IEEE

NEWSLETTER

VEHICULAR TECHNOLOGY GROUP

JULY 1975

AUTOMOTIVE ELECTRONICS

UHF TV RECEIVER TABOOS

450 MHz OFFSET CHANNEL OPERATION

AUTOMOTIVE FLOW SENSORS

A STRUCTURE FOR EMS

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NEW ADCOM MEMBERS

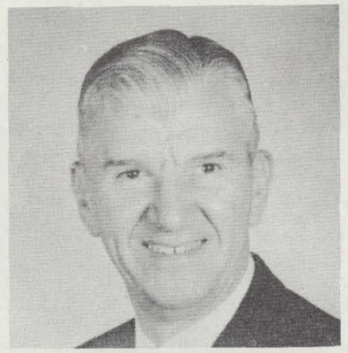
THE PRESIDENT'S MESSAGE

CHAPTER NEWS

MESSAGE FROM THE PRESIDENT

Sometime shortly after the appearance of the July issue of this Newsletter, you will be receiving a mail ballot requesting your vote for the election of 5 new ADCOM members. The people, whose names and qualifications appear on the ballot, have been selected by (1) a nominations committee appointed by your VTG President, and (2) from petitions filed by the membership at large. The nominations committee is made up of both ADCOM and non-ADCOM members to assure that a good cross-section of candidates is selected: candidates who will represent the best interests of the entire Vehicular Technology Group. It is not difficult to obtain candidates for this prestigious committee. It is, however, difficult to select those candidates who will dedicate the next three years of their time to serve you properly. By serving properly, I mean taking the time to become informed about the VTG and its organization, and by attending meetings as often as possible to participate in and contribute to the operation of the VTG. Attending all the meetings, though desirable and useful, cannot replace the ADCOM member who keeps in touch either by the written or the spoken word - the member who makes his contribution in spite of the lack of travel funds. Elsewhere in this Newsletter, you will be asked to submit the names of your candidates for the VTG ADCOM for 3-year terms to expire in December, 1978. Please give this request serious consideration and send in only the names of those candidates who have demonstrated a willingness to serve others through VTG Chapters or other IEEE committee work.

* * * *



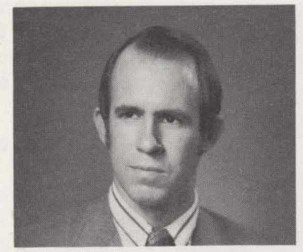
We are making reasonably good progress in a number of areas that I would like to call to your attention. In the area of awards, we were able to qualify one candidate for the Fellow award. Our recipient was Trevor Jones, whose resume appeared in the last issue of the Newsletter. I understand we have submitted the names of two additional Fellow candidates this year, thanks to the efforts of Jack Neubauer. Trevor Jones, although not able to fund a drive for a "Convergence 75" symposium on Automotive Electronics, feels that 1976 will be better because of the expected change in the economic outlook. "Convergence 76" will be sponsored by the VTG with SAE participation - just the reverse of "Convergence 74".

The Adhoc committee on Transportation has been in correspondence and there will be more to report on this after our meeting this month. Bob Fenton has done an excellent job in getting this area off dead-center.

D. Grimes, Educational Committee, and J. Simmons, Public Safety and Emergency Committee, are awaiting a charge from the ADCOM on what may be expected of those committees. This information should be available shortly after the ADCOM meeting in June - just in time to get organized for the opening of activities next fall. All other committees are functioning normally and some will be reporting in this issue. This briefing brings you up-to-date on recent activities of the VTG, and I will have more to report in the next issue.

NICK ALIMPICH

EDITOR'S NOTES



In this issue of the VTG Newsletter, we are fortunate to feature two contributed articles, as well as a third by a staff editor on several related subjects of special contemporary significance to communications-oriented readers. The subjects are related in that each echoes a separate, but important issue now being dealt with by the FCC. Furthermore, the effective utilization of UHF frequencies is a common thread of concern running through each of the topics.

The first article, by Newsletter Washington Editor, Eric Schimmel, takes note of the FCC's recent action in Docket 20485 in asking for comments on UHF TV receiver "taboos". These "taboos", originally adopted in 1952, provide protection for each assigned UHF TV channel by tying up 18 other channels with geographic restrictions.

In a second topic related to the effective use of UHF frequencies, Don Walker has contributed an article on EIA's comments to the FCC on 450 MHz offset channel operation with 12.5 kHz spacing. Don gave a talk on this subject to a recent Washington VTG Chapter meeting. John Dettra, VTG Newsletter Chapter News Editor, was present and suggested that Don summarize the issue for the Newsletter.

And in the third article, Jack Renner, one of our ADCOM members, takes note of the status of EMS (Emergency Medical Systems) today in contrast to a year ago. Jack gives his views on what the FCC's action in Docket 19880 means to those active in planning and implementing EMS systems.

While the above mentioned articles are concerned with the regulatory scene and the use of the spectrum, Kenny Guthrie, in his regular column for the Newsletter, gives you a "nuts and bolts" story on how to minimize the effects of lightning, a most timely subject. You will note that Kenny's receipe doesn't include any magic on how to avoid being hit, only how to improve your chances of staying alive when you're hit -- lots of little tricks.

Automotive Electronics Editor Bill Flemming's contribution covers a recent S. E. Michigan chapter meeting on "flow sensors" for automotive applications. Those of you active in this field have often made the point that developing adequate, economical "sensors" is the big challenge in the speed with which electronics will be employed in automobiles. Bill said they had an attendance of 75 at this meeting. He sent along a photo to prove his point.

How many of you received an April issue of this Newsletter? I've had several calls asking when it's going to be out. Well, you should have received an issue in April. But like the issue before it, it too was labelled January ... chalk that one up!

All chapter officer's should please note the next Newsletter deadline. Please get your information in to John Dettra in time for the next issue. We're interested in knowing your new slate of officer's for the new year.

Have a happy summer recess!

OLIN GILES

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VTG NEWSLETTER DEADLINES

Month of Issue	Final Copy To Be Rec'd. By Editor*	Target Mailing Date
October	9- 1-75	9-26-75
January	12- 1-75	12-31-75
April	3- 1-76	3-31-76
July	5-31-76	7- 2-76

*Inputs for newsletter staff editors should be received 1-2 weeks before these dates.

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AUTOMOTIVE ELECTRONICS

DATELINE: DETROIT

By BILL FLEMING

FLOW SENSORS FOR AUTOMOTIVE APPLICATIONS

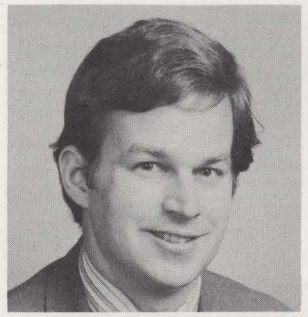
Our local chapter of VTG in southeast Michigan gave an evening technical symposium on the subject of flow sensors. Bob Terhune of Ford Motor Co. organized the program and Bill Fleming of GM Research Laboratories made arrangements for the meeting. Len Gau of Chrysler served as guest moderator at this meeting. Interest in the program was evidenced by attendance of 75 persons. The meeting was held at GM Research on the evening of March 20, 1975.

I thought it would be of interest to highlight the technical proceedings of the meeting.

•Vern Voss of GM Research, Warren, Michigan, described methods and problems of flow measurement. He began with a description of the GM Research flow measurement laboratory. The laboratory includes three precision flow setups:

1. A large-volume, air flow setup which delivers a constant-flow air stream to the sensor under test. Accuracy and repeatability of all flow conditions are within 0.1% of value. Flow is generated by the descent of an umbrella-shaped end piece which forces air out of a large-volume cylindrical tank. A servo-mechanism precisely regulates the descent of the end piece, and controlled air-flow over the range, 7 to 700 cfm, is obtained.
2. Additional range of air flow is obtained from a second setup. This setup consists of a 30-inch diameter cylinder, wherein a motor-driven piston forces air out of the cylinder.
3. Fluid flow is measured on a gravimetric basis. Once a steady flow is established, fluid passing through the flow sensor is collected for a fixed time interval. Switching a 3-way valve to a by-pass position ends the totalizing period. Total flow is then determined by dividing the mass of collected fluid by the time of collection. Fluid flow range as low as 0.03 lb/min (Vega engine idle-flow rate) can be accurately measured.

Vern concluded by showing several examples of flow sensor calibration data measured in his laboratory. He showed that certain flow sensors are sensitive to entry angle of the air stream, and that others are supplied with inaccurate calibration curves.



•Walt Masnik, President of FloTron Inc., Paterson, N.J., described a sensor which consists of fluid Wheatstone bridge arrangement. By use of a recirculating pump and a heat exchanger, the sensor linearly measures true mass flow of fluids at rates as low as 0.001 lb/min. The low-end flow rate is comparable to a dripping faucet, with 1 drip per second rate. Walt explained that in order to measure this low rate with 1% accuracy, this is equivalent to one being sure that, at least 99 out of every 100 drips are counted.

Measurement of low flow rates find automotive application as follows:

1. Fuel flow into the rich air-fuel mixture prechamber of a stratified charge engine.
2. Calibration of flow metering characteristics of individual fuel injectors.
3. Fuel flow into single-cylinder CFR engines.

This new, more accurate fuel metering was necessitated by the stringent engine emissions standards.

Walt concluded by listing some problem areas which can be encountered in use of the Flo-Tron sensor; they are:

1. Slight sensitivity to variations of fluid viscosity.
2. Destruction of internal elements by corrosive fluids.
3. Inability to measure gas flow or two phase flow.
4. Presence of bubbles in fluid give rise to erratic sensor output counts.
5. Transient response time constant is on order of 1 second--limited by speed of differential pressure pickup.

•Bob Joy, Vice President of J-Tec Associates, Cedar Rapids. Iowa, discussed the use of new type of shedded vortex sensor for detection of inlet air and exhaust flow rates. As the gas stream passes across a thin bluff-body strut, vortices are introduced into the stream. The J-Tec sensor utilizes an ultrasonic beam downstream of the strut to detect the frequency of vortex generation. This frequency is sensed by amplitude modulation of the beam due to vortex passage, and the frequency is proportional to volume flow of the gas.

Continued...

The sensor has a dynamic range of up to 150:1 (1 ft/s to 150 ft/s is a typical range) with accuracy better than 0.3%. The following features are also inherent to the sensor:

1. Linear characteristics.
2. Digital output.
3. Rapid response (equals transit-time for gas to move 0.25 inch).
4. Low pressure drop (less than 1.5 in. H_2O).
5. No moving parts.
6. Can operate at gas temperatures up to 800°F.
7. Responds to average velocity profile of gas stream across length of strut, thereby giving a spatially averaged measurement of flow rate.

Bob concluded by describing an interesting application where two sensors were placed into an automobile exhaust pipe. One sensor was installed in a forward direction to measure flow out of the pipe and the other in the reverse direction to measure reverse flow back into the pipe. During engine cranking flow reversals were pronounced.

The objective of this setup was to subtract these two readings in order to measure net flow out of the pipe. In practice, however, errors of up to 30% resulted. It was finally determined that large-amplitude pressure oscillations in the pipe were the probable source of error.

Chuck Miller, Director, Cox Instruments, Detroit, Michigan, described an ultra-low flow generator for primary calibration of fluid flow sensors. The generator utilized a screw-driven piston to meter fluids at rates varying from 1 cc/min to 1000 cc/min. Accuracy and reproducibility within 0.1% were cited.

Chuck mentioned that an often overlooked source of error is frequency variation of 60 Hz line voltage. The Cox generator used a synchronous electric motor, which in turn, responded to variations of line frequency. Although electric power companies maintain a precise 24-hour average value of 60 Hz, hourly variations of frequency can be as high as $\pm$0.25% Whenever one wishes to regulate instrument output to better than $\pm$0.25%, care must be taken therefore to avoid reliance on the line frequency for the desired accuracy.

Participants in VTG Symposium on Flow Sensors: (left to right) Chuck Miller of Cox, Verne Voss of GM, Bob Joy of J-Tec, and Walt Masnik of Flow-Tron.

Attendees at VTG Symposium on Flow Sensors; March 20, 1975 at GM Research Laboratories--attended by 75 persons.

CALL FOR PAPERS ON AUTOMOTIVE ELECTRONICS

The SAE Committee on Electrical and Electronic Systems (Passenger Car Activity) invites information on papers for the Winter and Fall 1976 Meetings of SAE. Typical areas of interest include:

1. Electronic Control Systems for the Engine
2. Fuel Injection Systems
3. Onboard Microprocessors
4. Automobile Electrical Components and Systems
5. Sensors and Actuators for Onboard Use

Papers to be considered for the February 1976 Automotive Congress and Exposition in Detroit must be received as soon as possible (preferably prior to June 31, 1975).

Offered papers should include:

1. Digest of 200-300 words which:
   a. Concisely states objective of paper
   b. Outlines problem the paper attempts to solve, or the method of approach to research
   c. Indicate the type of data to be included
   d. Summarizes the conclusions that may be expected in the paper
2. Tentative title of paper.
3. Name of author, position, affiliation, mailing address, and telephone number.

It is noted that selection of papers is based upon the supplied digest; therefore, descriptive information is important. Offered papers must not have been published elsewhere, and, if accepted, contributors will agree not to release their papers for publication through other media. Paper offers should be mailed to:

Electrical and Electronic Systems Committee
Passenger Car Activity
c/o Society of Automotive Engineers, Inc.
18121 East Eight Mile Road
East Detroit, Michigan 48021

NEW IEEE STANDARDS CATALOG AVAILABLE

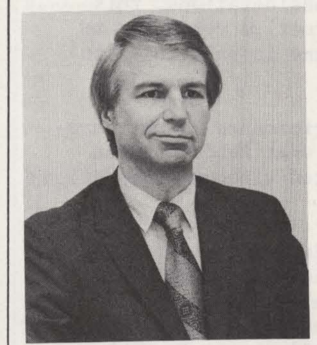
New York, N.Y. - The new 32 page IEEE Standards 1975 Catalog is now in print. Copies may be obtained without charge. The new catalog lists more than 350 standards publications by subject as well as in numerical sequence. Included in this new set of listings are the many American National Standards published by IEEE.

Standards developed within the Institute of Electrical and Electronics Engineers cover test methods, practices for electrical installations, units, definitions, graphic symbols, letter symbols, and applications methods. Engineers in such widely varied fields as antenna design, communications, power generation and distribution, microwave measurement, industrial applications, electromagnetic compatibility, and rotating machinery will find many authoritative documents that have received recognition both nationally and throughout the world.

Single copies of the new catalog may be obtained free from the IEEE Standards Department, 345 East 47th Street, New York, N. Y. 10017.

THE WASHINGTON SCENE

By ERIC SCHIMMEL
WASHINGTON NEWS EDITOR



BITING THE BULLET

We think a round of applause is due the Federal Communications Commission for issuing a new Notice of Inquiry into a sore (or sorry) old subject, UHF TV interference standards, commonly known as the UHF TV "taboos". This proceeding (Docket 20485) will re-examine the UHF protection criteria which were established twenty-three years ago, and which played a major role in the six year battle to gain some land-mobile sharing in the UHF TV band via Docket 18261.

Notwithstanding that in Docket 18262, the FCC reallocated the upper 14 UHF TV channels to the land-mobile services, 336 MHz. of valuable spectrum remain under the protection of these "taboos". We are not advocating wholesale incursion by land-mobile users into broadcast territory, but we do support any objective evaluation which may result in more effective utilization of this limited natural resource.

Clearly, this could be one of the most significant rulemakings of the century for spectrum users. As such, we have reproduced the entire document below. Hopefully some of you land-mobile types will demonstrate that you are pretty good at TV receiver design too.

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D. C. 20554

In the Matter of)
)
Re-evaluation and) Docket No. 20485
revision of the UHF)
TV "taboo" table.)

NOTICE OF INQUIRY

Adopted: May 14, 1975 Released: May 22, 1975

By the Commission:

1. Since 1952, when the present UHF channel assignment table was adopted (Sixth Report and Order in Docket 8736, et al) there has been much discussion and criticism as to the effect of the UHF TV "taboo" table (Sec. 73.698, Table IV) on the efficient use of the spectrum allocated to UHF TV. The "taboos" are restrictions on assignment of channels having certain frequency relationships, within certain required geographical separations. In addition to co-channel separations, the "taboo" table specifies separations to mitigate other kinds of interference which can be produced by various unwanted responses of UHF TV receivers to signals on channels relatively well spaced from the tuned channel.

2. The unwanted types of receiver responses include:

a. Intermodulation ($n \pm 2, 3, 4, 5$), 20 miles separation

b. Intermediate frequency (IF) beat ($n \pm 8$), 20 miles separation

c. Sound image ($n \pm 14$), 60 miles separation

d. Picture image ($n \pm 15$), 75 miles separation

e. Local oscillator radiation ($n \pm 7$), 60 miles separation

f. Adjacent channel ($n \pm 1$), 55 miles separation

where "n" is the number of the tuned channel. From the above tabulation, it will be apparent that, for each channel assigned, assignment of a total of 18 other channels is restricted within the respective distances shown.

3. In view of the steadily increasing demands for spectrum usage, we are concerned that all services apply the best feasible techniques for efficient spectrum utilization. We are continually encouraging the use of improved technology for this purpose in the respective radio services. In the instant proceeding we are making such an effort with regard to the UHF TV service.

4. We are, therefore, directing our attention here to a situation peculiar to UHF TV, wherein for each assigned channel the availability of eighteen other channels (108 MHz of spectrum space) is inhibited. We must endeavor to reduce, or eliminate, the impact of these "taboos".

5. Bearing in mind that the origin of the "taboos" lies in the performance of UHF TV receivers in rejecting signals on other than the desired channel, we must now re-evaluate the need for the "taboos" and determine whether receiver performance can be improved to make them unnecessary.

6. In 1952, when the "taboo" table was adopted, the need for the "taboos" was evident from consideration of contemporary UHF TV receiver performance. Also, since 1952, the NTSC color TV system was adopted and the ceiling effective radiated power was increased from one megawatt to five megawatts; these are changes which may affect any re-evaluation of the "taboo" problem.

7. In view of these considerations, this Notice of Inquiry solicits constructive responses to the "taboo" problem in general, and in particular to the following questions:

a. Considering the performance of contemporary TV receivers, what taboos can be reduced or eliminated without degradation of service?

b. Should the Commission abolish certain taboos in expectation that receiver performance improvements would ensue to cope with actual interference if it occurs as a result of taboo elimination? Without such performance improvements, to what extent would service be degraded?

c. What TV receiver improvements can be made to improve interference rejection?

d. Comments are requested on at least the following specific receiver improvement possibilities:

1. Noise figure
2. Front-end selectivity
3. Front-end linearity
4. Oscillator radiation
5. Optimum intermediate frequency
6. Direct RF pickup - IF or audio frequency
7. Subjective picture quality
8. Consequential improvements from reduction of tuning ratio, i.e., ratio of upper to lower limits of UHF TV allocation

e. What techniques would be useful in reducing or eliminating taboos, e.g.:

1. Receiver improvements per para. 7d
2. Cross polarization
3. Circular polarization
4. Very precise offset
5. Transmitter site selection by FCC for optimum spectrum usage.
6. Station operating parameters specified by FCC for optimum spectrum usage, e.g., power, antenna height, directional pattern, polarization.

f. Consideration must also be given to the economic and market impact of receiver improvements, from both the industry and the consumer viewpoints. The overall public interest in efficient spectrum utilization must also be considered, e.g., with regard to receiver improvements which improve spectrum utilization in ways which may not be readily apparent to the average television viewer. Comments on these and related matters are requested.

8. While the foregoing draws attention to some of the matters which must be considered in this proceeding, there are undoubtedly many others which will come to light during the proceeding. Consequently, all parties are invited to consider and comment on any relevant items, even though such items are not specifically mentioned herein. Recommended rule changes based on sound engineering studies are especially invited.

9. Should the completed inquiry authorized by this notice indicate that mandatory receiver standards are necessary and desirable, such standards would be adopted pursuant to authority granted to the Commission under Sections 1, 2(a), 3(b), 4(i), 301, 302, and 303 of the Communications Act of 1934, as amended (47 U.S.C. §§151, 152(a), 153(b)(d), 154(i), 301, 302, and 303). Comments are invited with regard to the proper jurisdictional basis, or lack thereof, for Commission regulation in this area.

10. Attention is invited to relevant exhibits listed in the Appendix hereto. These exhibits are being placed on file in the instant Docket for public inspection.

11. Pursuant to applicable procedures set forth in Section 1.415 of the Commission's Rules, interested parties may file comments on or before August 29, 1975, and reply comments on or before September 17, 1975. All relevant and timely comments and reply comments will be considered by the Commission before further action is taken in this proceeding. The Commission may also consider any other relevant information coming to its attention.

12. In accordance with the provisions of Section 1.419 of the Rules, an original and 14 copies of all comments, reply comments, pleadings, briefs and other documents shall be furnished the Commission. All filings in this proceeding will be available for examination by interested parties during regular business hours in the Commission's Public Reference Room at its Headquarters, 1919 M Street, N.W., Washington, D.C.

FEDERAL COMMUNICATIONS COMMISSION

APPENDIX

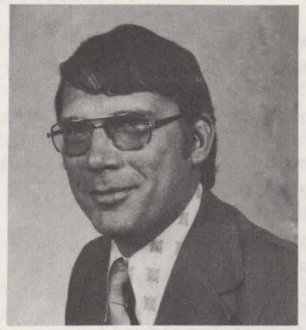
List of FCC Exhibits

Report T.R.R. 4.3.10	"Polarization Discrimination in Television Broadcasting" by Julian T. Dixon and John M. Taff, March 14, 1958. Available NTIS: PB 166-720 $3.25
Technical Paper #32537	"UHF-TV Taboos" by Julian T. Dixon, November 20, 1962.
Report T.R.R. 5.2.2	"UHF Assignment Plan" by Arnold G. Skrivseth, May 29, 1961. Available NTIS: PB 166-731 $3.25
Report R-6602	"Development of VHF and UHF Propagation Curves for TV and FM Broadcasting" by Jack Damelin, William A. Daniel, Harry Fine and George V. Waldo, September 7, 1966. Available NTIS: PB 174-288 $4.25
Report R-7105	"A Study of the Restrictive Effects of UHF TV Taboos - New York City Area" by Robert M. Bromery and Roger L. Herbstritt, October 29, 1971. Available NTIS: PB 234-670 $3.75
Report T-7201	"A Survey of Certain Performance Characteristics of Television Receivers" by Sidney R. Lines, June 9, 1972 Available NTIS: PB 236-991 $3.25
Report LAB 74-01	"A Study of the Characteristics of Typical Television Receivers Relative to the UHF Taboos" by Willmar K. Roberts, Lawrence C. Middlekamp, Hector Davis, Robert C. Bradley, Henry Van Deursen and Robert M. Bromery, June 1974. Available NTIS: PB 235-051 $5.25
Report RS 74-01	"VHF-TV Computer Assignment Program (VCAP)" by Gary S. Kalagian, August 1974. Available NTIS: PB 236-272 $4.25
Report RS 74-04	"Antenna and Power Statistics of Television Stations in the U.S." by John C. H. Wang, December 1974. Available NTIS: PB 240-200 $3.75
Report RS 75-02	"UHF-TV Computer Assignment Program (UCAP)" by Gary S. Kalagian, February 1975. Available NTIS: (Future)

NOTE: "NTIS" is National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Telephone: (703) 321-8543

CHAPTER NEWS



By JOHN DETTRA
CHAPTER NEWS EDITOR

Columbus	"Synchronous Longitudinal Reference Signal Generation" Robert Mayhan, Ohio State Univ. Elect. Eng. Dept, on February 12, 21 attending: Experimental study of its use in automatic vehicle control.
	"Environmental Impact and FCC Licensing" Paul Krumm, Columbia Gas of Ohio on April 9, 18 attending.
	"Clean Energy for Today and Tommorrow" Norm Fowlkes, Columbia Gas System Film on May 14, 14 attending.
Chicago	"Electric Vehicles--An Alternative" W.H. Shafer, Commonwealth Edison Company on February 5, 71 attending.
	"Design for System Relability in Personal Radio Signaling." George P. Schleicher, Illinois Bell Telephone Co. on April 16, 13 attending.
Dallas	"R.F. Noise Caused by Small Sparks" Charles M. White, Com. Eng., Houston Lighting and Power Co. on March 13.
	"Biotel-Dallas Ambulance Emergency Medical System" Charles Bowles, City of Dallas Com. Services and Bill Roberts, Chief, City of Dallas Fire Department on May 8.
Michigan, S.E.	"Emergency Medical Services Communication" James V. Nickel, P.E., Manager, Motorola Engineering Services. on February 26, 33 attending.
	"Air and Fuel Flow Sensors For Automative Applications" Symposium on March 20. GM Research Flow Measurements Laboratory-Methods and Problems. LaVerne Voss, Sr. Research Eng., GM Research Labs. An Electronic Mass Flow Sensor for Precise Measurements at Less Than a Pound per hour. Walter Masnik, Pres., J. Tec Associates A New Ultra Low Flow Positive Displacement Flow Generator for Primary Calibration. O.C. Miller, Dir of Instruments Products, Cox Intruments.
New York	"Considerations in Digital Communications" William Shand, Atlantic Research Corporation on February 25, 29 attending.
Orlando	"Today's Army Training for the Communications of Tommorrow" Major General Charles R. Myer, Commanding General, U.S. Army Training Center, Fort Gordon on October1, 54 attending.
	"Computer Control in Mobile Communication Systems" George F. McClure, Martin Marietta Corporation on October 10, 44 attending.
	"A High Capacity Mobile Telephone System" Richard H. Frenkiel, Bell Telephone Laboratories on January 16, 48 attending.

Continued...

	Tour of Communication Center, Orlando Police Department Capt. L.E. Sheffer, Adm. Officer, Orlando Police Department on March 13, 22 attending.
Philadelphia	"Survey of Practical Digital Voice Encoding Schemes" Dr. F.J. Wojach, General Electric, Pittsfield, Mass. on February 19.
	"Atmospheric Attenuation Effects in the 10 to 30 GHz Range" Dr. L.J. Ippolito, NASA on March 20.
Pittsburgh	"The New Pennsylvania State Police Radio Communications System" Trooper Michael A. Mulholland on February 18.
Sacramento	R.H. Hayes Pacific Telephone Company and O. Hill, Pacific Gas and Electric Company were speakers on November 9.
Washington	"Receiver Voting System to extend the range of hand-held portable radio units " John A. McCormick, General Electric Company on February 14.
	"Postscript to 900 MHz and 400 MHz Propagation in urban hilly terrain" Stuart F. Meyer, Mgr of Goverment Relation, RCA.

BOOK REVIEWS

By CARROLL LINDHOLM
BOOK REVIEW EDITOR

QUEUEING SYSTEMS, VOLUME 1: THEORY

Leonard Kleinrock

John Wiley & Sons (New York) 1975

I buy some books from a sense of guilt. This was how I acquired the present volume. I felt I should understand a great deal more about queues than I did. Previous books had done little to help. I knew queues were important in vehicular traffic flow, in telephone trunking, and in computer time sharing. What I had not found so far was a truly unified approach to the subject. Each problem seemed to have its own approach to a solution. The results were rarely simple. When I received Professor Kleinrock's book I first suspected this hadn't changed. Then I started reading. And, for me at least, the subject unfolded with uncommon clarity. This is due to the author's orientation paragraphs, his constant reminder of what we have learned up to now, his homey examples, his humor and his scholarship.

I was disturbed at first by the mathematics, but on step-by-step examination it was straightforward probability theory, which I knew, combined with a generous use of transform methods, which I also knew. In fact only the results were new to me, and this because I had been terrified by them before. Here were Erlang's formulas from telephone trunking theory emerging as simple results of more general formulations.

I am glad now that I delved this deeply into the subject. I became no expert in the process but I am suddenly much happier about my state-of-understanding regarding queues. All the important results of the book are collected in a ten-page summary at the rear of the volume.

I have not seen the second volume, but it will presumably be available shortly. It is concerned with applications, especially to computer systems and networks.

Needless to say I do recommend this book as a useful and understandable introduction to queueing theory.

INCREASED USE OF THE 450 MHz RADIO SPECTRUM THROUGH OFFSET CHANNEL OPERATION

By DON WALKER

INTRODUCTION

The rapid growth of the Land Mobile Radio Services has resulted in steadily increasing demands for additional channels to satisfy the needs of the various radio users. A number of approaches have been taken to provide these channels, including channel splitting and offset channel operation, spectrum allocation, increased equipment performance, and system design techniques.

This discussion will focus on one of these approaches, offset channel operation; it is based on work done by the Electronic Industries Association (EIA) in conjunction with the Federal Communications Commission (FCC) to ascertain the potential for expanded use of 450 MHz channels.

TECHNICAL & OPERATIONAL CONSIDERATIONS

As a starting point it should be mentioned that the word offset, as used herein, specifically means one-half channel offset; that is, we are considering the potential use of channels 12.5 KHz removed from the conventionally spaced 25 KHz channels in the 450 MHz band.

A number of factors must be considered to determine the effect that operating with a close channel spacing will have on radio system performance. Among the most important of these factors are the characteristics of the equipment involved. Specifically, the receiver selectivity in conjunction with the sidebands from an adjacent channel transmitter determines the magnitude of potential interference that can be expected. Consider that the modulation acceptance of a typical land mobile communications receiver is $\pm$ 7 KHz. Also, a maximum transmitter deviation of 5 KHz is permitted by FCC Rules. It is readily apparent that with a channel spacing of only 12.5 KHz, adjacent channel transmitter sidebands will be very close to the edge of the receiver passband. This situation is even further aggravated when transmitter and/or receiver drift occurs. FCC Rules and current technology permit the combination of these drifts to be as great as 4.5 KHz in the 450 MHz band. Thus, the sidebands from an adjacent channel transmitter could easily be directly within the receiver passband under certain circumstances.

The above described phenomenon is often referred to in terms of the interference protection ratio (or receiver discrimination) that exists against adjacent channel signals. Tests were made to quantify this protection, with the following results:

- With no modulation on the adjacent channel transmitter there is 55 dB of protection.

- With the adjacent channel transmitter deviating $\pm$ 5 KHz, and into heavy limiting, the protection is only 14 dB.

- With a deviation of $\pm$ 5 KHz, but limiting only on peaks, 25 dB of protection is afforded.

- Drift causes a change in protection of 5 dB/KHz.

Given this data, there is still a real challenge in selecting a protection ratio to use for a systems design. Obviously, the adjacent channel transmitter will not be into heavy limiting all the time; as a matter of fact, it will normally (in a voice system) have a relatively low deviation. Likewise, we would seldom expect to find equipment drift at a maximum; normally it will be relatively close to "on frequency." On the basis of these and other considerations, an interference protection ratio of 20 dB has been selected for use in designing offset systems.

With this important equipment parameter quantified, we can now move on to some of the systems considerations. One of our design goals in applying offset channels is to minimize interference, not only to the new offset user, but also to the existing adjacent channel user. Considering the relatively small amount of adjacent channel protection (20 dB), it is necessary to take steps to in some way limit the coverage of the offset signal; this will allow the offset channel to be "shoehorned in" between the existing 25 KHz spaced conventional channels which are, of course, in heavy use around the country. The method to be used is called an area of operation concept. Each offset user will be asked to define his area of operation in terms of some boundary, such as his own property, which will substantially preclude the presence of an adjacent channel mobile unit. This will establish a geographical spacing between the offset channel user and adjacent channel user, thus providing a basis upon which to provide the desired degree of interference protection.

The level of service for the offset user is established as a signal level of -110 dBw at the edge of his area of operation. This number will provide a balance between the offset user's desired signal and the potential for interference to an adjacent channel user outside the area of operation. Keeping in mind the previously discussed 20 dB interference protection ratio, an adjacent channel user will experience a maximum equivalent (undesired) signal of -130 dBw.

The use of single frequency channels vs. two frequency channels is another systems consideration that directly affects the potential for interference. If base stations and mobile units both operate on the same frequency, there is a possibility for the base station of one system to interfere with the base station of another system. This is true, not only for co-channel use, but also (with 20 dB of protection) for adjacent channel use. By assigning the base stations and mobile units on separate frequencies, however, (they are spaced 5 MHz apart in the 450 MHz band), there is no longer a possibility of base to base interference. This is the approach that is recommended for use with the offset channels.

OFFSET CHANNEL ASSIGNMENT GUIDELINES

A set of application guidelines for offset channels has been developed on the basis of the above described technical and operational considerations. These guidelines were designed to be used without requiring additional engineering considerations; thus they are appropriately conservative to allow for the wide range of situations to which they may be applied.

The graph in Figure 1 shows the permissible power and antenna height that may be used with the offset base station. The horizontal axis represents the distance that will exist between the location of the offset base station and the extremity of the offset user's area of operation. The vertical axis indicates the power that can be used. Several antenna heights are shown.

Mobiles will be permitted to use a power input of 3 watts.

Figure 2 depicts additional guidelines for assignment of offset channels. The left side of the diagram (0 miles) shows an adjacent channel base station; this can be any of the existing stations assigned on the conventional 25 KHz spaced 450 MHz channels. Then the following applies for any potential offset base station assignment removed 12.5 KHz from one of the existing adjacent channel assignments.

- The area of operation for an offset base station may not be closer than 2 miles to an adjacent channel base station; this constraint is necessary to minimize interference between the adjacent channel base station and offset mobile.

- An offset base station may not be assigned between 15 and 30 miles from an adjacent channel base station; this constraint is required to protect an adjacent channel mobile from offset base station interference.

- An offset base station may not be assigned within 5 miles of any existing co-channel base station.

ADDITIONAL RELATED GUIDELINES

The following additional guidelines were established relative to the use of offset channels:

- Mobile relay operation should be permitted.

- Non-voice telemetry should be permitted.

- One frequency simplex, portable-only systems should be permitted to operate on the mobile frequency, as long as they operate within the above described guidelines, and use antennas of unity gain or less.

- Offset channels should be considered for use in lossy transmission line systems; however, due to the unique nature of these systems, no specific application guidelines are offered.

- The guidelines described in this paper are based on the assumption that offset systems will be applied in suburban and rural areas where the (existing) adjacent channel base station antenna heights are generally in the range of 100-150 feet. It will be necessary to generate new guidelines if the offsets are to be used in areas with substantially greater adjacent channel antenna heights.

SUMMARY

This paper has briefly described key background considerations and application guidelines for potential use of 450 MHz offset channels. The guidelines must necessarily be somewhat restrictive, considering the relatively small amount of adjacent channel protection afforded (20 dB) and the desire to minimize interference. The utility of these channels, and any possible relaxation of assignment rules can best be determined by operational experience.

It should be emphasized that this paper reflects an EIA input to the FCC. Rulemaking has not yet occurred. Therefore, any resultant rulemaking may differ from the particulars described herein.

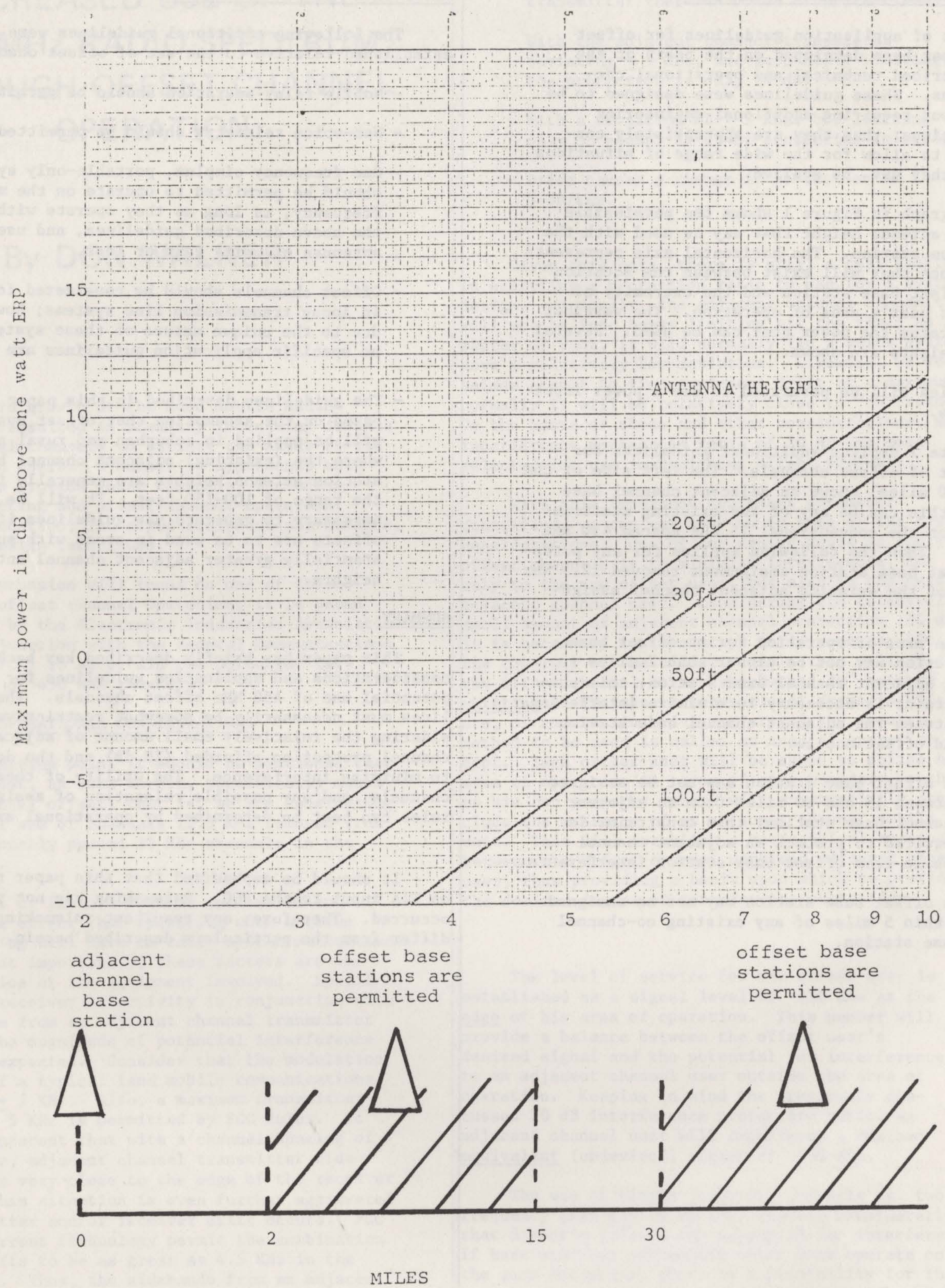


FIGURE 2

OFFSET CHANNEL ASSIGNMENT GUIDELINES

DOCKET 19880 - A STRUCTURE FOR EFFECTIVE EVOLUTION OF EMS COMMUNICATIONS

Presented by JOHN J RENNER

to

Associated Public-Safety
Communications Officers, Inc.
Williamsburg, Virginia

May 13, 1975

A year ago, those with interest in EMS were anxiously awaiting the outcome of Docket 19880. The comments on the proposed Rulemaking were in -- and the FCC was promising to act with minimum delay. The reactions to Docket 19880 were mixed -- everybody was for it but very few knew what they would do with it when they got it. Many were concerned that these recently formulated plans and the strenuous efforts that had been expected to introduce radio systems that serve ambulance/hospital and hospital/hospital contact using VHF would be obsoleted or made ineffective by the new Rules. They were concerned that the VHF capability -- though limited -- had produced a milestone -- a step towards medical coordination. Many EMS planners were in the midst or even at the height of an implementation program that had the express purpose of establishing voice contact between emergency medical personnel in the field and in the treatment facilities. Much of the planning emphasized the needs of rural areas -- and the need for a common system approach even if this were limited to a single common channel or two common channels. These planners saw no immediate need for bio-medical telemetry -- and they saw no need for more than VHF capability in rural areas. The urge to fill-out a program for accomplishing direct hospital contact at VHF seemed more important at the time than achieving the improvements that were proposed at UHF. There was a tendency to look upon the improvements at UHF as ones that derived previously from the use of bio-medical telemetry. There was a tendency among those who were using VHF to argue that UHF has inherently poorer coverage capabilities than VHF -- that the improvements of the proposed UHF structure would be costly -- that UHF equipment would not be readily available.

In the background that existed a year ago, it is little wonder that VHF continued to expand -- particularly in rural areas -- that UHF was looked upon as something for the future, something for the urban areas, something for those special cases that involve the use of telemetry. Many of what I will call the "taboos" against UHF of a year ago have been erased -- not entirely, but to the point where today more and more EMS planners are thinking UHF, sometimes thinking UHF but implementing VHF, but nonetheless reducing the gap in the time for transition.

The Rules that came out in July 1974 (Figure 1) established a system structure for EMS communications. They did much more than add the capability for telemetry -- they did much more than add channels for EMS -- they did much more than provide for the needs of the urban area. The allocations and the Rules provided a structure for system integration and system planning. Perhaps most important -- the Rules that came out in July did not require the abandonment of anything -- they added a unique provision for consolidating VHF links with hospitals, with the VHF for dispatch, and for the addition of a substantial new capability at UHF. They encouraged the planning of EMS systems and established the provision for filing of plans at the FCC. The consequences of Docket 19880 are shown in Figure 2.

The nine months since the Order in Docket 19880 have seen substantial activity. To my knowledge we do not have a system in operation that fully exploits the new Rules -- but we have several that take advantage of those Rules. Many systems are in advanced stages of planning or close to procurement. All of these systems are required to use a common multi-channel UHF structure but they are not required and do not conform to the same concepts of operation -- on this point there is room for concern that there may not be full compatibility among systems in different areas.

But I do not intend today to comment on the relative merits of different operational approaches to the implementation of a common system -- but rather to emphasize those characteristics of the regulatory structure that I feel provide the best chance for a good practical system payoff -- a good payoff in terms of operational effectiveness, and perhaps even more important, a good payoff in terms of cost effectiveness. The question that still confronts many states -- the problem that confronts many regional planners is today not so much whether to go to UHF -- but how and when.

There is no pat answer to this question. It is important to appreciate the benefits that can be derived from a shift to UHF -- an immediate shift to UHF -- and the opportunities it provides for making what is available more valuable -- as a part of a system that has growth potential.

The important characteristics of the UHF structure are:

An adequate channel structure

The availability of two-frequency (duplex channels)

The provision for use of mobile relay

Taking these in reverse order -- the mobile relay is the key to the common system concept. It is valuable because it provides a station at a fixed location that provides the radio links that tie together all of the participants in an EMS local environment. It is valuable because a mobile relay can be located where it can provide the best coverage. A mobile relay can be a key to cost effective system design because it does not require wirelines for remoting. Operation of the mobile relay may be remotely controlled by radio as shown in Figure 3. Once installed the mobile relay may be used by any number of vehicles or hospitals that equip with a proper radio unit. Multiple equipments may be located at a mobile relay to permit simultaneous handling of multiple calls. A system of mobile relays offers alternate coverage potential. A hospital will generally be within the coverage area of more than one mobile relay site -- and may use any one that will best serve its needs in a particular instance. The benefits of mobile relay operation derive from the use of a system of such stations to cover a wide area. Such a system of relays is illustrated in Figure 4 which shows a typical configuration of stations sited to serve a multi-county area. These stations at UHF provide full EMS capability for vehicular coordination -- (dispatch and contact with public safety systems) and full capability for medical coordination (hospital and medical contact). Direct vehicle-hospital radio links are provided. The coverage of a hospital or vehicle is extended to the full coverage potential of the relays that provide coverage to it. Coordination of a system of relays are facilitated by the use of communication control stations. In this case, two control stations -- each with multiple relays -- connected to a central coordination center by wire. Thus the central control has direct access to all participants in the entire coverage area. There is no comparable application of VHF stations that can do what is accomplished by this system of UHF mobile relays. The simplest comparison would be the use of VHF base stations to accomplish base to mobile coverage -- and the use of wirelines to remote such base stations to hospitals, as is done in many areas today. A serious disadvantage at VHF is that there is no provision for mobile relay operation. The base station must be located at the hospitals that are being served or remoted to the hospitals by wirelines. For good coverage, high towers are required in either case. Optimum coverage of a multi-county area would require selection of sites that are not the location of hospitals -- remote sites that have towers that serve other public safety radio services. Figure 5 illustrates the use of VHF base stations to serve the same multi-county area that I used to illustrate the use of UHF mobile relays. This would be the way to achieve full hospital/vehicle coverage on 155.340. If 155.280 is to be used simultaneously for hospital/hospital communication, then repeater base stations are required -- and these cannot be located at the same sites as 155.340 if simultaneous use is desired. We have compared the cost of VHF using remote stations for 155.340 and hospital stations for 155.280 with the cost of a UHF system of mobile relays -- with each relay fitted for simultaneous use of two channels. The radio equipment costs turn out to be about equal but wireline charges for remoting make the VHF system more costly -- there is substantial savings that derive from the absence of wireline charges in the UHF case. What is more important, the capabilities of the two systems are quite different. The UHF system has substantial flexibility. Additional system capacity may be added by simply adding units at a mobile relay site or sites. The use of duplex channels for the UHF system permit interference free operation of several radio units at the same site. The same is not true at VHF because these channels are single frequency channels. Transmission and reception are on the same channel. The use of single frequency channels at VHF and the close spacing between channels, limits the use of a VHF base station to one channel at a time. The same VHF station cannot simultaneously communicate on 155.340 and 155.280.

Of major importance, the UHF system of mobile relays with multiple channels performs all functions. Adjacent stations may communicate simultaneously on different channels. For example, the system of VHF base stations in the illustration has two channels for hospital contact, one for vehicle/hospital, a second for hospital/hospital -- other systems, other channels, and generally speaking, other base station sites are needed to satisfy the dispatch need. The UHF system would operate under an operations plan that permits all 10 channels to be used -- adjacent stations may operate simultaneously without conflict.

The most immediate advantage of the mobile relay system is that is can provide a tie between an existing VHF hospital system and an existing dispatch system whether that dispatch system be at low-band or high-band. Also, the mobile relay can be the tie between either of these systems and a new capability that utilizes the new UHF structure exclusively. Once a mobile relay is in operation, the cost for this additional tie with existing VHF units may be measured on a unit cost basis. To tie any VHF station, mobile or fixed station, into the UHF mobile relay requires only the addition of a VHF receiver at the mobile relay and a UHF receiver in the mobile or fixed station. The VHF station would retain its VHF capability but have the added opportunity of participating in a common system. A vehicle with low-band dispatch equipment could communicate with a hospital on high-band VHF, using this cross-banding technique.

The ability to bring VHF units into the common system through the technique of cross-banding at UHF mobile relays is a powerful tool. It should be understood and carefully evaluated in any future planning of EMS systems.

I have tried -- am trying -- to highlight, to emphasize the fact that Docket 19880 provides a valuable resource that can have both immediate and long term benefits. Immediate benefits can derive from the immediate use of the full UHF structure where you need it and from the use of the Mobile Relay concept to tie together all the elements of EMS communications, the existing and the new. Long term benefits will accrue as UHF units are added to the system.

I suggest that those who have implemented VHF for medical coordination -- or those who are in the process of doing so -- not feel that a shift to UHF detracts from what has been accomplished but rather that the structure offers new opportunities to reach the same objective better. I anticipate that a way will be found to make existing VHF a more valuable resource because it can be restricted to doing what it can do best, brief contact, brief communications -- and because something new will be added, a UHF structure that provides new capabilities and a substantial growth potential -- a formula for substantial expansion at minimum cost.

FIGURE 1

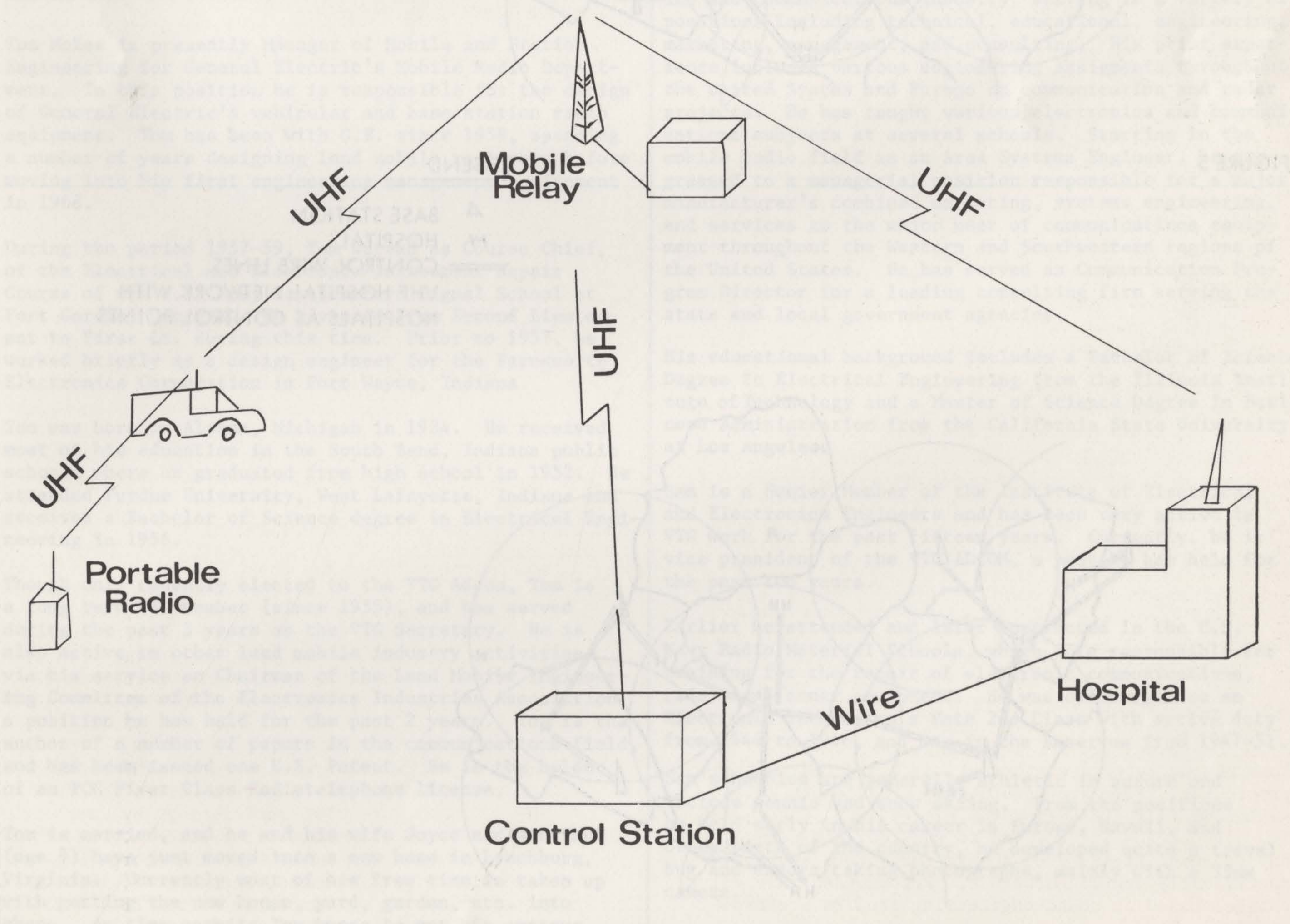
DOCKET 19880

- ESTABLISHED MEDICAL COMMUNICATION SERVICES
- PROVIDED A DEDICATED MULTI-CHANNEL UHF STRUCTURE
  - 10 CHANNELS DUPLEX
  - 4 CHANNELS DUPLEX
- MADE PROVISIONS FOR AN INTEGRATED EMS COMMON SYSTEM
  - DEDICATED UHF
  - EXISTING VHF
  - MOBILE RELAY
  - VHF/UHF CROSSBANDING
  - VEHICULAR REPEATER
- PROVIDED FOR FILING OF PLANS
- IDENTIFIED PAGING FREQUENCIES

FIGURE 2

CONSEQUENCES OF DOCKET 19880

- ALL AVAILABLE RESOURCES ARE UTILIZED
- MOBILE RELAY TIES TOGETHER NEW AND OLD
- HOSPITAL - EMERGENCY VEHICLE - DISPATCHER INTEGRATED IN SINGLE RADIO SYSTEM
- DIRECT PARTICIPATION OF PUBLIC SAFETY SUPPORT SERVICES IS PROVIDED
- ACCOMODATE LOCAL SITUATIONS AND REQUIREMENTS



MEDICAL COMMUNICATION SYSTEM

Figure 3

FIGURE 4

LEGEND

RADIO
WIRE LINES
MOBILE RELAY
HOSPITAL
CONTROL STATION
WORKING FREQUENCY
CENTRAL COORDINATING CENTER

PROPOSED UHF MOBILE RELAY SITES FOR COVERAGE OF FIVE COUNTRIES

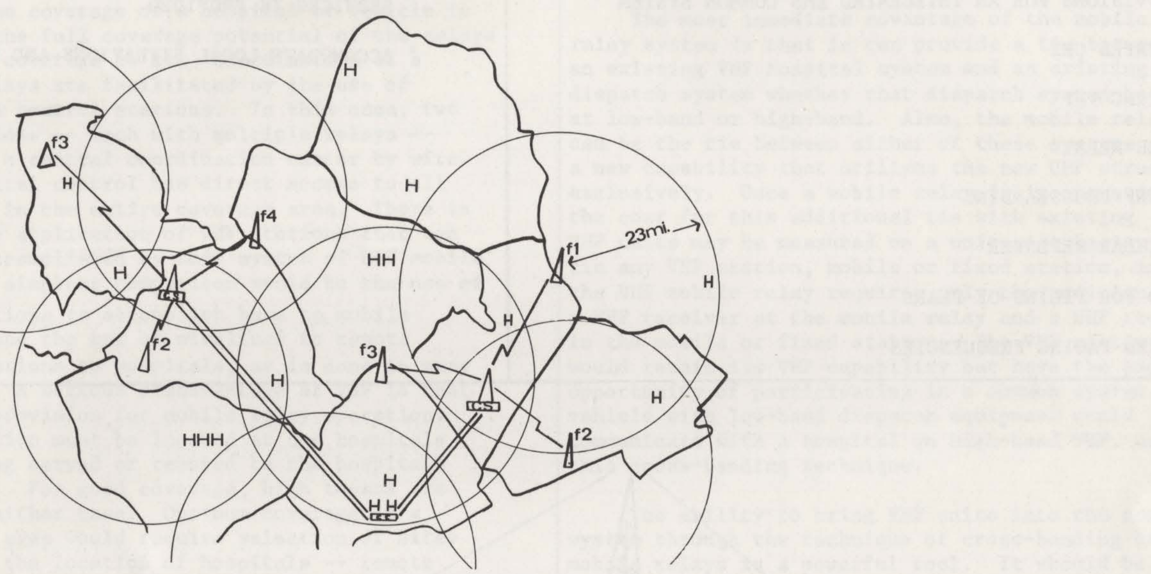
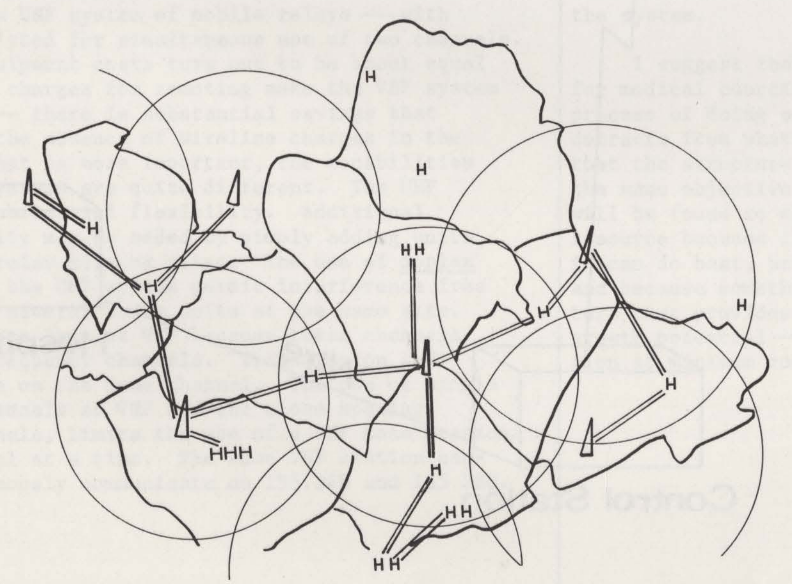


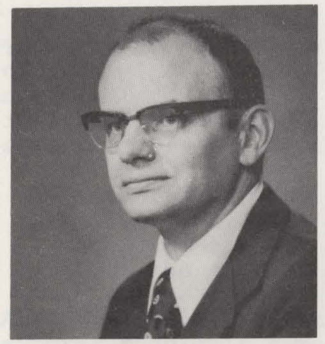
FIGURE 5

LEGEND

BASE STATION
HOSPITAL
CONTROL WIRE LINES
VHF HOSPITAL NETWORK WITH HOSPITALS AS CONTROL POINTS



MEET NEW/REELECTED MEMBERS OF ADCOM



Tom McKee

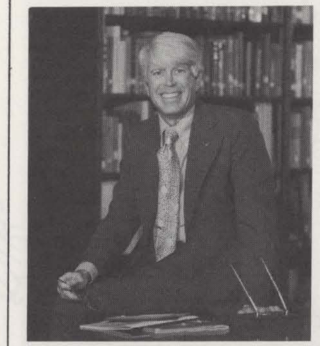
Tom McKee is presently Manager of Mobile and Station Engineering for General Electric's Mobile Radio Department. In this position he is responsible for the design of General Electric's vehicular and base station radio equipment. Tom has been with G.E. since 1959, spending a number of years designing land mobile receivers before moving into his first engineering management assignment in 1968.

During the period 1957-59, Tom served as Course Chief, of the Electrical and Electronic Instrument Repair Course of the U.S. Army Southeastern Signal School at Fort Gordon, Georgia. He advanced from Second Lieutenant to First Lt. during this time. Prior to 1957, he worked briefly as a design engineer for the Farnsworth Electronics Corporation in Fort Wayne, Indiana.

Tom was born in Alpena, Michigan in 1934. He received most of his education in the South Bend, Indiana public schools where he graduated from high school in 1952. He attended Purdue University, West Lafayette, Indiana and received a Bachelor of Science degree in Electrical Engineering in 1956.

Though only recently elected to the VTG Adcom, Tom is a long term VTG member (since 1955), and has served during the past 3 years as the VTG Secretary. He is also active in other land mobile industry activities via his service as Chairman of the Land Mobile Engineering Committee of the Electronics Industries Association, a position he has held for the past 2 years. Tom is the author of a number of papers in the communications field, and has been issued one U.S. Patent. He is the holder of an FCC First Class Radiotelephone license.

Tom is married, and he and his wife Joyce and son Paul (age 9) have just moved into a new home in Lynchburg, Virginia. Currently most of his free time is taken up with getting the new house, yard, garden, etc. into shape. As time permits Tom hopes to get his amateur radio station (K4ZAD) back on the air and more actively pursue his other hobbies of reading and gardening.



Sam Lane

Sam Lane is presently Deputy Director of the Communications Department of the County of Los Angeles. His responsibilities include managing all of the telecommunications engineering programs and supervising a technical staff of 70 professionals trained in a variety of electronics and telecommunications diciplines.

The County of Los Angeles communications system serves a population of nine million in an area approximately 4,900 square miles. Presently the system includes 5,000 mobile and portable two-way radios, 300 radio base stations, 125 microwave stations and a variety of command and control centers for law enforcement, fire protection and a variety of public service agencies.

Sam has had over 25 years of experience in the electronics and communications industry, serving in a variety of positions including technical, educational, engineering, marketing, management, and consulting. His prior experience includes various engineering assigments throughout the United States and Europe on communication and radar projects. He has taught various electronics and communications subjects at several schools. Starting in the mobile radio field as an Area Systems Engineer, he progressed to a managerial position responsible for a major manufacturer's combined marketing, systems engineering, and services to the major user of communications equipment throughout the Western and Southwestern regions of the United States. He has served as Communication Program Director for a leading consulting firm serving the state and local government agencies.

His educational background includes a Bachelor of Science Degree in Electrical Engineering from the Illinois Institute of Technology and a Master of Science Degree in Business Administration from the California State University at Los Angeles.

Sam is a Senior Member of the Institute of Electrical and Electronics Engineers and has been very active in VTG work for the past fifteen years. Currently, he is vice president of the VTG ADCOM, a post he has held for the past two years.

Earlier he attended and later instructed in the U.S. Navy Radio Material Schools, which were responsible for training for the repair of electronic communications, radar, and sonar equipment. He was discharged as an Electronic Technician's Mate 2nd Class with active duty from 1944 to 1946, and was in the Reserves from 1947-51.

Sam's hobbies are generally athletic in nature and include tennis and snow skiing. From the positions he held early in his career in Europe, Hawaii, and other parts of the country, he developed quite a travel bug and enjoys taking photographs, mainly with a 35mm camera.

Recently, Sam completed the requirements and is now a registered Professional Engineer in the state of California.

CONFERENCES

WESTERN ELECTRONIC SHOW AND CONVENTION (WESCON)

Civic Auditorium & Brooks Hall
San Francisco, Caligotnid
September 16-19, 1975

* * *

OCEAN '75

El Cortez Hotel & Convention Center
San Diego, California
September 22-25, 1975

This is the first combined IEEE conference on engineering in the ocean environment.

* * *

EASCON '75

Stouffer's National Center Inn
Washington, D.C.
September 29 - October 1, 1975

-- Digital Signal Processing
-- Space Communications
-- Radar Systems Engineering

* * *

IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

El Tropicano Motor Hotel
San Antonio, Texas
October 7-9, 1975

-- Power	-- Analysis and Modeling
-- Telephone	-- Measurement Techniques
-- Microwave	-- Spectrum Management
-- Satellite	-- EMC Management
-- Vehicular	-- EMP
-- Mass Transit	-- TEMPEST
-- Aerospace	-- Lightning and Statics
-- Biomedical	-- Grounding and Bonding
-- Radio and T.V.	-- Shielding
-- Computer	-- Hazards and Pollution
-- Environmental	-- Circuits and Systems
-- Law Enforcement	-- Standards

* * *

NATIONAL TELECOMMUNICATIONS CONFERENCE

Fairmont Hotel
New Orleans, Louisiana
December 1-3, 1975

-- Communication Switching
-- Space Communications
-- Communications Theory
-- Spectrum Utilization
-- Wire Transmission Systems
-- Vehicular Communications
-- Radio Communications
-- Communications Systems
-- Satellite Communications
-- Signal Processing
-- Fiber Optic Communications
-- Guided Wave Communications
-- Data And Computer Communications
-- Digital Voice, and Vidio Technology
-- Social Implications Of Technology
-- Energy And Environmental Impacts On Communications
-- Communications Role In National Growth
-- Industrial And Power Systems Communications
-- Control Systems (Dig. Or Analog)

* * *

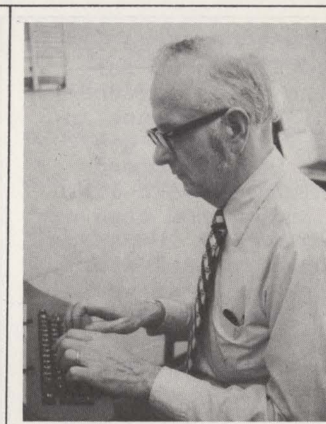
1975 IEEE INTERNATIONAL ELECTRON DEVICES MEETING

Hilton Hotel
Washington, D.C.
December 1-3, 1975

-- Device Technology
-- Integrated Electronics
-- Solid State Devices
-- Image Transducers And Optoelectronics
-- Electron Tubes

LESSENING LIGHTNING'S EFFECTS

By A. K. "Kenny" GUTHRIE
COMMUNICATIONS EDITOR



To paraphrase our founding fathers in this bicentennial season, "All lightning strokes are not created equal!" Just how unequal they are is indicated by this data taken during extensive observations on the Empire State Building:

100% of the strokes exceed 0 amps at crest
50% of the strokes exceed 18,000 amps
10% of the strokes exceed 58,000 amps
1% of the strokes exceed 120,000 amps

Although the fact that all strokes exceed zero amperes shouldn't come as a complete shock, we start reasoning from this point. If you have an installation which is a real "dog" and can survive no more than zero amps, you can look forward to a wipeout EVERY TIME your site is visited by lightning. But, if you "beef up" the installation so that it can survive an 18,000 ampere stroke (which is no big deal), HALF of the strokes will go to ground without doing damage. Get to the point that the installation can survive a 58,000 amp discharge, and NINE OUT OF TEN of the lightning strokes which come your way can be ignored.

There are a whole lot more "little" strokes than big ones! Every action which pushes the survival point up the ampere scale, even if slightly, gives a LEVERAGED improvement in the interval between damaging strokes. You will never know the exact crest current which your installation can survive, and you will never know the exact magnitude of the current which finally creams it. But, you do know that every constructive action which you take improves the probability of survival (or increases the interval of peace between the incidents of trouble).

Though the crest current is massive, its duration is brief. The typical stroke reaches crest in 2 microseconds; it decays to 50 percent of crest value in about 40 microseconds.

You can look at the lightning source as a constant current generator. The driving voltage is the potential developed between cloud and earth--nothing you can do about that! The source impedance is the loss through the atmosphere between cloud and a point near earth--that's beyond your control also. The impedance of the object struck is a miniscule part of the total and has little effect upon the current.

The stroke current, at whatever value it is, can enter your equipment <u>directly</u> via a "hit" to the antenna system or to connected power or telephone facilities. Once "in" it's going out, hopefully through the grounding provided. We hope, too, that the current will choose a non-damaging path between point of entry and point of exit.

Stroke current can affect your apparatus <u>indirectly</u> as distributed currents couple inductively to overhead or buried telephone or power facilities. The consequence of this coupling is longitudinal voltage stress between circuits connected to these facilities and the grounded portions of the gear.

It adopting a "survival" philosophy, the most critical point is the antenna system. If it is at a good VHF site, it's the highest thing around. The same factors which make it attractive for communication make it an attractive target for lightning. To make matters worse, this attractive target is directly connected to the equipment by a rather solid conductor--the coaxial cable shield.

You're faced with a filtering job. There is a constant-current generator, poised to deliver a brief but brutal shot to the antenna system. There is a heavy conductor, waiting to move this current, or a portion of it, into the equipment. Briefly stated, our objective is to keep this current out of the goodies! Equally brief, our approach is common to 'most any filtering task: SHUNT, THEN ISOLATE.

Every ampere taken to ground through a shunt path is one ampere which doesn't have to be dealt with inside the vulnerable equipment.

Since the shunt current is inversely proportional to the shunt impedance, we try for the lowest impedance we can reasonably get, on every shunt path to ground.

Having provided shunt paths--a predetermined preferred route for the stroke current--we multiply their effectiveness by adding isolation in series with the undesired paths. We deliberately increase the impedance of the path we want the stroke current to avoid--the path which leads to our equipment.

Inductance is the prime element of these impedances. Inductance can be friend or foe. We want low inductance in the shunt (grounding) conductors. We want high inductance in the path which leads toward vulnerable gear. There is a paradox here. We may recommend techniques in some cases which we avoid like the plague in others! The inductance used or avoided (as the case may be) may be lumped as, for example, a few turns wound in semi-flex coax cable. It may be distributed, as we run conductors in conduit. If may be the spot effect afforded by an abrupt change in direction of a conductor which carries high current.

Here's how to apply the "SHUNT, THEN ISOLATE" technique, starting from the antenna and working down:

SHUNT TECHNIQUES

- Use an antenna with directly grounded elements
- Solidly bond the grounded portion of the antenna to the grounded support structure (special attention to outriggers)
- Optimize tower grounding--ground until you run out of ideas or run out of money
- Ground coax cable shield to the tower at point of takeoff (essential when jacketed cable is used)
- Add auxiliary grounds to transmission line as convenient (especially at supports and building entries)

ISOLATION TECHNIQUES

- Bring coax cable off tower with minimum bending radius permitted by cable spec's
- Introduce as many right angle bends in the cable run as you can
- Route cable through conduit
- Wind semi-flexible cable into a coil of several turns and any convenient diameter near entry into equipment cabinet

If you apply these techniques, you'll have fewer amperes to dispose of in the equipment and you'll enjoy longer intervals between disasters. But...some strokes will still deliver current, and this current is going to go somewhere.

Once admitted to the cabinet, this residue of stroke current can choose (or divide) between three possible sinks:

- AC Neutral, after breaking down a power transformer or the primary wiring;
- Telephone Line Protector Ground, after breaking down your control panel and a line protection gap; or
- A cabinet grounding conductor.

Given a choice, I recommend the last one!

Every cabinet which has an antenna connected should have an effective ground. To be effective, it must be able to handle the current (#6 AWG Solid is reasonable), and its inductance should be minimized. GROUND WIRES SHOULD BE:

- SHORT. Inductance increases with length.
- FAT. Inductance decreases with diameter (but the major leverage is in length)
- STRAIGHT. Avoid bends which approach a right angle. When you must change direction, make the most sweeping arc which the realities of the installation will permit.
- IN THE CLEAR. Avoid mutual inductance effects. Keep grounding wires out of conduit, away from metal surfaces, and away from other wiring.

Above all, DON'T bundle grounding conductors with power or telephone conductors. The last thing you want is a path which couples the effect of stroke current back into your gear.

Try as you will, your grounding will have some inductance and there will be a voltage drop ($E = diL/dt$) across it. Under stroke conditions, the cabinet voltage will rise above its own ground reference, and certainly above the remote AC neutral ground and the remote telephone protector ground. This puts longitudinal stress from the cabinet toward these remote grounds, again putting stress across AC wiring in the station (including transformers) and the control panel.

A quick and effective way to remove stress on the AC side is to tie AC Neutral directly to the chassis. This transfers the stress to the AC supply wiring. You may blow a meter ring off the pole, but the station survives! If a solid connection doesn't appeal to you, a gas tube between AC neutral and chassis is also effective.

Control panel protection calls for a pair of single-element gas tubes (or a three-terminal gas tube) connected between each side of the telephone line and chassis. A stress between chassis and the telephone line protector will break down the gas tube, instead of wrecking the control panel.

This leave us with only one major stress mechanism--the effect inside the cabinet as stroke current moves from point of entrance to point of exit. There is a chance of burning a conductor open; there is a possibility of developing damaging voltage drops within the cabinet. The easy way to "solve" this problem is to avoid it. Keep the current out of the cabinet. Bring the coaxial cable into the cabinet adjacent to the ground wire (usually at the bottom). Then, bond the coax shield to the ground wire at the cabinet entry.

The major stresses in most installations are those which result from disposing of the current collected by the antenna system. Much of our damage arises as we deliver these currents to our power company and our telephone company. The techniques discussed will minimize both the current magnitude and our own internal damage.

Of course, it isn't wise to ignore the transients which come the other way--from the power and telephone networks into our boxes. Whole families of protective devices of proven efficacy are available--space doesn't permit a survey of them in this article. For now, we merely point out that a little series inductance in the power and telephone lines can have a very beneficial effect.

There's no point in wiring telephone connections like one was wiring a substation! Small-diameter twisted jacketed pair is somewhat inductive, and is the thing to use. It helps to run it in conduit.

On the power side, running the feed through conduit for at least 20 feet will multiply the effectiveness of a quick-response transient protector on the load side, and will tend to protect it from catastrophic damage. You can introduce inductance by tieing several hard knots in a power cord (for an interesting exercise, try calculating the flux linkages). A voltage regulating transformer provides transient protection in addition to its other significant benefits.

There's no one "magic wand" of overwhelming significance in this writeup. It's just a bunch of "little things." But, "Every little thing helps."

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