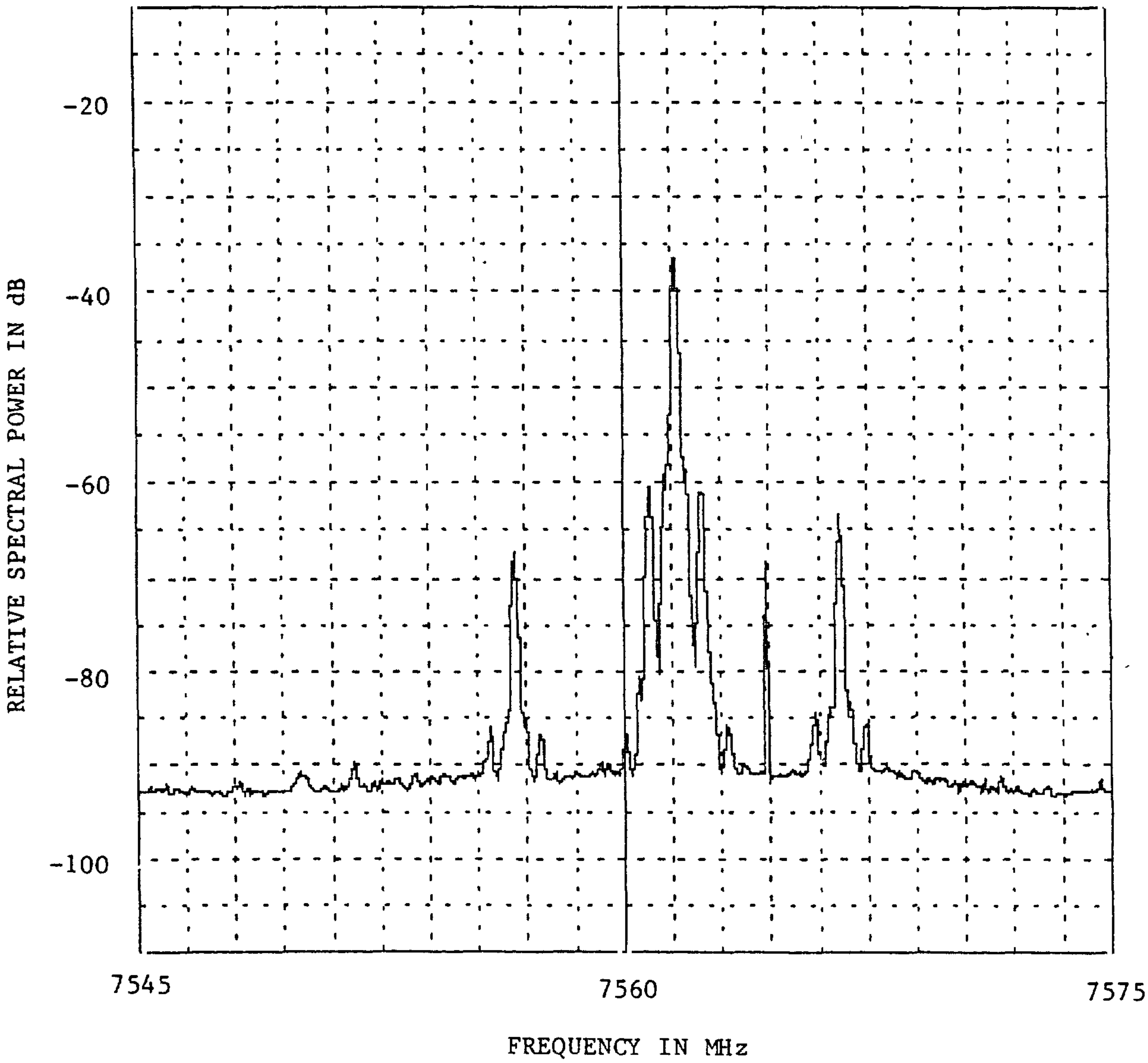


Figure A-66. Emission Spectrum of a Collins 552A-5 (f_o = 7560 MHz, Radiated).

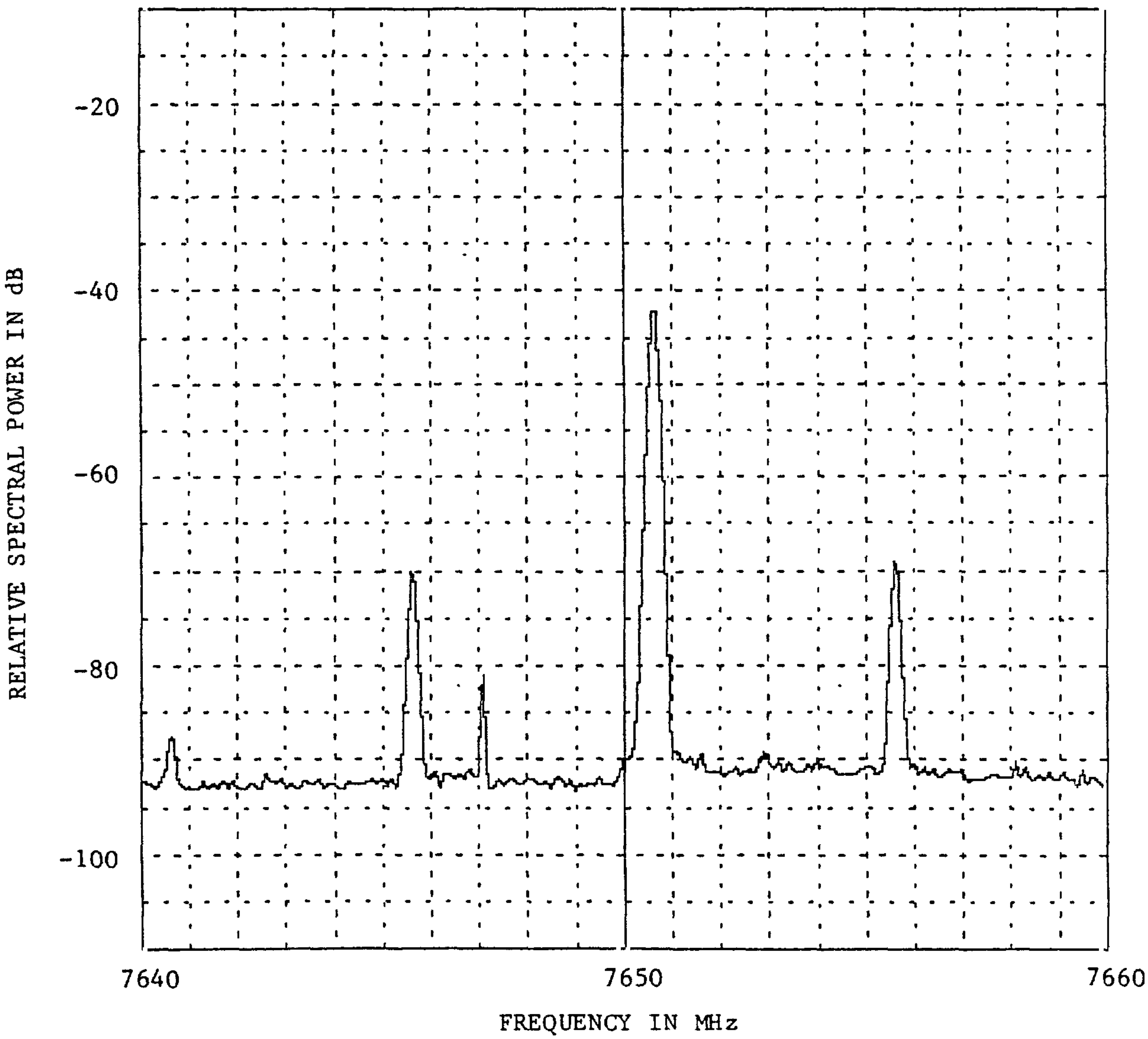


Figure A-67. Emission Spectrum of a Collins 552A-5 (f_o = 7650 MHz, Radiated).

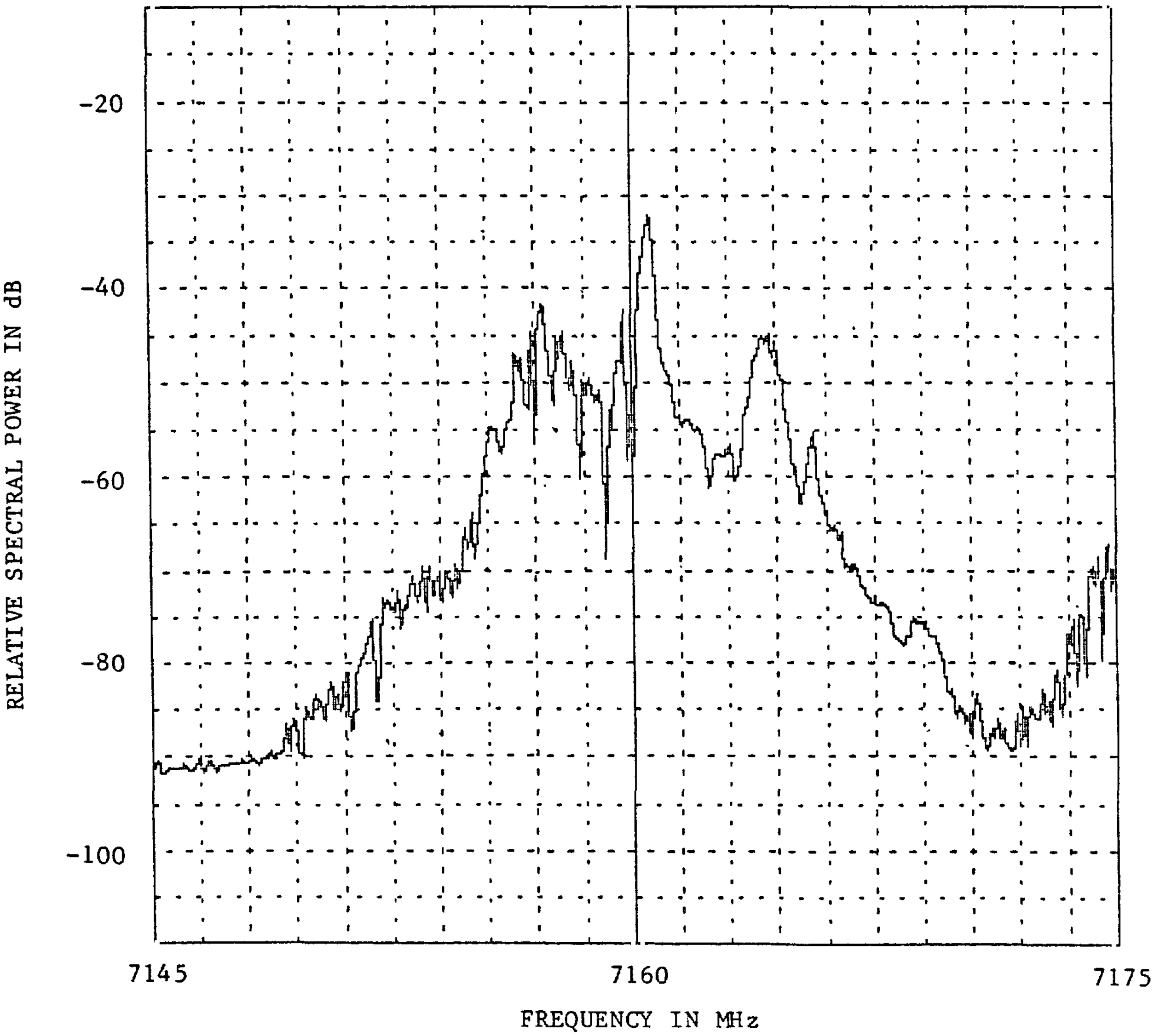


Figure A-68. Emission Spectrum of a Collins 552A-5 (f_o = 7160 MHz, Radiated).

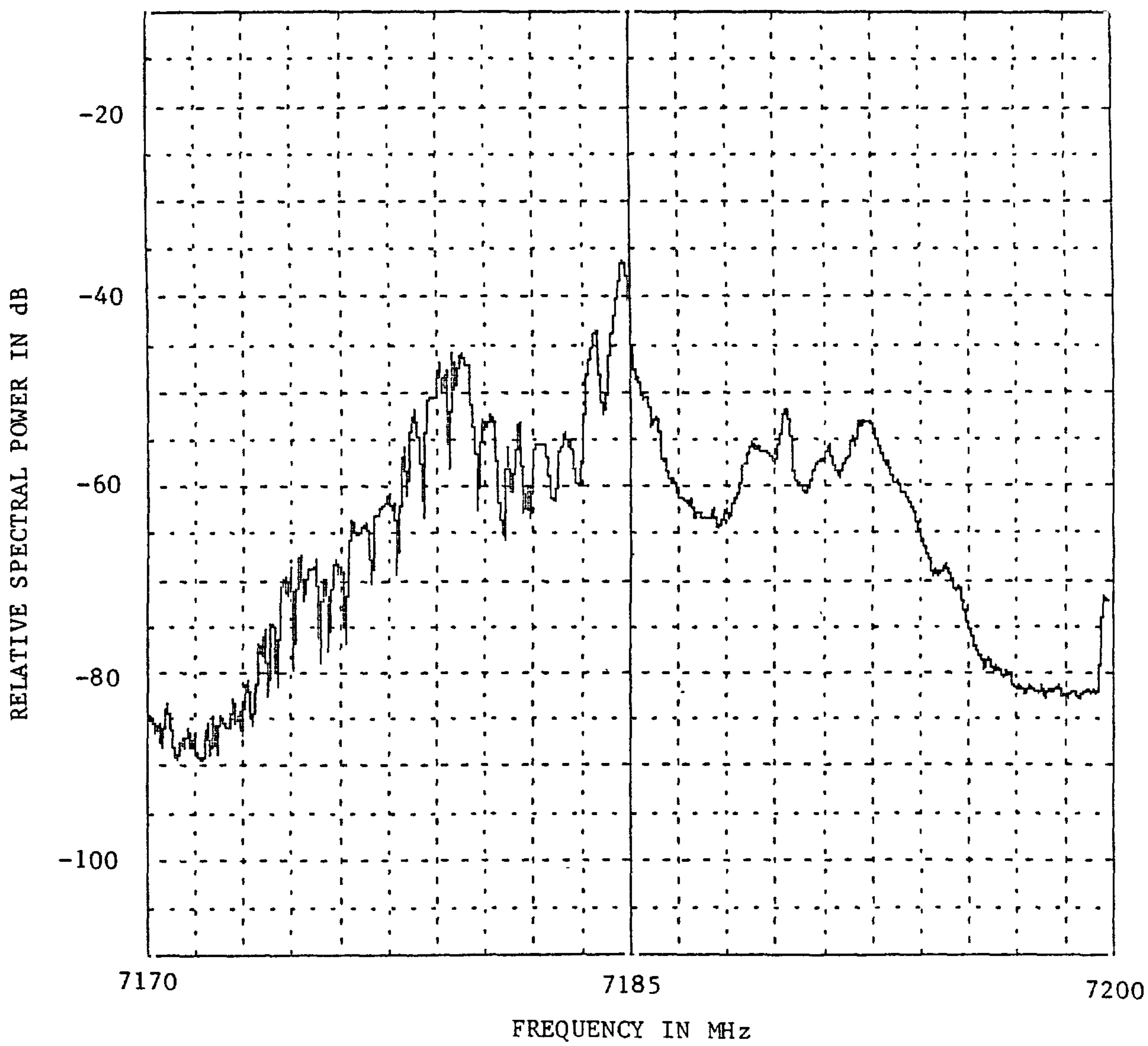


Figure A-69. Emission Spectrum of a Collins 552A-5 (f_o = 7185 MHz, radiated).

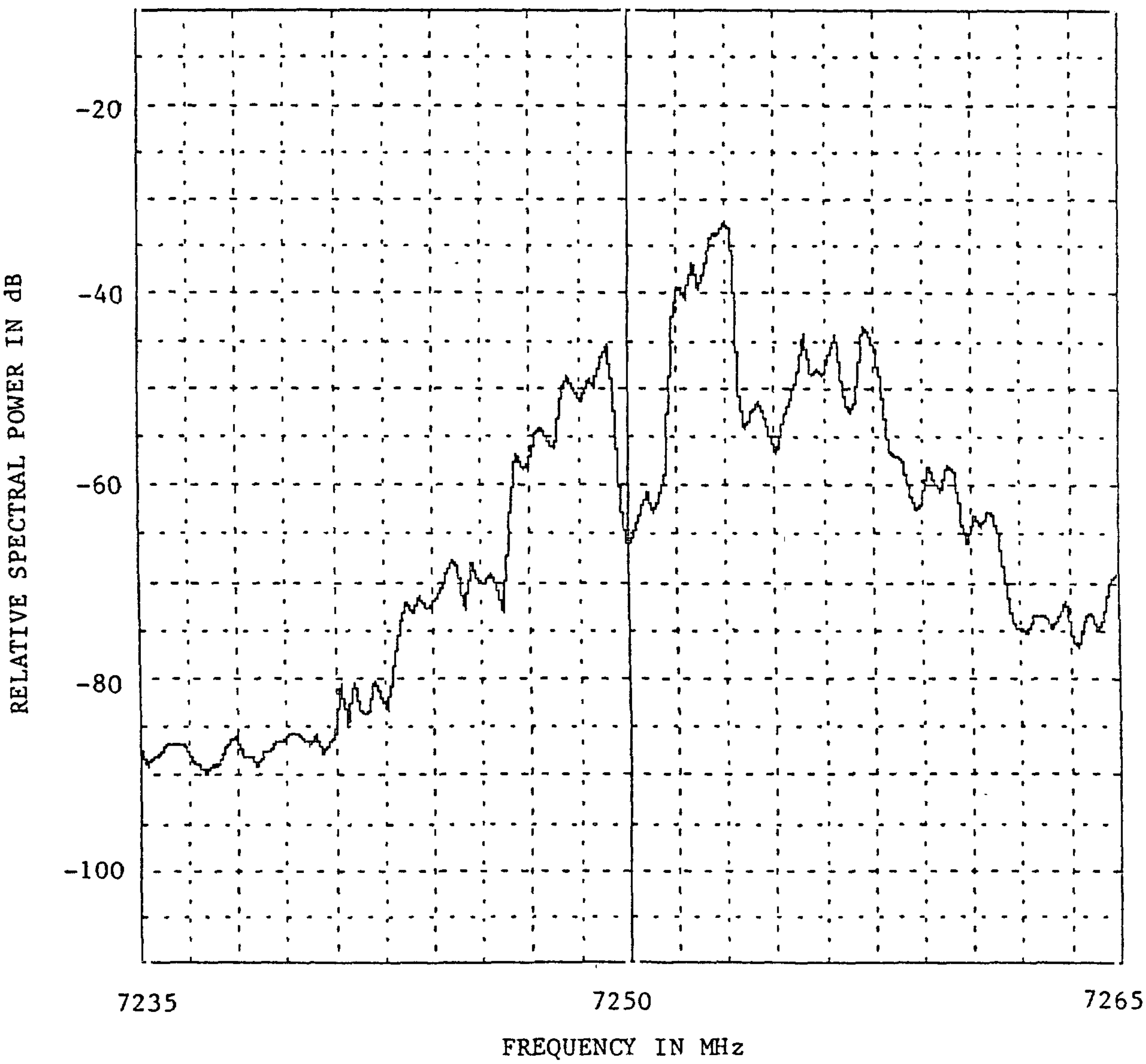


Figure A-70. Emission Spectrum of a Collins 552A-5 (f_o = 7250 MHz, Radiated).

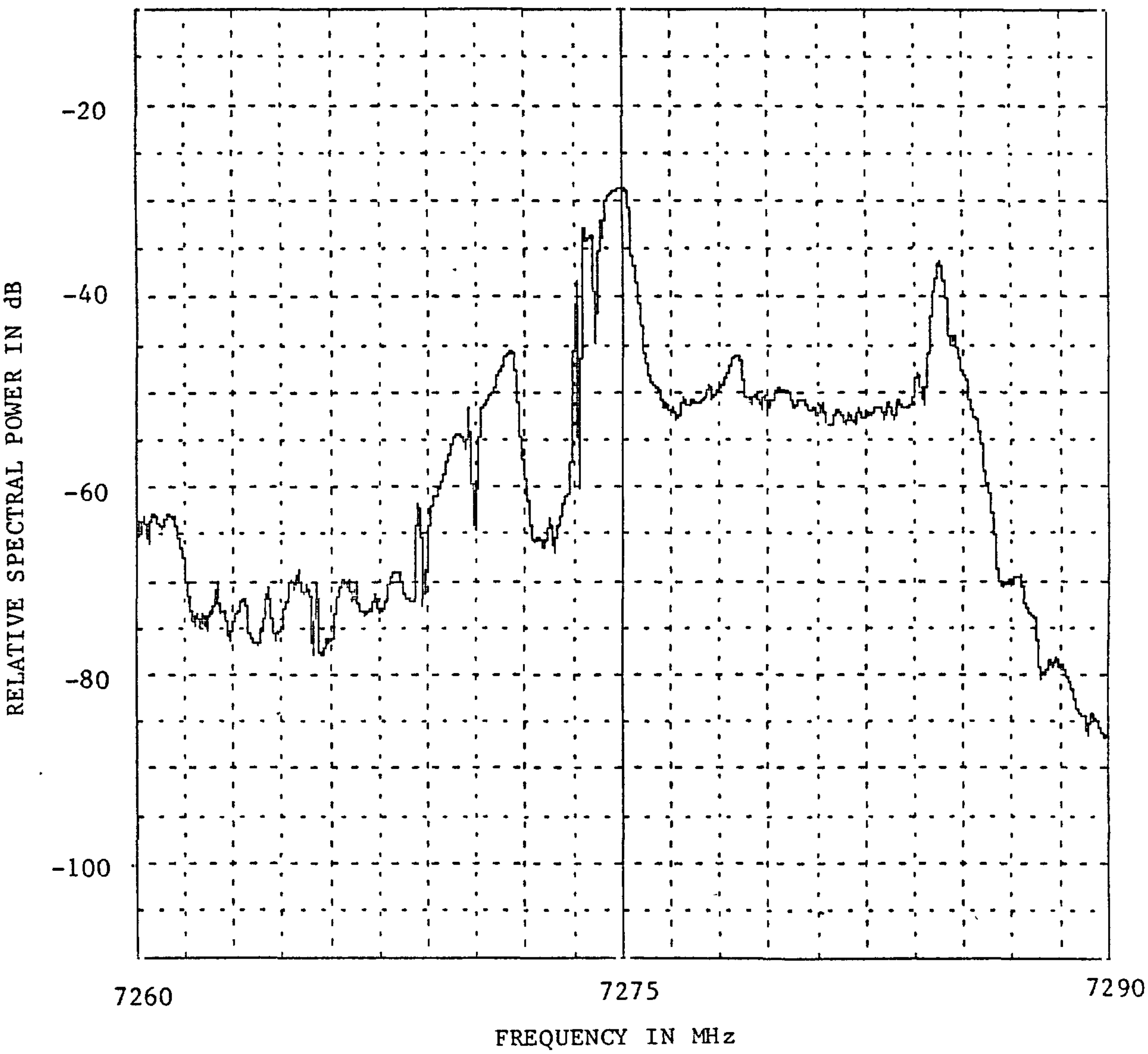


Figure A-71. Emission Spectrum of a Collins 552A-5 (f_o = 7275 MHz, Radiated).

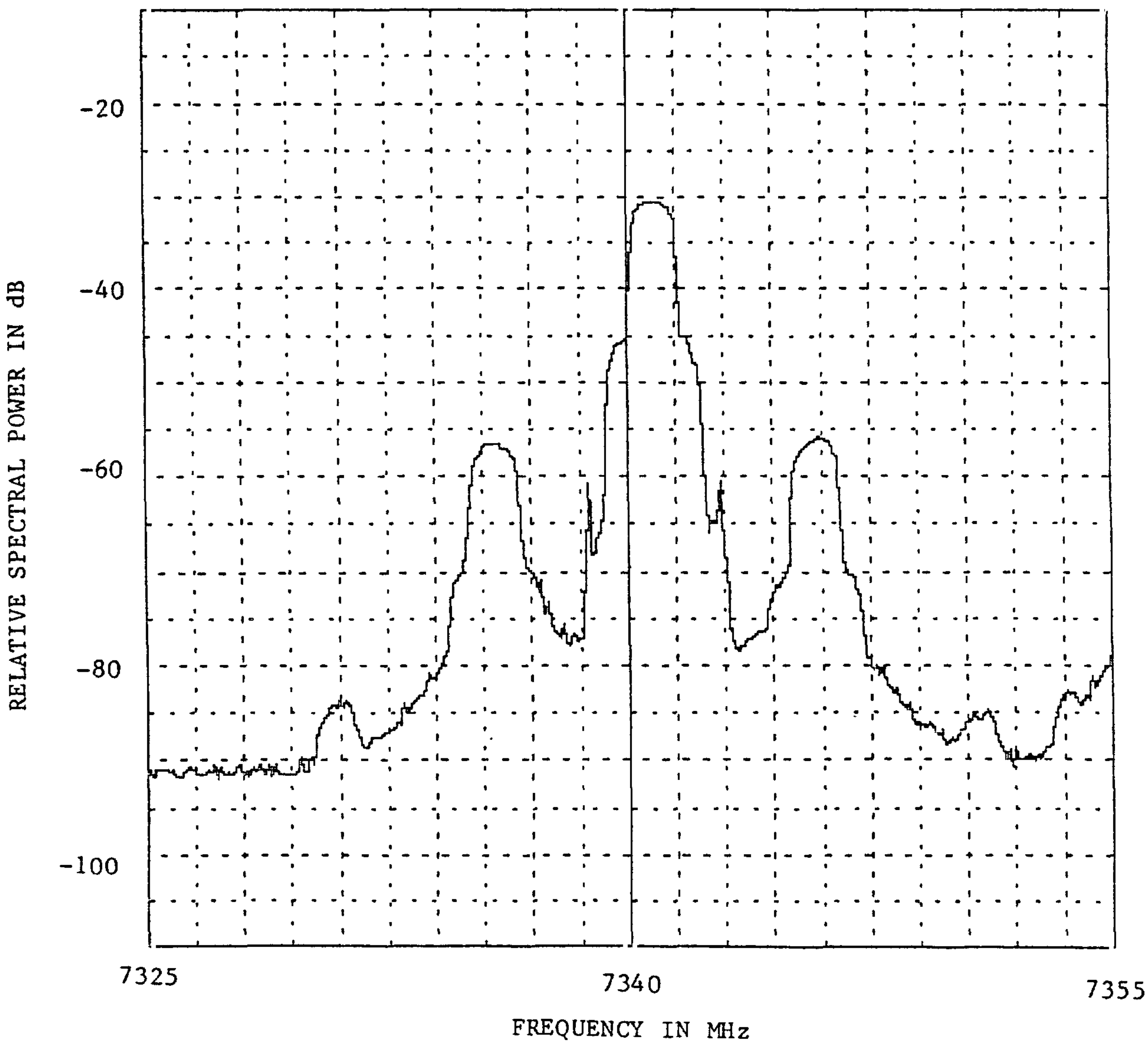


Figure A-72. Emission Spectrum of a Collins 552A-5 (f_o = 7340 MHz, Radiated).

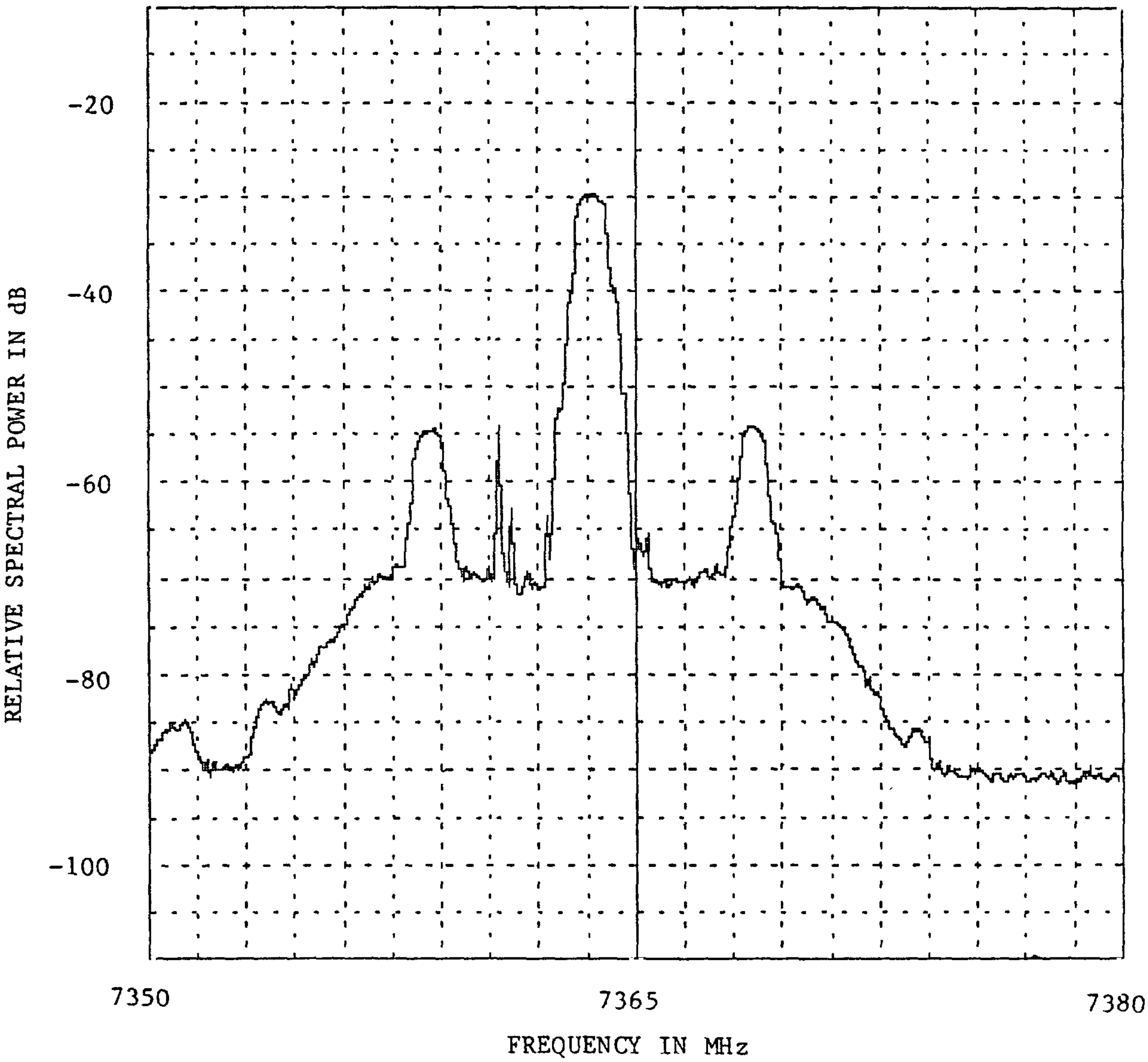


Figure A-73. Emission Spectrum of a Collins 552A-5 (f_o = 7365 MHz, Radiated).

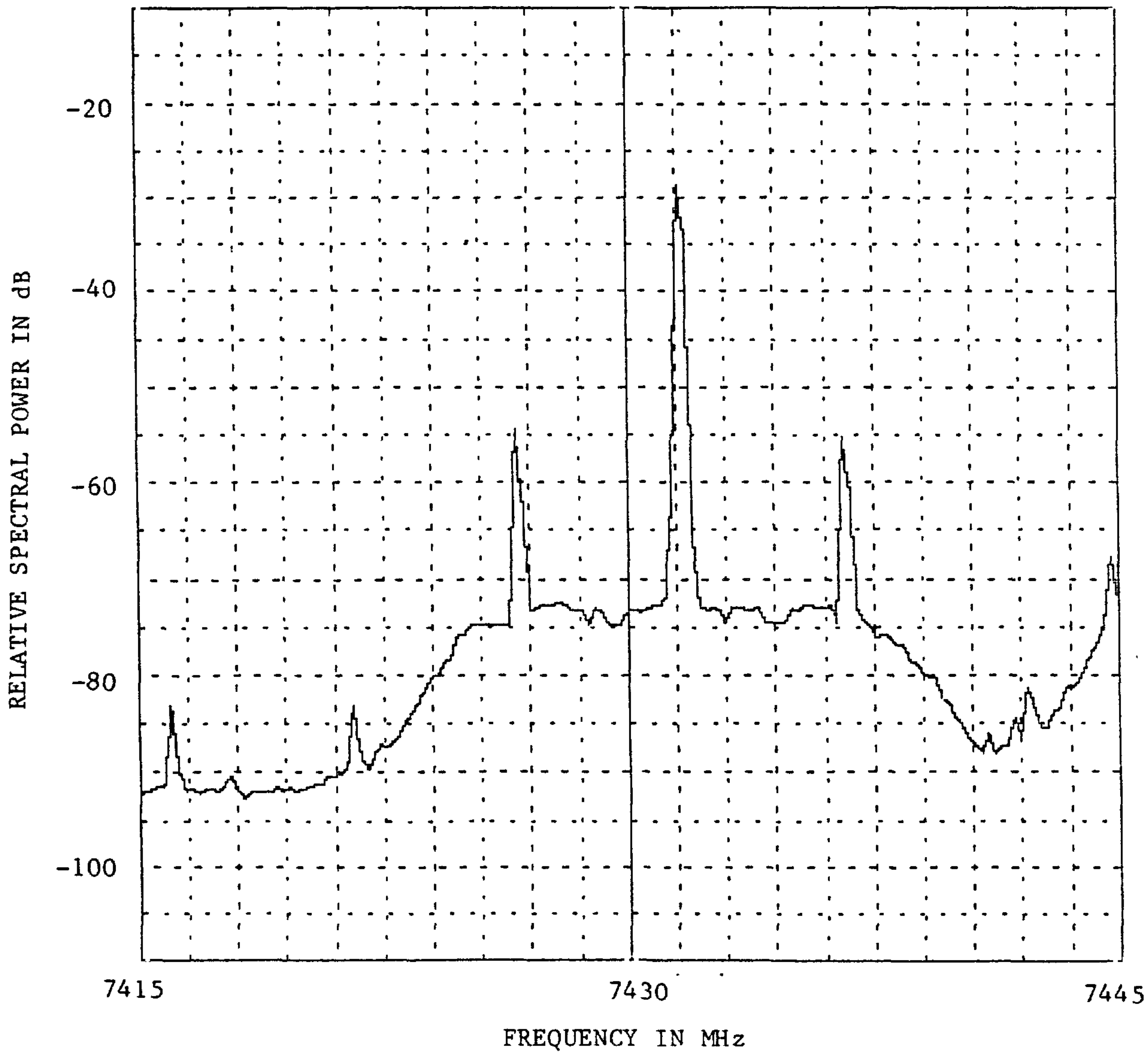


Figure A-74. Emission Spectrum of a Collins 552A-5 (f_o = 7430 MHz, Radiated).

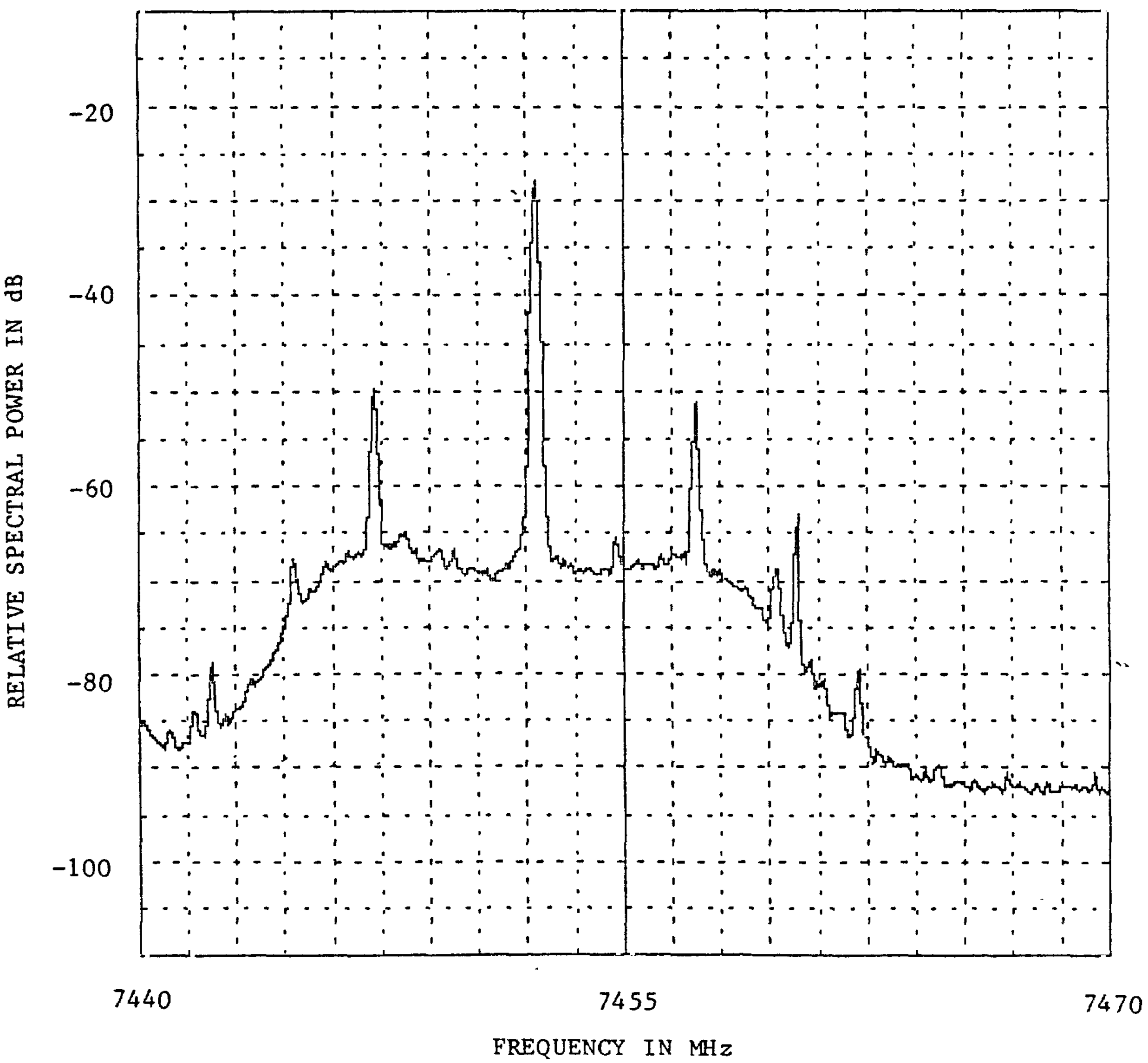


Figure A-75. Emission Spectrum of a Collins 552A-5 (f_o = 7455 MHz, Radiated).

APPENDIX B

REACCOMMODATION OF THE BONNEVILLE POWER ADMINISTRATION FIXED SYSTEMS IN THE 7900-8025 MHz BAND

BACKGROUND

The Bonneville Power Administration (BPA) is responsible for the transmission of power in the Pacific Northwest along with interfacing with Canada and California. In the Pacific Northwest, power that is predominately hydroelectrically generated, is usually transferred east to west and then north to Canada or south to California depending on the season. In summer, the higher demand for power in California is complemented by the supply from Canada and in winter the low Canadian power generation is complemented by the lower demand in California. Power generation is administered by the Army Corps of Engineers, the Bureau of Reclamation and some private enterprises. The users of power transmitted by BPA include electric companies, rural electrification commissions, and some major industries (e.g., aluminum smelting plants). The communications system employed to interconnect the various power generators, substations, and users are only a small part of the total operations, but serves an important function in the power transmission process. Constant monitoring of supply, demand, and circuit status and control of the circuit breakers at each part of the system is necessary to maintain uninterruptable service and to prevent a major blackout. The communication system used for this monitoring and control consists of point-to-point microwave (FDM/FM) systems utilizing frequency diversity in the 7125-8400 GHz frequency range.

The 7125-8400 GHz frequency range is comprised of several bands in the allocation tables. Presently, these bands are allocated nationally to the Government for Fixed, Mobile, and various space services on a primary basis. Internationally, the bands are allocated for the same services. However, significant changes regarding these services were made to the International Frequency Allocation Table for this band adopted in the Final Acts of WARC-79. These changes include the addition of the Fixed and Mobile Services to the previously exclusive FSS portion of the band (7250-7300 and 7975-8025 MHz) and recognition of the use of the MSS in the bands 7250-7375 and 7900-8025 MHz by footnote. In the national implementation of the WARC-79 results, the bands 7250-7300 and 7900-8025 MHz are allocated to the FSS and MSS on a primary basis with the Fixed Service on a secondary basis. By footnote, the Government Fixed-Satellite Service and the MSS in the bands 7250-7750 and 7900-8400 MHz are limited to military systems. The significant change is that, nationally, existing Government fixed systems operating in the 7900-7975 MHz band have been downgraded to secondary status. In addition, there is a planned transition between the DSCS-II and DSCS-III DOD communications satellites that use the 7900-8025 MHz band for the satellite up-path and includes use of some mobile earth stations. Therefore, the existing Government Fixed Service systems operating in the 7900-7975 MHz band which require primary status must be assigned new frequencies in the 7/8 GHz band.

A working group of the SPS of the IRAC was convened to determine what Government fixed systems would be affected and to establish a transition schedule for those systems to be reaccommodated. From investigations done by this working group, it was found that the majority of those systems to be reaccommodated were BPA microwave links located in the Pacific Northwest. Of the 107 affected frequency assignments, 56 were used by the BPA that is represented in matters of frequency management by the DOE. Due to the complexity of the problem, NTIA agreed to provide technical assistance to the DOE in identifying alternate spectrum for the BPA microwave systems. The BPA microwave systems involved utilize frequency diversity which complicates frequency selection for intrasystem compatibility, as well as for intersystem compatibility. The microwave environment in the Pacific Northwest consists of many Government users and is in the coordination zone of Canada. Canada has existing and planned uses in the 7250-8400 MHz band that must be taken into consideration. Alternate spectrum must be identified and the electromagnetic compatibility (EMC) of using these frequencies will be verified by automated means due to the large number of possible transmitter/receiver combinations.

This appendix documents the procedure used to identify alternate spectrum and presents the results of the initial phases of this study.

OBJECTIVE

The purpose of this study was to determine the portions of the 7/8 GHz band available to reaccommodate BPA fixed microwave systems operating in the 7900-7975 MHz band.

APPROACH

To assist the DOE in reaccommodating fixed systems operating in the 7900-7975 MHz band, the following approach was taken.

1. The existing and planned electromagnetic environment of the Pacific Northwest (including that of Canada in the coordination zone and in the immediate vicinity of the Pacific Northwest) in the 7125-8400 MHz frequency range was reviewed and documented.

2. Equipment and system characteristics operating in this environment, as taken from the Government Master File (GMF), the DOE, other agencies, and available equipment specification documents were collected.

3. For each affected frequency assignment, possible alternate frequencies using BPA proposed replacement frequencies or other available frequencies that have sufficient transmit/receive separation as well as a minimum three percent diversity frequency separation were determined.

4. For each alternate frequency, a determination, by automated means, was made for the relative interference-to-noise ratio (INR) for every

transmitter/receiver for relative INR for every transmitter/receiver interaction in the environment using general equipment specifications and free-space propagation loss.

5. For those interactions exceeding an INR = -10 dB, the propagation loss, the frequency dependent rejection (FDR), and/or antenna directivity using a terrain dependent propagation model and specific transmitter, receiver, and antenna characteristics was recalculated.

6. The advantages of utilizing cross-polarized or high-performance (shrouded) antennas, where applicable, were investigated.

7. The C/I for only those interactions where the INR could not be reduced below a value of -10 dB by the previous means and where alternate spectrum is not available, was calculated as outlined in EIA Bulletin 10-C.

8. At least two alternate frequencies for each affected frequency assignment and the qualitative effect of each on the EMC environment were identified. The DOE then submitted proposed changes of the frequency assignment to the Frequency Assignment Subcommittee (FAS). Coordination with Canada is being accomplished in the FAS process.

BPA System Description

The BPA microwave system is illustrated in Figure B-1. This system interconnects the various generators, substations, and users for monitoring and control of the power distribution in the Pacific Northwest. The system consists of predominantly 600-channel (with one 1200-channel backbone system) FDM/FM systems utilizing frequency diversity in the 7125-8400 GHz frequency range. There are 531 frequency assignments in the GMF describing the fixed point-to-point links of this system. Of these 531 assignments, 56 were identified in the 7900-7975 MHz frequency range to be reaccommodated. Three of these 56 assignments are in the process of being updated by the DOE, leaving 53 assignments to be addressed in this task.

A reliability factor of 99.995 percent, as specified by BPA, is required for this system due to the critical function it serves. (This factor is a requirement of the National Electric Reliability Council, of which DOE is a participant.) This is accomplished by a design fade margin of 40 dB with the use of frequency diversity with typical diversity spacings on the order of five percent (with a minimum of three percent). These separations are incorporated in a frequency plan used by BPA. This plan, shown on Figure B-2, consists of six diversity pairings with transmit/receiver separations of 180 MHz and diversity spacings of 420 MHz. This plan has been in use by the BPA since 1975 for all modifications to the existing systems, as well as additions of new links. Also shown in this plan are the BPA recommended replacement frequencies for those frequencies in the 7900-7975 MHz band and the new diversity plan that will be used in the future. The recommended replacement frequencies were developed to be used in conjunction with three existing frequencies in a link to be reaccommodated, and the future plan identifies diversity pairings that will be

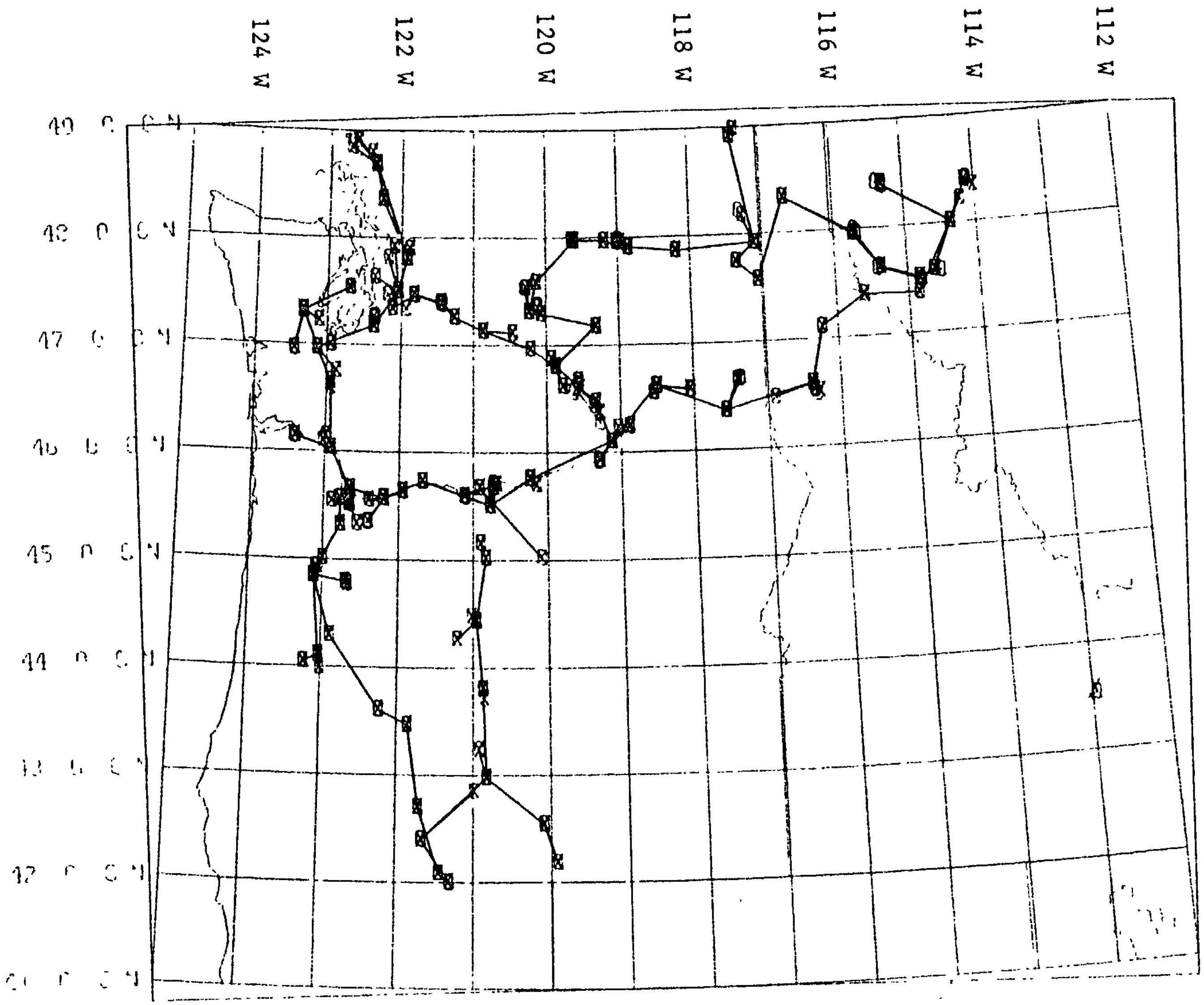
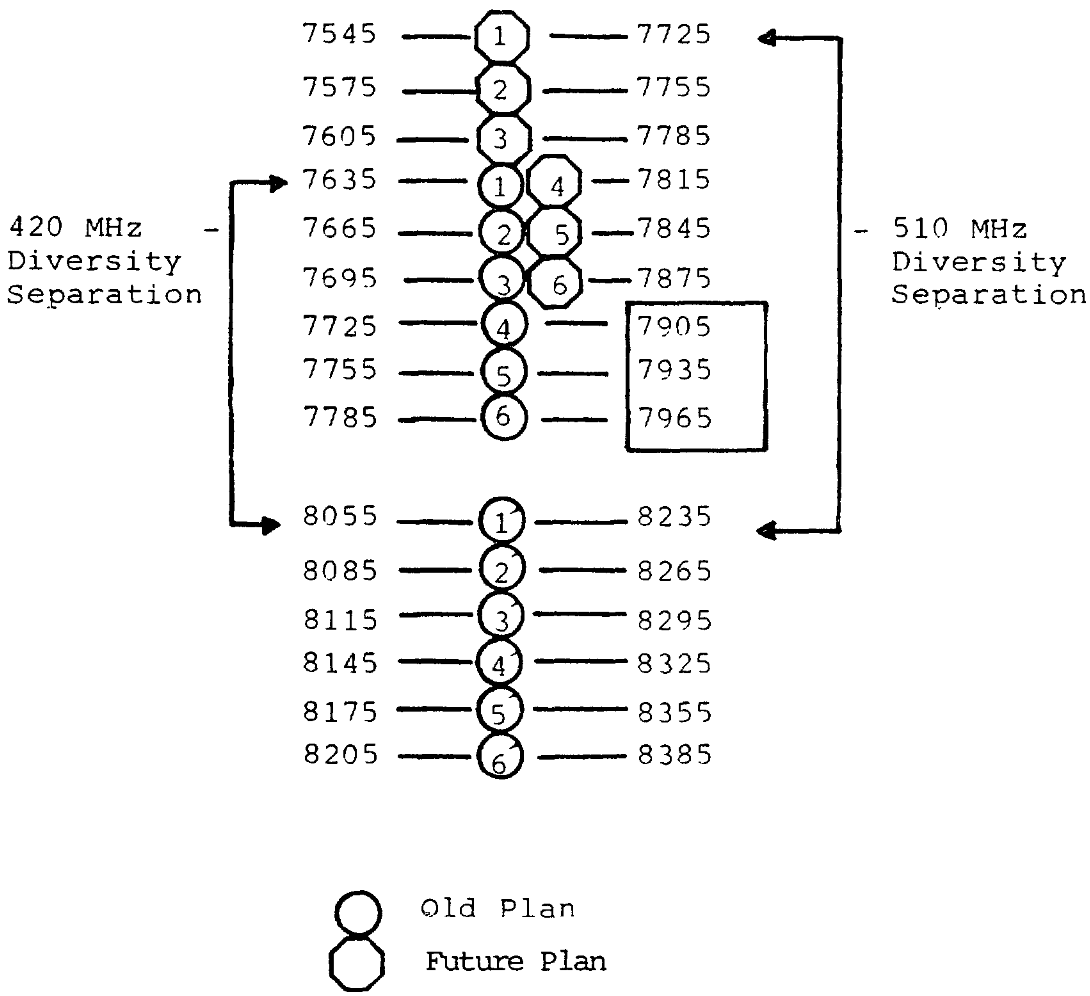


Figure B-1. Link Plot of DOE Assignments in the 7125-8400 MHz Band in the Pacific Northwest.

Transmit/Receive Separation (180 MHz)



BPA Proposed Replacement Frequencies

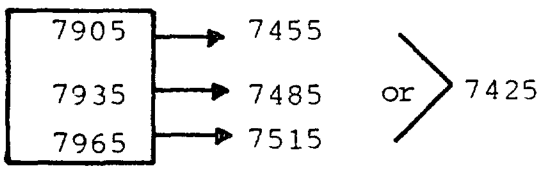
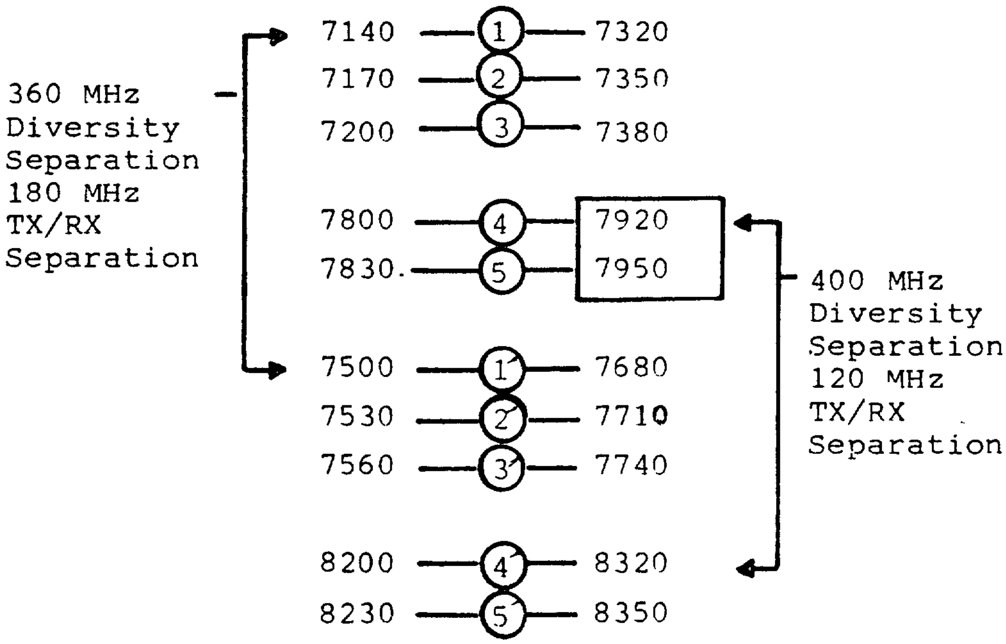


Figure B-2. BPA Frequency Plan (in MHz).



<u>NTIA Developed</u>
<u>Replacement Frequencies</u>

7920 → 8045 or 7620

7950 → 8075 or 7650

Figure B-3. Collins Frequency Plan (in MHz).

used on new or updated links. Additionally, there was an older frequency plan used predominately where Collins radios were utilized, frequencies of which are still in use on certain BPA links. This plan, shown in Figure B-3, which will be referred to in this report as the Collins frequency plan, utilizes five diversity pairings with transmit/receive separations of 120 and 180 MHz and diversity spacings of 360 and 400 MHz. Shown in this plan are NTIA developed replacement frequencies to be used at sites where frequencies from this older plan are still in use. Additionally, there are sites in the BPA system where neither plan is utilized. The alternate frequencies specified in Figures B-2 and B-3 were used at these sites where possible. Otherwise, vacant frequencies with a minimum three-percent diversity spacing and 120 MHz transmit/receive separation were used.

For the purpose of this study, the overall BPA microwave system was divided into ten overlapping areas that are addressed separately. The number and size of these areas were chosen based upon the location of the affected assignments as well as the number and complexity of assignments in the immediate area. These areas, shown in Figure B-4, are described by circles with varying radii centered at the BPA sites of Easton, Squak Mountain, Capital Peak, Dittmer, Wasco, Ice Harbor, Noxon, Foster Creek, Sand Springs, and Wolf Mountain. The areas of Seattle (i.e., Easton, Squak Mountain and Capital Peak), Wolf Mountain, and Noxon were specified by BPA to be of highest priority.

BPA System Environment

Frequency assignments in the Pacific Northwest in the 7125-8400 MHz band for all the Government agencies are plotted in Figure B-4. TABLE B-1 presents a breakdown of these assignments by Government agency and type of assignment. As seen in this table, there are 952 Government frequency assignments in the Pacific Northwest, of which 531 belong to the DOE. The 357 FAA frequency assignments compose the RML system that interconnects three remote radar facilities, Mica Peak (Eastern Washington State), Laurel Mountain (North Oregon), and Klamath Falls (South Oregon), to an indicator site at Auburn (near Seattle, Washington). Also, there are a number of RML systems providing radar data transmission between Air Route Surveillance Radars (ARSR) and associated ATC towers around Seattle. These systems consist of six separate RF channels operating on each hop. Four channels operate from the radar to the indicator and two channels operate from the indicator to the radar sites. The FAA frequencies used in the Pacific Northwest follow the FAA frequency plan shown in Figure 10. Another major system in the Seattle area is the Coast Guard's VTS. This system consists of seven radars to monitor harbor and sea-going surface craft in the Strait of Juan de Fuca and Puget Sound. The radars are located at strategic points in the harbor area remote from the VTC in Seattle. Microwave radio relay communication systems are used to deliver the video data to the VTC. The Navy has 14 frequency assignments in the 7/8 GHz band on the Pacific Coast and in the Strait of Juan de Fuca for fixed microwave functions.

Figure B-5 shows a plot of the Canadian fixed transmitters in the 7125-8400 MHz frequency range and in the immediate vicinity of the BPA area of operations. A link plot of these assignments was not possible since receiver locations are not recorded in the Canadian Master File (CMF). These assignments

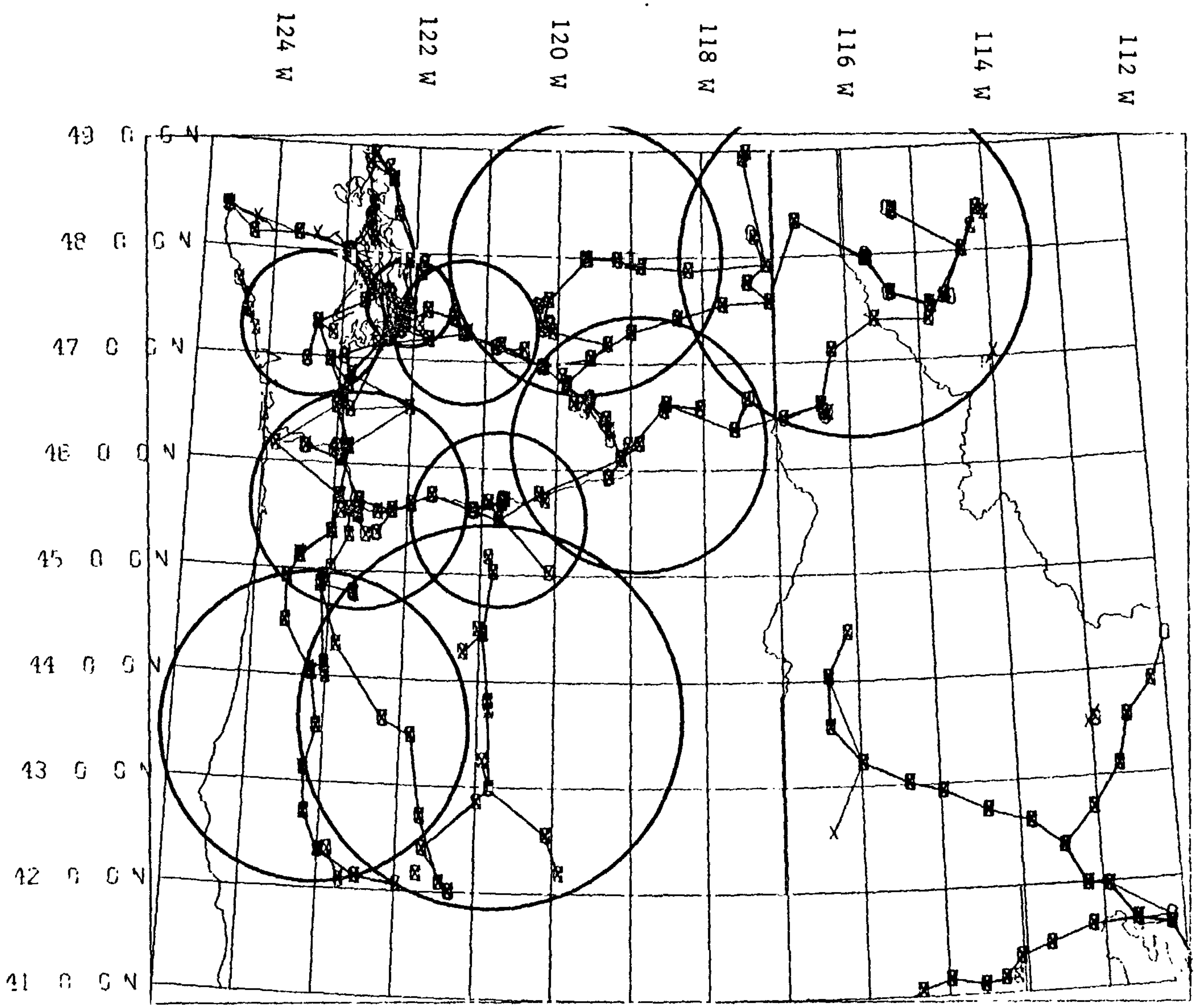


Figure B-4. Geographic Distribution of Frequency Assignments in the Pacific Northwest in the 7125-8400 MHz Band.

TABLE B-1

BPA MICROWAVE ENVIRONMENT
7250-8400 MHz

AGENCY(1)	NO. OF ASSIGNMENTS	STATION CLASS(2)	EMISSION(3)
AF	14	6 XT	.1A1, 2A2
		4 TB	M50F9
		4 FX	M20F9 - M36F9
AR	1	TY	M1.1F9
C	4	FX	M20F9
CG	30	FX	M30F9 - M40F9
DOE	531	8 XT	M20F9
		523 FX	M10F9 - M40F9
FAA	357	FX	M20F9 - M45F9
N	15	1 XT	M4PO
		14 FX	M12F9 - M25F9
TOTAL	952		

Notes

(1) Agency abbreviations as given in Appendix G of the NTIA Manual.

(2) Station class names and definitions as given in Section 6.1.4 of the NTIA Manual.

(3) Emission designators current before January 1, 1982.

(4) GMF data was current November 1981.

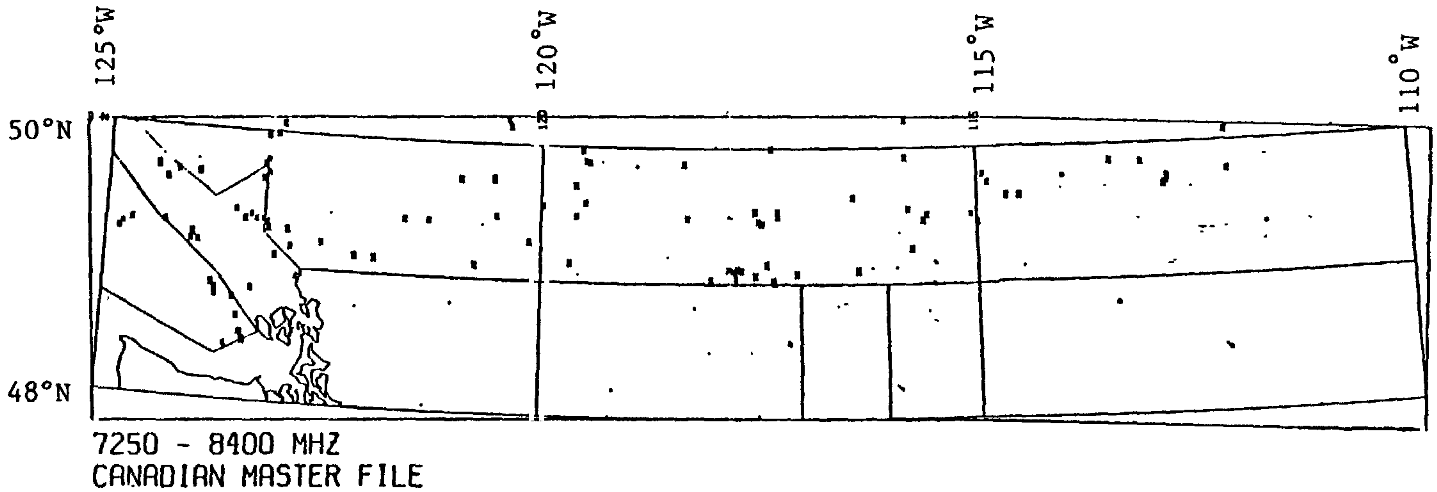


Figure B-5. Geographic Distribution of the Canadian Assignments in the 7250-8400 MHz Band.

were considered when selecting alternate frequencies for those BPA sites within the U.S./Canadian coordination zone outlined in Part 3.4 of the NTIA Manual. Canadian sites within a 160 km radius of a BPA site involving a replacement frequency were also considered when the BPA site was a mountaintop location.

Analysis

In general, for each site involving a frequency to be reassigned, vacant frequencies with the required diversity and transmit/receive separations were identified. These frequencies were then used as input to a microwave frequency verification model [Haseltine, 1974] that computes an INR for every possible transmitter/receiver interaction (both intersite and cosite) in the area under consideration. Each BPA area, previously mentioned, was the input environment to this computer program with at least a 120 km radius around the site involving a replacement frequency. Each interaction was considered on a link-by-link basis. The INR used as a basis for identifying potential interference cases was computed from Equation B-1.

$$INR = PT + GT + GR - FDR - LP - M - NR \quad (B-1)$$

where

INR = interference-to-noise ratio, in dB

PT = the average output power of the interfering transmitter, in dBm

GT = transmitting antenna gain in the direction of the receiving antenna, in dBi

GR = receiving antenna gain in the direction of the transmitting antenna, in dBi

FDR = frequency-dependent rejection (rejection due to the difference in tuning between a receiver and an interfering source), in dB

LP = free-space propagation loss, in dB

M = the cross-polarization mismatch discrimination, in dB (0 dB for like polarization)

NR = receiver noise level, in dBm

The program output only those interactions resulting in an INR of -10 dB or greater. The computer program MICROFAM was used to reduce the complexity of the problem by eliminating those transmitter/receiver interactions from further analysis that would result in INR values below the threshold. Those interactions output by the program were then analyzed further using a terrain dependent propagation model (i.e., TIREM) and specific equipment parameters. This process was repeated for each specific alternate frequency. For those alternate frequencies, the use of which still resulted in exceeding the interference threshold criteria, the possible advantages of using antenna cross-polarization and/or high performance antennas were investigated. The intended result was to identify at least two alternate frequencies for each affected frequency assignment and the qualitative effect of each on the EMC environment as well as the effect of the environment on the receivers with these new frequencies.

Results

Recommended frequencies for each of the 53 BPA links to be reaccommodated are listed in TABLE B-2. Shown in this table are two frequency plans for the BPA system as a whole, where more than one frequency was identified to be electromagnetically compatible. In all but five cases, two or more frequencies were found. Care should be taken when choosing alternate frequencies from both plans since each plan is not necessarily compatible with the other, especially when the links are close, or interconnected, to the adjacent areas. For example, if the frequency 7425 MHz is chosen for DOE LINK #787130, the same frequency from Plan 2 for the adjacent DOE LINK #787127 cannot be used. Frequencies listed in the column labeled "OTHER" are compatible with both plans. A detailed discussion of each BPA area, specific INR values and alternate frequencies identified which could be used in conjunction with high-performance antennas and/or changing the existing antenna polarization of some links has not been documented but can be supplied upon request.

TABLE B-2

RECOMMENDED ALTERNATE SPECTRUM FOR THE BPA SYSTEM

DOE LINK			ALTERNATE SPECTRUM(MHz)		
AREA	NUMBER	FREQ(MHZ)	1	2	OTHER
SEATTLE	786447	7965	7710	7640	
	786442	7940	7175	8040	
	786439	7915	8040		
	786445	7950	8075	7485	
	816278	7920	8045	7455	
	786444	7950	8075	7650	7485
	786443	7945	7635		
	787130	7905	7425	7875	
	787127	7965	7515	7425	
	786446	7965	8055	8250	
PORTLAND	786646	7965	7515	7605	
	786642	7905	7455		7350
	786595	7905	7455	7485	
	786596	7935	7485	7575	
	816301	7905	7455	7545	
	796108	7965	7605	7425	
	786201	7935	7560	7455	
	786448	7965	8205		
	786441	7935	7845	7875	7860

TABLE B-2(CONTINUED)

RECOMMENDED ALTERNATE SPECTRUM FOR THE BPA SYSTEM

DOE LINK			ALTERNATE SPECTRUM(MHz)		
AREA	NUMBER	FREQ(MHz)	1	2	OTHER
WEST OREGON	786644	7935	7485	7575	
	786647	7965	7425	7605	
	786641	7905	7515	7425	7875
EAST OREGON	786645	7950	8075	7650	
	786643	7920	8045	7620	
	786324	7920	8045	7620	
	786325	7920	8045	7620	
	786329	7950	7650	3045	
	786327	7920	7620	7425	
	786328	7950	7650	8045	
	786326	7920	7620	7455	
	816262	7965	7425	7455	
	786191	7905	7885	7425	
KENNIWICK	786196	7920	7455	7425	
	786556	7935	7485	7575	
	786553	7905	7425	7395	
	786554	7905	7455	7545	
	786343	7905	7515	7485	7885
	786197	7935	7485	7455	

TABLE B-2(CONTINUED)

RECOMMENDED ALTERNATE SPECTRUM FOR THE BPA SYSTEM

			ALTERNATE SPECTRUM(MHz)		
AREA	NUMBER	FREQ(MHz)	1	2	OTHER
FOSTER CREEK	786195	7905	7455	7545	7885
	786198	7935	7485	7575	
	786204	7965	7515	7425	
	786194	7905	7455	7545	
	786206	7965	7515	7605	
	786200	7935	7485	7575	
NOXON	786193	7905	7455	7545	
	786199	7935	7485	7575	
	786203	7965	7515	7605	
	786555	7905	7455	7545	
	786560	7965	7515	7605	
	786552	7905	7455	7545	
	786559	7965	7515	7605	
	786550	7895	8190		
	786557	7965	7530		

APPENDIX C

PROPOSED PLAN FOR DEVELOPMENT OF FREQUENCY ASSIGNMENT/VERIFICATION MODELS FOR NTIA

This appendix outlines a proposed program for the orderly development of automated frequency assignment/verification models for NTIA. These models would serve as an aid in NTIA's responsibility to manage the radio spectrum allocated for use by the Federal Government. These programs would assist in the various aspects of spectrum analysis and frequency assignment processes within NTIA including: analysis tasks to reassign frequencies to a large number of established stations because of allocation or policy changes; studies designed to identify alternate and improved spectrum management techniques; system reviews of proposed new Federal radiocommunication systems to assure future compatibility; studies addressing efficiency of spectrum use and band congestion; and the frequency assignment process.

For purposes herein a frequency verification model is defined as one which, given the operating frequency and other parameters, will verify the compatibility of one or more designated stations with its electromagnetic environment and/or identify stations with which it (they) conflicts. A frequency assignment model is one which, within a set of given constraints, will choose a suitable or "best" frequency or possible set of frequencies which are compatible with the environment. A frequency assignment model must, of course, include aspects of a frequency verification model. However, because of the iteration and hence time-consuming process often involved, a more simplified approximate approach is often taken. Once the tentative frequency is chosen, the more detailed verification model can be used to assure compatibility.

In establishing the basic goals for the development of these models, several key assumptions have been made. The first is that no attempt will be made to develop one all-encompassing model which is valid for all services and all bands. For example the strategy used in assigning radars can be significantly different than for fixed microwave stations or HF broadcast. The approach taken, then, should be to develop specialized models optimized around a given category of services and/or frequency bands. In developing a priority order for developing these models, first consideration will be given to bands and/or services where significant interagency interactions are involved. Also those services and/or bands which are generally managed by international organizations (e.g., WMO, ICAO, IMCO, INMARSAT) will be given lower priority. Also given lower priority are stations in bands and services which are typically authorized by band or area assignments rather than specific frequencies at specific locations. Many tactical and training operations of the military fall in this category. The models should first be developed as engineering models for use in analysis tasks. After refining the models and a demonstration of their effectiveness, they could then be considered for incorporation into the frequency assignment subcommittee process.

A review was made of the list of radio services identified in the NTIA Manual to help establish priorities for development of models as follows:

Radio Astronomy (RA)	Amateur-Satellite (AmSat)
Fixed (FX)	Broadcasting-Satellite (BSS)
Mobile (MO)	Earth Exploration-Satellite (EES)
Radiodetermination (RADIODET)	Fixed-Satellite (FSS)
Meteorological Aids (METAIDS)	Inter-Satellite (ISS)
Broadcast (BC)	Mobile-Satellite (MSS)
Standard Frequency (SF)	Radiodetermination-Satellite (RSS)
Amateur (Am)	Space Operations (Sp Ops)
Safety	Space Research (Sp Res)
	Standard Frequency-Satellite (SFS)
	Time Signal-Satellite (TSS)

DISCUSSION OF SERVICES

All other services are subsets of the above listed twenty services. In the following is a discussion of each service and identification of need for automated models.

Radio Astronomy. Within the IRAC, these stations are under the sole jurisdiction of one agency, the National Science Foundation. Also, in general, these stations are not authorized by frequency assignments and are not listed in the Government Master File (GMF). Therefore, a specific automated assignment/verification model for NTIA is not necessary. If radioastronomy stations operated in bands shared with other services (e.g., 406.1-410 MHz) were listed in the GMF, provision could be made for protection of these stations as part of another appropriate model.

Fixed and Mobile. Since these two services are often allocated jointly, they can be considered together. Bands allocated to the fixed and mobile services often involve significant interagency coordination and in some cases are among the most heavily assigned bands within the Government. Frequency assignment can often be complex and time-consuming as evidenced by recent studies. A frequency assignment and/or verification model or models designed for these services would be of significant help in NTIA spectrum management activities. For purposes here, the bands allocated to these services can be categorized into three groups. Below 30 MHz, the predominant interference mechanism is often via ionospheric refraction (skywave) or groundwave and as such can involve very complex radio propagation aspects. Frequency assignment and coordination often involve internationally agreed procedures and channel plans. More study is necessary to fully identify the need for such a model and will initially be given a lower priority. Between 30 MHz and 500 MHz, the dominant communication mode is narrowband (± 25 kHz) voice. For example, the fixed and various mobile services are generally operated in specific bands. Government aeronautical mobile stations are primarily operated in the bands 118-136 MHz and 225-400 MHz; the maritime mobile stations in the band 156.25-162.0125 MHz; and land mobile stations in the bands 30-50 MHz, 138-150.8 MHz, 162.0125-174 MHz, and 406.1-420 MHz. The Fixed Service is predominantly operated in the bands 162.0125-174 MHz and 406.1-420 MHz and often is used in support of land mobile networks. In terms of numbers of assignments, these bands include the most congested portions of the Government allocated spectrum. In developing a frequency assignment/verification model for these services, it is proposed that initially the bands used predominately by aeronautical and maritime mobile stations be excluded. Those bands, in general, are managed by a limited set of agencies, typically either FAA, DOD or Coast Guard: and specific frequency assignment practices are employed within those respective agencies. The fixed and land mobile services, in contrast, are used by all of the major Government agencies. The significant interagency sharing of frequencies occasionally leads to conflicts. More importantly, frequencies along the Canadian border are becoming increasingly difficult to coordinate. A need for an automated assignment/verification model is evident. General specifications of such a model are outlined later in this appendix. Frequencies above 500 MHz are predominantly used for wideband communications including multichannel voice, video, telemetry, telecommand and data links. As in the lower bands, significant interagency sharing occurs especially in the following bands:

1710-1850 MHz
2200-2300 MHz
4400-4990 MHz
7.125-8.5 GHz
14.4-15.35 GHz

The need for an automated frequency assignment/verification model in several of these bands has been demonstrated herein (see Appendix A) and by Hurt and Crandall (1980). General specifications of such a model are outlined later in this appendix.

Radiodetermination. The Radiodetermination Service includes a wide variety of types of radiolocation and radionavigation systems. For purposes of this discussion, they will be categorized into two groups: pulsed radars and everything else. Also pulsed radars that are operated in the Meteorological Aids Service will be included in this discussion with the pulsed radars in the Radiodetermination Service since their characteristics are similar. In general, the types of pulsed radars where specific frequency assignments are used are the large fixed-location radars such as those used in the 1-6 GHz range. Transportable and mobile radars are typically operated under a band assignment with specific frequencies either coordinated locally or by operator selection and are not included here. A detailed study of the compatibility among radars in the 2700-2900 MHz band demonstrated the congestion in the band (Hinkle, 1983). Other studies have been completed of the 1215-1400 MHz, 3100-3900 MHz and 5650-5925 MHz bands indicating various degrees of usage. A preliminary automated model had been developed assigning frequencies to radars based on the concept of designed frequencies, although the model is no longer operational. Because of congestion encountered in certain pulsed radar bands and the interagency interactions involved, a need is evident for an automated frequency verification/assignment capability. However, a lower priority effort is suggested.

Radiodetermination systems, other than the pulsed radars, include a very diverse set of radiolocation and radionavigation systems. Further study is necessary to define any NTIA requirements for automated capability in this area.

Meteorological. Meteorological aids are generally of two types: radiosondes and weather radars. In one study of a band allocated for use by radiosondes

(Flynn, 1980) no need was demonstrated for an automated frequency assignment/verification model for these systems. Typically the radiosondes are given band assignments and are locally coordinated among a limited number of agencies. Discussion of frequency assignment of weather radars has been included under the category of Radiodetermination.

Broadcast. The only significant broadcasting activities by the Federal Government are those of the international broadcasting in the 3-30 MHz bands. Development of an assignment model for these activities is in progress and is described by Lucas (1983).

Amateur and Amateur-Satellite. These are not activities of the Federal Government.

Safety. The operation of the various safety services are normally authorized under international agreements, and the need does not exist apparently for automated models.

Broadcasting-Satellite. In support of U.S. preparation for the upcoming 1983 Regional Administrative Radio Conference of the ITU, NTIA, NASA and the FCC have jointly sponsored the development of an analysis program for the BSS called Spectrum Oribt Utilization Program (SOUP-5). This model has been implemented by various agencies and by the ITU in Geneva. Documentation of this model is povided by ORI (1982).

Earth Exploration-Satellite. Radiocommunications within the EES Service can be categorized into passive sensing, active sensing and the associated telecommand, telemetry and data relay associated with the sensing functions. Frequency assignments are not used for the passive sensing, and currently little or no use is being made of active sensing. The associated radio links are typically coordinated via recognized national and international organizations such as the World Meteorological Organization. No apparent need exists for a specific automated model. However, earth stations in the EES Service which are in bands shared with other services could be considered by another appropriate model such as a fixed and mobile model.

Fixed-Satellite. The United States is currently in the preparatory stage for the upcoming 1985/88 World Administrative Radio Conference (WARC) for the Space Services using the Geostationary Orbit. As part of this effort NTIA has initiated a Federal Government program for development of automated computer capability in preparation for that conference. Development of this model is underway and is described by Ng (1982). The primary emphasis of this model is on the Fixed-Satellite Service although space radiocommunication systems servicing both fixed and mobile satellite stations can also be considered by the model.

Inter-Satellite Service. No operational use is presently being made of this service in the United States. Any future use (e.g., Tracking and Data Relay Satellite System by NASA and MILSTAR Satellite System by DOD) will be coordinated within those respective agencies. A specific model for NTIA is not warranted at this time.

Mobile-Satellite Service. The Mobile-Satellite systems used by the Federal Government consist of the tactical military systems in the 225-400 MHz band, the MARISAT system in the 1535-1660 MHz band, and the Defense Satellite Communications Systems (DSCS II/III and FLTSATCOM) in the 7.25-8.4 MHz band. NTIA automated frequency assignment models appear necessary for these systems. This is because frequencies used in the military systems are typically authorized via band and area assignments rather than specific frequencies and locations. The specific frequencies and locations are typically coordinated locally. However, mobile-satellite functions in the 7.25-8.4 MHz band can be accommodated by the FSS model described above. The frequencies used by MARISAT are coordinated internationally via the INMARSAT organization. However, earth stations operated in bands shared with other services (especially the 7-8 GHz band) could be considered by another appropriate model.

Radiodetermination-Satellite Service. The only current uses of this service by the Federal Government are Global Positioning System (GPS) and Transit System in the Radionavigation-Satellite Service. Those systems operate on fixed specific frequencies and therefore no automated models are necessary.

Space Operations and Space Research Service. Operations in these services include the DOD Space Ground Link Subsystem and the NASA Space Tracking and Data Network, Deep Space Network and Tracking and Data Relay Satellite Systems. These operations are all very dynamic with respect to frequency usage. Specific frequencies are often subject to detailed local time scheduling by recognized coordinating groups such as the Mojave Frequency Coordinating Group. A specific NTIA frequency assignment model is not warranted. However, earth stations in the services which are shared in bands used by other services could be included in other appropriate models (e.g., fixed and mobile).

Standard Frequency-Satellite and Time Signal-Satellite Services. There is no current use of these services.

Summary. From the above discussion the need for and priorities for development of the following frequency assignment/verification models have been identified.

Category	Proposed Priority
Fixed and Land Mobile (30-500 MHz)	1
Fixed and Mobile (500-15000 MHz)	2
Pulsed Radars (1-6 MHz)	3 (more study needed)
Fixed and Mobile ($\leq$ 30 MHz)	4 (more study needed)
HF Broadcast	In progress
Broadcasting-Satellite	Operational
Fixed-Satellite	In progress
Radiodetermination (other than pulsed radars)	More study needed

PRELIMINARY SPECIFICATIONS FOR A FIXED AND LAND MOBILE FREQUENCY ASSIGNMENT/VERIFICATION MODEL (30-500 MHz)

Several studies have been undertaken of the Government fixed and land mobile bands (Crandall, 1982) (Moran and Flynn, 1982) from which a need was expressed for automated frequency assignment/verification models. Factors that influenced this need were the large number of assignments involved, the extensive interagency coordination, the increasingly difficult process of coordinating assignments with Canada, and the possible introduction of new narrowband technology.

In defining the initial specifications for this overall model, it became apparent that two distinct modes of operation would be desirable. The first would be useful in addressing the more theoretical aspects of optimum or near optimum frequency assignment. This mode would encompass many aspects of the model developed by Hale (1980) and subsequently generalized by Berry (1982). Simply stated this model, given an RF environment and a set of rules defining the frequency separation restraints among all stations, will assign frequencies to each which will minimize, in a quasi-optimum sense, the total bandwidth required. This model is not limited to fixed and land mobile applications but can be used wherever specific frequency separation rules can be defined. This model can serve as a useful aid in examining various frequency assignment and spectrum management problems. These include: examination of various forms of channelling plans to identify the most spectrum efficient methods; studies of band congestion to identify alternate methods of frequency assignment (e.g., Para. 8.2.16 of the NTIA Manual stating that the most heavily used channel should be assigned first); studies of spectrum standards and effects or spectrum efficiency of improved standards; and in the comparison of the relative spectrum efficiency of competing technologies such as FM, SSB and Spread Spectrum.

Key features of this model should include:

a. Ability to generate RF environment locations by three methods: (1) direct input of a selected subfile of the GMF, (2) specific user input location, and (3) computer-generated environments either randomly located throughout a defined area, randomly distributed among a set of user specified sites or randomly distributed about user specified sites.

b. Ability to assign frequencies using various, near-optimum, assignment strategies as discussed by Hale (1980).

c. Ability to specify frequency assignment rules by two methods: (1) when the frequency assignments can be categorized into five or fewer classes (e.g., narrowband fixed, wideband mobile, etc.), frequency-distance separation rules for each combination can be entered as used by the program; and (2) as an alternative method for any number of classes of equipments, a constraint matrix can be entered which, for each specific pair of assignments, identifies which specific frequency separations are precluded. In the latter case, the user must take into account distance relationships and equipment characteristics in developing constraints.

d. Appropriate interference routines when using the GMF as a source file.

e. Convenient input and output formats.

The second mode of operation for the fixed and land mobile model would be oriented towards the more practical day-to-day frequency assignment problems of identifying available frequencies for use and verifying the compatibility of a proposed assignment with its environment. An existing NTIA model called the Graphic Display Model (GDM) could form the initial core of a more comprehensive operational model. This model is described in NTIA (1982) and is critiqued by Crandall (1982). This primary capability of the GDM is in the selection and display of frequency assignment information by band and geographic area. The output of the GDM is intended for use by radio frequency planners and managers in the preliminary assessment of spectrum availability. It is normally intended for use in the bands 29.89-50, 138-144, 148-150.8, 162-174 and 406.1-420 MHz, although a secondary mode is optionally available for use in other bands. In the normal mode (i.e., used for one of the above bands), the model has two principal options: Clear Channel Analysis and Third-Order Intermodulation. Only the former will be discussed here.

In the Clear Channel Analysis option, the model retrieves frequency assignment records from the GMF for selected areas and are graphically displayed in geographical relationship to a specifically proposed fixed or base station. Cumulative interference power levels at the specified new station are also predicted and displayed in tabular and/or histogram form. Area assignments are not included in the interference predictions but are provided as a supplemental listing. The assignments which are retrieved and displayed are those which produce a predicted spectral power density at the proposed site which exceeds a reference level. Specifically, the transmitter power is assumed to be evenly distributed across the authorized bandwidth. After accounting for propagation loss, the resulting received spectral power density is compared with a reference level of 2.5 x 10 watts/Hz--an assumed receiver threshold value. The cumulative effect of each transmitter is considered, taking into account overlapping or partially overlapping bandwidths. Clear channels are identified as those frequencies where predicted power density is less than the reference level as shown in Figure 16.

The GDM has had only moderate use within the spectrum management activities. Whereas the model is useful for identifying possible frequencies for use by a new system, frequencies so selected must be verified and coordinated by conventional manual means. This follows from the number of stated and unstated limitations of the model.

Crandall (1982) discusses limitations of this model which are repeated below.

a. <u>Propagation Loss Predictions.</u> The loss predictions are theoretical and intentionally biased toward some degree of exaggeration of interference potential (i.e., conservative results). The EPM-73 propagation model developed at the Electromagnetic Compatibility Analysis Center (ECAC), which is included in the GDM, is no longer accepted as a reference model by ECAC or NTIA. Validated models, such as the NTIA N-Lambda model and/or terrain dependent models such as TIREM, would give more realistic results. The assumption used in the model of 30-meter (100 foot) antenna heights for all stations can, in some cases, result in significant errors. The antenna height data is readily accessible by computer and should be considered in an updated model. Additionally, the model employs a median (50 percentile) loss value. For conservative prediction results one could question whether another value might be more appropriate, such as 10 percentile which is used in the FCC Rules and Regulations and in Annex I of the NTIA Manual for land mobile interference calculations.

b. Mobile Stations. For simplicity, the model assumes that all mobile stations are located at a fixed point indicated in the assignment. A better approach would be to either retrieve the radius of operation data from the GMF or assume a value such as 40 km to be used in any interference calculation.

c. Adjacent Channel Interference. Adjacent channel interference is considered only to the extent of overlap of the emission bandwidths of the two systems. That is, if the emissions overlap, the interfering signal is considered cochannel with no rejection; if they don't, the signal is ignored completely. Even though receiver data is limited, a much more realistic approach could be used such as the generalized off-frequency rejection curve used in Annex I of the NTIA Manual.

d. Interference Calculations. Interference power is calculated in one direction only, from fixed or base station transmitters to a receiver at a proposed new location. This is at best only half of the total assignment problem. A fully operational model must consider both paths of interference.

e. Antenna Gain. In the current model, an antenna gain of 0 dBi is used in all calculations. In the 406.1-420 MHz band, antenna gains of 8 dBd (10 dBi) and 10 dBd (12 dBi) are not uncommon. Considering both interfering and receiving antenna gains, the isotropic antenna assumption can result in up to 24 dB error. Since antenna gain is readily accessible from the GMF, the actual gain should be included in all calculations.

Another very important feature that could be added to the model would be the ability to access the Canadian assignment file. Since coordination of assignments with Canada has become an increasingly difficult task, direct accessibility of the model to both the GMF and Canadian assignment files in a combined analysis would be highly desirable.

Additionally, more flexible input and output options need to be developed to easily add to, delete from or modify existing environments, provide for user specified analysis options (e.g., propagation loss percentile, interference criteria) and user specified output modes.

For an analytical capability, a frequency assignment option would also be useful. Presently, the GDM identifies available channels but does not provide aid in choosing among these available channels. Use of near optimum assignment strategies developed by the use of the COLOR model and incorporating limitations of the use of the channeling plans should be included.

In summary, for the fixed and land mobile bands, an overall model with two modes of operation has been described which will enhance NTIA spectrum management capabilities in these bands.

APPENDIX D

EXCERPTS FROM THE TABLES OF FREQUENCY ALLOCATIONS

Presented in this appendix are excerpts of the international and national tables of frequency allocations pertaining to the 7125-8500 MHz frequency range. Excerpts of the previous national and international table (pre-WARC-79) from the NTIA Manual are presented as TABLE D-1. TABLE D-2 shows the applicable footnotes to the pre-WARC-79 allocation tables. The current national and international allocations and the corresponding footnotes are shown in TABLES D-3 and D-4, respectively.

TABLE D-1

PRE-WARC-79 INTERNATIONAL AND NATIONAL ALLOCATIONS PERTAINING TO THE 7125-8500 MHz BAND

INTERNATIONAL			*UNITED STATES*				
Region 1 *MHz*	*Region 2* *MHz*	*Region 3* *MHz*	*Band* *MHz* *1*	*National* *Provisions* *2*	*Government* *Allocation* *3*	*Non-Government* *Allocation* *4*	*Remarks* *5*
6425-7250	FIXED MOBILE		6425-6575	NG		MOBILE	
			6575-6625	NG		FIXED NG8	
			6625-6875	NG		FIXED FIXED-SATELLITE (Space-to-Earth) NG8 NG103	
			6875-7125	NG		FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE NG103 NG118	
	379A 392AA 392B 393		7125-7250	G 392B	FIXED MOBILE		
7250-7300	FIXED-SATELLITE (Space-to-Earth) 392D 392G		7250-7300	G 392D US100	FIXED-SATELLITE (Space to Earth) G107		
7300-7450	FIXED FIXED SATELLITE (Space to-Earth) MOBILE 392D		7300-7450	G 392D	FIXED FIXED SATELLITE (Space-to Earth) MOBILE G107 G108		
7450-7550	FIXED FIXED SATELLITE (Space to-Earth) METEOROLOGICAL-SATELLITE (Space to-Earth) MOBILE 392D		7450-7550	G 392D	FIXED FIXED-SATELLITE (Space to Earth) METEOROLOGICAL- SATELLITE (Space-to-Earth) MOBILE G104 G107 G108		
7550-7750	FIXED FIXED SATELLITE (Space to Earth) MOBILE 392D		7550-7750	G 392D	FIXED FIXED SATELLITE (Space to-Earth) MOBILE G107 G108		
7750-7900	FIXED MOBILE		7750-7900	G	FIXED MOBILE		
7900-7975	FIXED FIXED SATELLITE (Earth to space) MOBILE		7900-7975	G	FIXED FIXED SATELLITE (Earth to space) MOBILE G107 G108		

TABLE D-1 (CONTINUED)

INTERNATIONAL			UNITED STATES				
Region 1 *MHz*	*Region 2* *MHz*	*Region 3* *MHz*	*Band* *MHz* *1*	*National* *Provisions* *2*	*Government* *Allocation* *3*	*Non-Government* *Allocation* *4*	*Remarks* *5*
7975-8025	FIXED-SATELLITE (Earth-to-space) 392H		7975-8025	G US100	FIXED-SATELLITE (Earth-to-space) *G107*		
8025-8175 FIXED *FIXED-SATELLITE* (Earth-to-space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 394B	8025-8175 EARTH EXPLORATION- SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	8025-8175 FIXED *FIXED-SATELLITE* (Earth-to-space) MOBILE Earth Exploration- Satellite (Space-to-Earth)	8025-8175	G	EARTH EXPLORATION- SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE G102 G107 G108		
8175-8215 FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL- SATELLITE (Earth-to-space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 394B	8175-8215 EARTH EXPLORATION SATELLITE (Space to Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL- SATELLITE (Earth-to-space) MOBILE	8175-8215 FIXED FIXED SATELLITE (Earth-to space) METEOROLOGICAL- *SATELLITE* (Earth-to-space) MOBILE Earth Exploration- Satellite (Space to-Earth)	8175-8215	G	EARTH EXPLORATION- SATELLITE (Space to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL- SATELLITE (Earth-to-space) MOBILE G102 G103 G104 G107 G108		
8215-8400 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 394 394B	8215-8400 EARTH EXPLORATION- SATELLITE (Space-to Earth) FIXED FIXED-SATELLITE (Earth-to space) MOBILE	8215-8400 FIXED FIXED-SATELLITE (Earth to-space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 394	8215-8400	G	EARTH EXPLORATION- SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE G102 G107 G108		
8400-8500	FIXED MOBILE SPACE RESEARCH (Space-to-Earth) 394A 394D		8400-8500	G, NG	FIXED MOBILE SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)	

TABLE D-2

FOOTNOTES TO THE ALLOCATION TABLES BEFORE THE WARC-79 APPLICABLE TO THE 7125-8500 MHz BAND

INTERNATIONAL	U.S. NATIONAL
392B—The band 7 145-7 235 MHz may be used for Earth-to-space transmissions in the space research service, subject to agreement between the administrations concerned and those having services operating in accordance with the Table, which may be affected. 392D—As an exception, passive fixed-satellite systems also may be accommodated in the band 7 250-7 750 MHz subject to: (a) agreement between the administrations concerned and those having services, operating in accordance with the Table, which may be affected; (b) the co-ordination procedures laid down in Articles 9 and 9A. Such systems shall not cause any more interference at active earth station receivers than would be caused by the fixed or mobile services. Power flux density limitations at the Earth's surface after reflection from the passive fixed-satellites shall not exceed those prescribed in the present Regulations for active fixed-satellite systems. 392G—In Algeria, Austria, Bulgaria, Cyprus, Cuba, Ethiopia, Finland, Hungary, Japan, Kuwait, Lebanon, Liberia, Malaysia, Morocco, the Philippines, Poland, the United Arab Republic, Yugoslavia, Roumania, Sweden, Switzerland, Czechoslovakia and the U.S.S.R., the band 7 250-7 300 MHz is also allocated to the fixed and mobile services. 392H—In Algeria, Bulgaria, Cuba, Ethiopia, Finland, Hungary, Japan, Kuwait, Lebanon, Morocco, Poland, the United Arab Republic, Yugoslavia, Roumania, Sweden, Switzerland, Czechoslovakia and the U.S.S.R., the band 7 975-8 025 MHz is also allocated to the fixed and mobile services. 394—In Australia and the United Kingdom, the band 8 250-8 400 MHz is allocated to the radiolocation and fixed-satellite services. 394A—In the United Kingdom, the band 8 400-8 500 MHz is allocated to the radiolocation and space research services. 394B—In Israel, the band 8 025-8 400 MHz is allocated, on a primary basis, to the fixed and mobile services and, on a secondary basis, to the fixed-satellite service. 394D—In Austria, Belgium, France, Israel, Luxembourg and Malaysia, the allocation to the space research service in the band 8 400-8 500 MHz is on a secondary basis.	US100—In the Additional Protocol to the Final Acts of the Space EARC, Geneva, 1963, a declaration on behalf of the USA states that the USA cannot accept any obligation to observe the exception claimed by Cuba in those footnotes to the Table of Frequency Allocations which were adopted by the EARC and which specifically named Cuba. **U.S. GOVERNMENT** G102—In the band 8025-8400 MHz, Earth Resources Satellite (ERS) System earth stations (receiving) within the US&P will be limited in number. It may be necessary to operate fixed-satellite service earth stations (transmitting) within the coordination area of an ERS earth station. Such operations will be coordinated in accordance with established procedures. G103—In the band 8175-8215 MHz, it may be necessary to operate meteorological-satellite earth stations (transmitting) within the coordination area of an Earth Resources Satellite (ERS) earth station (receiving). Such operations will be coordinated in accordance with established procedures. G104—In the bands 7450-7550 and 8175-8215 MHz, it is agreed that although the military space radio communication systems, which include earth stations near the proposed meteorological-satellite installations will precede the meteorological-satellite installations, engineering adjustments to either the military or the meteorological-satellite systems or both will be made as mutually required to assure compatible operations of the systems concerned. G107—Military earth stations in the band 7250-7750 and 7900-8400 MHz and 20.2-21.2, 30-31, 92-93, 102-103, 140-141 and 150-151 GHz may be fixed, transportable or located on board a ship or aircraft. G108—Planning and use of the bands 7300-7750, 7900-7975 and 8025-8400 MHz by mobile earth stations and the band 8025-8400 MHz by stations of earth resources satellite systems, necessitate the development of technical and/or operational sharing criteria to ensure the maximum degree of electromagnetic compatibility with existing and planned systems within these bands.

TABLE D-3

THE U.S. NATIONAL AND ITU TABLE OF FREQUENCY ALLOCATIONS
FOR THE 7125-8500 MHz BAND

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
7075-7250	FIXED MOBILE		7075-7125	809		FIXED MOBILE NG118	
			7125-7190	US252 809	FIXED G116		
			7190-7235	809	FIXED SPACE RESEARCH (Earth-to-space)		
	809 810 811		7235-7250	809	FIXED		
7250-7300	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 812		7250-7300		FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth) Fixed G117		
7300-7450	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile 812		7300-7450		FIXED FIXED-SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth) G117		
7450-7550	FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile		7450-7550		FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL- -SATELLITE (Space-to-Earth) Mobile- Satellite (Space-to-Earth) G104 G117		
7550-7750	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile		7550-7750		FIXED FIXED-SATELLITE (Space-to-Earth) Mobile- Satellite (Space-to-Earth) G117		
7750-7900	FIXED MOBILE except aeronautical mobile		7750-7900		FIXED		

TABLE D-3(CONTINUED)

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
7900-7975 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 812			7900-8025		Fixed FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) G117		
7975-8025 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 812							
8025-8175 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8025-8175 EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 814	8025-8175 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8025-8175	US258	EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) (No Airborne Transmission) G117		
8175-8215 FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8175-8215 EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE 814	8175-8215 FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8175-8215	US258	EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) (No Airborne Transmissions) G104 G117		
8215-8400 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8215-8400 EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 814	8215-8400 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8215-8400	US258	EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) (No Airborne Transmissions) G117		

TABLE D-3(CONTINUED)

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
8400-8500	FIXED MOBILE except aeronautical mobile SPACE RESEARCH (Space-to-Earth) 816 817		8400-8450		FIXED SPACE RESEARCH (Space-to-Earth) (Deep Space Only)		
	818		8450-8500		FIXED SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)	

TABLE D-4

FOOTNOTES APPLICABLE TO THE U.S. NATIONAL AND THE ITU TABLE OF FREQUENCY ALLOCATIONS FOR THE 7125-8500 MHz BAND

INTERNATIONAL

809 In the band 6 425-7 075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7 075-7 250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the earth exploration-satellite (passive) and space research (passive) services in their future planning of this band.

810 Subject to agreement obtained under the procedure set forth in Article 14, in Region 2, the band 7 125-7 155 MHz may be used for Earth-to-space transmissions in the space operation service.

811 Subject to agreement obtained under the procedures set forth in Article 14, the band 7 145-7 235 MHz may be used for Earth-to-space transmissions in the space research service. The use of the band 7 145-7 190 MHz is restricted to deep space; no emissions to deep space shall be effected in the band 7 190- 7 235 MHz.

812 The bands 7 250-7 375 MHz (space-to-Earth) and 7 900-8 025 MHz (Earth-to-space) may also be used by the mobile-satellite service. The use of these bands by this service shall be subject to agreement obtained under the procedure set forth in Article 14.

813 In the band 8 025-8 400 MHz, the power flux-density limits specified in No. 2570 shall apply in Regions 1 and 3 to the earth exploration-satellite service.

814 In Region 2, aircraft stations are not permitted to transmit in the band 8 025-8 400 MHz.

815 Subject to agreement obtained under the procedure set forth in Article 14, the band 8 025-8 400 MHz may be used for the earth exploration-satellite service (space-to-Earth) in Bangladesh, Benin, Cameroon, China, the Central African Republic, the Ivory Coast, Egypt, France, Guinea, Upper Volta, India, Iran, Israel, Italy, Japan, Kenya, Libya, Mali, Niger, Pakistan, Senegal, Somalia, Sudan, Sweden, Tanzania, Zaire and Zambia, on a primary basis.

816 In the space research service, the use of the band 8 400-8 450 MHz is limited to deep space.

817 Different category of service: in Belgium, Israel, Luxembourg, Malaysia, Singapore and Sri Lanka, the allocation of the band 8 400-8 500 MHz to the space research service is on a secondary basis (see No. 424).

818 Alternative allocation: in the United Kingdom, the band 8 400-8500 MHz is allocated to the radiolocation and space research services on a primary basis.

U.S. NATIONAL

US252-The bands 2110-2120, 7145-7190 MHz, 34.2-34.7 GHz are also allocated for Earth-to-space transmissions in the Space Research Service, limited to deep space communications at Goldstone, California.

US258-In the band 8025-8400 MHz, the non-Government earth exploration- satellite service (space-to-Earth) is allocated on a primary basis. Authorizations are subject to a case-by-case electromagnetic compatibility analysis.

U.S. GOVERNMENT

G104-In the bands 7450-7550 and 8175-8215 MHz, it is agreed that although the military space radio communication systems, which include earth stations near the proposed meteorological-satellite installations will precede the meteorological-satellite installations, engineering adjustments to either the military or the meteorological-satellite systems or both will be made as mutually required to assure compatible operations of the systems concerend.

G116-The band 7125-7155 MHz is also allocated for Earth-to-space transmission in the Space Operations Service at a limited number of sites (not to exceed two), subject to established coordination procedures.

G117-In the bands 7250-7750 and 7900-8400 MHz and 20.2-21.2, 30-31, 39.5-40.5, 45.3-45.5 and 50.4-51.4 GHz the Government fixed-satellite and mobile-satellite services are limited to military systems.

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report is a spectrum resource assessment of the 7125-8500 MHz band. Included is information on frequency allocaltions, technical standards, spectrum usage, and identification of spectrum-management issues pertaining to this band. The spectrum-management issues addressed were identified, based on band use, for the last five years, for peacetime applications along with expected band use as a result of the Final Acts of WARC-79. (Emergency and/or wartime applications in this band will be the subject of a subsequent assessment.) Recommendations are made to improve the current spectrum-management process to ensure efficient use of this band in the future. Recommendations include modifying certain technical standards, developing sharing criteria among several of the services using this band, and developing a frequency assignment model for fixed operations. Preparation for the upcoming Space WARC, as it pertains to this band, is also discussed.

16. Key Words *(Alphabetical order, separated by semicolons)*

Fixed Service; Fixed-Satellite Service; Interference; Mobile-Satellite Service; Spectrum Management; Spectrum Resource Assessment; 7125-8500 MHz Band

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