QEX 29
July 1984
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The ARRL Experimenters' Exchange

Airborne Packet Repeater

Each weekend this summer, Gordon Bass, K2UIR, is making trips in his private plane from Rochester, NY to Rockport, ME. A packet-radio repeater operating on 145.01 MHz is aboard the plane using the call sign W2DUC (SSID-0). It will employ a PK-1 TNC packet controller, a whip antenna and have a power output of 10 watts. The altitude of the flights will be about 10,000 feet. Approximate times are: Fridays starting at 1830 to 1900 hours; Sundays at about 1630 hours EDT. Flight time is about 1 to 1.5 hours.

FCC Grants Spread Spectrum STA

As mentioned in last month's QEX, the FCC has granted a second Special Temporary Authority for spread-spectrum tests to the Amateur Radio Research and Development Corp. (AMRAD). Named in the STA are: Terry Fox, WB4JFI; David Borden, K8MMO; Robert Bruninga, WB4APR; Charles Phillips, N4EZV; Jim Elliott, K5KSY; Scott Schaefer, WR4S; Ted Seely, N4GFQ; Hal Feinstein, WB3KDU; William Hickey, WA5FXE; Joseph Crecente, KA3CHM; William Howard, K1LNJ; and Douglas Hardie, WA6VVV.

All tests proposed under the STA will use frequency hopping. Experiments 1 and 2 will use the bands 3675-3995, 7050-7295, 14100-14345, 21100-21345, and 28100-29300 kHz with service frequencies of 3725, 7100, 14150, 21150 and 28350 kHz, ±10 kHz for establishing communications and technical coordination. Prior announcements of tests on all bands except 10 meters will be made via W1AW bulletins.

Experiment 1 will use equipment designed by N4EZV. Experiment 2 may use the same equipment or the Yaesu FT-980 with external frequency control and will test a selective-addressing procedure where a unique frequency-hopping sequence is derived from a station's call sign. Experiment 3 will operate on the 144-, 220- and 420-MHz bands and use an N4EZV transceiver as well as ICOM hand-held radios modified for external computer control.

FCC Proposes Part 15 and 90 Spread Spectrum

The FCC has requested comments on its proposal to authorize spread-spectrum systems under Parts 15 and 90 of its rules. The FCC proposes to allow spread-spectrum systems to operate on any range of frequencies above 70 MHz without any restriction on their occupied bandwidth. The proposed rules are designed to minimize the likelihood of harmful interference so that it is comparable to that of existing Part 15 devices. The Commission also proposes that under Part 90 the Police Radio Service be able to use spread spectrum for physical surveillance, stakeouts, raids and other such activities on a secondary basis to operations of licensees regularly authorized on these frequencies.

The entire FCC Notice of Proposed Rulemaking is printed in this issue of QEX. This notice is recommended reading for all amateurs interested in (particularly weak-signal) operation at VHF and above. If you wish to comment to the FCC, your comments must be filed by September 14, 1984 and reply comments on or before October 12, 1984. As always, well-researched, logical and nonemotional comments will have much more impact than emotional hyperbole. Please send a copy of your comments to ARRL Hq.

Ah, The P/F Bit!

In this issue of QEX you will find two proposals for solving the poll/final-bit problem that is yet to be resolved in AX.25 level 2, the Amateur Radio link-level packet-radio protocol. One is by Phil Karn, KA9Q, and the other is by Bob Richardson, W4UCH. If you wish to comment on the best solution, please drop a line to Chairman, ARRL Ad Hoc Committee on Digital Communications, 225 Main St., Newington, CT 06111 before August 10, 1984.

Rocky Mountain Packet Amateur Radio Association

The Rocky Mountain Packet Amateur Radio Association (RMPAR) has been formed, according to word received from Don Brown, NØBRZ, (313) 451-6217. RMPAR now has two repeaters on Confer Mountain and Pikes Peak giving nearly blanket packet-radio coverage from Northern New Mexico, all of Eastern Colorado, and Southern Wyoming. They plan to add sites to extend coverage into Nebraska and more of Wyoming. The club president is Linc Haymaker, KØZCO. Thanks NØBRZ.

Daughter Board for Vancouver TNC

Various schemes have been developed to extend the memory capacity of the Vancouver Amateur Digital Communications Group (VADCG) terminal-node controller (TNC) board. Terry Fox, WB4JFI, of AMRAD has just completed the design and layout of

(continued on page 17)

The following is an excerpt from the Thursday, May 24, 1984 edition of the Federal Register, Vol. 49, No. 102. It summarizes rule proposals for the authorization of Spread Spectrum and other wideband emissions not presently provided for in the FCC Rules and Regulations.

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Parts 15 and 90

[Gen. Docket No. 81-413; FCC 84-169]

Authorization of Spread Spectrum and Other Wideband Emissions Not Presently Provided for in the FCC Rules and Regulations

AGENCY: Federal Communications Commission.

ACTION: Notice of proposed rulemaking.

SUMMARY: This action proposes changes in Part 15 of the Rules to allow spread spectrum usage for low power communication devices operating on frequencies above 70 MHz. Special protection from interference is given to the Radio Astronomy, Safety and TV bands.

Changes in Part 90 of the Rules are also being proposed to allow law enforcement officers to operate direct sequence and time hopping spread spectrum transmitters on selected frequencies in the Police Radio Service. Before any licensed law enforcement officer can operate a spread spectrum transmitter on these frequencies, he must first obtain approval from the local area coordinator of the Police Radio Service of the district in which the license and equipment are to be used.

DATES: Comments are due by September 14, 1984 and replies by October 12, 1984.

ADDRESS: Federal Communications Commission, Washington, D.C., 20554.

FOR FURTHER INFORMATION CONTACT: Dr. Joseph McNulty, (301) 725-1585. Dr. Michael Marcus, (202) 632-7040.

List of Subjects

47 CFR Part 15

Radio frequency devices.

47 CFR Part 90

Private land mobile radio services.

Further Notice of Inquiry and Notice of Proposed Rulemaking

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].

Adopted: April 26, 1984.

Released: May 21, 1984.

By the Commission.

Introduction and Background

1. On June 30, 1981, the Commission adopted a Notice of Inquiry ("Inquiry") (46 FR 51259; 87 FCC 2d 876), for the authorization of certain types of wideband modulation systems. The Inquiry is unusual in the way that it deals with a new technology. In the past, the Commission has usually authorized new technologies only in response to petitions from industry. However in the case of spread spectrum, the Commission initiated the Inquiry on its own, since its current Rules implicitly ban such emissions in most cases, and this prohibition may have discouraged research and development of civilian spread spectrum systems. As the next step in this proceeding, we are proposing in this Notice of Proposed Rulemaking rules that would authorize the use of spread spectrum under conditions that prevent harmful interference to other authorized users of the spectrum. We anticipate that this authorization will stimulate innovation in this technology, while meeting our statutory goal of controlling interference. We are issuing a Further Notice of Inquiry to solicit comments that will enable us to develop the appropriate test procedures for spread spectrum devices.

2. Spread spectrum is a term applied to communications systems that spread radio frequency energy over a wide bandwidth by means of an auxiliary spreading code. The spreading of the bandwidth can be accomplished in many different ways and the systems are usually classified by the type of spreading technique which they employ. They are commonly referred to as: direct sequence (or pseudonoise), frequency hopping, time hopping, pulsed FM (or chirp) and hybrid systems. (These terms are defined in Section 15.4 of the proposed rules in Appendix B.) The spreading or dilution of the energy in spread spectrum systems over a wide bandwidth results in several possible advantages: short range interference-free overlays on other emissions, resistance to interference from other emissions, and low detectability. While we do not anticipate that spread spectrum will replace other types of modulations, the unique characteristics of spread spectrum offer important options for the communications system designer.

3. Although most spread spectrum systems are presently used in government applications, there are some non-government systems also in operation. In some instances, the existing Rules and Regulations allow such operation, in other cases, permission to operate has been obtained through special authorization. Under § 90.209(b) and under footnote US217 in § 2.106 of the Rules and Regulations, spread spectrum systems for radiolocation purposes can be licensed for operation in the 420-435 MHz band. Also, special authorization was given to the Amateur Radio Research and Development Corporation to conduct spread specturm tests in the 50.0-54.0, 144-148 and 220-225 MHz bands. Under Part 25 of the Rules and Regulations which deals with Satellite Communications, licensees are only required to meet certain power attenuation standards and are not limited in operation by any specific emission designators. This, plus the wide bandwidth available in the 4.4-4.7 GHz band, has enabled Equatorial Communications Company to use spread spectrum in its satellite communications.[1]

4. These are some of the services in which spread spectrum systems are now operating in accordance with the current FCC Rules and Regulations. In the Inquiry, we sought to determine whether it would be in the public interest to authorize spread spectrum in an additional number of services and over a broader range of frequencies. There is some interest in spread spectrum communications because these systems offer certain advantages over conventional communications systems. For example, since the spreading functions for these systems are not uniquely specified different codes can be used to obtain selective addressing as well as message privacy. As a result, code-division multiple access systems can be implemented using spread spectrum techniques. Also, the low spectral density needed for spread spectrum communications systems, as well as the ability of some of these systems to process signals that are buried far into the noise, offer a potential for shared spectrum use with existing systems on a non interference basis. Finally, spread spectrum systems could be useful in applications to control multipath interference.

5. In the Inquiry, we also requested comments on the interference potential of spread spectrum systems to existing services, their frequency allocations, and the measurement of their emissions for monitoring as well as equipment authorization purposes. Information was also solicited concerning what services might be authorized, what transmitted power should be allowed, how can the transmissions be measured, should spectrum overlay of existing systems be allowed and what potential exists for interference with existing communications.

6. We also brought to the public's attention a study mde by the MITRE Corporation on the potential use of spread spectrum techniques in non-government applications ("Scales Report") and a second study made by the IIT Research Institute (IITRI) on the analysis of interference caused by spread spectrum signals ("Newhouse Report").[2] Comments were invited on the appropriateness of using the theoretical models developed in these reports as a basis for rulemaking.

Discussion of Comments and Reply Comments

7. Sixteen comments and twelve reply comments were filed in response to the Inquiry. A list of those filing comments is contained in Appendix A. The comments received were primarily in reply to the questions raised in the Inquiry and no new matters or issues of significance were raised. Although several questions in the Inquiry specifically addressed the use of spread spectrum in police applications, there were no responses to the Inquiry from police agencies or associations or from any public safety group. The replies to the Inquiry were primarily from manufacturers, individuals and broadcast groups.

8. In general, most of the replies were favorable to the overall concept of spread spectrum communications. It was felt that there are many useful communications applications which could be achieved with spread spectrum techniques that could not be satisfactorily developed with any other technology. However, many had reservations about the particularly implementation of spread spectrum systems and expressed concern over the potential for interference with existing communications systems. Because the technology is so new, many urged the Commission to proceed slowly with its implementation until we have had successful operating experience with these systems, including the identification and measurement of spread spectrum signals and their interference potential. There was particular concern among some parties that regular communications might be interrupted and the Commission might not be able to detect the source of the interference.

9. Various parties as well as the Commission suggested many civilian applications of spread spectrum techniques. These were:-

a. Wireless data terminals;
b. Wireless microphones;
c. Cordless telephones;
d. Wireless intercoms;
e. Remote area telephone service;
f. Radionavigation and ranging;
g. Intrusion alarms;
h. Police radar;
i. Police tracking and trailing devices;
j. A wide range of telemetry applications; and
k. Remote control applications both domestic and industrial.

Although many of these applications duplicate existing services, there are some instances where spread spectrum systems could provide a superior and less expensive alternative to the systems presently in use. Lucasfilm Ltd., which makes extensive use of wireless microphones, made this observation in their comments:

> [W]e would like to offer the Commission comment from a potential user for whom spread-spectrum techniques may provide the only solution to a standing problem. * * * special circumstances surround the use of FCC-authorized "radio microphones" in the production of theatrical motion pictures. It is the experience of every user with whom I have compared notes, that narrow-band FM radio microphones provide unreliable communications. Multiple transmission paths cause frequent complete drop-outs of signal, with the resultant loss of a great deal of time and money. * * * One need only listen to the tapes from the locations of C3PO of the next "Star Wars" film with its nearly continuous dropouts to realize the potential importance of spread spectrum techniques.
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> [Lucasfilm Ltd., Comments, June 28, 1982: pages 1 and 2]

10. Regarding the use of spread spectrum techniques in police communications, only GE and the IEEE Communications Society Subcommittee commented on whether non-jammable police radars could be developed using spread spectrum. Both thought that this type of spread spectrum implementation was not needed at the present time. Although no formal responses were received on this issue, we did receive an informal inquiry from Transcrypt/International Inc. concerning the use of spread specturm in police trailing applications.[3]

11. Concerning the parameters that characterize spread spectrum emissions and the methods for their detection and measurement, there as much broad comment but very little concrete detail. It was generally felt that each type of wideband modulation system has its own unique characteristics, and that different measurement techniques would be needed for each of the different spread spectrum systems. Some thought

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[1] On April 14, 1980, Equatorial was granted permission to provide a 9600 bit per second data distribution service using spread spectrum transmissions. The signals were broadcast from a large earth station in Mountain View, California and were rebroadcast from a satellite to customers which received them with 0.6 meter (2 foot) diameter receiving antennas. Over 6000 of these systems were sold in 1983. Equatorial's filings with the Commission concerning this system have been given the reference file numbers W-P-C-3078 and W-P-C-3476. On March 5, 1984, Equatorial was granted permission to use spread spectrum in a 1200 bit per second satellite uplink using a 1.2 meter (4 foot) transmitting antenna. Equatorial's filings with the Commission for this system have been given the Continued reference file numbers 962-DSE-P/L-83 and 963/964/985-DSE-ML-83. In both of these cases, the data is spread to 5 MHz using direct sequence pseudonoise modulation. This spreading is essential for these applications in order to allow the use of small antennas and prevent interference to other satellites and terrestrial users.

[2] Walter C. Scales, "Potential Use of Spread Spectrum Techniques in Non-Government Applications", the MITRE Corporation, PB 81-165284, December 1980.

Paul Newhouse, "Procedures for Analyzing Interference Caused by Spread-Spectrum Signals", IIT Research Institute, Report ESD-TR-77-003, AD-A056911, February 1978.

Copies of these reports may be purchased from the National Technical Information Service, Springfield, Va., 22161, Tel. (703)-487-4650. Scales and Newhouse have presented tutorials at the FCC on their reports. These presentations are useful background information for those preparing comments in this area and copies of videotapes are available from the Prism Corporation, 4545 42nd St., NW, Suite 109, Washington, D.C. 20016, Attn: Donna Edwards, Tel: (202)-686-8250

[3] Transcrypt/International Inc. has developed frequency hopping transmitters which they have been demonstrating to law enforcement agencies for possible use in the police radio service.

that the average power per unit of bandwidth would be an adequate measure of the spectral emissions and that this measurement could be made on a spectrum analyzer. However, no specific procedures were given for making these measurements, and no useful analysis was provided of the levels and character of the emissions to be expected at various distances from a spread spectrum transmitter. It was suggested that the American National Standards Committee C63 on Radio-Electrical Coordination might be of some help to the Commission in setting up adequate monitoring and measurement standards.

12. Although few parties commented on the Newhouse and Scales theoretical models, those who did felt that the models were not sufficiently accurate or complete to be used as a basis for frequency allocation or to predict the interference to conventional systems from spread spectrum signals. They felt that both Newhouse and Scales have greatly expanded our knowledge in this area; but, that for any theoretical model to be accepted as a standard, it would have to be first thoroughly checked against experimental data over a wide range of test conditions.

13. The topic that caused the most concern was the potential interference that spread spectrum systems might cause to existing services. Some concern was also expressed about the possibility of spread spectrum systems interfering with each other. GE felt that the interference problems presented by spread spectrum systems may be so great as to preclude their successful implementation in the land mobile services. Because of this, they thought that spread spectrum systems should not be authorized in mobile services but should be confined to the FIXED services.

14. Both GE and RCA objected to authorizing spread spectrum systems in the Industrial, Scientific and Medical (ISM) bands because many Part 15, low power consumer devices, such as home security devices and video disc systems, have already been authorized to operate in some of the bands. Not only were they concerned that spread spectrum systems operating in the ISM bands might cause interference to these devices, they also feared that any interference could lead to restrictions on the ISM bands for all Part 15 devices. Although RCA's objections were limited to the ISM bands below 1000 MHz, GE did not qualify its objections. All other parties responding to this issue felt that spread spectrum systems should be authorized in the ISM bands.

15. With the exception of NTIA, all of the respondents who specifically addressed the issue were against the overlay of spread spectrum systems upon existing services. However, these respondents made no explicit objection to the use of spread spectrum in low-powered, limited range applications. Indeed, most of the suggested applications for spread spectrum implementation were for systems of this type. Nevertheless, there was considerable concern about the interference to existing services from spread spectrum systems, regardless of the power levels involved. It was hoped that the interference could be minimized or completely eliminated, through the establishment of sufficient standards for the measurement and monitoring of spread spectrum emissions. In their comments, NTIA has pointed out that there are military and government spread spectrum systems which are presently operating in the frequency bands of other services, and are apparently causing no harmful interference to these services. However, they also state that in order to prevent interference to the overlayed services, some constraints and limitations had to be placed upon the operation of the spread spectrum systems.

Proposed Rulemaking for Spread Spectrum Authorization

16. It appears that most low power communication devices, currently authorized under Part 15 of our Rules and Regulations, could be considered as potential candidates for spread spectrum. As the staff at the Commission's Laurel Laboratory facility has considerable experience in measuring the emissions from Part 15 devices, the authorization of spread spectrum devices under this section of the Rules is attractive, since the expertise of the Laboratory staff could be drawn upon in establishing measurement standards for these devices and monitoring their emissions. However, most of the measurements at the Laboratory have been made on narrowband transmitting systems. Consequently, we will also have to rely on comments and help from outside the Commission in developing meaningful measurement standards for broadband systems. We would like to draw upon industry's knowledge and resources in this area and invite their comments on the development of such broadband measurement standards.

17. The authorization of spread spectrum systems under Part 15 of the Rules is attractive from another point of view. With the exception of frequency hopping systems, spread spectrum devices require continuous bands of spectrum in which to operate. But since Part 15 low power communication devices are authorized to operate on all frequencies above 70 MHz, subject to certain restrictions, spread spectrum systems authorized under this Part of the Rules would have access to this broad continuous area of spectrum. This essentially unlimited amount of spectrum is therefore important to spread spectrum use. Also, authorization of spread spectrum devices under Part 15 would allow considerable experimentation to be done on devices such as wireless microphones and wireless data terminals without Commission regulations restricting their development. At the same time, the Commission might be spared the immediate need to allocate additional spectrum space for these services and for other requested services such as cordless telephones. Many specific problem areas, such as those pointed out by Lucasfilm Ltd., could perhaps also be eliminated by Part 15 spread spectrum authorization. The use of spread spectrum in existing types of Part 15 devices, such as cordless phones and garage door openers, might increase their interference rejection capability while decreasing their potential interference to other systems and improving their privacy.

18. The authorization of spread spectrum systems under Part 15 of the Rules and Regulations would be unrestrictive and unregulatory in nature, since devices operating under Part 15 do not have to be licensed and users do not face eligibility requirements, content regulation, or coordination requirements. This would allow the forces of the marketplace to drive the implementation of this new technology, unhampered by regulations other than those needed to prevent harmful interference to licensed systems. Because of this, we are proposing to allow spread spectrum usage, under Part 15 of our Rules, for all low power communication devices which transmit or receive information on frequencies on or above 70 MHz. For frequency hopping, time hopping and pulsed FM systems, the levels of emissions which are being proposed are comparable with those presently authorized in the Rules for low power communication devices. For direct sequence systems, the levels of emission have been chosen so that the signals will not affect passable television quality (TASO grade 3) at a distance of 10 meters from the transmitter. Television receivers, because of there wide channel bandwidth, are generally more sensitive to interference than narrowband receiving systems. Hence, the emission limits which have been chosen to protect the television services, should be sufficient to protect narrowband systems from interference also. Emergency and radio astronomy bands have been protected in the proposed rules by placing stringent limits on the radiation which can be emitted in these bands. (See paragraph 15.126(c) of the proposed rules in Appendix B.) These constraints should minimize the probability of harmful interference to any of the existing services.

19. Spread spectrum devices, authorized under the rules proposed in this NPRM, will be required to be certified as a prerequisite to marketing. The Rules for the certification of Part 15 low power communication devices are given in the Rules and Regulations under Part 15, Subpart B. The Commission has the discretionary authority to call in sample devices for testing as part of the certification process. As we have done in the past with cordless telephones, CB radios, home computers and other devices and in response to the comments received in this proceeding, we expect to engage in a thorough sampling program until we are confident that the manufacturers have gained sufficient knowledge and skill in building them, so that they pose no potential interference problems.

20. The present Rules specify power and bandwidth limits for all low power communication devices. They also specify that, for devices authorized under the general provisions of Section 15.122, periodic operation in the bands 41.66–40.70 MHz and above 70 MHz, the duration of each transmission shall not be greater then one second and the silent period between transmissions shall be at least 30 times the transmission duration but in no case less than 10 seconds. Although, we are proposing to authorize spread spectrum systems under a new, separate section of the Part 15 Rules, § 15.126, the new proposed rules were modeled after those of § 15.122 and were made consistent with the rules and requirements of that section to the greatest extent possible. Nevertheless, in order to accommodate spread spectrum system under this Section of the Rules, some of these requirements have to be amended.

21. As we have indicated above, we are proposing to allow spread spectrum systems to operate on any range of frequencies above 70 MHz without any restrictions on their occupied bandwidths. And since a requirement of a 10 second minimum time between transmissions for spread spectrum devices could severely hamper the development of this technology, we are proposing to eliminate this restriction for these devices. However, spread spectrum systems would be subject to power and spectral occupancy limits that are comparable with those presently in the Rules, and for frequency hopping, time hopping and pulsed FM systems, a modified form of the 1/30 transmission on/off time requirement would apply also.

22. Time hopping and pulsed FM, spread spectrum systems can meet the present power and transmitting time on/off limits, if the measured field strength of their emissions on any frequency is no greater than those presently specified in this Part of the Rules, and if their duty cycles are less than 3.3%. Frequency hopping systems will also meet these requirements, if they are subject to this same field strength criteria, if 30 or more hopping frequencies are used, and if the transmission time on any one frequency is less than 1 second. However, because frequency hopping, time hopping and pulsed FM systems could cause considerable interference to television reception if they were allowed to indiscriminately operate within the television bands, restrictions have been placed upon the use of the television bands by these systems. If these systems operate on frequencies which fall within the television bands, it is proposed that they either be designed so that they do not have a total time of occupancy on any single television channel that is greater than one second out of every 30 seconds, or that they be provided with a switch or switches, that will enable the equipment to be operated on channels which are unused in that area. A television channel will be considered as used in an area, if the spread spectrum transmitter under consideration will produce a field, within the grade A contour of the television station using that channel, which is greater than 10 microvolts per meter.

23. With regards to interference, direct sequence systems pose a different type of problem since they require a continuous occupancy of the frequency bands in which they are operating. Juroshek has shown that the interference to television by direct sequence signals is of the same magnitude as that from narrowband signals of equivalent power.[4] But for narrowband interference, a signal to interference ratio of 50 dB will yield a television picture of passable quality.[4,5] At the grade A contour, most locations can tolerate a wideband or narrowband interference signal of approximately 10 microvolts per meter. Thus, the proposed maximum emission level of 33 microvolts per meter, measured at 3 meters, corresponds to no significant interference to most TV receivers that are 10 meters away from the emitter at the grade A contour, or 15–100 meters away (depending on channel number) at the grade B contour. It should be noted that this level of radiation is far below that presently allowed for Part 15 of the Rules and Regulations for spread spectrum devices are presented in Appendix B.

24. The limits on the effective radiated power from spread spectrum devices, operating on frequencies on or above 70 MHz, are presented in § 15.126(a) (cf. Appendix B). It should be noted that no fixed limits are being placed on the radiated power of spread spectrum devices operating in the 902–928 MHz, 2400–2483.5 MHz and 5725–5875 MHz ISM bands.[6] In these bands, all devices are allowed sufficient power for satisfactory operation, providing they do not cause harmful interference to other users of the bands, or produce unacceptable levels of radiated emissions outside the bands. The proposed rules would authorize spread spectrum systems to share these bands on a secondary non-interference basis with the primary users.[7] The majority of the comments favored allowing spread spectrum systems to operate in these bands. Also, in the previously cited report, "Potential Use of Spread Spectrum Techniques in Non-Government Applications", Scales recommended that the Commission consider the implementation of spread

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[4] John R. Juroshek, "A Preliminary Estimate of the Effects of Spread-Spectrum Interference on TV", NTIA Report 78-6, June 1978.

[5] CCIR Report 523, 1974, "System Models for the Evaluation of Interference", International Telecommunications Union, Geneva.

[6] RM-4428, a petition for rulemaking filed by Geostar Corporation for a radiolocation satellite service, requested use of the 2483.5–2500 MHz band. The availability of this band for spread spectrum communications systems will depend on the final disposition of the Geostar petition.

[7] NTIA has recently studied the current and potential electromagnetic usage of these three bands. Their findings are contained in the following reports.

Bohdan Bulawka, "Spectrum Resource Assessment in the 902–928 MHz Band" NTIA Report 80-46, September 1980.

Robert T. Waston, "Spectrum Resource Assessment in the 2300–2450 MHz Band", NTIA Report 81-78, September 1981.

William B. Grant, John C. Carroll and Charles J. Chilton, "Spectrum Resource Assessment in the 5650–5925 MHz Band", NTIA Report 83-115, January 1983.

spectrum systems in the ISM bands. Although GE and RCA have presented arguments against the shared usage of the ISM bands, we do not feel that they outweigh the considerable advantages to be gained from sharing these bands with spread spectrum systems. If spread spectrum systems can contend with the heavy interference from the other users of these bands, then these bands could offer an excellent proving ground for high power spread spectrum applications. Comments are requested on this issue.

25. In response to Transcrypt/International's inquiry concerning the use of spread spectrum in police communications, we are proposing to authorize frequency hopping and direct sequence systems to operate on a limited basis on certain frequencies in the Public Safety Radio Services. This authorization would be only for Police Departments' use of Public Safety spectrum for the purpose of communications in connection with physical surveillance, stakeouts, raids and other such activities and would be on a secondary basis to operations of licensees regularly authorized on these frequencies. Approval of the area frequency coordinator must be obtained prior to operation. The proposed changes to Part 90 of the Rules and Regulations to accomplish this are presented in Appendix B.

26. Because criminals have become increasingly more sophisticated in the means which they use to monitor police communications and detect surveillances, law enforcement officers must use increasingly sophisticated methods to guard their communications. Since spread spectrum transmissions are not readily detectable by criminals monitoring the air waves and are difficult to jam, this form of communications can become an extemely valuable tool for police. Federal law enforcement agencies, operating radio systems under 47 USC 305 have been authorized on a case by case basis by the National Telecommunications and Information Administration to use spread spectrum in their operations. This proposed rule gives state and local law enforcement agencies this same, important capability.

27. Under the proposed change to Part 90 of the Rules, frequency hopping systems would be allowed to operate on any of the frequencies which are presently available to the Police Radio Service and listed in § 90.19(d) of the Rules. The power limit specified for the users of these frequencies is 2 watts. Hence, frequency hopping systems, which are operating on these frequencies, are not expected to cause harmful interference to other users, if their maximum output power is kept below 2 watts. However, if the hop rate of these systems is greater than 10 hops per second and more than 10 hopping frequencies are used, then we feel that a maximum output power of 15 watts can be allowed and still not cause objectionable interference to the other users, since the time of continuous occupancy of any single frequency, by the frequency hopping system, will be less than one tenth of a second. Also, direct sequence spread spectrum systems will be allowed to operate in the 37.01–37.43, 39–40, 44.61.6.–46.6, 154.6375–156.250 and 158.715–159.48 MHz, Public Safety bands, if their maximum integrated output power is limited to 10 mW per KHz. The level of this signal is about one-tenth of that allowed for the other users of these bands and therefore the potential for interference is small.

28. We recognize that there is a potential for increased interference in allowing spread spectrum systems to share spectrum with conventional radio services. The proposed operation of spread spectrum devices under Part 15 of the Rules on frequencies above 70 MHz could, depending upon power levels allowed and other technical details, potentially affect Private Radio, Mass Media, and Common Carrier Services. We are particularly determined to avoid harmful interference to the Public Safety Radio Services from devices operting under both Part 15 and Part 90 of the Commission's Rules. Communications in the public safety services are directly related to the safety of life and propoerty. As such, harmful interference could have a direct and adverse effect on the public. Public safety licensees operate radio systems in the 30 MHz, 150 MHz, 450 MHz, 470 MHz, 800 MHz private land mobile bands. We have attempted to minimize this potential for interference by choosing conservative technical standards and, in the case of operation under Part 90, by requiring frequency coordination. We request comments on the ability of our proposed rules to ensure the integrity of public safety communictions as well as other services.

29. Although automatic identifiers for spread spectrum systems are not being considered in this proceeding, we may in the future have to consider some form of transmission identifier to assist us in identifying and locating units which may be causing interference. Hence, comments are sought on the feasibility of using such identifiers and the particular form that they might take. (As an example, Del Norte Technology Inc. uses a blanking technique to superimpose Morse code on their emissions with the identifiers DN and DNT for their spread spectrum radiolocation devices.)[8] It should be noted that there could be some difficulties with using these identifiers. For instance, the transmitted designator could be so strong that it could cause interference even when the signal it is identifying is not causing any, and on the other hand, it could be so weak that it might remain undetected while the signal which it is identifying is causing interference. We are requesting comments as to whether these difficulties pose real hindrances to the use of transmitter designators with spread spectrum communcations systems. If not, what form should the designator take and what power levels should be specified?

30. We may wish to consider spread spectrum transmissions that are carried by line conducted carrier current. There are many practical applications of spread spectrum systems which could be realized if the transmissions could be carried by this means. At the present time, line conducted transmissions are only allowed in restricted instances because of the danger of feeding interference back into the mains. Anticipating a possible future concern of the Commission in this area, we are requesting comments on the conditions under which this method of transmission would be practical for spread spectrum systems in domestic, business and industrial environments. Also, what power levels and frequency ranges should be specified and what range of transmission frequencies should be allowed? What precautions should be taken so that excessive spread spectrum signal strength does not feed back into the mains?

31. One area in which we expect signficant growth for spread spectrum systems is in its use in wireless data terminals. The Commission has already received several inquiries concerning this use for spread spectrum and experimental licenses for such devices have already been issued.[9] To help us anticipate industry's needs in this area, we are requesting comments as to whether the Rules, proposed here, are sufficient to allow spread spectrum wireless data terminals to operate efficiently in domestic, business and promising application, should we consider authorizing two classes of wireless data terminals under Part 15 as is presently done with computing devices? Alternatively, should such data terminals require a license if they exceed a certain emission limit? If so, what power and emission limits should be imposed? On the other hand, if in order to operate efficiently, these terminals would require bands of their own, where should they be located and what should the power limits be?

Notice of Inquiry

32. For equipment authorization and monitoring purposes, standards will have to be established for the measurement of spread spectrum emissions. However, because of the unique problems associated with the detection and measurement of these signals, we are unable to this time to furnish the appropriate procedures for their measurement. These will be released with the final Report and Order. To develop these procedures, we will need considerable assistance from business and industry to help solve the many difficult problems associated with these types of measurements. Some areas of concern about which we seek comments are:

1. With the power levels proposed for Part 15, spread spectrum transmitters, is it feasible, or even possible with our present measurement techniques, to measure the field strength of emissions from this equipment at outdoor 3 meter test sites? If so, what antennas would be the most suitable for making the measurements? (It should be kept in mind that, since most antennas become very inefficient at high frequencies, i.e., their antenna factors become very large, it may not be possible to detect and accurately measure low powered, spread spectrum signals, at these test sites. Also, remember that, since it is proposed that spread spectrum operations be allowed on all frequencies above 70 MHz, several different antennas will be needed to span the range over which these systems will be operating.) Would the same measurement procedures suffice if field strength levels listed in § 15.126(a) were to be decreased by 20 dB? What would the test procedures be in this case?

2. Measurements could perhaps be made more easily and accurately indoors, by measuring the output signal from the devices at a point just prior to any passive antenna tuning network that is used. What should be measured here: the total power of the unmodulated carrier, the power density over a specified frequency range or some other parameter? How can these measurements be coordinated with the field strengths specified in § 15.126(a) of the proposed Rules (cf. Appendix B)? Will there be any difficulty in adjusting the data for transmission line loss and antenna gain?

3. Perhaps all of the equipment authorization measurements will have to be made indoors on a test bench. For accuracy and repeatability in making these measurements, we may require that the manufacturer install, on devices that are submitted for test, some type of low loss RF connector at a point on the device just prior to any passive antenna tuning network that is used. What type of a connector should be specified? (If possible, the generic name of the connector should be used rather than the brand name.)

4. How should the connector be coupled to the network to prevent it from loading down the device? What impedence matching standards should be specified to prevent either the connector or the measuring equipment, which is to be attached to the connector, from interfering with the operation of the device? (Remember, that these connectors, if required, will only be mounted on the piece of communications equipment which the manufacturer submits for testing. They will not be allowed on devices which are produced for the general public. Hence, the addition of the connector to the device should not substantially change its operating characteristics.)

5. What equipment should be used to make the measurements? Are both spectrum analyzers and field intensity meters adequate for making these measurements or would the noise floors of these instruments mask the signals which are being measured?

6. What IF bandwidth should be used? Although the specification of a 1 MHz IF bandwidth is appealing and is easily attainable on most instruments, it is perhaps not adequate for measuring spread spectrum signals because their bandwidth is so large. The tradeoff for reduced IF bandwidth is the speed of making the measurements and it would take 10 times longer to scan a given spectrum with an instrument with a 1 MHz IF bandwidth as it would with one that had a 10 MHz bandwidth. And for signals which may span several GHz, even a 10 MHz IF bandwidth may not be adequate.

7. What scanning speed should be used to ensure that a representative sample of the spread spectrum transmission is actually being measured? Would a scanning speed that is one twentieth that of the spreading code be sufficient?

8. To speed up the measurements, what equipment could be used that will provide a greater IF bandwidth and yet would not sacrifice the accuracy of the measurements?

9. How can the test procedures for both indoor and outdoor measurements be automated?

10. What test data should we ask the manufacturers to supply for equipment authorization purposes?

We will give consideration to the information, which is submitted, in setting up our internal measurement standards, which we will make available to the public in a technical note or report.

How to File Comments

33. In accordance with the procedures set forth in Section 1.415 of the Commission's Rules, interested persons may file comments on or before September 14, 1984 and reply comments on or before October 12, 1984. All relevant and timely comments will be considered by the Commission before final action is taken in this proceeding. In reaching its decision, the Commission may take into consideration information and ideas not contained in the comments, providing that such information, or a writing indicating the nature and source of such information, is placed in the public file, and provided that the fact of the Commission's reliance on such information is noted in the Report and Order.

34. In accordance with the provisions of § 1.419 of the Commission's Rules, formal participants shall file an original and 5 copies of their comments and other materials. Participants wishing each Commissioner to have a copy of their comments should file an original and 10 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 during regular business hours in the Commission's Public Reference Room at

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[8] 47 FR 34415, "Revisions of Parts 2 and 90 of the Commission's Rules and Regulations to permit inland assignment of frequencies in the 420–450 MHz band for non-Government radiolocation". Second Report and Order, General Docket No 80-135, Paragraph 14.

[9] Hewlett-Packard has been issued experimental licenses under Part 5 of the Rules to develop and operate direct sequence, spread spectrum wireless data terminals in the 2450–2550 MHz band. All of the licensed facilities are in California. Although the need to broadcast call signs has been waived by the Commission in this instance, the identifying call signs associated with these facilities are: KM2XPS, KM2XPV, KM2XPW, KM2XPX AND KM2XPY.

Continued

its headquarters at 1919 M St., NW., Washington, D.C. All written comments should be sent to: Secretary, Federal Communications Commission, Washington, D.C., 20554. For general information on how to file comments, please contact the FCC Consumer Assistance and Small Business Division at (202) 623-7000. For further information on this proceeding, contact Dr. Joseph McNulty at (301) 725-1585 or Dr. Michael Marcus at (202) 623-7040.

Initial Regulatory Flexibility Analysis

35. *Reason for Action.* The Commission believes that its rules and policies should be reviewed in the context of current social, technological and financial environments in which licensees and applicants operate, so that service to the public may be facilitated while the least regulatory cost is imposed. It is in this light that it is considering modification of its Part 15 and Part 90 rules.

36. *The objectives.* The Commission proposes to accommodate spread spectrum systems by reducing regulation to the maximum extent feasible. The commission believes that such action will lead to a more rapid development of spread spectrum technology in the civilian sector.

37. *Legal basis.* Action proposed herein is taken pursuant to Sections 4(i) and 303 of the Communications Act of 1934, as amended.

38. *Description, potential impact and number of small entities affected.* We do not believe that this NPRM will have a detrimental impact upon small entities. Indeed, insofar as our action contemplates spectrum reuse, it is likely that it will benefit both small and large entities which seek to enter the new markets that this action will create. Also, since the action is deregulatory in nature and no new, restrictive regulations are being proposed, it should provide expanded business opportunities for all vendors and users of communications equipment, both small and large. Beyond this, we are unable to quantify the potential effects of this action on small entities. Comments are requested on this point by interested parties.

39. *Recording, record keeping and other compliance requirements.* The proposed modifications of Part 15 of the Rules would require only record generation by the manufacturer sufficient to meet type acceptance standards for the equipment. Modifications of the Part 90 rules require only a simple onetime notification of the area coordinator of the Police Radio Service of the district in which the license and equipment are to be used.

40 *Federal rules which overlap, duplicate or conflict with this rule.* The proposed rules were coordinated with the National Telecommunications and Information Administration. Their replies on this issue will be carefully considered to ensure no conflict will be encountered with Federal rules.

41. *Any significant alternatives minimizing impact on small entities and consistent with the stated objective.* None.

Other Procedural Matters

42. *Ex Parte Considerations:* For purposes of this non-restricted notice and comment rulemaking proceeding, members of the public are advised that ex parte contacts are permitted, from the time the Commission adopts a notice of proposed rulemaking, until the time a public notice is issued stating that a substantive disposition of the matter is to be considered at a forthcoming meeting, or until a final order disposing of the matter is adopted by the Commission, whichever is earlier. In general, an ex parte presentation is any written or oral communication (other than formal written comments/pleading and formal oral arguments) between a person outside the Commission and a Commissioner or a member of the Commission's staff which addresses the merits of the proceeding. Any person, who submits a written ex parte presentation, must present a copy of that presentation to the Commission's Secretary for inclusion in the public file. Any person, who makes an oral ex parte presentation addressing matters not fully covered in any previously-filed written comments for the proceeding, must present a written summary of that presentation to the Commission's Secretary for inclusion in the public file on the day that the presentation is made. A copy of the summary must also be presented to the Commission official who receives the oral presentation. The written presentation and summary, described above, must state the docket number of the proceeding to which they relate. For further information, see § 1.1231 of the Commission's Rules (47 CFR 1.1231). A summary of the Commission's procedures governing ex parte presentations in informal rule making proceedings is available from the FCC Consumer Assistance and Small Business Division, Federal Communications Commission, Washington, D.C., 20554.

43. *The Commission's action in this proceeding:* Accordingly, the Commission adopts this Notice of Proposed Rulemaking (NPRM) under the authority contained in Section 4(i) and 303 of the Communication Act of 1934, as amended.

Federal Communications Commission.
William J. Tricarico,
Secretary.

Appendix A—List of Parties Supplying Comments and Reply Comments to the Notice of Inquiry

The following parties supplied Comments to the Notice of Inquiry:

Association of Maximum Service Telecasters, (MST)
American Petroleum Institute.
American Telephone and Telegraph Company, (ATT)
Communications Satellite Corporation, (COMSAT)
Cryptext Corporation
General Electric, (GE)
GTE
Hewlett-Packard, (HP)
M/A-COM
Motorola
National Association of Broadcasters, (NAB)
National Association of Business and Educational Radio, Inc., (NABER)
RCA
Telecommunications Engineering, Inc., (TEI)
Special Industrial Radio Service Association, (SIRSA)
U.S. Dept. of Transportation, Maritime Administration

The following parties supplied Reply Comments to the Notice of Inquiry:

American Broadcasting Companies, Inc., (ABC)
American Telephone and Telegraph Company, (ATT)
Wesley G. Bush
Lawrence F. Chesto
Communications Theory Committee of the IEEE Communications Society
Del Norte Technology, Inc.
Equatorial Communications Company (Equatorial)
General Eectric, (GE)
Hewlett-Packard, (HP)
IEEE Committee on Communications and Information Policy
Lucasfilm, Ltd.
U.S. Dept. of Commerce, National Telecommunications and Information Administration, (NTIA)

Appendix B—Proposed Changes for FCC Rules and Regulations Part 15 and Part 90 Changes

PART 15—[AMENDED]

§ 15.4 [Amended]

1. Section 15.4, General Definitions, is amended by adding paragraphs (w), (x), (y), (z), (aa) and (bb) as follows:

(w) *Spread Spectrum Systems.* A spread spectrum system is an information bearing communications system in which: (1) information is conveyed by modulation of a carrier by some conventional means, (2) the bandwidth is deliberately widened by means of a spreading function over that which would be needed to transmit the information alone. (In some spread spectrum systems, a portion of the information being conveyed by the system may be contained in the spreading function.)

(x) Direct Sequence Systems. A direct sequence system is a spread spectrum system in which the incoming information is usually digitized, if it is not already in a binary format, and modulo 2 added to a higher speed code sequence. The combined information and code are then used to modulate a RF carrier. Since the high speed code sequence dominates the modulating function, it is the direct cause of the wide spreading of the transmitted signal.

(y) Frequency Hopping Systems. A frequency hopping system is a spread spectrum system in which the carrier is modulated with the coded information in a conventional manner causing a conventional spreading of the RF energy about the carrier frequency. However, the frequency of the carrier is not fixed but changes at fixed intervals under the direction of a pseudorandom coded sequence. The wide RF bandwidth needed by such a system is not required by a spreading of the RF energy about the carrier but rather to accommodate the range of frequencies to which the carrier frequency can hop.

(z) Time Hopping Systems. A time hopping system is a spread spectrum system in which the period and duty cycle of a pulsed RF carrier are varied in a pseudorandom manner under the control of a coded sequence. Time hopping is often used effectively with frequence hopping to form a hybrid time-division, multiple-access (TDMA) spread spectrum system.

(aa) Pulsed FM Systems. A pulsed FM system is a spread spectrum system in which a RF carrier is modulated with a fixed period and fixed duty cycle sequence. At the beginning of each transmitted pulse, the carrier frequency is frequency modulated causing an additional spreading of the carrier. The pattern of the frequency modulation will depend upon the spreading function which is chosen. In some systems the spreading function is a linear FM chirp sweep, sweeping either up or down in frequency.

(bb) Hybrid Spread Spectrum Systems. Hybrid spread spectrum systems are those which use combinations of two or more types of direct sequence, frequency hopping, time hopping and pulsed FM modulation in order to achieve their wide occupied bandwidths.

2. New § 15.126 is added to read as follows:

§ 15.126 Operation of spread spectrum systems above 70 MHz.

Low power spread spectrum communication devices may be operated above 70 MHz subject to the following conditions:

(a) Low power spread spectrum communications systems are limited to operation on frequencies above 70 MHz. With the exception of the frequency bands listed in paragraph (c) of this section, the emission of RF energy on any frequency shall not exceed the field strengths in the following table:

Frequency (MHz)	Field strength at 3 m (uv/m): Frequency hopping time hopping pulsed FM systems	Field strength at 3 m (uv/m): Direct sequence systems
70 to 130	500	33
130 to 174	[1]500-1500	33
174 to 260	1500	33
260 to 470	[1]1500-5000	33
470 and above	[2]5000	39

[1] Linear interpolation.

[2] These power limits apply on all frequencies above 470 MHz except in the 902-928 MHz, 2400-2483.5 MHz and 5725-5875 MHz frequency bands, where adequate power to perform the particular communications task will be allowed, providing that the device causes no harmful interference to other authorized users of these bands, and does not produce spurious or harmonic emissions outside the bands which are larger than the values listed in the Table. Power, in excess of that which is necessary for satisfactory operation, is not allowed.

Note.—Spread spectrum systems using the 902-928 MHz, 2400-2500 MHz and 5725-5875 MHz bands should be cautioned that they are sharing these bands on a secondary basis with systems, supporting critical government requirements, that have been allocated the usage of these bands on a primary basis. Many of these systems are airborne radiolocation systems that emit a high EIRP which can cause harmful interference to other users. For further information about these systems, write to:

Director, Office of Plans and Policy, U.S. Department of Commerce, National Telecommunications and Information Administration, Room 4096, Washington, D.C. 20230.

Also, future investigations of the effect of spread spectrum interference to Government operations in the 902-928 MHz band may necessitate that the general limit on radiated power, as specified in the proposed rules, not be relaxed in this band and that the general limit apply.

(b) Hybrid spread spectrum systems, which use direct sequence modulation in combination with other types of modulation, are restricted to the emission limits given in paragraph (a) of this section for direct sequence systems.

(c) Emission of RF energy shall not fall in any of the bands listed below:

MHz	GHz
73 to 75.4	10.6 to 10.7.
108 to 118	15.35 to 15.4.
121.4 to 121.6	19.3 to 19.4.
156.7 to 156.9	23.6 to 24.0.
240 to 285	31.3 to 31.8.
328.6 to 335.4	51.4 to 54.25.
404 to 406.2	58.2 to 59.0.
608 to 614	64 to 65.
960 to 1215	86 to 92.
1400 to 1427	100 to 102.
1535 to 1670	105 to 116.
2690 to 2700	164 to 168.
4200 to 4400	182 to 185.
4990 to 5250	217 to 231.

Note.—A radiation level below 5 microvolts per meter at 3 meters will be considered to meet this requirement. For type acceptance of spread spectrum equipment whose emissions overlay these frequency bands, it must be demonstrated, by either measurements or analysis, that this emission limit is met.

(d) For frequency hopping systems, at least 30 hopping frequencies, separated by at least 20 kHz, shall be used, and the time of occupancy on any frequency shall not be greater than 1 second. For time hopping and pulsed FM spread spectrum devices, the duty cycle shall be less than 3.3%.

(e) Frequency hopping, time hopping and pulsed FM spread spectrum systems that operate on frequencies which fall within the television bands, shall either (1) be designed so that they do not have a total time occupancy on any single television channel that is greater than one second out of every 30 seconds or (2) be provided with a switch or switches, that will enable the equipment to be operated on channels which are unused in that area. A television channel will be considered as used in an area, if the spread spectrum transmitter under consideration will produce a field, within the grade A contour of the television station using that channel, which is greater than 10 microvolts per meter. For type acceptance of frequency hopping, time hopping and pulsed by FM spread spectrum transmitters, it must be demonstrated, by either measurements or analysis, that these conditions are met.

(f) The antenna of the spread spectrum device shall be permanently mounted on the enclosure containing the device. A microphone, keyboard, data entering or signal entering unit may be external to the device, providing that it is permanently connected to the enclosure with a cable not longer than 1.5 meters. If a power cable is used, it must not be longer than 3 meters and be permanently attached to the device. If the device is operated outdoors, it must not be mounted at a height greater than 10 meters above the ground. If it is operated indoors, it must be operated a'

A Solution to the AX.25 Poll/Final Problem

The West Coast VHF-UHF Conference was held during the weekend of May 4, 5, and 6, 1984, in Paso Robles, California. Apart from the usual booths of dealers and products, a solution to the AX.25 Poll/Final problem was being discussed in a nearby forum. Here is the latest concerning this subject, as told to us by Bob Richardson, W4UCH, in his letter of June 13, 1984.

This paper proposes a solution to the possibly confused interpretation of the original AX.25 Level 2 protocol. The original protocol is concerned with the proper use of the Poll/Final bit and the distinction between command and reply frames.

When confusion reigns, it is sometimes helpful to go back to the fundamentals. I suggest following the thread out of the cave through X.25, through HDLC, to the daylight of IBM SDLC and using a little common sense. The following additions to the rules of the game eliminate any ambiguity and clarify muddy waters:

1. IFRAMES: The last frame of a packet always has the P/F bit of the control byte set to 1. Obviously, a single frame packet is the last one, so it has the P/F bit set.

2. SFRAMES: The P/F bit is always reset to zero unless there is a status request. The status request may be manual or automatic when the T2 timer times out. The possibility of two simultaneous status requests is so remote as to be nearly impossible. So why not handle this remote case in the software? Reception of an RNR would still allow the receiving station to test status by sending an RR with the P/F bit set to 1.

3. UFRAMES: SABM and DISC are commands, so set the P/F bit to 1. DM, UA, FRMR, and UI are "don't care" varieties and should be accepted with or without the P/F bit set.

NOTE: Both our software approach AND the GLB Electronics PK-1 will accept the non-AX.25 TAPR version 3.1 packets with or without the above modifications. I suggest a one- to two-year grandfather clause be in the new AX.25 update if my recommendations are accepted and implemented. Surely TAPR users can switch in a two-year time frame by simply updating EPROMS. -- Bob Richardson, W4UCH, Drawer 1065, Chautauqua, NY 14722.

(More on the Poll/Final Problem can be found on pages 16 and 17.)

a height which is not greater than 10 meters above the lowest level where a receiving unit is located.

(g) If the device is to be operated from public utility lines, the RF energy fed back into the power lines shall not exceed 250 microvolts at any frequency between 450 kHz and 30 MHz.

PART 90—[AMENDED]

§ 90.7 [Amended]

3. Section 90.7, Definitions, is amended by adding the following definitions in the alphabetical order.

* * * * *

Direct Sequence Systems. A direct sequence system is a spread spectrum system in which the incoming information is usually digitized, if it is not already in a digital format, and modulo 2 added to a higher speed code sequence. The combined information and code are then used to modulate a RF carrier. Since the high speed code sequence dominates the modulating function, it is the direct cause of the wide spreading of the transmitted signal.

* * * * *

Frequency Hopping Systems. A frequency hopping system is a spread spectrum system in which the carrier is modulated with the code information in a conventional manner causing a conventional spreading of the RF energy about the carrier frequency. However, the frequency of the carrier is not fixed but changes at fixed intervals under the direction of a pseudorandom coded sequence. The wide RF bandwidth needed by such a system is not required by a spreading of the RF energy about the carrier but rather to accommodate the range of frequencies to which the carrier frequency can hop.

* * * * *

Spread Spectrum Systems. A spread spectrum system is an information bearing communications system in which: (1) Information is conveyed by modulation of a carrier by some conventional means, (2) the bandwidth is deliberately widened by a spreading function over that which would be needed to transmit the information alone. (In some spread spectrum systems, a portion of the information being conveyed by the system is contained in the spreading function.)

§ 90.19 [Amended]

4. Section 90.19 (g)(3), Police Radio Service, is revised as follows:

(3) A licensee may use, without special authorization from the Commission, any mobile service frequency between 40 and 952 MHz listed in paragraph (d) of this section for communications in connection with physical surveillance, stakeouts, raids, and other such activities. Such use shall be on a secondary basis to operations of licensees regularly authorized on the assigned frequencies. The maximum power that may be used for such communications is 2 watts output. Other provisions of this part, including the requirements for station identification, shall apply. Spread spectrum transmitters may be operated on Public Safety frequencies between 37 and 952 MHz, providing that they are type accepted by the Commission under the provisions of §§ 2.803 and 90.203, and meet the following conditions:

(i) Frequency hopping transmitters can be operated, with a maximum output power of 2 watts, on any mobile service frequency between 40 and 952 MHz listed in paragraph (d) of this section. If their hop rate is greater than 10 hops per second and 10 or more hopping frequencies are used, their maximum output power may be increased to 15 watts.

(ii) Direct sequence spread spectrum transmitters may be operated in the 37.01–37.43, 39–40, 44.61–46.6, 154.6375–156.250 and 158.715–159.48 MHz bands with a maximum integrated output power of 10 mW per kHz.

(iii) Use of spread spectrum transmitters under this section of the Rules is subject to approval by the local area coordinator of the Police Radio Service of the district in which the license and equipment are to be used.

§ 90.207 [Amended]

5. Section 90.207, Types of emissions, is amended by revising paragraph (k) as follows:

(k) For stations in the Fire, Police and Power Radio Services utilizing digital voice modulation, in either the scrambled or unscrambled mode, F3Y emission will be authorized. Authorization to use F3Y emission is construed to include the use of F9Y emission subject to the provisions of § 90.233. P2D emission is allowed for stations using direct sequence spread spectrum transmitters in the Police Radio Service.

§ 90.209 [Amended]

6. Section 90.209, Bandwidth limitations, is amended by adding paragraph (h) as follows:

(h) Direct sequence spread spectrum transmitters which are operating in the 37.01–37.43, 39–40, 44.61–46.6, 154.6375–156.250 and 158.715–159.48 MHz bands will have any radiated emissions outside these bands attenuated by the following factors:

(1) On any frequency removed from the edge of the band by a displacement up to 40 kHz, the attenuation will be at least 50 dB.

(2) On any frequency removed from the edge of the band by a displacement greater than 40 kHz, the attenuation will be at least 80 dB.

[FR Doc. 84-13814 Filed 5-23-84; 8:45 am]
BILLING CODE 6712-01-M

ID Timer With Tone and Display

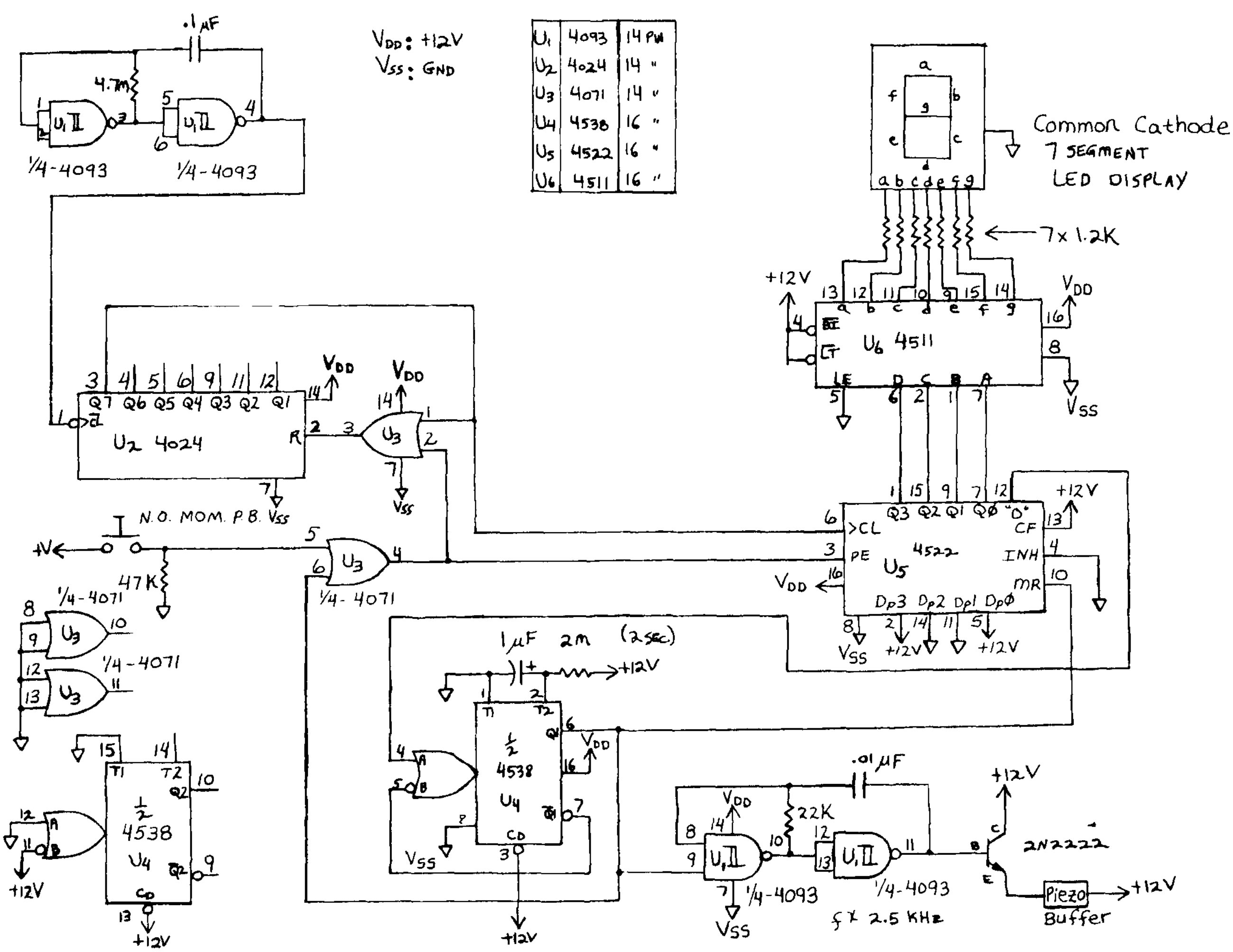
By Donald G. Varner,* WB3CEH

This is a good weekend project for those interested in building an ID timer for their station. ID timers are useful for keeping track of elapsed time between ID's, thus making it unnecessary to exchange calls after each or several short transmissions.

The timer incorporates six CMOS logic IC chips, a seven-segment LED display, and buzzer. The timing interval between "buzzes" is approximately nine minutes, which was found to work out nicely. The display shows the number of minutes remaining until ID. At "Ø" minutes, the buzzer will sound and the timer will automatically reset to nine minutes. A manual reset switch will also reset the timer.

Some considerations on circuit layout are as follows. The resistors and capacitors associated with U1 (4093) should be kept as physically close to the chip as possible. Also, the 2N2222 transistor should be near the buzzer. The supply voltage is 12-V dc to 13.6-V dc, and current drain was measured to be approximately 65 mA maximum. Voltage sources could be from a 12-V dc power supply already being used to power a piece of equipment. Many rigs have a 12-V dc or a 13.6-V dc output available on the rear panel for powering external equipment.

This is a simple but fun project to build, and serves as a useful operating aid in the shack. For those thinking of installing an ID timer, this should fit the bill.



*214 Bryant St., Vandergrift, PA 15690

Coax Loss Program for the HP-97 and TRS-80C

By I. L. McNally, K6WX

During the period of April 1973 to August 1976, Walt Maxwell, W2DU, published a series of articles in QST about the misunderstandings associated with SWR and coax line losses. Since this time, many amateurs have acquired computers and have successfully applied them to Morse code and RTTY operation. The computer is also useful in performing many calculations encountered in radio. I have prepared many programs covering antennas, networks, etc., but one of the most useful has proven to be "coax loss."

If the cable attenuation is low, (less than 1 dB), the increase in loss because of standing waves is very small. However, if the cable is "lossy," the increase in attenuation is significant. Even with a matched load, modest cable attenuation results in some reduction in power delivered to the load.

I have prepared a program for the TRS-80C that will compute all of the factors related to coax loss in the presence of standing waves. The program prompts each entry, displays the results, and transmits the data to the printer. If desired, the printer commands may be deleted to obtain display presentation only.

Computers are finding widespread use in Morse and RTTY operation, and their application to solving radio problems is an added bonus. This program is readily adaptable to other computers.

TRS-80C "Coax Loss" Program Procedure

The inputs are:

1. Input Power (PI). If this is expressed as 100, all of the power answers will be percentages of the input power.

2. Line length (L) in feet.

3. Impedance of the cable (Zo).

4. Cable attenuation in dB per 100 feet (X). A graph of this data can be found in The Radio Amateur's Handbook.

5. SWR (SI) measured at the input to the line.

With these five inputs, the following factors are computed, displayed and printed.

1. SWR (SO) at line input.

2. Load Resistance (ZR).

3. Forward Power (PF).

4. Load Power (PL).

5. Reflected Power (PR).

6. Power which would be delivered to a matched load (PM).

7. Additional loss (LA) in dB because of standing waves.

8. Total loss (LT) in dB in the presence of standing waves.

```
1 PRINT#-2, "DETERMINATION OF FACTORS FOR A GIVEN LENGTH OF TRANSMISSION LINE,
 CHARACTERISTIC IMPEDANCE, LINE ATTENUATION AT THE DESIRED FREQUENCY AND THE
 MEASURED SWR AT THE INPUT TO THE TRANSMISSION LINE."
5 PRINT "WHAT IS THE INPUT POWER? EXPRESS AS 100 AND THE ANSWERS  WILL BE AS PER
CENTAGES OF THE   INPUT POWER."
10 INPUT "ENTER"; PI
15 PRINT#-2, PI "INPUT POWER (PI)."
20 PRINT "WHAT IS THE IMPEDANCE OF THE COAX CABLE OR TRANSMISSION LINE (ZO)?"
25 INPUT "ENTER"; ZO
30 PRINT#-2, ZO "IMPEDANCE OF THE COAX CABLE OR TRANSMISSION LINE (ZO)."
32 PRINT "WHAT IS THE LENGTH OF THE TRANSMISSION LINE IN FEET?"
34 INPUT "ENTER"; L
36 PRINT #-2, L "LENGTH OF TRANSMISSION LINE IN FEET."
38 PRINT "WHAT IS THE VALUE OF LINE ATTENUATION PER 100 FEET AT THE DESIRED
   FREQUENCY?"
40 INPUT "ENTER"; X
42 PRINT #-2, X "ATTENUATION PER 100 FEET AT THE DESIRED FREQUENCY."
44 A=L*X/100
60 PRINT#-2, A "MATCHED LOAD ATTENUATION OF THE COAX CABLE OR TRANSMISSION LINE
   IN dB (A)."
```

*26119 Fairland Drive, Sun City, CA 92381

```
61 PRINT "WHAT IS THE SWR AT THE INPUT TO THE LINE (SI)?"
62 INPUT "ENTER"; SI
63 PRINT#-2, SI "INPUT SWR (SI)."
64 M=SI-1
65 N=SI+1
66 Q=N/M
67 R=A/10
68 T=10^R
69 U=T+Q
70 SO=U*(1/(Q-T))
71 PRINT#-2, SO "SWR AT OUTPUT (SO)."
72 ZR=ZO*SO
73 PRINT#-2, ZR "LOAD RESISTANCE (ZR)."
74 S=ZR/ZO
75 C=(S-1)/(S+1)
76 G=EXP(-.46*A)
80 H=EXP(-.23*A)
85 J=C^2
90 PF=PI/(1-(J*G))
95 PRINT PF "FORWARD POWER (PF)."
96 PRINT#-2, PF "FORWARD POWER (PF)."
100 PL=(1-J)*H*PI/(1-(J*G))
105 PRINT PL "LOAD POWER (PL)."
106 PRINT#-2, PL "LOAD POWER (PL)."
110 PR=PF-PI
115 PRINT PR "REFLECTED POWER (PR)"
116 PRINT#-2, PR "REFLECTED POWER (PF)."
120 K=SQR(PF/PR)
125 SI=(K+1)/(K-1)
135 PM=PI/10^(A/10)
140 PRINT PM "POWER TO MATCHED LOAD (PM)."
141 PRINT#-2, PM "POWER TO MATCHED LOAD (PM)."
145 LA=4.343*LOG(PM/PL)
150 PRINT LA "ADDITIONAL LOSS IN dB DUE TO PRESENCE OF STANDING WAVES."
151 PRINT#-2, LA "ADDITIONAL LOSS IN  dB DUE TO PRESENCE OF STANDING WAVES."
155 LT=A+LA
160 PRINT LT "TOTAL LOSS IN dB  IN THE PRESENCE OF STANDING WAVES."
161 PRINT#-2, LT "TOTAL LOSS IN dB IN THE PRESENCE OF STANDING WAVES."
165 PRINT#-2, "PROGRAM PREPARED FOR TRS-80CC BY I.L.MCNALLY  K6WX."
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```
DETERMINATION OF FACTORS FOR A GIVEN LENGTH OF TRANSMISSION LINE,    CHARACTERIST
IC IMPEDANCE, LINE ATTENUATION AT THE DESIRED FREQUENCY AND THE      MEASURED SWR
 AT THE INPUT TO THE TRANSMISSION LINE.
 100 INPUT POWER (PI).
 53.5 IMPEDANCE OF THE COAX CABLE OR TRANSMISSION LINE (ZO).
 122 LENGTH OF TRANSMISSION LINE IN FEET.
 .9 ATTENUATION PER 100 FEET AT THE DESIRED FREQUENCY.
 1.098 MATCHED LOAD ATTENUATION OF THE COAX CABLE OR TRANSMISSION LINE     IN dB
 (A).
 1.65 INPUT SWR (SI).
 1.92329389 SWR AT OUTPUT (SO).
 102.896223 LOAD RESISTANCE (ZR).
 106.405383 FORWARD POWER (PF).
 74.4127847 LOAD POWER (PL).
 6.40538308 REFLECTED POWER (PF).
 77.6604674 POWER TO MATCHED LOAD (PM).
 .185526784 ADDITIONAL LOSS IN  dB DUE TO PRESENCE OF STANDING WAVES.
 1.28352678 TOTAL LOSS IN dB IN THE PRESENCE OF STANDING WAVES.
PROGRAM PREPARED FOR TRS-80CC BY I.L.MCNALLY  K6WX.
```

This is an example of the printout obtained using the Flex DOS 9.0 with Dynacalc.

```
COAX CABLE FACTORS
INPUT POWER (PI)                    100
CABLE (ZO)                         53.5
LENGTH (L) FT                       122
ATTEN/100 FT (X)                     .9
LINE ATTEN (A)                    1.098
INPUT SWR (SI)                     1.65
SI-1=M                              .65
SI+1=N                             2.65
N/M=Q               4.0769230769230077
A/10=R                            .1098
10^R=T               1.287656427432767
T+Q=U                5.364579504355844
OUTPUT SWR (SO)       1.92329388993201
LOAD RES. (RL)       102.8962231113626
ZR/ZO=S               1.92329388993201
(S-1)/(S+1)=C        .3158402557853958
G=EXP(-.46*A)        .6034572969121727
H=EXP(-.23*A)        .7768251392122765
J=C^2                .0997550671745842
FORWARD POWER (PF)   106.4053830775548
LOAD POWER (PL)      74.41278461964729
REFLECTED (PR)       6.405383077554841
K=SQR(PF/PR)         4.075766034204087
SI=(K+1)/(K-1)        1.65024451722237
POWER TO MATCHED     77.66046739608367
LOAD (PM)
LOG(PM/PL)           .0185524433146283
ADDL DB LOSS (LA)    .1855244331462828
TOTAL DB LINE LOSS   1.283524433146283
WITH STANDING WAVES
(LT)
```

Determination of Cable Attenuation

If the loss in the coax cable is unknown or suspected to be high because of age or moisture, this second program provides a ready means of determining the attenuation factor. Applying a modest amount of power to a cable with the far end shorted, measurements are made of the forward power (PF), and the reflected power (PR). With these two inputs, the program will instantly determine the cable attenuation in dB.

```
1 PRINT#-2, "CABLE ATTENUATION BY MEASURING FORWARD AND REFLECTED POWER WITH FAR
 END OF CABLE SHORTED."
5 PRINT "WHAT IS THE FORWARD POWER?"
10 INPUT "ENTER"; PF
20 PRINT#-2, PF "FORWARD POWER (PF)."
25 PRINT "WHAT IS THE REFLECTED POWER?"
30 INPUT "ENTER"; PR
35 PRINT#-2, PR "REFLECTED POWER (PR)."
40 B=PF/PR
45 C=B^.5
50 D=C+1
55 E=C-1
60 F=1/E
65 G=D*F
70 H=G-1
75 I=G+1
80 J=1/I
85 K=H*J
90 A=4.343*LOG(K)
100 PRINT A "CABLE ATTENUATION IN dB (A)."
105 PRINT#-2, A "CABLE ATTENUATION IN dB (A)."
110 PRINT#-2, "PROGRAM PREPARED  FOR TRS-80C BY I.L.McNALLY K6WX."
```

```
CABLE ATTENUATION BY MEASURING FORWARD AND REFLECTED POWER WITH FAR END OF CABLE
 SHORTED.
 20 FORWARD POWER (PF).
 11 REFLECTED POWER (PR).
-1.29820305 CABLE ATTENUATION IN dB (A)
PROGRAM PREPARED  FOR TRS-80C BY I.L.McNALLY K6WX.
```

HP-97 #33 Coax Loss

```
001  *LBLA   21 11
002  DSP4   -63 04
003  RCL1    36 01
004  PRTX      -14
005  SPC     16-11
006     1       01
007     -      -45
008  P⇄S     16-51
009  STO1    35 01
010  P⇄S     16-51
011  RCL1    36 01
012     1       01
013     +      -55
014  P⇄S     16-51
015  RCL1    36 01
016  P⇄S     16-51
017     ÷      -24
018  P⇄S     16-51
019  STO2    35 02
020  P⇄S     16-51
021  RCL3    36 03
022  PRTX      -14
023  SPC     16-11
024     1       01
025     0       00
026     ÷      -24
027   10^x   16 33
028  P⇄S     16-51
029  STO3    35 03
030  RCL2    36 02
031     +      -55
032  STO4    35 04
033  RCL2    36 02
```

```
034  RCL3    36 03
035     -      -45
036   1/X       52
037  RCL4    36 04
038     x      -35
039  P⇄S     16-51
040  PRTX      -14
041  STO2    35 02
042  SPC     16-11
043     1       01
044     0       00
045     0       00
046  PRTX      -14
047  RCL2    36 02
048     1       01
049     -      -45
050  RCL2    36 02
051     1       01
052     +      -55
053     ÷      -24
054  STO4    35 04
055  RCL3    36 03
056  SPC     16-11
057     8       08
058     .      -62
059     6       06
060     8       08
061     6       06
062     ÷      -24
063  STO5    35 05
064     2       02
065     x      -35
066   e^x       33
```

```
067   1/X       52
068  STO6    35 06
069  RCL5    36 05
070     4       04
071     x      -35
072   e^x       33
073   1/X       52
074  STO7    35 07
075  RCL4    36 04
076   X²        53
077  RCL7    36 07
078     x      -35
079   CHS      -22
080     1       01
081     +      -55
082  STO8    35 08
083     1       01
084     0       00
085     0       00
086  RCL8    36 08
087     ÷      -24
088  PRTX      -14
089  SPC     16-11
090  STO0    35 00
091  RCL4    36 04
092   X²        53
093   CHS      -22
094     1       01
095     +      -55
096  ENT↑      -21
097  RCL6    36 06
098     x      -35
099     1       01
```

(HP-97 #33 Coax Loss Program Continued on Page 14)

Bits

BV Engineering

BV Engineering is a small company dedicated to producing reasonably priced professional software for the engineering market. They support 96 different computer systems and formats. A list of hardware for currently supported systems is available upon request.

Three programs are described here: the Electronic Circuit Analysis Program, the Signal Processing Program, and the Scientific Graph Printing Program. These are stand-alone programs that share common data files to further improve their utility, and are directed at the electronic and systems engineer and secondary school student.

The Electronic Circuit Analysis Program

The Electronic Circuit Analysis Program (ACNAP) analyzes passive and active circuits consisting of components such as resistors, capacitors, inductors, controlled current sources, operational amplifiers, transistors, and FETs. The program takes a look at the response of any linear network that has up to 21 nodes and 60 components. Every command is either menu driven or program prompted, and circuit topology data is saved to a named file or retrieved from a previously generated file for further analysis or editing. ACNAP's optimized code is fast, calculating the response of a typical 5 node circuit in 0.4 seconds.

ACNAP works with component tolerances to provide Worst Case and Monte-Carlo analysis. With a few short commands, the program calculates the minimum, maximum, mean, and 3 sigma points of a circuit's gain and phase response to any frequency input. Linear, as well as logarithmic frequency sweeps, are easily specified. The sensitivity of the gain/phase response to components at a frequency or range of frequencies are similarly calculated from tolerance data.

The circuit's Noise Equivalent Bandwidth is automatically calculated, and the user is prompted for all the information needed to accomplish this. The spectral data (magnitude/phase) is saved to a named file which, when used with the Signal Processing Program, adds transient analysis capability to ACNAP. The user can compute the response of his circuit to any time domain input waveform. This includes square waves, triangle waves, pulses, or any other user defined waveform. Waveforms can be generated by SPP or user-written programs in BASIC, FORTRAN, or other languages. Both ASCII and binary file structures are supported.

ACNAP works with the PLOTPRO Scientific Graph Printing program to plot the gain/phase information on any 80 or 132 column printer. (PLOTPRO is described more fully in another section of this article.)

The ACNAP (Version 1.34) program is available for 8/5.25 inch CP/M systems including Apple II+ CP/M, IBM PC, VICTOR 9000, and TRS-80 models I/III/IV. The price is $49.95 ($3 shipping and handling charges should be added when ordering BV Engineering programs). An 8087 coprocessor version is available for the IBM PC and VICTOR 9000 at a cost of $10 more. California customers should add 6% sales tax when ordering ACNAP, SPP, or PLOTPRO. Orders and inquiries should be addressed to BV Engineering, Professional Software, P. O. Box 3351, Riverside, CA 92519, tel. (714) 781-0252.

Signal Processing Program

The Signal Processing Program (SPP) contains an integrated set of routines that analyze linear and non-linear systems and circuits, and their effects on user specified time domain waveforms. The 512 point Fast Fourier Transform and its inverse is the basis of much of this program. Linear processing is conducted in the frequency domain and non-linear processing is performed in the time domain. The use of this program is enhanced by its ability to switch rapidly between these two domains.

The SPP will take any transfer function and compute the time domain response of that system to any user-generated input function. If the system is composed of a number of transfer function blocks, the SPP will multiply and list them. All transfer functions may be saved or recalled from a disk file, edited or multiplied by other transfer functions. This can be performed manually or from other disk files.

An extensive set of time domain manipulation routines are provided. These perform linear and non-linear operations on the signal. In addition to this, provisions are made for multiplying and adding one time domain signal from another on a disk file. A fast convolution of two time domain signals may be performed using FFT techniques. The time domain operations include constant or signal addition and multiplication, absolute value, positive and negative clipping, reciprocal, RMS calculation, and MIN, MAX point determination. Time domain signals are easily edited using SPP. All time and frequency domain operation results may be saved or recalled from named disk files in ASCII or binary format.

Many of the basic time domain signals such as rectangular pulses and sine waves are automatically generated. The SPP utility routines SIGGEN1 and SIGGEN2 may be used to generate a number of more complex wave shapes.

The frequency domain operations include the inverse FFT, Laplace transfer function generation

(BITS continued)

- multiplication - and evaluation, spectra multiplication, and spectra filtering. A built in Noise Equivalent Bandwidth calculation and comprehensive editing features are included. The SPP shares common data files with ACNAP and PLOTPRO, and adds transient analysis capability to them. These results can be plotted on any printer using PLOTPRO. Interfacing user data files generated by BASIC, FORTRAN, or other languages, is possible and fully documented with both ASCII and binary file formats supported.

The SPP is available for $59.95 in both 5.25/8 inch CP/M formats including Apple+ CP/M, IBM PC, VICTOR 9000, and TRS-80 Models I/III/IV. The 8087 coprocessor version for the IBM PC and VICTOR 9000 is available for $10 more. Write BV Engineering.

Scientific Graph Printing Program

The Scientific Graph Printing Program (PLOTPRO), is a set of four-linked Microsoft BASIC programs that make scientific graphs on any 80 or 132 column printer. It creates linear, semi-logarithmic, and full logarithmic plots with one or two Y axes, and will plot multiple functions on the same graph. Forced scaling and autoscaling are supported as well as optional grid lines to aid in graph interpretation. Grid lines may be spaced on linear or logarithmic boundaries. They may be automatically assigned by the program itself, or begin and end at user-specified points. Plots such as time history or frequency response can be obtained using any printer.

The PLOTPRO program creates templates of the physical appearance of any graph. Some of the specifications of these templates are the type of scaling (linear, log, forced or autoscale), graph labeling, axis labeling, plot labeling, and ranges for each axis. The templates also contain user-specified control codes in order to use many types of advanced printers. Templates are saved to disk files for future use.

PLOTPRO controls plotting and printing of infinite length graphs limited only by the length of paper. It also plots vertical formats suitable for use in reports, and viewgraphs. PLOTPRO works without special plotters, complicated data interfaces, assembly language "hooks," or reserved graphics memory, and is completely menu driven with program-prompted inputs.

PLOTPRO is completely compatible with ACNAP and SPP. Data files for PLOTPRO may be generated by any user program in various languages, or data may be entered manually. Data is transferred to the program in the simple form of (X,Y) pairs in a disk file.

The cost of PLOTPRO (Version 2.0), manual, and sample data files are available is $49.95. It is available for 8/5.25 inch CP/M systems and disk formats including Apple II+ CP/M, IBM PC, VICTOR 9000, and under TRSDOS for the TRS-80 Models I/III/IV.

(Diagrams of these programs can be found on page 14 - 15.)

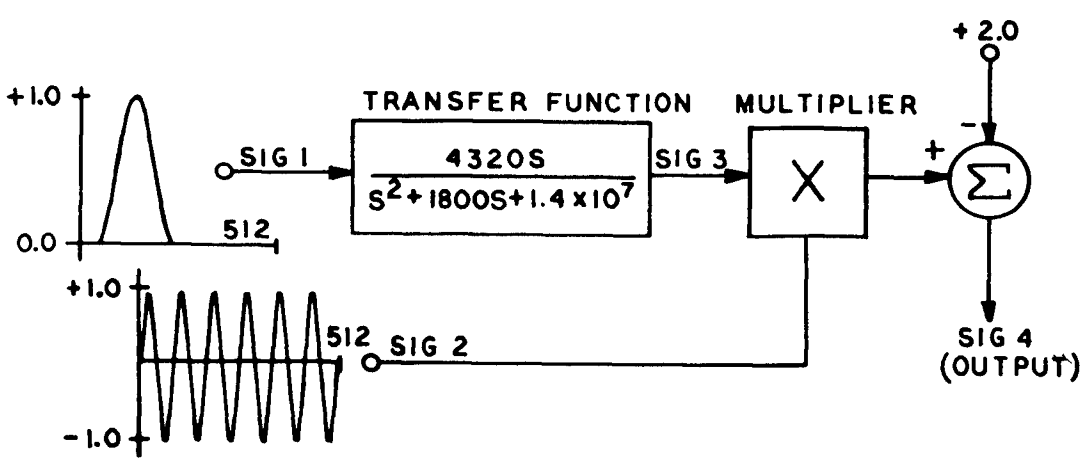
(HP-97 #33 Coax Loss Program Continued)

```
100      0      00
101      0      00
102      x     -35
103   RCL8   36 08
104      ÷     -24
105   PRTX     -14
106    SPC   16-11
107   STO9   35 09
108    1/X      52
109      1      01
110      0      00
111      0      00
112      x     -35
113    LOG   16 32
114      1      01
115      0      00
116      x     -35
117   PRTX     -14
118    SPC   16-11
119   RCL3   36 03
120      -     -45
121   PRTX     -14
122    SPC   16-11
123      1      01
124      0      00
125      0      00
126   RCL6   36 06
127      x     -35
128   RCL6   36 06
129      ÷     -24
130   RCL9   36 09
131      -     -45
132   RCL6   36 06
133      x     -35
134   PRTX     -14
135    RTN      24
136    R/S      51
```

```
SI     1.6500  ***
A      1.0980  ***
SO     1.3233  ***
PI   100.0000
PF   106.4016  ***
PL    74.3892  ***
LT     1.2849  ***
LA     0.1865  ***
PR     6.4016  ***
```

(BITS continued from page 13)

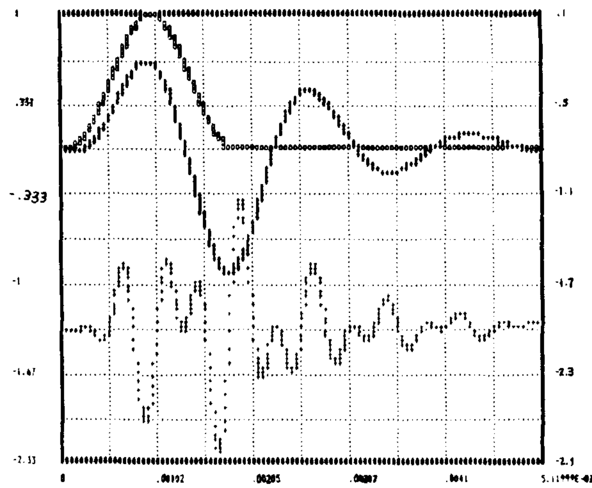
Non-linear Transient Analysis Output Example Using SPP



System Haversine transient response

SIG1/SIG3 Y Axis

Output response

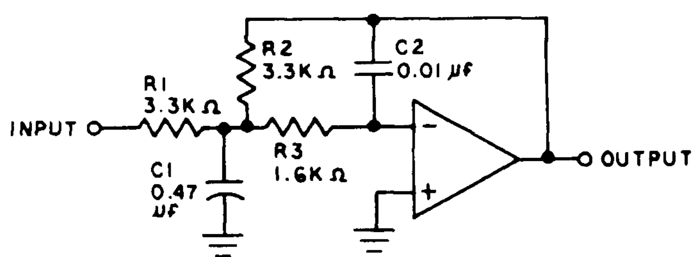


X axis Time in seconds

o - LEFT AXIS - SIG1 - Input Haversine From File SIG1
- LEFT AXIS - SIG3 - Data From File SIG3
+ - RIGHT AXIS - Output results (SIG4) from file SIG4

Output plotted using PLOTPRO

ACNAP Output Plotted Using PLOTPRO

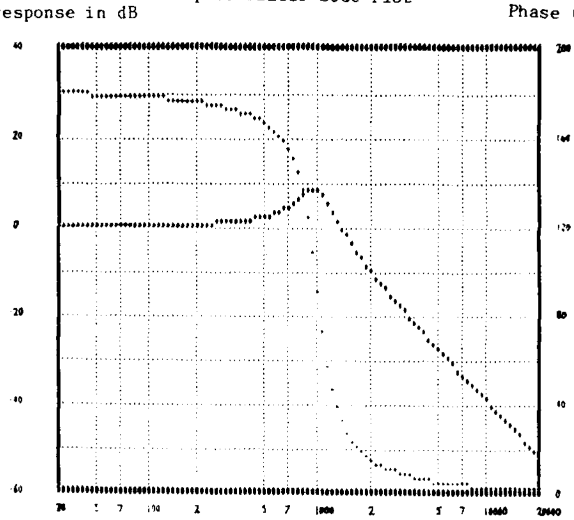


LOWPASS FILTER

Lowpass Filter Bode Plot

Output response in dB

Phase (Deg.)



Frequency (Hz)

- LEFT AXIS - Magnitude response in dB from File LP.MAG
+ - RIGHT AXIS - Phase response in degrees from file LP.PHS

A Solution to the Poll/Final Problem

Phil Karn, KA9Q

AMSAT

This article proposes a solution to an oversight in the original AX.25 Level 2 protocol having to do with the proper use of the Poll/Final bit and the distinction between command and reply frames.

For those of you unfamiliar with the problem, here's a short primer. The P/F ("Poll/Final") bit in the control field of each X.25 LAPB frame is provided for asking the status of the other end of a link, particularly after a timeout. When the P/F bit is set to elicit a response from the other end of the link, it is referred to as the P-bit and the frame becomes a "command frame". The other end must send a "response frame", also with the P/F bit set, which in this case becomes an F-bit. Since the Poll and Final functions share the same bit, there must be some indication as to whether the frame is a command or a response. For unnumbered frames, there is no problem; SABM and DISC are always commands, while UA, DM and FRMR are always responses. An I-frame is always a command. (UI, which is not defined in X.25 LAPB, should probably be considered a command, but this doesn't really matter here.) However, a supervisory frame (RR, RNR or REJ) can be either a command or a response, so some other mechanism is necessary to resolve the ambiguity.

In an X.25 LAPB frame with the P/F bit set, the distinction is made by looking at which address (yours or his) is present in the address field. If it contains your address, the frame is a poll command to which you must respond; if it contains the other station's address, it is the response to your poll. One cannot "guess" from the context of the frame (i.e., whether or not you're expecting a response to an earlier poll) because both stations might poll each other simultaneously, a very likely possibility if a momentary link failure or QRM affects both transmission directions.

Unfortunately, when we invented the addressing scheme for AX.25 we lost this information. The address fields are always the same - they contain both callsigns. Therefore you cannot reliably determine if a frame you receive with the P/F bit set is a command or a response. While X.25 LAPB does provide for an alternate way to recover after a timeout (by sending ONLY the oldest unacknowledged I-frame in hopes of generating an S-frame response with an indication of what the receiver expects) there are reasons for a better solution.

1. Resending unacknowledged I-frames after a timeout can result in inefficient use of the channel, particularly if the timeout was due to the receiver's acknowledgement being lost. In addition, the TAPR implementation (and probably others) appear to resend ALL unacknowledged data, which is specifically forbidden under X.25 LAPB.

2. When the remote end becomes busy (say, due to a slow printer), it sends a RNR (receiver not ready) to flow control the sender. X.25 LAPB requires the sender to wait for a RR (receiver ready) before sending more information. The sender may not transmit any more I-frames before getting explicit permission from the receiver in the form of an RR frame. Since this RR frame could get lost, the sender could wait forever; therefore it must take the responsibility to periodically poll the other end to see if the busy condition still exists. Polling with the P/F bit takes much less channel bandwidth than continually resending unsolicited I-frames in the hopes that the receiver might be ready for them.

   Right now, this isn't too much of a problem because our links are generally slower than our computers or terminals. However, when our link speeds surpass our computer or terminal rates and flow control becomes common, we'll find ourselves wasting a lot of the extra channel capacity on retransmitted I-frames.

To resolve these problems I am formally proposing the following revision to the AX.25 standard. Basically, I am proposing that a reserved bit in the SSID byte of the source and destination address fields contain the information formerly provided by the address field of X.25 LAPB. This can be done in an upward compatible way, preserving compatibility with existing implementations of AX.25.

For the purposes of this proposal, bits within octets (bytes) of the address field are numbered from 1 to 8, with bit 1 being the least significant bit (the address extension bit.) Currently, there is no use for bit 8 in the SSID octets of the source and destination fields (this is the "H" or "has been repeated" bit in repeater fields.)

An upward-compatible AX.25 station would determine if the station it is in communication with adheres to the revised standard by comparing bit 8 in the source address SSID with bit 8 in the destination address SSID in received frames. Since the present standard calls for these bits to be set to 0, equality would indicate that the other station is an "old" implementation and the "new" station would act accordingly (i.e., according to present procedures).

(continued from front page)

a daughter board that extends RAM to 8 or 32 kbytes, extends EPROM to 8, 16 or 32 kbytes, adds programmable signaling rate control, permits 2 programmable interrupts, and includes a kludge field. The kludge field has six spaces for 16-pin DIP sockets, one 24-pin DIP socket, and an 11 x 17-hole area spaced 0.1 inch on centers, where you can do your own thing without resorting to dead-bug construction techniques. Installation consists of removing some chips from the VADCG TNC board, plugging the daughter board into sockets thus vacated, then plugging some of the removed chips plus some others into the daughter board. Look for technical details in the AMRAD Newsletter. Meanwhile, the daughter boards are available from Technetronics Systems, Inc., Attn: Chuck Phillips, 6134 Columbia Pike, Falls Church, VA 22041, for $25 plus $2.25 for shipping and handling. Thanks WB4JFI - W4RI

However, if the bits differ it can then determine if a given frame is a command or response by whether the source or destination SSID field has bit 8 set, using rules analogous to LAPB. In other words, if LAPB would call for a given frame to be sent as a "command", i.e., with the other station's address in the address field, bit 8 in the destination SSID byte is set to one and bit 8 in the source SSID is set to zero. If LAPB would call for the frame to be send as a "response", bit 8 in the source SSID would be set to one and to zero in the destination SSID.

Summarizing in tabular form:

X.25 LAPB addressing rules:

Direction	Command	Response
A->B	B	A
B->A	A	B

AX.25 (revised):

Command (either direction)

dest SSID bit 8	src SSID bit 8
1	0

Response (either direction)

dest SSID bit 8	src SSID bit 8
0	1

Note that the same callsign (that of the commanded station) would have bit 8 of its SSID set in both the command frame and its response. This is because the commanded station's callsign occupies the destination field of the command, while it occupies the source field of the response. On the other hand, bit 8 of the commanding station's SSID byte would be zero in both the command and response frames.

Since all X.25 frames are classed as either "commands" or "responses", even when there is no ambiguity (e.g., I-frames are always commands), all AX.25 frames should also be marked as such. The UI frame, which is not defined in X.25, is defined as a command frame for this purpose.

In summary, this proposal has the following advantages:

1. Upward compatibility with existing implementations of AX.25 which comply with the "old" requirements concerning reserved SSID bits.

2. Complete conceptual conformance to LAPB with respect to "commands" and "responses" when communicating with other stations also following this revised protocol.

   The AX.25 address which is "marked" by bit 8 in its SSID byte corresponds to the choice of address "A" or "B" which would normally be used in LAPB. This allows much closer adherence to well-established LAPB procedures for link recovery and flow control, and much better channel utilization under these conditions.

3. Compartmentalization to the greatest possible extent of the differences between AX.25 and CCITT X.25 caused by the former's specialized addressing scheme. This would allow more structured implementations that draw upon existing procedures and software developed in non-amateur X.25 networks.

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