Frequency, Efficient Use of
Modulation
Notice of Inquire

Notice of Inquiry (NOI) initiated to gather information that will assist the Commission in formulating policy regarding wideband modulation techniques. NOI seeks to identify radio services which might benefit from these techniques and methods to characterize the technical parameters of wideband signals. One particular type of wideband modulation, spread spectrum, is examined in detail. GEN Docket No. 81-413

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of

Authorization of spread spectrum and other wideband emissions not presently provided for in the FCC Rules and Regulations.	Gen Docket No. 81-413

NOTICE OF INQUIRY

(Adopted: June 30, 1981; Released: September 15, 1981)

BY THE COMMISSION; COMMISSIONER JONES ABSENT.

INTRODUCTION

1. The Federal Communications Commission is initiating this Inquiry to gather information that will assist it in formulating policy regarding the use of wideband emissions. The Commission has before it a number of requests, beth formal and informal, to authorize systems employing wideband modulation techniques for such diverse services as communications, radiolocation and telemetry operations. Because of the fundamental differences between wideband and narrowband types of modulation, the present Commission Rules and Regulations do not appear to provide the proper mechanisms for dealing with these requests. Indeed, our present rules implicitly forbid the use of some new technologies in this area.

2. Basically, a system employing wideband modulation takes an information signal of a small bandwidth and after modulation of a radio carrier, produces a radio frequency CRF) signal of a much larger bandwidth. Although conventional amplitude modulation (AM) and frequency modulation (FM) do result in spreading the

information signal's bandwidth, the resultant RF bandwidth is still comparable to the bandwidth of the baseband signal. The modulation technique used in the FM broadcasting service increases the baseband signal's bandwidth by approximately a factor of sixteen. Although this is an example of wideband modulation, the FM broadcast signal's bandwidth still remains less than 240 kilohertz. In the context of this Inquiry, we shall concern ourselves with modulation techniques in which the baseband signal's bandwidth is greatly expanded; in some cases expansions of 1000 will be typical. This may result in RF bandwidths of many megahertz.

3. This Inquiry is designed to serve two purposes. We hope to gather information to: 1) assist us in identifying specific radio services presently authorized by the Commission, as well as ideas for new services, where the authorization of wideband modulation techniques would serve the public interest; and 2) identify the technical parameters which characterize a wideband emission, including procedures used to measure these parameters, and identify technical standards necessary to insure operation on a minimum interference basis.

SPECTRUM MANAGEMENT PHILOSOPHY

4. Historically spectrum management policy has evolved around narrowband communication systems. In the early days of radio, there were few radio systems and much spectrum in which to operate. Users were assigned a carrier frequency and their transmissions were required to remain in a small band of frequencies (bandwidth) about the carrier. As time progressed more users wished access to the spectrum. Advancing technology provided relief in two ways: 1) it increased the upper limit of usable spectrum; and 2) it provided the means for reducing the bandwidth occupied by existing stations. So as the Commission's frequency allocations were pushed higher and higher, users were required to "consume" less and less of the spectrum. In the land mobile services, allotted bandwidths were actually halved a number of times.

5. This environment of advancing technology leading to smaller and smaller bandwidths has established a trend among radio regulatory agencies, including the Commission, of reducing band-widths to achieve higher spectrum efficiency. 1 Obviously, reducing bandwidth is at least one way of increasing spectrum efficiency, but

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FOOTNOTE

1 Although there is no universally accepted measure of spectrum efficiency, it can be defined in general terms as the ratio of communications accomplished to spectrum used. These terms are usually difficult to quantify, but they may involve parameters such as: information delivered, users satisfied, radio frequency bandwidth occupied, geographical area covered and the time the spectrum is denied to other users. For a detailed discussion of metrics in this area see D. Hatfield, "Measures of Spectral Efficiency in Land Mobile Radio", IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-19, No.3, Aug. 1977, p. 266 and D.R. Ewing and L.A. Berry, "Metrics for Spectrum-Space Usage", Office of Telecommunications, OT Report 73-24, 1973.

it may not always be the best way. In a 1959 paper, J.P. Costas showed the somewhat surprising result that decreasing bandwidth does not always increase spectrum efficiency, but that under certain communication conditions very large bandwidths are needed for efficient spectrum use. 2 Wideband modulation techniques in certain applications may actually increase spectrum efficiency over narrow-band techniques, due to both natural interference and interference caused by other users.

SPREAD SPECTRUM MODULATION

6. One class of bandwidth expansion techniques which is of particular interest is spread spectrum modulation. It was originally developed for military applications concerning covert communications and/or resistance to jamming. Generally spread spectrum systems transmit an information signal by combining it with a noiselike signal of a much larger bandwidth to generate a wideband signal. The spreading of the information signal over a

wide band-width has obvious military advantages in that the resultant emission is more difficult to detect or jam than narrowband emissions.

7. Although basic spread spectrum theory was developed in the early 1950's and the military today is developing a number of operational systems, there are few civil applications of this technology. However, much of the earlier government funded research has now been declassified and is available for the general public. 3 Moreover, new advances in device technology, such as large scale integrated circuits, charged-coupled devices, and surface acoustic wave devices, give promise to lower-cost spread spectrum systems. Current FCC Rules, however, implicity forbid spread spectrum's use in most services. 4 This alone may be inhibiting research and development in civil applications.

8. The CCIR defines a spread spectrum system as "one in which the average energy of the transmitted signal is spread over a bandwidth which is much wider than the information bandwidth. 5

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2 J.P. Costas, "Poisson, Shannon, and the Radio Amateur", Proc. IRE, Vol. 47, pp. 2058-2068, December 1959.

3 Current published searches of Federally-funded research on spread spectrum techniques include: "Spread Spectrum Communications", May 1980, PB 80-809726 and "Spread Spectrum Communications", May 1980, PB 80-809734. These and all other reports cited herein with "PB" or "AD" accession numbers are available from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161.

4 On March 6, 1981 the Private Radio Bureau issued a Special Temporary Authorization (STA) to the Amateur Radio Research and Development Corporation (AMRAD) for the purpose of conducting experiments on spread spectrum modulation. In order to permit

spread spectrum, the STA waived two sections of the Commission's Rules. Thus, even the Amateur Radio Service, which is dedicated "to the advancement of the radio art", implicitly forbids spread spectrum modulation.

Actually it appears that this definition could apply to any wideband modulation scheme. R.C. Dixon, in his book entitled Spread Spectrum Systems, narrows this definition by adding the requirement that "some signal or operation other than the information being sent is used for broadbanding (or spreading) the transmitted signal. 6

9. There appear to be three basic types of spread spectrum techniques of interest to the Commission: a) direct sequence modulated, b) frequency hopping, and c) pulsed-FM. Hybrid systems may be formed from the combination of two or more of these basic types. A brief description of each type follows; more detailed information is available in an IEEE press publication entitled Spread Spectrum Techniques and an FCC funded report by the MITRE Corporation. 7

10. Direct sequence systems, sometimes called pseudonoise systems, employ a key generator to produce a high speed binary code sequence. An information signal is combined with this code sequence. This composite signal is then used to modulate an RF carrier. The code sequence determines the RF bandwidth, resulting in a spread spectrum signal. At the receiver another key generator produces a replica of the transmitter's code sequence, and the incoming RF signal is multiplied with this sequence. This collapses the RF bandwidth into a bandwidth which is commensurate with the information alone. Conventional narrowband demodulation techniques are then used to recover the

information signal from the RF carrier. The critical problem in direct sequence systems is to synchronize the key generators in the transmitter and receiver.

11. Frequency hopping systems also use key generators at the transmitter and receiver. However, here the binary code sequence is used to control a frequency synthesizer. At the transmitter, the RF carrier is modulated in a conventional manner by the information signal. The carrier frequency is determined at any given moment by the code sequence; hence the carrier "hops" around in the frequency domain. Again the receiver and transmitter key generators are synchronized, and the receiver local oscillator tracks the changing frequency of the carrier. Conventional demodulation techniques are used at the receiver. Frequency hopping systems can be programmed to miss selected frequencies as they hop. They require only moderate accuracy in synchronization, as the speed of the code sequence generator is much less than in direct sequence systems.

12. Pulsed-FM or chirp systems are similar to frequency hopping

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5 International Telecommunication Union, International Radio Consultative Committee, Recommendations and Reports of the CCIR, 1978, XIVth plenary Assembly, Kyoto, 1978, "Spread Spectrum Modulation Techniques", Report 651, Volume 1, pp. 4-14.

6 R.C. Dixon, Spread Spectrum Systems, New York, Wiley-Interscience, 1976, p. 3.

7 Spread Spectrum Techniques, ed. Robert C. Dixon, New York, IEEE Press, 1976. Walter C. Scales, "Potential Use of Spread Spectrum Techniques in Non-Government Applications", the MITRE Corporation, PB 81-165284, December 1980. The report by Mr. Scales will be inserted in the record of this proceeding.

systems in that the carrier frequency is varied. Frequency hopping systems shift the carrier among discrete frequencies, whereas in pulsed-FM systems the carrier varies smoothly across a band of frequencies. The transmitted signal is a swept-frequency pulse, similar to a signal produced by a laboratory sweep generator. This type of signal is relatively easy to generate today using a voltage controlled oscillator. Conventional narrowband modulation of the sweeping carrier is used to convey the information signal. At the receiver a dispersive filter accumulates and sums the transmitted energy received over a certain interval. By releasing this energy in one coherent burst, the filter compresses the signal into a narrow time slot and the signal behaves like a high power, narrow pulse.

ADVANTAGES AND APPLICATIONS OF SPREAD SPECTRUM IN THE CIVILIAN ENVIRONMENT

13. Spread spectrum modulation offers radio users a number of unique advantages. Only a receiver employing the same code sequence as the transmitter will be capable of decoding the transmitted signal and recovering the information signal. By assigning each receiver in a network a different code, the user may selectively address a particular receiver by employing the corresponding code at the transmitter.

14. By assigning different code sequences to different systems, i.e. the transmitters and receivers of each licensee, many such systems may be able to share a common frequency allocation. This could be done without the explicit coordination necessary for trunking, time division multiple access or frequency division multiple access. Transmitters will only be able to communicate with their intended receivers; in fact, each system should be unaware of the operation of other systems. This uncoordinated channel sharing is called cede division multiple access (CDMA).

15. Selective addressing and code division multiple access could prove attractive to both radio users and the Commission. The message privacy and security inherent with coded transmissions would certainly be attractive to law enforcement agencies, mobile telephone users and perhaps some business users. If the Commission chooses to allocate new spectrum for a personal radio service, spread spectrum modulation with CDMA techniques could be used to restrict the allocation to its originally intended use; i.e. users could only communicate with units employing the same code structures. This would facilitate the use of the allocation for "personal business" and prohibit the transformation of the band into a "hobby service" as has happened in the 27 MHz Citizens Radio Service. Because each discrete address code is essentially a new channel, spectrum efficiency may be improved over conventional systems. This has been

theorized in a number of papers, particularly in regards to cellular land mobile communications. 8

16. In 1978 the FCC funded a study by the U.S. Department of Commerce, National Telecommunications and Information Administration (NTIA), on the spectrum efficiency of multiple independent spread spectrum land mobile radio systems. The study concluded that in this application spread spectrum was not as efficient as conventional FM modulation. 9 The report determined that in a band allocated exclusively to spread spectrum systems, base stations and mobile stations would have to operate on separate frequencies to prevent interference. When two mobile stations are transmitting at the same time, the station that is closest to the receiving station can saturate the front end of the receiver thereby preventing the far station from being received. As with conventional

systems, this problem can be reduced by controlling the output power of all mobiles. But in the absence of power control, the "near-far" problem limits the spectrum efficiency of spread spectrum systems. However, in our opinion the report's conclusions apply only to direct sequence or fast frequency hopping systems, not all spread spectrum systems.

17. Another inherent property of spread spectrum modulation is the low power density of the transmitted signal. Because the transmitter output power is distributed across a wide band of frequencies, the power density (watts/hertz) is very small. In fact some spread spectrum systems can operate with the desired signal below the noise level at the receiver. This power density reduction can be used to advantage in applications involving covert communications, prevention of interference to other users, and privacy.

18. In Private Radio Docket 80-9 the Commission has considered the use of spread spectrum modulated trailing devices. 10 These devices would allow law enforcement personnel to track moving

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8 George R. Cooper, Ray W. Nettleton, and David P. Grybos, "Cellular Land Mobile Radio: Why Spread Spectrum?", IEEE Communications Magazine, Vol. 17, No. 2, pp. 17-24, March 1979; Robert P. Eckert and Peter M. Kelly, "Implementing Spread Spectrum Technology in the Land Mobile Radio Services", IEEE Transactions on Communications, Vol. COM-22, pp. 867 - 869, August 1977.

9 L.A. Berry and E.J. Haakinson, "Spectrum Efficiency for Multiple Independent Spread-Spectrum Land Mobile Radio Systems", U.S. Department of Commerce, National Telecommunications and Information Administration, Report 78-11, PB-291539, November 1978.

10 Report and Order, PR Docket 80-9, adopted January 8, 1981, FCC 81-1. For information concerning the ability of spread spectrum systems to share spectrum with conventional systems, see the following submissions:

Comments of Del Norte Technology, Inc. dated 3/31/80.

Reply Comments of Hewlett-Packard Company dated 5/15/80.

Reply Comments of American Telephone and Telegraph Company dated 5/16/80.

Copies of these documents will be inserted in the record of this proceeding.

vehicles without visual contact and their low power density would make them virtually undetectable to all others. Although the Commission has formally endorsed the concept of spread spectrum trailing devices, their use at this time is not permitted because the Commission has not addressed the issue of technical standards. Considering the low interference potential of these devices, it may be appropriate for the Commission to adopt only inband/out-of-band emission limitations. We invite comments indicating what standards will be necessary for the implementation of spread spectrum systems in covert trailing operations.

19. Spread spectrum systems also provide an interference rejection capability not possible with conventional narrowband systems. The strength of interfering signals at the receiver

output is reduced by the system's "processing gain". This gain is approximated by the ratio of the transmitted RF bandwidth to the original information signal's bandwidth. Processing gain may suppress interfering signals by as much as 40 dB.

20. The low power density and interference suppression capability of spread spectrum systems suggests a unique application, that of band overlay. It may be possible in some circumstances to overlay spread spectrum systems on spectrum used by conventional services with little or no mutual interference. Obviously this would increase the spectrum efficiency of the affected band and could release additional spectrum for allocation to other services. Short range systems, such as cordless telephones, might prove ideal for such an application. Many of these telephones are carrier current devices, operating on frequencies adjacent to the AM broadcast band. Current demand may already exceed the spectrum available for these telephones. If the United States decides to implement a WARC 79 decision to reallocate 1605 to 1705 kHz to the Broadcasting Service, cordless telephones will lose these frequencies. It may be impossible to find suitable additional spectrum to offset this loss. However, spread spectrum modulated telephones could possibly be overlayed on another frequency band. Not only would this relieve the problem of spectrum scarcity, but the orthogonal codes used in spread spectrum systems should prevent interference between neighbors' telephones without specific coordination. Surface acoustic wave devices, already employed in a number of television receivers, might be used to generate and receive spread spectrum signals at an affordable price.

21. Although theoretically band overlay is possible, more consideration must be given to interference from spread spectrum systems to conventional communications systems. The CCIR examined interference from direct sequence and frequency hopping systems to conventional AM voice, FM voice and FDM/FM voice signals. 11 The

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11 International Telecommunication Union, International Radio Consultative Committee, Recommendations and Reports to the CCIR, 1978, XIVth Plenary Assembly, Kyoto,

1978, "Considerations of Interference from Spread-Spectrum Systems to Conventional Voice Communications Systems", Report 652, Volume 1, pp. 14-22.

report gives signal to interference protection ratios for the cases considered and concludes that a potential for sharing exists, but further examination is required to determine detailed sharing criteria. The IIT Research Institute examined the performance of voice communications systems in the presence of spread spectrum interference in a report prepared for the Department of Defense. 12 The report concludes that a direct sequence interfering signal affects system performance similar to white Gaussian noise and a frequency hopping signal results in interference similar to that produced by a periodic pulsed signal.

22. NTIA has conducted several studies on the feasibility of overlaying spread spectrum systems on communications bands. The FCC funded a study to determine the effects of spread spectrum interference on TV. The study concluded that the amount of interference caused by a constant amplitude spread spectrum system should be about the same as that caused by a narrowband FM land mobile signal, as long as the spread spectrum RF bandwidth is less than 2 MHz. 13 If the spread spectrum RF bandwidth is greater than 6 MHz, the spread spectrum signal should have some advantage because of the out-of-band rejection capability of a TV receiver. This study suggests the possibility of overlaying very wide bandwidth spread spectrum signals on existing television bands.

23. Another study performed by NTIA examined the compatibility of spread spectrum and FM land mobile radio (LMR) systems. 14 It concluded that it would not be possible to overlay a spread spectrum LMR system onto a frequency band already occupied by

conventional FM LMR systems without causing interference. The definition of overlay in this study was interpreted to mean the unrestricted operation of both spread spectrum and FM mobiles throughout the same service area. According to this report, the extreme range of propagation conditions encountered in a LMR environment can not be overcome by the reduction in interference obtained with a spread spectrum system. Interference can be reduced by increasing the RF bandwidth of the spread spectrum system, but this reduction is not sufficient to compensate for the wide range of signal conditions in

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12 Leonard Farber and J. Cormack, "Performance of Voice Communications Systems in the Presence of Spread Spectrum Interference", IIT Research Institute, Report No. ESD-TR-77-005, AD A050844, December 1977.

13 J.R. Juroshek, "A Preliminary Estimate of the Effects of Spread-Spectrum Interference on TV", U.S. Department of Commerce, National Telecommunications and Information Administration, Report 78-6, PB-286623, June 1978.

14 J.R. Juroshek, "A Compatability Analysis of Spread-Spectrum and FM Land Mobile Radio Systems", U.S. Department of Commerce, National Telecommunications and Information Administration, Report 79-23, PB-300651, August 1979.

the LMR environment. However, the report did indicate that if a frequency hopping system was programmed to avoid frequency channels already in use, the signal suppression necessary for unrestricted operation might be achieved.

24. In 1978 the IIT Research Institute prepared another report on spread spectrum for the Department of Defense, this time developing procedures for analyzing interference caused by spread spectrum signals. 15 The report presents mathematical procedures for predicting interference conditions when conventional receiving systems are subjected to offending signals from spread spectrum transmitters. The procedures are generally applicable to all types of spread spectrum, signals. This report seems to be a good foundation on which Commission procedures to analyze spread spectrum interference could be based. We specifically request comments on the appropriateness of using this report as a basis for rule making.

25. An interesting characteristic of wideband systems is their ability to provide high resolution range measurements. Because the velocity of propagation of a radio signal is known, the distance between a transmitter and a receiver can be determined by measuring the time it takes a signal to propagate between them. A precise measurement of the signal's arrival time at the receiver is necessary. Because the uncertainty in measuring the arrival time is inversely proportional to the signal's bandwidth, wideband signals provide greater resolution than narrowband signals.

26. Del Norte Technology, Inc., a manufacturer of radiolocation equipment, has designed a radiolocation system which uses pulsed-FM technology. The system operates in the 420-450 MHz band and can determine distances up to 50 kilometers with an accuracy of plus or minus 2 meters. Del Norte has petitioned the Commission to amend its Rules to permit the marketing and use of this system. 16 A radiolocation system such as this could improve the accuracy of both aircraft and ship navigation.

27. A major concern with the use of spread spectrum is the Commission's ability to monitor and locate stations using this modulation technique. Because the emitted signal is both wideband and encoded, specialized receivers are necessary to demodulate it. The number of virtual "channels" realized with spread spectrum modulation may be very

large, further limiting the Commission's ability to detect and monitor all transmissions. This problem is not necessarily restricted to spread spectrum systems; any system

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15 Paul Newhouse, "Procedures for Analyzing Interference Caused by Spread-Spectrum Signals", IIT Research Institute, Report No. ESD-TR-77-003, AD A056911, February 1978. This report will be inserted in the record of this proceeding.

16 Del Norte Technology, Inc., Petition for Rulemaking, General Docket 80-135, filed May 10, 1979.

employing digital modulation techniques, whether for privacy or merely to facilitate communications, will pose a complex monitoring problem for the Commission. However, there are regulatory approaches that will mitigate this problem. Monitoring the technical parameters of a spread spectrum signal certainly poses much less of a problem than monitoring the same signal for message content. The Commission may choose to restrict the number of authorized user codes, assign them to licensees on a permanent basis or require that user codes be registered with the Commission. Spread spectrum systems could be authorized in services which have had few enforcement problems. Only spread spectrum techniques which can be decoded with a conventional wideband receiver might be authorized. Finally, considering the low interference potential of spread spectrum emissions, it should be noted that spread spectrum signals strong enough to cause interference will probably be strong enough to locate.

MATTERS TO BE ADDRESSED IN THIS INQUIRY

28. In December of 1979, the FCC issued a contract to the MITRE Corporation for the purpose of researching the potential use of spread spectrum techniques in non-government applications. MITRE has completed its study and submitted its report to the Commission. 17 The report presents a view of the potential benefits, costs and risks of spread spectrum communications and examines in detail many of the concepts briefly discussed in this Inquiry. Two examples of hypothetical implementations are considered: a slow frequency hopping system with FM voice and an intrusion detector using fast frequency hopping. We wish to direct attention to this report in the hope that it will stimulate further discussion and specifically request comments on it.

29. The Commission would also like to inquire about the measurement techniques used to evaluate spread spectrum systems. The Electromagnetic Compatibility Society (EMCS) of the Institute of Electrical and Electronics Engineers has written the Chief Scientist expressing their concern about broadband RF measurement and analytical techniques that may be required to evaluate the interference potential of broadband emissions to electronic equipment. 18 They are concerned about establishing a technical standard to promote good engineering practice in this area. The EMCS has suggested some basic steps to represent a model for evaluating the interference potential of broadband emissions. They believe that a model should be developed to, or in consonance with, the development of measurement and analytical techniques. This model would

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17 Walter C. Scales, Supra.

18 Letter, dated September 12, 1979 to Dr. Stephen J. Lukasik from Jacqueline R. Janoski. A copy of this letter will be inserted in the record of this proceeding.

help define the technical characteristics that need to be considered. This Inquiry will afford an opportunity for all parties to assist in addressing our concerns regarding the measurement techniques that will be necessary to describe the interference potential and technical characteristics of spread spectrum and other wideband systems.

30. Comments are also invited on all of the issues discussed in this Inquiry. Suggestions of services which might benefit with the allowance of wideband modulation techniques are specifically requested. Comments on analytical procedures which the Commission could employ to evaluate the interference potential of wideband systems would be particularly helpful. In this regard, we again ask for comments on using the IIT Research Institute's report (reference 15) as a basis for Commission rule making. All parties interested in the development of wideband systems are urged to file comments in this proceeding.

31. The questions listed below are not exhaustive. They merely typify the Commission's areas of concern. Information not directly responsive to these questions but relevant to the general subject matter of the Inquiry. is welcome and invited. To facilitate staff review each response should clearly state the precise topic or question being addressed.

32. Please provide answers and supporting data to the following questions:

(a) What services can be accommodated by the use of spread spectrum systems? Can they be implemented by band overlay or will they require dedicated frequency allocations?

(b) In the case of band overlay, should a spread spectrum system be required to operate on a non-interfernce basis with conventional systems? Should spread spectrum systems accept any interference they receive from other spread spectrum or conventional systems without protection from the Commission?

(c) Should each wideband modulation technique be considered on its own merits as to its spectrum use and efficiency?

(d) How should the power levels of spread spectrum systems be expressed? What power levels are necessary for operation? How can this power be measured?

(e) What narrowband receiver characteristics should be considered in determining the interference potential of spread spectrum systems to conventional narrowband emissions? Do these characteristics affect the possibility of having spread spectrum systems and conventional systems co-exist in the same frequency band?

(f) Will special test equipment be necessary to evaluate spread spectrum emissions? What type of detector, peak, quasipeak, or average, is best suited for measuring the interference potential of spread spectrum emissions?

(g) Can systems which use different wideband modulation

methods be evaluated by the same measurement techniques? Will the transmitter duty cycle affect the measurement techniques and the results?

(h) If the Commission chooses to authorize spread spectrum systems, will detailed technical standards be needed? If so, what standards? Would establishing inband/out-of-band emission limitations be sufficient?

(i) Should the Commission consider authorizing spread spectrum modulated cordless telephones? How much more expensive than present cordless telephones would these units be?

(j) From a spectrum utilization standpoint, are there any capabilities or efficiencies which spread spectrum or other wideband systems possess that would allow the transmission of more information for a given frequency band than is now possible using conventional systems?

The following questions generaly generally refer to ideas developed in the MITRE Corporation's report:

(k) Should the Commission authorize spread spectrum systems only if they utilize the spectrum more efficiently than conventional techniques or should spectrum efficiency be weighed along with the potential benefits of spread spectrum such as selective addressing, uncoordinated use, and secure communications? In such a case should spectrum efficiency be defined in terms of either instantaneous users/MHz, total users/MHz, or total users/MHz/square kilometer?

(l) Because the spectrum efficiency of spread spectrum appears to be high when transmitting low-rate data at microwave frequencies, what services could be implemented with this type of system?

(m) Which ISM bands might be suitable for spread spectrum overlay? How detrimental would this be to existing users? What sort of services could use ISM band overlay?

(n) Would the increased cost of spread spectrum equipment prohibit its acceptance by users? How much would equipment cost be expected to increase?

(o) Is it necessary for the Commission to monitor the message content of all types of transmissions? If spread spectrum is authorized, should the Commission require that equipment not have the capability of multiple user codes? Should user codes be assigned by the Commission? On a permanent basis? Should spread spectrum stations be required to identify themselves at some point in their transmissions with conventional modulation techniques, or some other means?

(p) Considering spread spectrum's low power density, would it be possible to design a police radar that could not be readily detected by motorists with monitors? How much more expensive

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than conventional police radars would such a unit be? What bandwidth would be required?

(q) Should the Commission consider a slow frequency hopping system with FM voice for any new personal radio service allocation? Could such a system be implemented today? At what increased cost over conventional systems? Would the potential advantages, such as privacy and uncoordinated channel access, outweigh the potential disadvantages, such as increased enforcement problems, if such a service was authorized by the Commission?

(r) In Appendix C of the MITRE Corporation's report, a model simulating the Citizens Band Service is developed. Is this model suitable for analyzing slow frequency hopping in the land mobile services? If not, what modifications would be necessary to make it suitable?

PROCEDURAL MATTERS

33. In view of the foregoing, we seek to obtain information from interested members of the public in order to assist the Commission in resolving the regulatory problems presented by wideband modulation techniques. We specifically request respondents to address the questions in paragraph 32.

34. Accordingly, pursuant to Sections 4(i), 4(j), 403 and 404 of the Communications Act of 1934, as amended, IT IS ORDERED that the aforementioned Inquiry IS HEREBY INSTITUTED.

35. In accordance with the provisions of Section 1.415 of the Commission's Rules, interested parties may be comments on or before March 15, 1982. Reply comments must be filed on or before June 30, 1982. Pursuant to the procedures set forth in Section 1.419 of the Commission's Rules, an original and five copies should be filed by formal participants with the Secretary of the Commission. Participants wishing each Commissioner to have a copy should include six additional copies. Members of the general public who wish to express their interest by participating informally may do so by submitting one copy. All comments are given the same consideration, regardless of the number of copies submitted. All comments should be clearly marked General Docket No. 81-413, and will be available for public inspection in the Public Reference Room at the Commission's headquarters. All written comments should be sent to: Secretary, Federal Communications Commission, Washington, D.C. 20554. For further information on this proceeding, please contact Michael Kennedy at (202) 632-7073. For general information on how to file comments, please contact the FCC Consumer Assistance and Information Division at (202) 632-7000.

FEDERAL COMMUNICATIONS COMMISSION,

WILLIAM J. TRICARICO,
Secretary.

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