ISSUES AND STATUS OF 1/4-INCH VIDEOTAPE RECORDING STANDARDS

Robert G. Thomas
American Broadcasting Companies
New York, N.Y.

Early in 1983, two manufacturers of ENG camera/recorders submitted separate documents to the SMPTE Committee on Video Recording and Reproduction Technology (VRRT) proposing substantially different 1/4-inch cassette videotape recording formats. This prompted VRRT to form the Working Group on 1/4-inch Cassette-Based Video Recording Format with the author as Chairman. The Working Group is charged with the development of electrical and mechanical draft standards for a video recording format utilizing 1/4-inch cassette tape for professional ENG applications in the 525/60 television system. Primary consideration is to be given to a compromise between the two formats already submitted to VRRT, and a goal of one year was set for establishment of agreement in principle.

Working Group meetings have been held at four- to six-week intervals since June, 1983. At present, membership is composed of about thirty-five engineers from broadcasting organizations and manufacturers of cameras, recorders, tape and cassettes.

Effort by the Working Group has been directed to three principal areas:

- Development of a user specification. A subcommittee of engineers from North American networks, broadcasting groups and technically advanced individual stations, has compiled a report which serves as a unified guide to broadcasters' requirements for ENG recorders and field editing equipment.

- Development of a common interface between camera and recorder. Because 1/4-inch recorders represent a significant departure from existing products, the Working Group has a unique opportunity to standardize mechanical docking arrangements and electrical interface, virtually unencumbered by restraints imposed by equipment already in use. The important elements of the mechanical interface have been established by a cooperative effort of the manufacturers in response to broadcasters' recommendations. Attention will now be placed on remaining mechanical details and a common electronic interface. The benefits of this effort will be shared jointly by broadcasters, who will enjoy the flexibility of matching any new ENG camera to any 1/4-inch VTR, and by equipment manufacturers, who will be able to release new products with the assurance of continued compatibility in the future.

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C.

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- Standardization of recording format. Achieving a single format is the most important - and the most challenging - aspect of the Working Group's task. Because each of the proposed formats is based on different system concepts, it first appeared that a compromise format would be very difficult to achieve. Subsequently, however, a test conducted by the Working Group showed one of the formats to be a viable ENG medium. That finding, in conjunction with the fortuitous development of a new tape oxide formulation, raised expectations in early 1984 that a common format might indeed be attainable. There followed a period of intensive discussions during which both manufacturers demonstrated their dedication to compromise. As a result, in April 1984, it was possible for the Working Group to issue a press release announcing adoption of a tentative common format. For the tentative format to be fully accepted, however, it must be shown to satisfy performance requirements of the user report. Plans are being formulated for a performance demonstration upon which a judgement of format acceptability will be made by the Working Group.

The paper will describe, in datail, the technical considerations involved in selection of an appropriate format and will recount the events that have lead to adoption of the tentative compromise format. Procedures employed and the results obtained in the demonstration to evaluate the tentative format will be available in mid-October and will be reported in full. Finally, a description will be given of anticipated future developments in the ongoing standardization program for a 1/4-inch ENG record format and the related issues.

F.

C.

THE ROLE OF IEEE IN STANDARDIZATION FOR BROADCASTING

Robert G. Thomas, Chairman
IEEE Audio-Video Techniques Committee

Standards, either self-administered, or in the form of government regulations, have been an integral part of broadcasting virtually since the inception of the industry. Several categories of technical standards exist in broadcasting today. Those which are legislated by FCC regulation naturally carry the most significance for the U.S. broadcaster, but there are also requirements for international interchange of programs that must be observed. Also, recognizing the need for uniform operational practices to ensure technical quality and to facilitate compatibility within North America, the industry itself has developed and adopted numerous self-regulatory standards through such organizations as the ANSI, EIA, SMPTE and NTC, as well as various other bodies. In addition, recommended practices, although not carrying quite the significance of mandatory performance standards, are nevertheless widely accepted and generally adhered-to in the interest of technical integrity. Linking these many levels of performance standards are the measurement procedures involved in assessing compliance, and it is here that IEEE contributes by providing practical standardized methods of technical performance evaluation.

The IEEE program for standardization in the field of broadcasting is directed by the Administrative Committee (Ad Com) of the Broadcasting Group which, in turn, is a constituent of the Broadcast, Cable and Consumer Electronics Society. In the near future, it is expected that the Broadcasting Group will attain the somewhat enhanced status of an independent Society within IEEE, but this will not have a significant effect on standardizing activities. Ad Com membership is comprised of engineers having diversified experience and responsibility with individual broadcast stations, group facilities, public and commercial networks, consulting firms, equipment manufacturers, common carriers and the Federal Government. These individuals are thus involved in, and responsive to, the changing needs of broadcasting, and can direct IEEE broadcast activities accordingly. In addition to managing the affairs of the Broadcasting Group, the Ad Com oversees technical committees, where IEEE standards for broadcasting are actually developed and maintained. At present there is no activity by IEEE for standardization of RF measurements; however, studio system measurements and technical definitions are the object of an active standards program being conducted by the Audio-Video Techniques Committee. A description of the committee and its work will be the subject of the remainder of this paper.

The Audio-Video Techniques Committee evolved from a predecessor group, the Video Techniques Committee of the IRE. Many standards still extant are the products of the IRE committee, which was highly productive in the 1950's. When the IRE and AIEE consolidated in 1963 to form the new IEEE, the Video Techniques Committee remained in tact, but it was not until 1971, when the IEEE management adopted a more aggressive policy toward standardization, that momentum was regained. Also at that time, the responsibility for studio audio measurements was acquired by the committee and its name was changed to reflect its broader scope.

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The Audio-Video Techniques Committee is concerned strictly with measurements associated with broadcast studio systems and with definitions related to all phases of broadcasting and CATV. It is not involved with measurements on radiated signals nor does it establish levels of performance or recommended practices. Standards developed by the committee are essentially "dimensionless" in that they describe measurement procedures, but do not specify the level of performance or the way in which performance should be optimized, except by reference to standards arising in other organizations.

The chairman of the committee is appointed for an indefinite term by the Ad Com. He then appoints individual members for two year terms. Consistent with the scientific nature of IEEE and its independence from commercial influence, members of the committee serve as individual experts in broadcast technology rather than as representatives of a specific company or organization. Although members are generally reimbursed by their employers for expenses associated with committee business, and this support is gratefully acknowledged, they nonetheless participate solely on the basis of their personal technical competence. Members of the 1982 committee are listed in Appendix A.

All of the members participate in committee business by providing advice on policy matters, by assisting with the disposition of requests from IEEE administrators regarding the revision or reaffirmation status of existing standards and, of greatest importance, by meticulous, and often repeated, reviews of proposed new standards before they are submitted for approval by the IEEE Standards Board. In addition, six of the members also serve as chairmen of one of the six subcommittees of the parent Audio-Video Techniques Committee.

The subcommittees are the working groups where the actual development of a new standard takes place in a methodical process from initial exploratory discussions to detailed refinement of the final draft document. Members of each subcommittee are recruited and appointed for two year terms by the subcommittee chairman on the same basis of individual expertise that characterizes membership qualification on the parent committee. There six subcommittees, each devoted to a particular sector of studio engineering. Subcommittees are listed in the Organization Chart, Fig. 1, which also indicates the reference number that has been assigned, for convenience of administration, to the parent committee and each subcommittee.

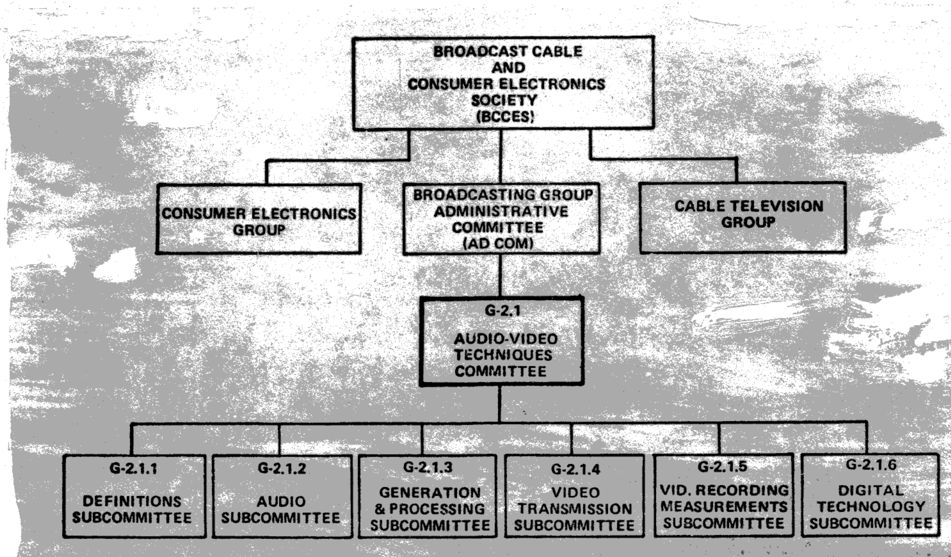

Figure 1. Organization of IEEE Broadcast Standards Activity

Before embarking on a detailed description of the work now before each of the subcommittees, perhaps it would be appropriate to describe the process involved in generating a new standard to illustrate the flow of the document as it develops. Refer to Fig.2 on the following page, where the development process is depicted.

A standard is developed or revised in response to a need within the industry. It might be initiated by a request from outside the committee, or it could arise from a suggestion by a committee or subcommittee member. Information is also received from IEEE standards administrators periodically as it becomes necessary to reconsider the status of each existing standard to determine if it should be revised, reaffirmed or simply withdrawn, as in the case of a document that has outlived its usefulness. When a need has been identified, the proposal is thoroughly examined by the committee in its role as Sponsor, to determine the worthiness of the new project in relation to other work. Unfortunately, there are many more possibilities for new standards than the manpower of the committee is capable of handling, so a high degree of selectivity is required to ensure that projects are chosen for maximum effectiveness and benefit to the industry. For instance, several existing IEEE broadcast standards are in drastic need of revision to bring them up to date, and the committee has recognized its responsibility to clear away this long standing backlog before undertaking new assignments in related fields. Therefore, it will be a while before we will have the capability for developing new standards in those particular fields.

Returning to the development process, once a concensus has been reached on the desirability of generating a new standard or revising an existing one, a Project Authorization Request (PAR) is submitted to the IEEE for consideration by the Standards Board. The PAR describes the scope of the new standard or revision, provides a time schedule for completion of the work, and lists organizations with which the project will be coordinated. The latter factor is very important, because a standard cannot be developed by IEEE in isolation from other work, of a related nature, that might be concurrently going on in another standardizing organization. A recent example is the coordination established between IEEE, where revision of the standard for measurement of luminance level has begun, and EIA, where elimination of setup is under consideration. These are obviously related projects that must be closely coordinated; similar and equally important examples exist in many other projects.

When a PAR has been approved, the appropriate subcommittee begins discussion of the topic and, as uncertainties are clarified and differences in personal preferences resolved, it becomes possible to write a draft which is then successively refined. During this process every effort is made to accommodate diverse viewpoints and, needless to say, great reliance is placed upon a spirit of cooperation and a willingness to compromise on the part of the subcommittee members. After the subcommittee has completed a draft standard, a ballot is conducted among its members and if the draft is substantially approved it is forwarded to the main committee for review. Any revisions thought necessary by the main committee are then appended to the document, which is then returned to the subcommittee for additional rework. This process may be repeated several times before the final, polished recommended standard is ready for ballot by the main committee. If approved, it is submitted to the Standards Board where it is considered, not for its technical content — that is the responsibility of the Audio-Video Techniques Committee, but on the judicial basis that the document has been developed in accordance with IEEE regulations and does, in fact, represent a concensus within IEEE. If approved by the Standards Board, the document is published as an IEEE Standard for use by the industry.

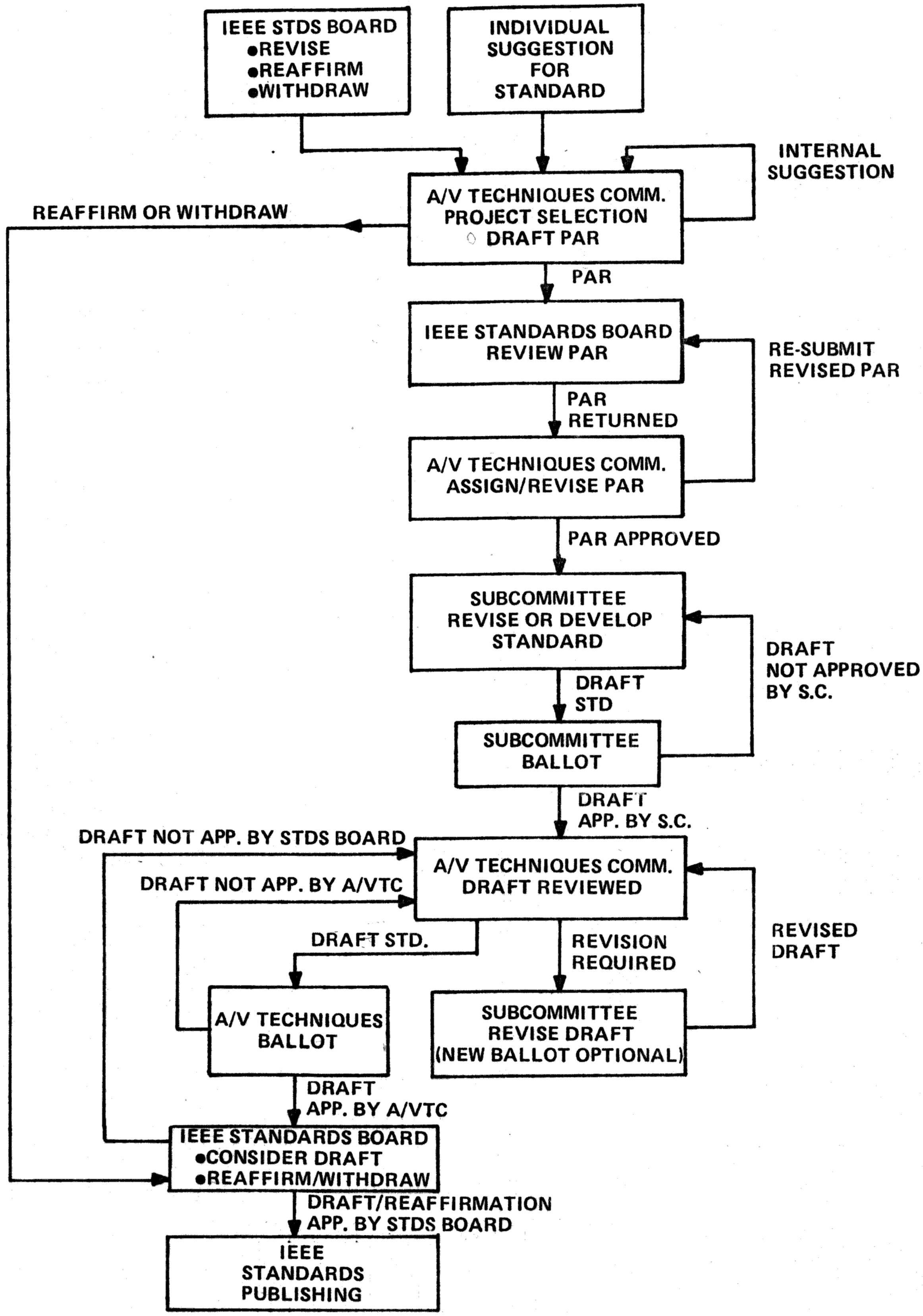

Figure 2. IEEE Broadcast Standards Development and Maintenance Procedure

The various stages in the standards development process just described are all represented by actual projects currently under consideration by the Audio-Video Techniques Committee and its subcommittees. Work in progress by each of the subcommittees is summarized in Appendix B, and explained in detail in the sections which follow.

Definitions Subcommittee G-2.1.1

Gwyneth H. Mallinson, Chairman

There is an unfortunate tendency among some engineers to discount the importance of precise definitions of technical terms. Definitions cannot be taken lightly, however, for they are essential factors in equipment and system performance specifications, and often play a crucial role in legal documents, such as contracts and patents. They also function as useful reference material for engineers new to the field, for students, and for correct usage in other standards and technical literature. Additionally, the unique nature of broadcasting has resulted in specialized definitions of some terms which are quite different from those that are generally understood and accepted in other phases of engineering. Thus, to avoid misunderstanding, particularly in the somewhat insular field of broadcasting, we must have a source of standard definitions that apply to our specific method of usage in precise, unambiguous language.

In keeping with the rapid advance of television studio engineering toward increased development of digital technology, the Definitions Subcommittee has recently completed a useful and most timely "Glossary of Digital Television Terms", which has just been published as IEEE Standard 847.

At present, the subcommittee is engaged in a comprehensive revision of IEEE Std 201, "Definitions of Terms Related to Television". This standard was revised in 1979, but the extent of the revision was intentionally restricted with the expectation that further revision, of significantly broader scope, would follow in short order. That further revision is the present task of the Definitions Subcommittee, and the scope has been widened to include all terminology related to television, including transmission, reception and CATV, in addition to the usual emphasis on studio engineering terms.

The method being employed by Ms. Mallinson to accomplish this ambitious task is to utilize the permanent members of her subcommittee for developing definitions of common terms and for continuity of style. However, when groups of terms of a specialized nature are approached, she brings in experts from that particular field who then participate as pro tem members only for the duration of the project for which they are uniquely suited to contribute. This method has been successful with CATV terms, and is now being applied to a compilation of television special effects definitions. As definitions are compiled for each major segment of nomenclature, they will be published in draft form in Transactions on Broadcasting or other appropriate journals in order to solicit suggestions and comments from the field. Then they will be published in final form as separate IEEE standards until the entire television field has been covered, at which point they will all become part of a major revision of Std 201.

The success of this approach will be determined to a great extent by cooperative effort from workers in specialized sectors of television technology who are willing to share their knowledge either through temporary subcommittee membership or by meticulous review of published drafts with comments referred to Ms. Mallinson.

Audio Measurements Subcommittee G-2.1.2

Kevin. G. Dauphinee, Chairman

One of the oldest (1953) and most frequently used IEEE broadcast standards is Std 152, "Recommended Practice for Volume Measurements of Electrical Speech and Program Waves". In short, this standard establishes the volume unit, or VU, and specifies meter ballistics and scale design for measurement of VU.

As is well known, new requirements have arisen for measurement of audio level, and new techniques have been developed to fulfill certain objectives. These have resulted in the Peak Program Meter (PPM), which has had widespread acceptance in Europe, and in experimentation with "loudness" meters having as their basis the perceived loudness of program material rather than objective measurements having no relation to psychoacoustic effects. Furthermore, new display devices are being introduced in stand-alone units and as integral parts of modern audio consoles.

All of the above events were culminating at about the time Std 152 became due for review, so this seemed to be a propitious opportunity to address the entire problem of audio level measurement and display. Mr. Dauphinee agreed to join the Audio-Video Techniques Committee and to reestablish the Audio Subcommittee, which had been inactive for many years. The subcommittee has now begun consideration of the project and has decided at the outset to concern itself only with quantitative aspects of audio level measurement. That does not preclude possible reliance on subjective testing by qualified organizations, but the subcommittee itself will not become engaged with subjective evaluations. Emphasis will initially be on a review of VU measurement and its relation to PPM, specifications for visual indicators and consideration of the transmission or storage system that might follow the indicator. The need for laboratory support is anticipated, and steps are being taken to secure this useful adjunct to the subcommittee's effort.

The Audio Subcommittee, although progressing with its present responsibilities, is still considered to be in a formative stage and would thus benefit from acquisition of additional members who can contribute to the current project or to projects envisioned for the future, which encompass standardized measurement of audio signsl-to-noise ratio and a wide range of digital audio measurement standards. Qualified interested engineers should contact Mr. Dauphinee if they wish to participate in such a program.

Video Generation and Processing Measurements Subcommittee G-2.1.3

Laurence J. Thorpe, Chairman

This subcommittee had been inactive for many years, but was completely reorganized by Mr. Thorpe in 1981. By that time, three projects had accumulated, all requiring urgent attention:

Std 202	Measurement of Aspect Ratio and Geometric Distortion
Std 208	Measurement of Resolution of Camera Systems
Project 606	Measurement of Colorimetry and Transfer Characteristic (Gamma) of Camera Systems

Following an initial review, it was determined by the subcommittee that Std 202 was least important of the whole assignment. In the interest of getting on with the more important projects of camera measurement, it was decided to revise Std 202 with only minimal modifications to incorporate modern scan rates and units of measure. This work is now virtually complete, and the revised document should be ready for submission to the IEEE Standards Board by the end of 1982.

In considering the measurement of resolution, the subcommittee is employing a system approach that will treat the lens, pickup device and camera proper all as a single entity. Without the inherent simplification of the system concept, resolution evaluation would be hopelessly complicated due not only to the myriad combinations of the major components themselves, but also to the way they interact with each other. Thus, order will be brought to an otherwise chaotic situation by consideration of a "total system", leaving the composition of the system, in terms of lens, pickup devices, etc., to the manufacturer and user, who would then share responsibility for resolving differences arising from possible system variations. This approach does not relieve the need for eventual standardization of pickup device characterization but it has the very practical advantage of permitting immediate progress with a camera system resolution measurement standard.

Perhaps even more complex than resolution measurement are the dual issues of transfer characteristic and colorimetry. Project 606 was originally meant to deal only with transfer characteristic (gamma). However, coincident with the reorganization of the subcommittee it became apparent that camera gamma cannot be evaluated in isolation of colorimetry, so the latter parameter was added to the scope of the project. Colorimetry, in a broad sense, is one of the factors receiving attention outside of IEEE, however, as applied to camera performance, and especially because of its role in conjunction with camera gamma, colorimetry is a vital area of concern for the Generation and Processing Subcommittee.

A considerable amount of independent research has been done in all the fields now being examined by the subcommittee, so one of the first accomplishments has been to procure and distribute related technical papers. Additionally, Mr. Thorpe has asked each member of his subcommittee to write a position paper on topics for which divergent views exist. These will provide a firm basis for reaching a concensus or, should that ideal state not be attainable, the papers will help lead the way toward acceptable alternate standards as a compromise.

Two task forces have been organized within the subcommittee to individually concentrate on the areas of resolution and gamma/colorimetry. They will meet separately, but will convene at regular subcommittee meetings. Although there was a decline in activity for several months, work is resuming and additional members are being sought.

Video Transmission Measurements Subcommittee G-2.1.4

James M. Walter, Chairman

The most recent accomplishment of the Video Transmission Subcommittee was revision of IEEE Trial Use Standard 511, "Measurement of Linear Waveform Distortion". The salient feature of this standard is the specification of a T-step waveform for evaluation of video system transient performance. As originally issued in 1977, the standard was only granted Trial-Use status, a classification applied to documents which have elements of immediate usefulness to the industry, but for which substantial agreement has not been reached in committee. Trial-use standards are issued for a period of two years, the first year being used for collection of comments and the second year for revision. Std 511 was issued as a full-status standard in 1979, following refinement of the original version. It has been adopted for use in several major studio installations where it has been found to give a more realistic assessment of transient performance than the 2T sine squared pulse and bar test signal.

Following the development of Std 511, Mr. Walter was appointed chairman, and he has since reorganized the subcommittee to resume work on another project initiated by the previous membership of the subcommittee. Specifically, that project is revision of IEEE Std 206, "Measurement of Differential Gain and Differential Phase in Television Systems".

Laboratory and studio practices have changed immensely since the standard was originally adopted, as have the magnitude of normally-encountered differential gain and phase errors and the precision with which they must be measured. Finally, growing use of digital processing techniques has resulted in effects on differential gain and phase measurement that did not exist when Std 206 was initiated, or even when it was reaffirmed in 1972. The latter consideration has already been addressed by the Digital Technology Subcommittee, which some time ago prepared a specification for measuring differential gain and phase in digital television systems. It is anticipated that the specification will be incorporated as part of the major revision of Std 206. However, as work is just getting underway on the whole revision, a draft suitable for review by the Audio-Video Techniques Committee is not expected before the end of 1983.

Renewed effort is also being applied to another project: revision of Std 205, "Measurement of Luminance Signal Levels". It is this standard that establishes the familiar "IRE Unit". Although of nearly archival status, the standard requires modernization and, above all, a possible major revision, depending on the outcome of EIA deliberations on elimination of setup. This is the situation alluded to earlier with regard to the need for close coordination. At present, not much effort is being directed at the revision of Std 205 but, as completion of other work proceeds, and a final decision on setup is reached, attention will once again be applied to an update of this most useful document.

When current projects have completed, the attention of the subcommittee might turn toward measurement of signal-to-noise ratio in video transmission systems, dynamic gain, crosstalk from digital circuits or performance of fiber optic transmission systems. In the meantime, guidance in selection of suitable projects will be sought from the field.

Video Recording Measurements Subcommittee G-2.1.5

Alan S. Godber, Chairman

Some industry practices become so widely adopted and universally accepted that they become de facto standards. Such has been the case with measurement of video signal-to-noise ratio (SNR), especially for VTRs. However, there are some variations in method that can cause significant differences in results, leading to confusion in equipment specification and possible misunderstanding between users and equipment manufacturers. Additionally, it is sometimes necessary in VTR system evaluation to differentiate between sources of noise, such as the noise from tape and noise generated within the VTR itself. In those cases it is desirable to employ evaluation procedures that tend to exalt noise from one specific source while suppressing noise effects from other parts of the system. All of these factors began to converge, pointing to the necessity to develop a standard that would not only codify the existing de facto policies already in effect, but also encompass a wide variety of special requirements for VTR and tape SNR evaluation.

It was recognized early in the project that different categories of SNR measurement existed, and that these could be broadly divided into self-explanatory classifications as follows:

1. VTR Specification, Qualification and Acceptance Tests
2. Routine Operation Performance Verification
3. Tape Evaluation
4. Research and Development

The first category is of most importance to users since it explicitly standardizes test conditions, such as test signal characteristics and measurement bandwidth, that influence SNR measurement. In the respect that certain measuring instrument characteristics are part of the document, the standard deviates from the usual IEEE practice of developing "dimensionless" standards. However, it was thought appropriate, if not essential, to do so in this case because of the dependency of accurate VTR noise evaluation on the somewhat arcane details of measurement practice.

The test conditions and method of measurement described in the category, VTR Specification, Qualification and Acceptance Tests are THE standard for measurement of VTR systems. As implied by the title, this category is applicable to SNR specifications in manufacturers' catalog material, to testing of sample equipment for type approval, and to system acceptance testing following installation of equipment at the user's premises. Recommendations in the other categories are listed because of their usefulness or economy in situations where less rigorous methods will suffice or where special test conditions are required, as in tape evaluation. Thus, it would be expected that small stations might utilize techniques listed under Routine Operation Performance Verification which, although not necessarily producing the accuracy or repeatability of the more accurate Standard Method, could be accomplished with equipment readily available in small studio plants.

The SNR document has just received approval by the IEEE Standards Board, and will be available as soon as it is published as IEEE Std 618, "Measurement of Luminance Signal-to-Noise Ratio in Video Magnetic Tape Recording Systems".

A color television picture that has been recorded and reproduced in encoded analog form exhibits noise impairment in the luminance component and the chrominance components. Until recent years, emphasis has been on evaluation of luminance noise but, as the subcommittee was approaching the completion of the standard for that component, the importance of chroma noise measurement became apparent to the industry. Rather than delay release of the substantial work already accomplished for Project 618, it was decided to publish what was available for luminance SNR, then proceed with a new project for chroma noise measurement.

Chroma noise is an issue too complex for detailed discussion here, suffice it to say it is the result of random amplitude and phase variations in the chrominance part of encoded color television signals. It is perceived, after chroma demodulation, as streaky "color noise" which is particularly objectionable in highly saturated colors of certain hues. Commercial instruments have been available for measurement of the amplitude and phase disturbances in chroma, but the subcommittee members had reservations about several factors associated with measurement techniques and have deliberated on each point in doubt, relying on supplemental laboratory experiments where appropriate. A first draft for a recommended standard is now being prepared. The IEC is also considering chroma noise, and the IEEE Video Recording Measurements Subcommittee is advising the U.S. National Committee on policy in this matter.

Another new recommendation being considered by Mr. Godber's subcommittee is Project 619, "Measurement of Moiré in Video Magnetic Tape Recording Systems". Moiré is an interference pattern in a reproduced picture, resulting from spurious video frequencies generated by the VTR signal system. Effort has been applied to the moiré project at irregular intervals while the subcommittee has been concentrating on SNR measurement, but as a conclusion to SNR effort is being approached, increasing attention will be applied to moiré measurement standardization, and a first draft is now being refined. In addition, the subcommittee is consulting with the EBU on work going on there for moiré evaluation.

Digital Technology Subcommittee G-2.1.6
Abraham A. Goldberg, Chairman

Although television studios are predominantly analog in nature, a considerable amount of digital equipment is coming into use, so it is frequently necessary to convert video signals from analog to a digital format for digital processing, and then reconvert to analog. At each point in the system where the conversion process takes place there is a possibility for introduction of signal distortion, often of a character not previously encountered in purely analog systems. It has been common in the past for development of broadcast measurement standards to lag industry field practice because the techniques involved generally evolve from a gradual process of experimental refinement and the slow emergence of various preferences. Mr. Goldberg and the members of his subcommittee have reversed this situation, however, by drawing upon their extensive laboratory experience to produce a document of immediate practical value to broadcast engineers who are encountering digital television equipment for the first time.

The work is being done as Project 746, "Performance Measurements of A/D and D/A Converters for PCM Television Signals". The object in preparing this document has been to provide a battery of tests that will fully evaluate A/D and D/A converters (codecs). Methods are given for measurement of SNR, differential gain and phase, low-frequency linearity, and frequency response. Furthermore, it was determined at the beginning of the project that the techniques developed would be capable of execution with common television test facilities readily available to the studio engineer. Thus, standardized performance evaluation will be possible without acquisition of special test equipment. If, in the future, specialized test equipment having unique attributes for digital evaluation becomes available, the standard can be revised to include it, but in the meantime, the industry can enjoy useful evaluation methods without additional capital investment.

The document was developed in separate parts by several individual subcommittee members who each prepared a section pertaining to a certain aspect of codec performance. These separate recommendations were then reviewed by the entire subcommittee, returned to the authors for revision, and then re-reviewed in a continuing process of refinement. The draft is now virtually complete in the subcommittee, and is ready for forwarding to the Audio-Video Techniques Committee for review, after which it will be submitted for Standards Board approval and publication.

Prior to embarking on the codec evaluation project, the Digital Technology Subcommittee prepared a description of techniques for measurement of differential gain and differential phase in digital television systems. In addition to providing the basis for one section of project 746 for codec evaluation, the earlier work will become a part of the general revision of Std 206, now in progress by the Video Transmission Subcommittee.

As work on their present project draws to a close, the Digital Technology Subcommittee has been considering possible new areas of endeavor, with measurement of bit error rate a likely possibility. But in addition to whatever projects may be taken on exclusively by this subcommittee, it is more than likely that it will become increasingly involved in work by the other subcommittees as digital techniques make further inroads to all phases of broadcasting, gradually eroding the boundaries that now separate "analog" and "digital" technology.

From the foregoing description of work in progress, it is apparent that the Audio-Video Techniques Committee is involved with projects ranging in character from overdue revision of nearly-archival standards to timely documentation of sophisticated new techniques. In view of that variety, it is interesting to observe that all of the projects are being approached with equally high levels of enthusiasm by the subcommittees, regardless of the character of the task. Presumably, this admirable attitude results from an acknowledgement that an orderly program for standardization must place the highest priority on maintenance of existing documents and from the realization that older standards, when appropriately revised, continue to be valuable assets to broadcast engineers working in modern situations.

Looking to the future, we see no lack of need for new measurement standards. Even now, consideration is being given to how the IEEE might contribute to standardizing performance measurement of teletext systems, and several other opportunities for standards development have been cited throughout this paper. Additionally, anticipated developments in multichannel sound, enhancement of NTSC picture quality and HDTV will impose new demands on the techniques employed to assure the technical performance of studio systems.

Foremost of all the committee objectives, however, is to provide standards that fulfill the practical needs of broadcast technology. That cardinal objective can best be achieved through comments, suggestions and, above all, active participation, by engineers who are confronted daily with the problems that standards are meant to alleviate. That brings us to the prime purpose of this paper, which is to make engineers aware of the standards program in progress on their behalf, and to solicit their active cooperation in developing standards to meet the needs of an evolving broadcast industry.

APPENDIX A

1982 AUDIO-VIDEO TECHNIQUES COMMITTEE

Irwin C. Abrahams
Kevin G. Dauphinee
Alan S. Godber
Abraham A. Goldberg
Harold Isaacs
Thomas B. Keller, Jr.
Stephen B. Lyman
Gwyneth H. Mallinson
Waldemar J. Poch, Secretary
Frederick M. Remley, Jr.
Hans Schmid
Robert G. Thomas, Chairman
Laurence J. Thorpe
James M. Walter
Larry H. Will
Robert A. O'Connor (Ex Officio)

APPENDIX B

Subcommittees and Current Projects of the Audio-Video Techniques Committee G-2.1

G-2.1.1 Definitions
Gwyneth H. Mallinson, Chairman
Ampex Corporation, 401 Broadway, Redwood City, CA 94063

Std 847	Glossary of Digital Television Terms. Published 1982.
Std 201	Definitions of Terms Related to Television. Comprehensive rev. in progress.
–	Definitions of Cable Television Terms. First draft complete.
–	Definitions of Special Effects Terms. First draft in progress.

G-2.1.2 Audio Measurements
Kevin G. Dauphinee, Chairman
American Broadcasting Cos., 57 W 66th St., New York, NY 10023

Std 152	Measurement of Audio Volume. Preliminary study initiated.

G-2.1.3 Video Generation and Processing Measurements
Laurence J. Thorpe, Chairman
Sony Broadcast Prods. Co., 677 River Oaks Pkwy., San Jose, CA 95134

Std 202	Measurement of Aspect Ratio & Geometric Distortion. Rev. in progress.
Std 208	Measurement of Resolution of Camera Systems. Study in progress.
P 606	Measurement of Colorimetry & Transfer Characteristic. Study in progress.

G-2.1.4 Video Transmission Measurements
James M. Walter, Chairman
RCA Corp David Sarnoff Research Center, Princeton, NJ 08540

Std 511	Measurement of Linear Waveform Distortion. Published 1980.
Std 205	Measurement of Luminance Signal Levels. Preliminary study initiated.
Std 206	Measurement of Differential Gain & Phase. First draft complete.

G-2.1.5 Video Recording Measurements
Alan S. Godber, Chairman
CBS Television Network, 555 W 57th St., New York, NY 10019

P 618	Measurement of Luminance SNR in VTRs. Released for publication.
P 619	Measurement of Moire in VTRs. First draft under consideration.
P 948	Measurement of Color Noise in VTRs. First draft in preparation.

G-2.1.6 Digital Technology
Abraham A. Goldberg, Chairman
CBS Technology Center, 227 High Ridge Rd., Stamford, CT 06905

–	Measurement of Differential Gain and Differential Phase in Digital Television Systems. Complete; to become part of Std 206.
P 746	Performance Measurements of A/D & D/A Converters for PCM Television Signals. Advanced draft under consideration.

IEEE TRANSACTIONS ON BROADCASTING, VOL. BC-28, NO. 3, SEPTEMBER 1982

RECENT ACTIVITIES of the IEEE AUDIO-VIDEO TECHNIQUES COMMITTEE

Robert G. Thomas, Chairman

RCA Corporation
Building 13-2-1
Camden, NJ 08102

The IEEE Audio-Video Techniques Committee is organized under the auspices of the Administrative Committee of the Broadcasting Group of BCCES. It is responsible for preparation and maintenance of IEEE definitions and standards for measurements pertaining to broadcast studio systems. The committee is concerned with measurement procedures only; it does not establish levels of performance or recommend operating practice.

Consistent with the scientific foundation of IEEE, members are appointed to the committee in the capacity of individuals who are experts in various phases of broadcast technology, rather than as representatives of a specific company or association. Members provide counsel in administration of committee business, which encompasses periodic reviews of existing IEEE broadcast standards, initiation of new standards, and review of proposed standards prior to submittal to the IEEE Standards Board. Some members also serve as chairmen of one of the six subcommittees which function as working groups for development or revision of standards applicable to a specific facet of the broadcast system. The subcommittees are listed below with the name and address of the chairmen, status of projects in progress, and recently completed work.

To be worthwhile, measurement standards developed by the committee must fulfill the practical requirements of all who are involved with the technical considerations of broadcasting. This is accomplished by codifying currently accepted practices (de facto standards), by developing an acceptable unified method where diversity and disagreement have existed, and by developing innovative techniques to satisfy needs that are only just becoming apparent. Inspection of the project listing will reveal that present work in the committee spans that entire gamut. New projects will be undertaken as resources permit. In the meantime guidance is solicited from engineers whose field experience has revealed the need for a measurement standard not currently available. Suggestions and comments should be forwarded to the Chairman.

1982 Committee Members

Irwin C. Abrahams	Harold Isaacs	Robert A. O'Connor	Robert G. Thomas, Chairman
Kevin G. Dauphinee	Thomas B. Keller, Jr.	Waldemar J. Poch	Laurence J. Thorpe
Alan S. Godber	Stephen B. Lyman	Frederick M. Remley, Jr.	James M. Walter
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Subcommittees and Current Projects of the Audio-Video Techniques Committee G-2.1

G-2.1.1 Definitions

Gwyneth H. Mallinson, Chairman; Ampex Corporation, 401 Broadway, M.S. 3-10, Redwood City, CA 94063

Std. 201 Definitions of Television Terms. Comprehensive revision in progress.

P847 Glossary of Digital Television Terms. Published 1982.

G-2.1.2 Audio Measurements

Kevin G. Dauphinee, Chairman; American Broadcasting Companies, 57 West 66th Street, New York, NY 10023

Std. 152 Measurement of Audio Volume. Preliminary study initiated.

G-2.1.3 Video Generation & Processing Measurements

Laurence J. Thorpe, Chairman; Sony Broadcast Products Co., 677 River Oaks Parkway, San Jose, CA 95134

Std. 202 Measurement of Aspect Ratio & Geometric Distortion. Rev. in progress.

Std. 208 Measurement of Resolution of Camera System. Study in progress.

P606 Measurement of Colorimetry and Transfer Characteristic (Gamma) of Camera Systems. Study in progress.

G-2.1.4 Video Transmission Measurements

James M. Walter, Chairman; RCA Corporation, David Sarnoff Research Center, SW 208, Princeton, NJ 08540

Std. 205 Measurement of Luminance Signal Levels. Preliminary study initiated.

Std. 206 Measurement of Differential Gain & Differential Phase. First draft.

Std. 511 Measurement of Linear Waveform Distortion. Published 1980.

G-2.1.5 Video Recording Measurements

Alan S. Godber, Chairman; CBS Television Network, 555 West 57th Street, Floor 10, New York, NY 10019

P618 Measurement of Luminance SNR in VTRs. Released for publication.

P619 Measurement of Moiré in VTRs. First draft under consideration.

P948 Measurement of Color Noise in VTRs. First draft in preparation.

G-2.1.6 Digital Technology

Abraham A. Goldberg, Chairman; CBS Technology Center, 227 High Ridge Road, Stamford, CT 06905

\- Measurement of Differential Gain & Differential Phase in Digital Television Systems. Complete; to become part of Std. 206.

P746 Performance Measurements of A/D and D/A Converters for PCM Television Signals. Advanced draft under consideration.

SPECIAL SESSION
NANBA
TECHNICAL COMMITTEE

<u>DOCUMENTS</u>

E. <u>SMALL FORMAT VIDEOTAPE RECORDERS</u>

Presented by:

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Senior Equipment Planning Engineer
American Broadcasting Companies

April 6, 1984

SMALL FORMAT VIDEOTAPE RECORDERS

This is an exciting era in the field of Electronic News Gathering (ENG) in broadcasting. Cameras are on the brink of incorporating fully solid state technology with all of its familiar advantages. Manufacturers of video recorders are similarly developing new products that promise improved performance, greater efficiency and smaller size and weight. At the same time, most users are wondering what to do about their existing ENG equipment which, in many cases, is now fully depreciated and is viewed as something less than state-of-art, if not just plain worn out.

As the many circumstances now confronting us begin to converge, we are presented, at one and the same time, with a tremendous opportunity and a formidable enigma. We have before us the prospect of great improvements in our capability for news reporting at the very moment news is moving to the forefront of importance at all levels of commercial broadcasting. However, enticing this opportunity is, though, it is accompanied by many vexing uncertainties: Just how should we go about the exploitation of the many advantages that seem to be offered by new technology? To which of the several recording systems now available or promised for the future should we commit ourselves? How do we avoid becoming unintentionally burdened with an "orphan" format? Should a changeover be made gradually or all at once? Or, should there be no change at all for now - should we patch-up what we have until the situation stabilizes? These are some of the questions that are being asked throughout the ENG field, and how effectively they are answered by each broadcaster will be an important factor in the future success of his news operation.

The decision making process is complex because it is comprised of both business and technical considerations. It is the purpose of this paper to assist with the technical aspects of the problem by providing some background on small format videotape recorders for ENG. The term "small format" refers to cassette-based systems employing tape widths of less than one-inch. The specific formats we will be considering are listed in Figure 1, and include 3/4-inch U-matic, 1/2-inch Betacam and Hawkeye (M-format), and the two 1/4-inch systems recently introduced by Bosch-Fernseh and Hitachi.

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When considering the performance characteristics of ENG equipment it is essential to weigh picture quality expectations against the basic purpose of the program, the conditions under which it is produced, and the monetary outlay for equipment, crews and transportation. Content is the sine qua non of news programming; some minimum level of video quality is required to tell the story, but additional quality does not necessarily tell it better. To over-emphasize picture quality could, in fact, intrude upon the creative process by imposing unnecessary constraints on the cameraman in terms of excess weight or size of equipment, shorter battery life, or shorter record time per cassette. All of this does not mean we should yield in the quest for an improved on-air look, in fact, systems recently introduced have achieved improved performance at minimal cost, but such efforts must be continually evaluated in the context of news presentation. The concern for picture quality might best be addressed in the post production phase in terms of improved multiple-generation dubs.

The basis upon which 3/4-inch video recorders were judged at the time of their introduction, was the film equipment and development processes they supplanted. Similarly, any new ENG recording equipment should be assessed in relation to 3/4-inch U-matic. To qualify as a legitimate successor to U-matic, four criteria (Figure 2) should be met by the new system:

1. Conformance to a single industry standard
2. Reduced size and weight
3. Capability for superior quality dubs
4. Reduction of signal processing picture impairments

The 3/4-inch format in common use today has become a de facto industry standard because it has been universally accepted by broadcasters and has been uniquely available virtually only from a single source, which tended to limit variants that might otherwise have diluted the standard. As a result, U-matic equipment is readily available throughout the world, it is supported as a complete system with a variety of equipment that is well understood by operators and maintenance technicians, and it has thus become the universal medium for news recording among networks, affiliates and independents. One commitment to the U-matic format is illustrated by the situation at ABC, where we have five hundred BVU-type machines and an equal number of industrial machines - certainly a weighty matter when a change is contemplated!

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To capriciously change from the existing de facto standard to a new ENG recording format is to risk isolation from the rest of the broadcast community. Consider the chaos that would result from a multiplicity of so-called "standards." For example, a network news crew on a breaking story rushes a cassette to a nearby affiliate for relay only to be frustrated because the affiliate has incompatible equipment and is unable to play the tape. Pool feeds with heavy reliance on equipment and tape interchange would be impossible to implement. Stringer crews could find themselves outcasts due to equipment incompatibility. Although an in-house standard might suffice at a geographically isolated independent station, it is unthinkable for most broadcasters. When a new format is adopted it absolutely must conform to a single industry-wide standard.

For an investment in new equipment to be worthwhile, there must be some "payback." One of the most significant returns sought is a saving in size and weight, not only in camera-mounted recorders where the advantages are obvious, but in field editing equipment that must be shipped over great distances, transported near the site of the news, and then set up in remote locations that are often lacking in convenience. For example, the Travel Edit Pack normally supplied to ABC field crews is contained in thirteen shipping cases having a total weight of seven hundred pounds. Approximately one-half of that weight is devoted directly to the videotape recorders, a timebase corrector and edit controller, the remainder being monitors and other support equipment. The cost to ship one Travel Pack from the U.S. to Central America by commercial airline is $1500, and once there it must be transported locally by the field crew to their working location, perhaps a hotel room. Air freight cost for the same trip on a per pound basis is $10,000. With over fifty of these systems in circulation worldwide, the incentive to reduce size and weight is quite clear, and it has been an item of top priority in our discussions with potential vendors.

One of the principal influences on the size of a tape transport, and hence its weight, is the width of tape used. Tape width has an indirect influence on transport dimensions because narrower tape requires shorter distances in the tape path to accommodate angular transitions. Furthermore, the physical properties of narrow tape with respect to edge guiding forces permit thinner tape stock to be employed, thus enabling a greater length of tape to be housed in a given cassette size.

.../

A comparison of cassette sizes for the systems under consideration is shown in Figure 3. In all cases, program length for these cassettes in their associated ENG format is twenty minutes which, because it has been a customary capability of the ubiquitous U-matic portable recorder, is considered a minimum record time by field crews. The advantage of the 1/4-inch Compact Video Cassette (CVC) is very apparent in this comparison. What may not be so obvious is the practical advantage to the cameraman of being able to stuff several 1/4-inch cassettes into his jacket pocket in preparation for a day's shooting.

An advantage often sited for employing standard consumer Beta and VHS cassettes which are used, respectively, for Betacam and M-format broadcast equipment, is that in an emergency, cassettes can be purchased in retail stores (although they would not be loaded with the professional grade tape required for peak performance in broadcast service). Although less widely acknowledged, a disadvantage to the use of consumer cassettes is "shrinkage," a euphemism for pilferage which, distasteful as it might be, is a reality that could represent substantial loss of tape inventory if consumer cassettes were widely used in ENG. In the long run, however, it is physical size that distinguishes one cassette from another, and which indirectly affects transport size and weight. A comparison of typical mechanical characteristics of 3/4-inch and 1/4-inch VTRs is given in Figure 4, where advantages accruing from use of the smaller format may be readily seen.

An earlier comment made reference to enhancement of on-air ENG picture quality through improvements in post production dub quality. In the new systems this is accomplished in two ways. First, there is a basic improvement in picture quality resulting from separation of brightness and color components in the record and reproduction processes. Second, editing and dubbing operations retain the component format whenever possible, even avoiding FM demodulation and re-modulation in many instances. The combination of these techniques commonly yields third generation dubs from the new formats that are, in most respects, equivalent to first generation U-matic performance. Typical first generation performance of 3/4-inch and 1/4-inch systems is shown in Figure 5. Note, in particular, the reduction of chrominance noise, which is the key to the enhanced performance of all the new formats. How this is accomplished is to be the subject of following description.

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In the spectrum of the U-matic recorded signal, chrominance and luminance sidebands overlap in the region of 1MHz as illustrated in Figure 6. In addition, luminance upper sidebands are severely attenuated due to high frequency losses in the record and reproduction processes. The result of these two effects is objectionable interference between luminance and chrominance and poor transient response in reproduced pictures.

Two approaches have been employed to overcome difficiencies associated with the U-matic format. In the Hawkeye system, or M-format as it is commonly known, chrominance is separated from luminance and decoded to baseband Q and I components. As shown in Figure 7, luminance is then recorded on one track as an FM signal, and the two color difference components from decoded chroma are recorded on a separate, substantially narrower track. The I component is recorded as high level, high frequency FM, and the narrow bandwidth Q signal is recorded as low level, low frequency FM. An important principle of this method is that the I FM carrier acts as HF bias to linearize the recording of the Q component to improve I/Q channel isolation. Furthermore, I and Q signal bandwidths are optimum for color transmission requirements because luminance and color components are handled in entirely separate channels, and because there is no subcarrier involved in the recording process, the reproduced picture does not suffer from crossmodulation effects and subcarrier moiré.

A somewhat different approach is taken in the Betacam format illustrated in Figure 8. Luminance is recorded on one track as in the M-format, but two equal-bandwidth color difference signals are compressed to one-half of their real time duration and recorded on a second track using FM. In the playback mode, R-Y and B-Y color difference components are time expanded to their original durations and re-encoded with Y to replicate the original NTSC video. Again, many of the undesirable artifacts that degrade U-matic performance are eliminated by recording brightness and color components in completely independent channels.

Further improvements in both systems may be realized in dubbing by leaving the playback signals in their component state without intermediate encoding and decoding. In editing, however, serious complications arise from the use of components, especially when it becomes necessary to combine NTSC-encoded live material with recorded material in component form. Monitoring also becomes awkward when a mixture of component and encoded signals are processed together in a normal plant. Therefore, the potential

.../

advantages of component dubbing may not be economically realizable but, as already discussed, ENG performance does not demand superlative quality. When editing is involved, the most practical approach, as illustrated in Figure 9, is to encode reproduced tape video to NTSC, perform necessary effects and edit operations, then decode the combined video for component recording on the master VTR. In short, complexity interjected by component video into the otherwise routine editing process is only tolerated because of the dramatic improvement in video performance which results from component recording.

To the misfortune of nearly all concerned, the manufacturers of M and Betacam formats have failed to agree upon a common standard. Each manufacturer has recently initiated development of separate SMPTE standards for their own individual format but the essential commonality is missing, making these two "standards" no more useful to broadcasters than two "standard," but different, track gauges would be to the nation's railroads.

Timely developments in 1/4-inch cassette-based recording formats have revealed new possibilities for compactness in ENG video recorders. Additionally, and perhaps of greater importance, the industry has been presented with a new opportunity for development of a common industry-wide format standard. Intense effort by an SMPTE Working Group has been underway since June 1983 to rationalize rather significant differences in 1/4-inch formats promulgated by Bosch-Fernseh and Hitachi. This effort is not confined to the record format alone, but encompasses mechanical and electrical characteristics of the camera/VTR interface as well. So in the future, if the Working Group succeeds, ENG crews will be able to mount a 1/4-inch recorder directly on the back of any new-type camera without resorting to special adaptors.

Both 1/4-inch systems utilize separate channels for brightness and color as in the 1/2-inch systems. The Hitachi format is similar to Betacam in that luminance is recorded in real time as FM on one track, and (R-Y) (B-Y) color difference signals are compressed 2:1 in time and then recorded on a separate C track, as illustrated in Figure 10. On playback, the color difference signals are expanded to their original durations and combined with luminance to reproduce video as originally recorded.

.../

Bosch employs a different approach. Before recording, composite NTSC video is decoded into luminance and two color difference components. The luminance (Y) component is expanded to 1.5 times its normal duration, and each color difference signal is compressed by a factor of one-half. As in the other systems, two tracks are recorded, but each track handles both luminance and color difference components as shown in Figure 10. Color difference signals are recorded sequentially so that, for each TV line of the original picture, one complete brightness signal is recorded, but only one of the two color difference signals is recorded. This method of line-sequential color recording is designated "Lineplex" by Bosch.

An advantage claimed for the Lineplex format is that expansion of luminance duration reduces its recorded bandwidth from the normal 3.6MHz to only 2.4MHz, resulting in long recorded wavelengths. Another advantage cited for Lineplex is that channel bandwidths for brightness and color is in the correct ratio of 3:1. However, these advantages are obtained at the expense of vertical color resolution, which is diminished to one-half normal because of line-sequential color transmission; in effect, one-half of the color information in the picture is discarded. Moreover, additional loss of vertical resolution is incurred with each generation in dubbing.

Because of fundamental differences in the characteristics of video in the Bosch and Hitachi systems, there are corresponding differences in the parameters of the FM record formats, as illustrated in Figure 11. Bosch, because luminance bandwidth requirements have been actually decreased by two-thirds, is able to utilize lower FM carrier frequencies. The resultant longer wavelengths recorded on tape should not be affected by head/tape separation losses to the extent that the shorter wavelengths in the Hitachi format might be. This is said to improve signal-to-noise ratio (SNR) and also make the Bosch format more immune to dropouts caused by intrusion of dust and other foreign particles. There are many influences on the practical effects of SNR and dropouts, however. Although recorded wavelength is one, no less important is scanner and head design, and implementation of dropout detection and concealment circuitry. Whether the benefits claimed for Lineplex are worth a 50% reduction in vertical color resolution is a matter of conjecture.

.../

Hitachi has chosen to record the full color picture and has thus had to employ higher carrier frequencies as can be seen in Figure 11. As a result, the signal-to-noise ratio initially suffers in relation to the Bosch format. Hitachi has proposed to counteract the loss of SNR by the use of metal particle tape. But there are disadvantages to metal particle tape, primarily because its magnetic properties impose penalties on head design and make recordings subject to deterioration in severe environmental conditions. At the urging of the SMPTE 1/4-inch Working Group, Hitachi is optimizing their system parameters for standard oxide tape. Further developments in the tape field are expected to overcome some of the remaining SNR disadvantages in the near future.

To summarize, the fundamental difference between Bosch and Hitachi formats is long wavelength versus short wavelength recording. The former requires a deletion of color information (Lineplex) to make room on tape for the longer signal wave lengths, while the latter relies on special tape and refined design techniques to accommodate short recorded wavelengths. In the long run, it will be user expectations, in combination with manufacturers' true willingness to compromise, that will determine the final outcome of the standardizing process for 1/4-inch formats.

Generally speaking all of the systems now provide, to varying degrees, three out of the four criteria listed earlier which should be met by a replacement for U-matic. They are all smaller and lighter (although that cannot be said for some of the recorder/ players intended for editing), their dub quality is better, and they produce intrinsically better pictures from the camera. What is obviously lacking is conformity to a single industry standard, and that issue is at the core of the entire ENG enigma.

The standards issue is bound to be resolved eventually; it cannot possibly resist the pressure that is building within the industry. Hopefully, the SMPTE will be instrumental in developing a standard. If not, honors might go to the format which is supported by a system of ancillary equipment having the greatest variety and flexibility. It is essential, however, that the format ultimately adopted be the best one for ENG, and it is here that a thorough understanding of technical principles becomes indispensable to the broadcaster. Unfortunately, a brief technical overview as presented here cannot, in itself, answer the myriad questions associated with format selection, but it might provide a foundation of understanding upon which informed decisions can be made.

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What should be done in the meantime? For one thing, there is a need for user input, especially from medium- and small-size facilities, both in the open forum of the standardizing process, and in direct contact with equipment manufacturers. ABC has participated in numerous productive dialogs with manufacturers who have been consistently attentive and responsive to our comments, particularly from the field crews who experience the real world of ENG. Smaller users might not have such direct access to design departments, but the opportunity should not be ignored for feedback through manufacturers' marketing and sales forces, and network engineering staff.

This is a good time to establish a plan and alternate contingency plans for the day when a changeover in ENG facilities is begun. The strategy adopted will naturally depend on the size and deployment of the existing ENG operation, the budget and anticipated requirements of the news department. The present plan at ABC envisions conversion of European systems first, followed by bureau-by-bureau changes in the U.S. and concluding with conversion of facilities in New York and Washington, and finally Asia.

Finally, when should a change be made? Certainly not until a common industry standard has been established, by whatever means that will be accomplished. Avoid, at all costs, the temptation of a premature decision that could lead to ownership of an orphan format. After all, U-matic is not so bad; we have been using it for a long time and the longer standardization of a replacement format remains elusive, the more profitable U-matic looks. In the final analysis, consider how many viewers complain about ENG picture impairment. If a change in facilities is not mandatory right now, wait awhile longer. That Great Standard in the Sky is on its way!

The author would like to express his appreciation to Michael Fisher, Vern Pointer, and Julius Barnathan for permission to present this paper, and for the counsel and advice received in its preparation.

Robert G. Thomas

SMALL VTR FORMATS

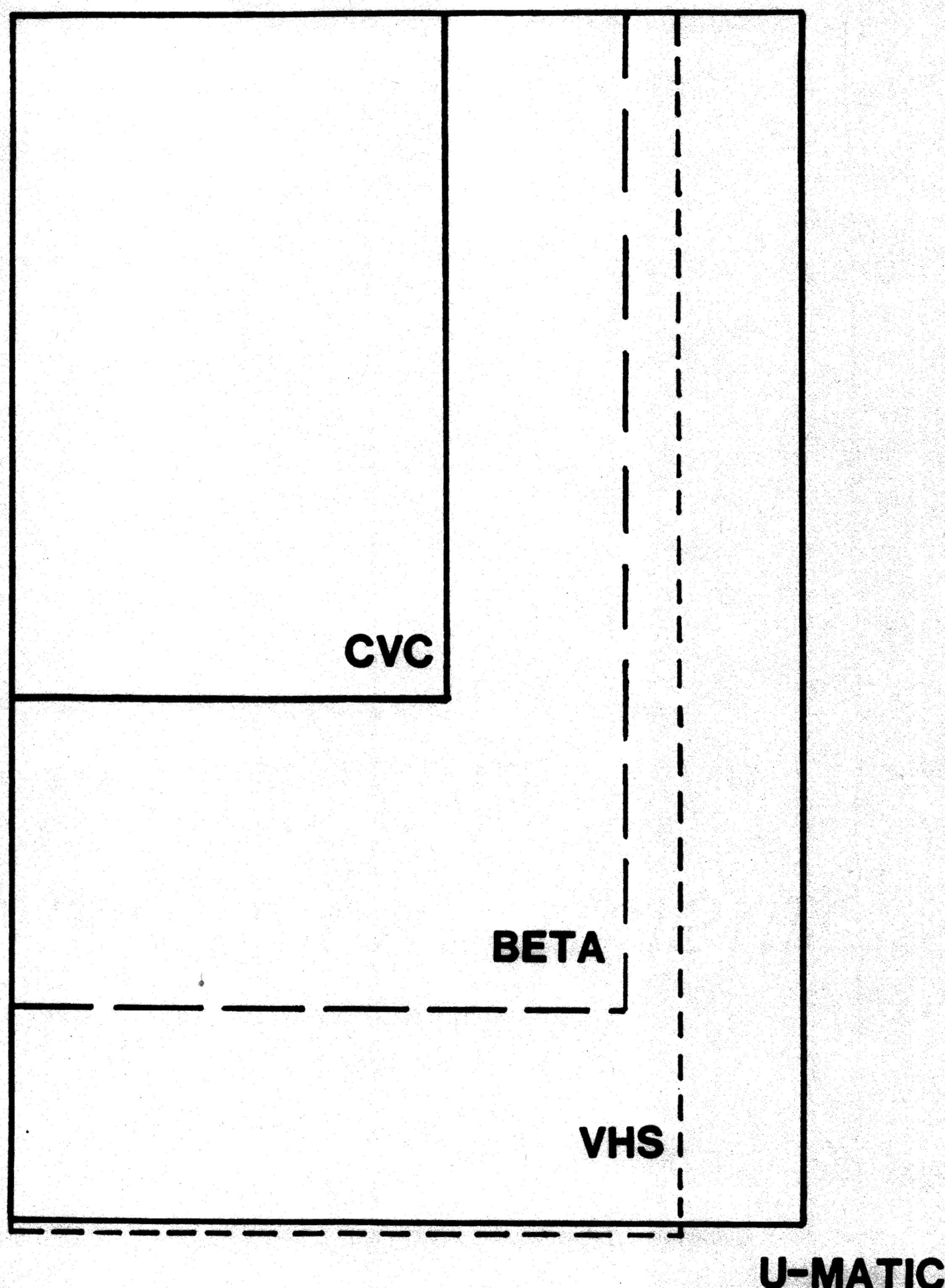
3/4-INCH	U-MATIC
1/2-INCH	BETACAM
1/2-INCH	HAWKEYE
1/4-INCH	BOSCH-FERNSEH
1/4-INCH	HITACHI

FIGURE 1

CRITERIA FOR A NEW ENG RECORDING SYSTEM

- SINGLE INDUSTRY STANDARD
- REDUCED SIZE AND WEIGHT
- SUPERIOR DUB QUALITY
- REDUCED PICTURE IMPAIRMENT

FIGURE 2



CASSETTE SIZE COMPARISON

FIGURE 3

3/4–" - 1/4"
MECHANICAL COMPARISON

	3/4"	1/4"
RECORD TIME	20	20 MINS.
TAPE SPEED	95.3	120 MM/S
DRUM DIAM	110	60 MM
WRITING SPEED	10.26	5.5 M/S
TAPE USAGE	18.1	7.6 CM^2 /S
VTR WEIGHT (TYP)	12	6 LBS.

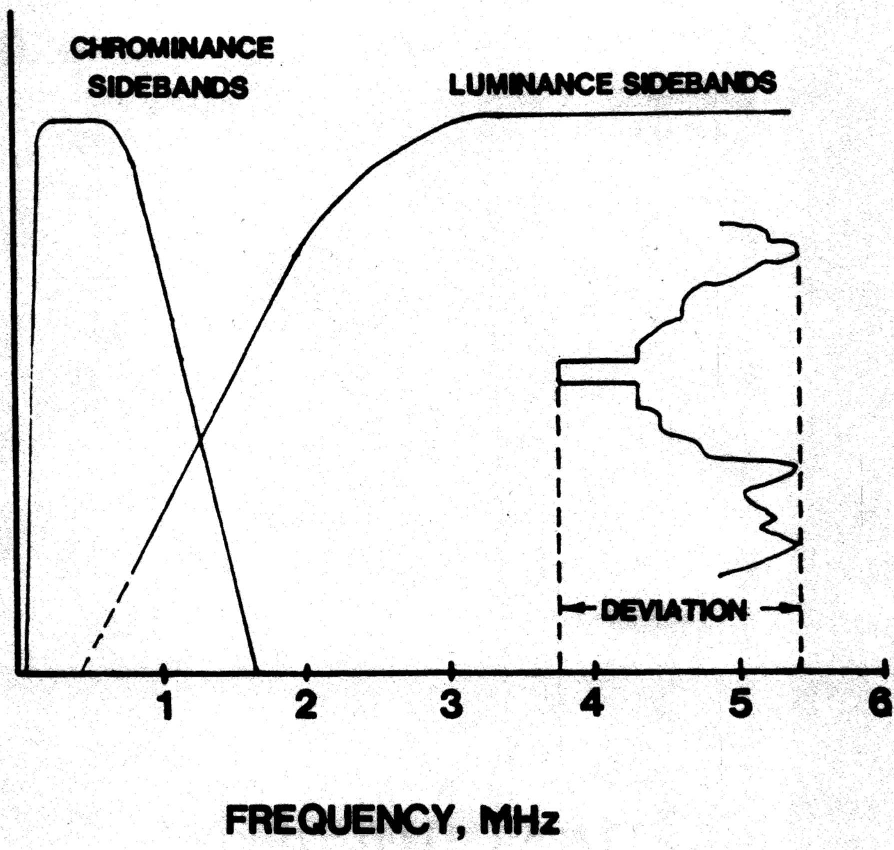
FIGURE 4

3/4" - 1/4"
ELECTRICAL COMPARISON

	3/4"	1/4"
LUMINANCE B.W.	3.2	3.6 MHZ
CHROMINANCE B.W.	1.1	1.3 MHZ
LUMINANCE SNR	46	47DB
CHROMINANCE SNR	37	47DB
K-FACTOR	5	3%
DG/DP	5/5	3%/3°

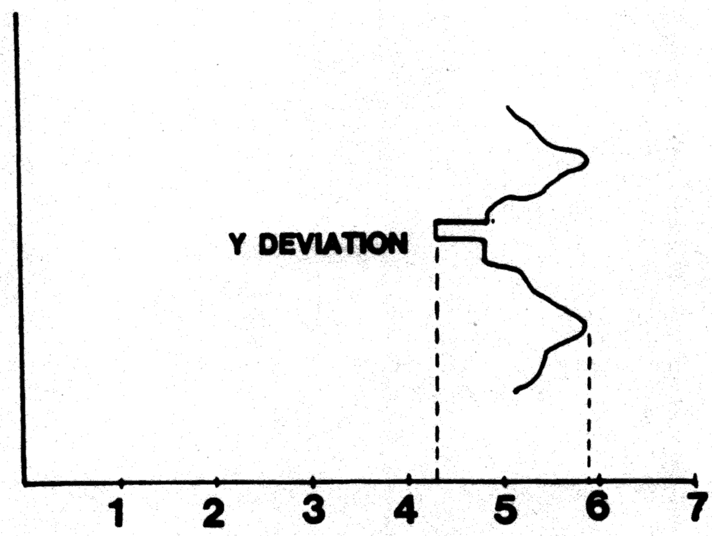
(TYPICAL PERFORMANCE)

FIGURE 5

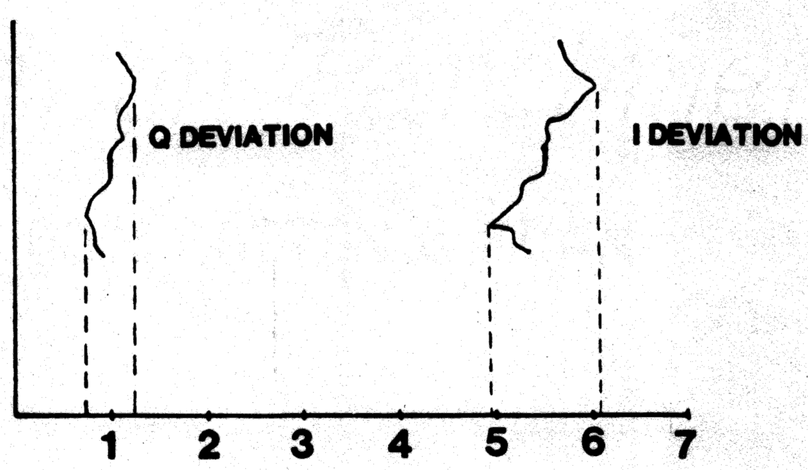


U-MATIC FM SPECTRUM

FIGURE 6



HAWKEYE (M-FORMAT)



NOTE: Q RECORD LEVEL 12 dB BELOW I RECORD LEVEL

FIGURE 7

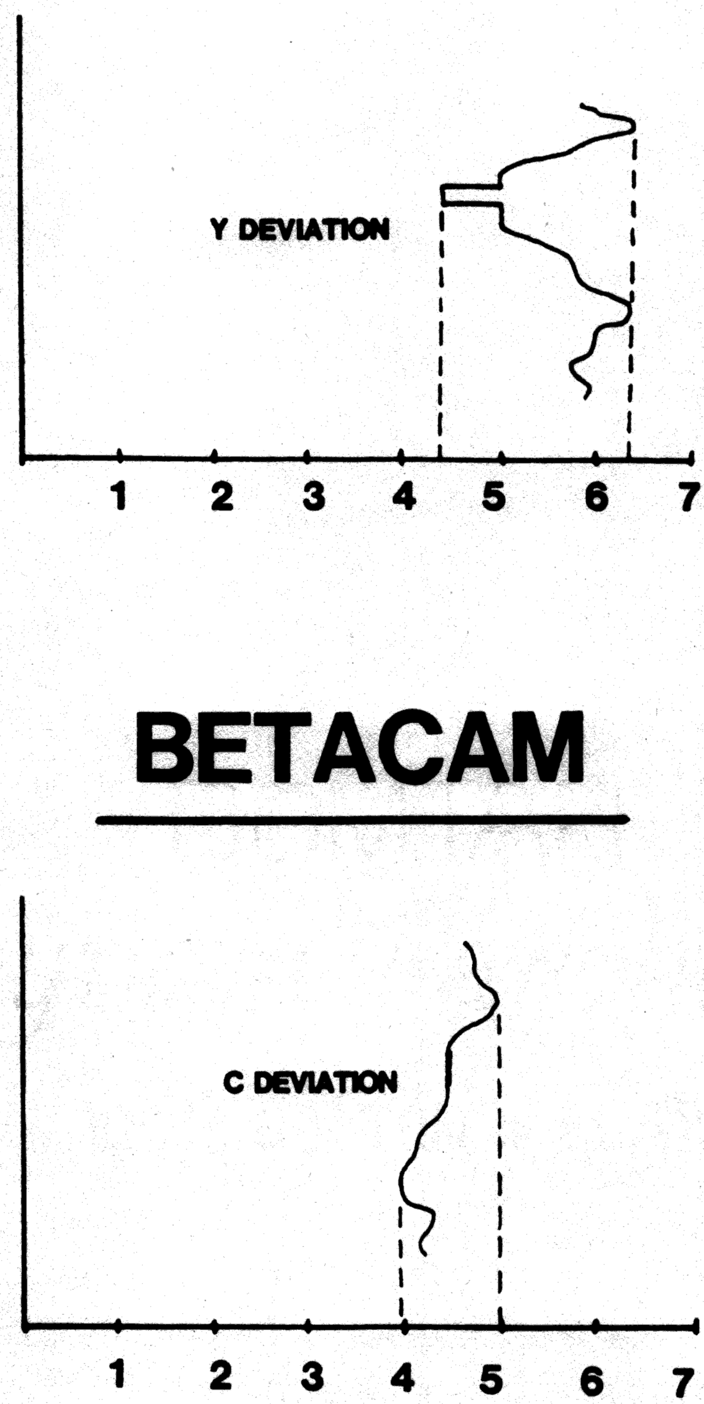
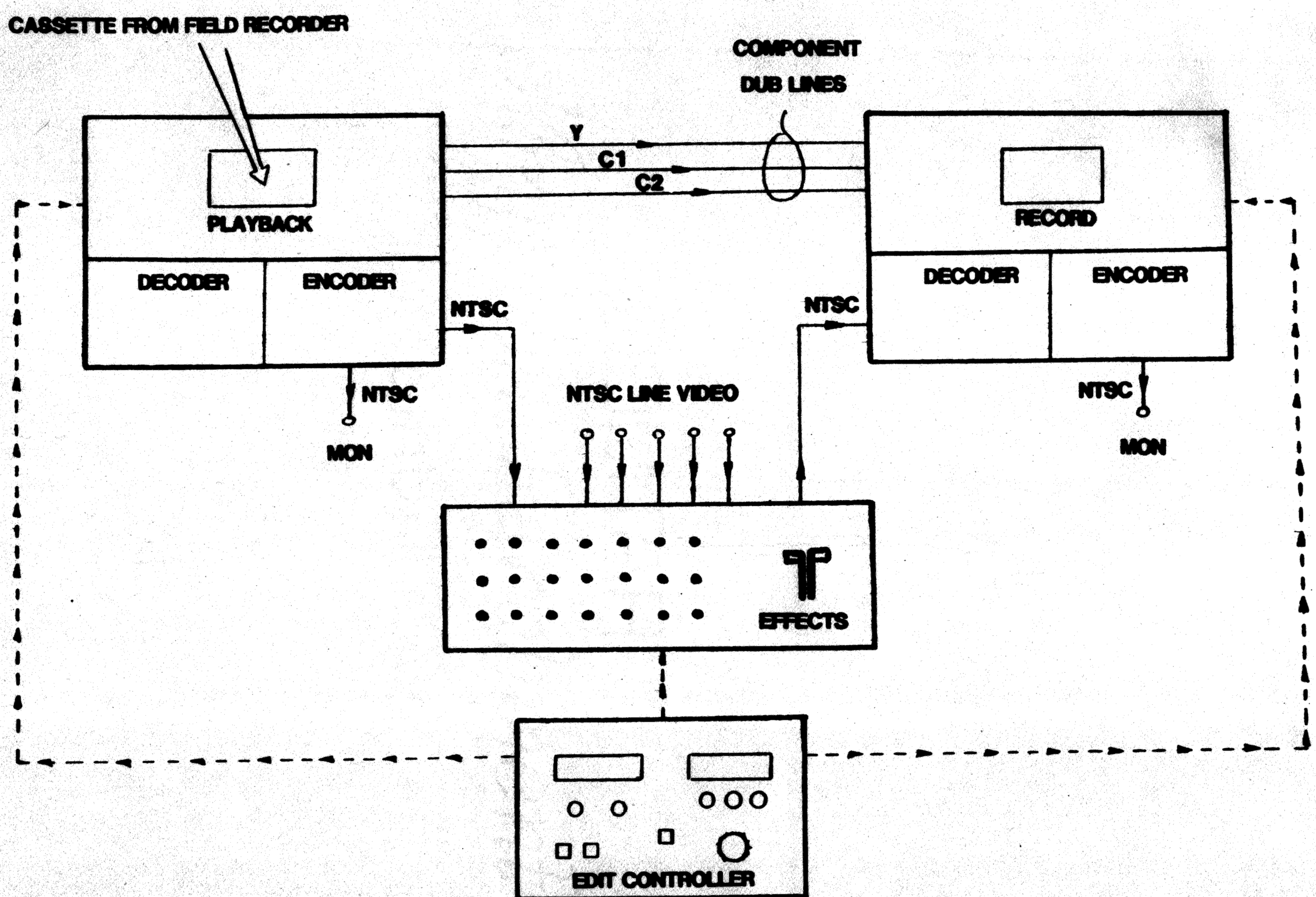


FIGURE 8



CASSETTE FROM FIELD RECORDER
COMPONENT
DUB LINES
Y
C1
C2
PLAYBACK
DECODER
ENCODER
NTSC
NTSC
MON
RECORD
DECODER
ENCODER
NTSC
NTSC
MON
NTSC LINE VIDEO
EFFECTS
EDIT CONTROLLER

FIGURE 9

BOSCH-FERNSEH LINEPLEX

|←1H→|

EVEN TRACKS

1	2	3	4	5	6	7	8	9
Y	Y	R-Y	B-Y	Y	Y	R-Y	B-Y	Y

11	12	13	14	15	16	17	18	19
Y	Y	R-Y	B-Y	Y	Y	R-Y	B-Y	Y

ODD TRACKS

1/4-INCH SIGNAL FORMATS

HITACHI - VERSION III

|←1H→|

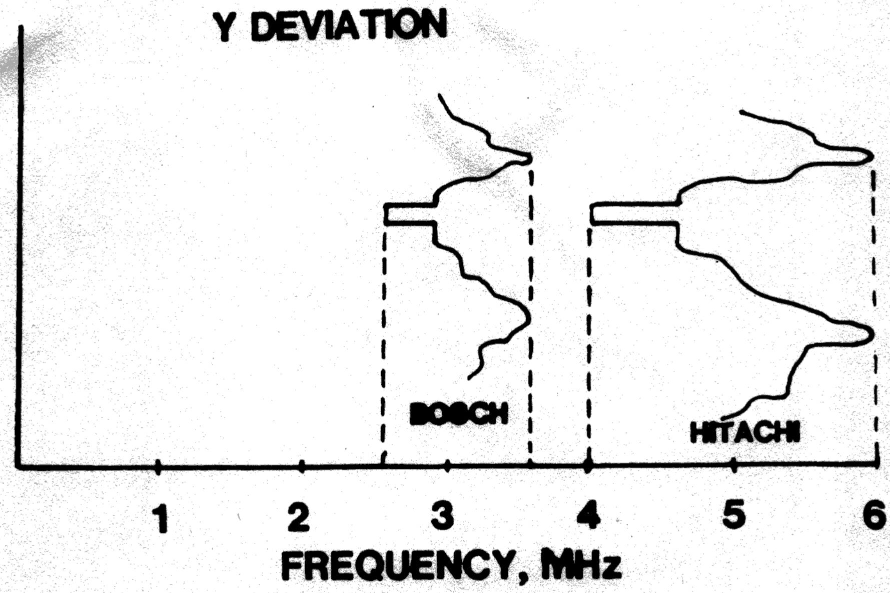
Y TRACK

1	2	3	4	5	6	7	8	9

11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19
R-Y	B-Y	R-Y	B-Y	R-Y	B-Y	R-Y	B-Y	R-Y	B-Y	R-Y	B-Y	R-Y	B-Y	R-Y	B-Y	R-Y	B-Y

C TRACK

FIGURE 10



1/4" FM DEVIATION

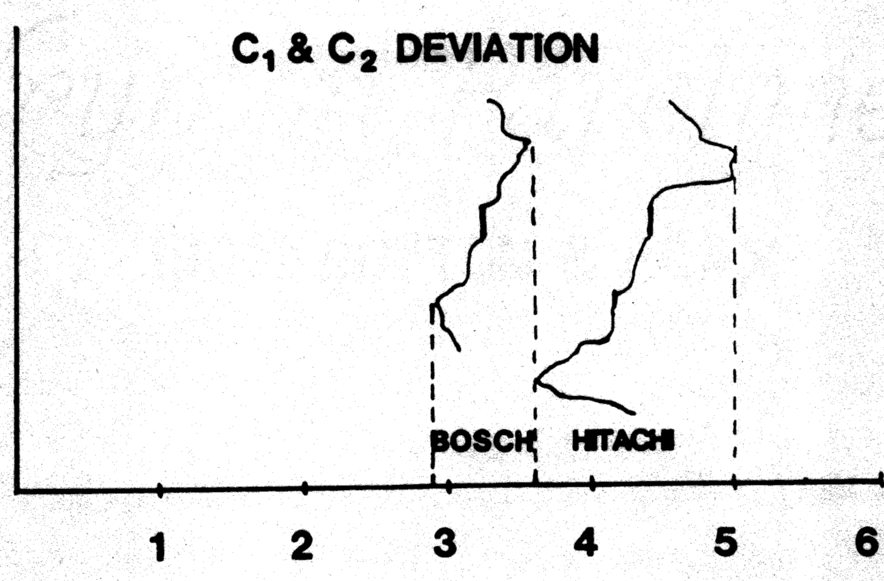


FIGURE 11

EVALUATION OF SMALL-FORMAT VTR PERFORMANCE

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- ABSTRACT -

Recently developed component analog television recording formats appear to offer numerous advantages to broadcasters. A process for the technical evaluation of equipment employing these new formats has been in use at ABC for several years. Rigorous laboratory measurements and field tests are used to determine the unique capabilities of specific product lines as well as a comparative assessment of competing formats. The rationale for each test is given and refinements in test techniques, introduced as the evaluations progressed, are described. The significance of objective and subjective test results is considered in relation to the practical application of recording equipment in the broadcast plant. Suggestions are given for adaptation of complex evaluation procedures to the resources normally available to broadcasters with limited test facilities.

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For the first twenty-five years of television broadcasting, news reporting was based upon the medium of photographic film. But in 1971, a quantum change occurred with the introduction of U-matic recording, ushering in the concept of Electronic News Gathering (ENG), perhaps the most significant technical development in modern journalism. So universal was the acceptance of U-matic, that it swiftly became a <u>de facto</u> standard, universally embraced by the entire industry from the largest networks to the smallest stations.

The status quo was maintained in ENG recording with the U-matic format reigning unchallenged until 1982, when Sony and Matsushita introduced competing Betacam and M formats. This new equipment offered two advantages over the U-matic system they were intended to supplant. First, they were based on the concept of component analog recording, and thus avoided chroma noise and various artifacts associated with the U-matic color-under system. Second, they arrived in an era when it had become feasible to combine an ENG camera and recorder into a single, integrated package that could be managed by one person.

Despite the efforts of all concerned, competitive rivalry between the proponents of Betacam and M formats precluded the possibility of a new single standard that would have promoted universal program exchange to the degree already enjoyed with U-matic. Use of U-matic continued virtually undiminished, and marketplace forces began in their own uncertain way to determine the dominant 1/2" format. At the same time, ENG recording on 1/4" tape was proposed by two manufacturers.

An SMPTE Working Group was chartered to pursue development of a common standard from the two diverse 1/4" proposals, and began with a study of the performance of each 1/4" format relative to the other and relative to U-matic, which was taken as a benchmark ENG system. An objective test program emphasized measurements that could be related to subjective picture quality. A subjective phase of the tests involved recordings of live scenes which, when analyzed, generally correlated with the numerical results and test chart analyses. The format tests were very instructive, and have been subsequently used as the basis for numerous small-format evaluations conducted at ABC.

VTR evaluations should not be taken lightly. To be of real value they must be meticulously carried out in a process that is time consuming and costly. Even before embarking on such an undertaking, evaluations should be placed in perspective with other vital elements of the small-format VTR selection process.[1]

The first consideration when contemplating a format change is the economic justification for supplanting existing equipment. A second key requirement is to develop an appreciation for the practical needs of Operations who are, after all, customers of the Engineering department! Additionally, market size, local competitive situation, current status of the equipment renewal and amortization cycle, and allocated capital, must all be given appropriate weight in relation to the needs of Operations. If the necessary prerequisites are found to exist, a program for carrying out the evaluations can be formulated.

Two approaches can be taken with format evaluations, depending on technical and financial resources. Large organizations can enjoy full benefits of exhaustive objective measurements in elaborately equipped laboratories supplemented with extensive hands-on experience in Operations. Companies not so well endowed can still gain useful knowledge of equipment performance by using existing facilities, however modest, and carefully planned subjective evaluations which employ familiar operating practices and normal program sources. While the use of a full range of test equipment will produce numerical data that can be saved for reference, the subjective approach will be no less valuable in depicting nuances in performance that will equip the small user with insight to the most subtle differences between formats.

One generalization must be explained before proceeding. Although every effort will be made to describe useful techniques, detailed procedures must necessarily be avoided because of space limitations. Furthermore, testing in the composite, rather than component mode will be stressed. At some point, both modes should be evaluated and relative performance compared, however, most U.S. broadcasters exist primarily in an NTSC environment, so concentrating on composite performance evaluation will yield the most practical results in the shortest time.

One of the most significant performance attributes of any VTR is resolution in luminance and chrominance. In component analog formats, resolution in the two channels may be treated independently. Considering luminance resolution, an electronically-generated multiburst is the most readily available and easiest to interpret test signal. Due to limitations in some VTR signal systems, half-level multiburst (50 IRE p-p) should be used to avoid misleading results caused by waveform distortion. If a test signal generator is unavailable, a multiburst test chart may be reproduced by a camera. Tube cameras might require somewhat greater than normal horizontal peaking to compensate for aperture loss; high quality CCD cameras generally reproduce multiburst charts with good response with normal peaking. In either case, since there will be some high frequency rolloff at the camera output, multiburst characteristics at the VTR input should be noted for reference when judging VTR amplitude response. Carefully applied, camera multiburst charts can provide almost as much useful information about VTR resolution as a signal generator source, and they have the added advantage that they duplicate typical field origination. Another good luminance resolution test chart is, naturally, the commonly available vertical resolution wedge, which is capable of yielding a very useful quasi-objective comparisons of VTR resolution.

Multiburst response does not always completely characterize luminance resolution because most small-format VTRs employ some form of noise reduction. Depending on the sophistication of the noise reduction system and the degree of noise reduction employed, low amplitude high frequency picture information, which cannot be distinguished from random noise in simple noise reduction systems, is often diminished along with the noise. [Figure 1.] This results in reproduced pictures which appear sharp in contrasty parts of the scene, but which fail to correctly render subtle texture in grass, tree foliage, skin blemishes, and hair detail, i.e., pictures acquire an unnatural "cartoon" look. This effect becomes exceedingly obnoxious in multiple-generation dubs.

An early method for evaluating detail resolution was with the use of a very low level multiburst, perhaps 10 IRE Units, superimposed on a variable pedestal so that the entire video dynamic range could be explored. Recently this technique has been superseded by a sequence of video carrier frequencies amplitude modulated with a bow-tie envelope. [Figure 2.] Detail resolution is indicated by the accuracy with which the central nulls are reproduced. While revealing for those fortunate enough to have access to such specialized test gear, the bow-tie test, or any analytical test for that matter, can be easily circumvented with a camera and live scenes which emphasize texture.

At ABC we use a "standard" series of outside scenes near Lincoln Center that are useful for judging detail resolution as well as most other attributes of small-format VTRs. The buildings at Lincoln Center are constructed of distressed marble having nebulous dark veins trailing through the stone. We have found through numerous evaluations, that an excellent correlation exists between measured detail resolution and the subjective rendition of this stone. In addition, the columns of Lincoln Center buildings present numerous vertical edges of high contrast that are a critical test for large-signal resolution, transient response, and edge busyness. Distant buildings contain medium contrast window detail useful for evaluation of mid-range resolution, and some architecture presents closely-spaced horizontal detail that reveals FM system aliasing. All broadcasters have similar natural scenes nearby that, with consistent use and gradual familiarization, will serve admirably for inexpensive and practical analysis of luminance resolution without spending one cent on test equipment.

Evaluation of chrominance resolution is not quite so straight forward as for luminance. Again, test equipment manufacturers have answered the need with a variety of suitable techniques. The obvious approach is use of a limited range sweep frequency for measuring the amplitude response of the color difference channels. Another is a modulated sine squared pulse to simultaneously indicate amplitude response and phase linearity. A multipulse signal is also available for similar dual-parameter analysis. Specialized test signals for color difference channel analysis are used exactly as in luminance channel investigation, except their that their spectra are tailored specifically to the narrower chroma bandwidth. They are useful for equipment adjustments, verifying specifications and objective comparisons of competing products, but they do not produce data that is easy to relate to subjective performance. This is partly due to our relative unfamiliarity with correlation between chroma channel characteristics and color picture quality, and partly to certain intentional departures from ideal chrominance processing which are incorporated by manufacturers to achieve optimum subjective performance.

Once again, purely subjective testing can produce an outstanding appreciation for chrominance channel performance without resorting to specialized test equipment, and using only facilities commonly available to broadcasters. ABC has developed a series of simple color-stripe test charts that have proved invaluable in our small-format investigations. These charts are based on one developed many years ago by Tektronix for color monitor I and Q channel evaluation. Our version consists of alternate colored stripes, made by pasting 1/4" strips of appropriately colored paper at 1/4" intervals on a suitably colored background. The charts are 9" x 12", with 17 cycles of alternating colors. When standing vertically and framed to occupy one-third of picture width, these charts generate a spatial frequency of approximately 1MHz that is optimum for exercising the color difference channels as well as encoders and decoders.

The most useful color stripe combination is red and blue. These two colors produce large level changes in the R-Y and B-Y channels with comparatively little change in luminance, thus restricting the source of picture impairments primarily to chroma channels. Red and cyan is another useful stripe combination, because it produces a nearly worst case level change situation simultaneously in both the chrominance and luminance channels. Camera video output to the VTR may be composite NTSC or components, depending on whether encoders and decoders are to be included in the evaluation.

Typically, the most prominent distortion generated by component analog VTRs in pictures of stripe charts is related to the transient response of the color difference channels. In fact it is common, when monitoring R-Y and B-Y waveforms, to observe that the basic 1 MHz repetition rate of color variation is doubled to 2 MHz. It might be argued that sophisticated modulated sine squared pulse testing, which seldom reveals such gross distortion, is a more realistic test because its spectrum is confined to the chroma channel passband. Nothing could be further from the truth; graphics, product shots, and many real outdoor scenes contain color transitions as short as the ones produced in the stripe charts. It is of interest that this phenomenon is completely absent in Type-C VTRs, casting some doubt on the existence of a "universal" 1/2" format.

While the stripe charts described above are helpful in analyzing certain aspects of color difference channel performance, they do not reveal chroma resolution. For that purpose, a variation on the stripe chart is employed, in which a combination of stripes and wedges explores the resolution of the color difference channels under a variety of conditions. This chart is constructed of strips of constant width, pasted down at angles to generate wedges without resorting to cutting or handling delicate thin sections of paper. By framing the stripe and color resolution charts at various angles and zooming in and out, a great deal can be learned about chroma channel performance.

As with luminance resolution, outdoor scenes offer numerous examples of chroma detail that, although uncontrolled in comparison to home made test charts, is revealing without requiring extra effort or expense. In addition to chroma resolution, such scenes will reveal luminance/chrominance delay errors, low frequency streaking, large area hue shift, shading and pedestal drift. Two of the best subjects for investigating chroma channel performance are also the most abundant: tree foliage and grass.

Before leaving the topic of resolution, note should be made of an excellent reference picture, the BBC Test Card Number 61 Flesh Tone Reference. The basis for production of this chart and recommendations for its use have been described in detail[2] and will not be elaborated upon here, except to say that the subject matter is rich in detail sensitive to the performance attributes of VTR formats, making it one of the most useful picture sources employed in ABC evaluations. It is available in two sizes from major suppliers of test charts, the largest size (18" x 24") being preferable.

One of the techniques applied to recording systems to stretch performance beyond the intrinsic capabilities of component analog small formats is nonlinear preemphasis. The fundamental principal of nonlinear preemphasis is the application of large amounts of high frequency peaking (preemphasis) to small signal level transitions with successively less peaking to larger level changes. [Figure 3.] The intent is to reduce noise and enhance edge resolution as much as possible without incurring over-deviation. As with most techniques for extending performance, there are side effects that should be considered in format selection.

One requirement of nonlinear preemphasis processing is precise control of signal levels because if levels are incorrect, nonlinear preemphasis (or postemphasis) will necessarily be incorrect, causing transitions to be excessively peaked or underpeaked, depending on the level errors. Another side effect that occurs is in reproduction of small circles. Due to the tendency of nonlinear preemphasis to slightly advance the timing of slow, low level video transitions, such as upper and lower edges of circles nearly tangent to scanning lines, circles tend to become geometrically distorted into squares. This effect is most easily observed with test pictures containing small circles, or eye detail.

Another impairment common to component analog small formats is "edge-busyness." This is the result of three phenomena. First, uncorrected timebase errors cause edge jitter which increases across the line as video becomes more distant from the point at which TBC correction is applied. Second, because of imperfect encoding and decoding, scene edges contain components from both the luminance and chrominance channels; incidental delay variations between the two channels introduces a crawling, fuzzy jitter on vertical transitions. Third, high frequency sidebands are generated in the FM spectrum by sharp edges in video, causing aliasing after demodulation; aliasing is akin to moire' and causes small random time-modulation of edges, which we interpret as "busyness."

Edge-busyness is best measured on an oscilloscope in conjunction with a window signal and sine squared pulse. Jitter on the leading and trailing edges of the window can be compared; uncorrected timebase errors will dominate trailing edge jitter, while leading edge jitter will be a composite of position modulation by all three causes of edge-busyness. A sine squared pulse test identifies alias components by localization of jitter at some predominant levels on the pulse, usually near the baseline. Again, complex laboratory analysis can be completely bypassed with a meaningful direct observation of the reproduced window itself, using nothing more than a camera, monitor and home made window chart.

Video signal-to-noise ratio (SNR) is a parameter of interest in small-format evaluation, but one difficult to analyze subjectively because the newer formats perform very well with respect to noise. Preference should be given to SNR measurement through playback channels utilizing auto-tracking play heads, if installed. That is the play mode most often used for freeze frame, slow motion, and time compression effects and is of greatest interest to the broadcaster. However, published SNR specifications apply to reproduction with fixed Record/Play heads, resulting in about a 1 dB better SNR specification than is actually realized in typical production applications of the new small-format VTRs.

Measurement of luminance SNR has been standardized for composite VTRs[3], and the same techniques can be directly applied at the encoder output of small-format component analog systems. Standard measurement bandwidth is 10kHz-4.2MHz, but a variation advocated by manufacturers is the use of a subcarrier notch filter to attenuate the unbalanced subcarrier frequently present at the encoded output of component analog systems. However, this filter also attenuates high frequency noise components in the measurement passband, causing the SNR to appear at least 1dB better than it actually is. [Figure 4.] This error may be compensated by measuring Y-channel SNR both with and without the subcarrier trap. The difference between those two measurements is the effect of the trap on video noise only, since there is no subcarrier in Y-channel output. The notch correction factor thus obtained is then subtracted from the SNR measured with the trap at the composite output, to obtain the true luminance signal-to-noise ratio.

Standardization of chrominance SNR measurement in composite VTRs has been nearly completed by IEEE and those methods may be directly transferred to small formats operating in the composite NTSC mode. Measurement of chrominance SNR in the composite mode is accomplished with a uniform color input test signal, usually full-field red, and a measurement bandwidth of AM and PM chrominance noise at the VTR encoded output of 100Hz-500kHz.

Chrominance SNR in the component mode is measured with a 100Hz-1.5MHz passband in the individual R-Y and B-Y channels. But to be meaningful, that component data must eventually be converted, along with Y channel SNR, to NTSC color noise performance - an indirect and complex relationship. Alternatively, one of the component signal generators now available for producing appropriate Y, R-Y and B-Y levels may be used to create an artificial color field for measurement of composite chrominance SNR at the encoded output of the machine. When measuring composite or component chrominance noise, it is essential to avoid "illegal" colors, i.e., colors that fall outside the NTSC gamut (100 IRE of subcarrier at 50% luminance with subcarrier in phase with burst, for example), otherwise the permissible operating range of chroma processing circuits might be exceeded.

Perhaps the impression has been given that small formats introduce gross picture impairments that dominate master tapes. Actually, currently available 1/2" formats perform very well when used with discretion. In the case of M-II and Betacam SP, it is virtually impossible to <u>subjectively</u> distinguish between a master recording of a live program and a third generation dub of the master. That does not apply to test charts, but then we don't broadcast test charts (intentionally), so why is so much attention directed toward these lower-order impairments? It is simply because, to discern relative format performance capabilities, each system under evaluation must be stressed to its limits.

To magnify subtle performance differences, masters are recorded simultaneously on the two or more formats under comparison; the masters are then dubbed on the separate formats through five or more generations. For objective evaluation, multiple-generation dubs from competing formats are analyzed with waveform monitors and other test equipment, and numerical results compared. In subjective evaluations, multiple-generation dubs from two formats may be combined into a common split-screen display, or reproduced simultaneously on identical adjacent monitors. Production of the dubs is an exacting task, requiring precise adjustment of each VTR for peak performance to avoid masking small, but crucial format performance differences. Dubs should be produced by full interchange, in which the last-recorded cassette is removed from the record transport and inserted into a second transport for playback, and so on until the required number of generations has been completed.

One important facet of format evaluation is ascertainment of the relative quality of composite and component dubbing. This is done exactly as in format comparisons, except multiple-generation dubs are made from a common master by a 1-wire composite NTSC connection and by a 3-wire component connection. Recent advancement in encoder and decoder technology has resulted in surprisingly good performance from composite dubs, which is quite apparent in composite/component comparisons, and focuses attention on the questionable cost/benefit relationship involved in scrapping amortized composite edit rooms for replacement by new and elaborate component facilities. This is one of the most important aspects of format evaluation, and it should be thoroughly examined by all broadcasters contemplating a radical change in existing composite production facilities.

Subjective judgement of picture quality should not be entrusted to engineers alone, who generally dwell persistently on exotic and arcane low level effects that may not really be of practical significance in determining picture quality. Operating personnel should play a decisive role in determining format preferences, especially in actual equipment selection, where operating features are a key consideration. To implement this policy, time must be allotted for access by editors, field crews and maintenance personnel to obtain hands-on experience in their customary operating environment so they become qualified to participate in the final decision process. Intimate involvement by Operations can also be the basis for a dialogue between user and manufacturer to encourage product improvements. Given the present competitive situation, broadcasters are well positioned, not only to acquire small-format equipment for evaluation, but to materially influence later generations of products.

There are many facets of small-format VTR evaluation that, of necessity, have gone unmentioned in this paper because they are not concerned with specifically-developed techniques. Audio performance is one obvious omission, as is editing performance, gyroscopic influences on the camera-mounted VTR, and the entire spectrum of environmental effects. These are all important factors, but beyond the time limitations of this paper. The intent of the paper has been to encourage broadcasters of modest means to learn for themselves what the different formats can offer as the basis for an intelligent purchase decision.

In conclusion, I would like to thank Julius Barnathan, President of Operations and Engineering at Capital Cities/ABC for his direction in the advocacy of practicality in testing of all broadcast equipment, Max Berry for his counsel and support, and Mike Stefanidis, who performed all of the laboratory tests associated with the ABC format evaluations.

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Detail Resolution Impaired By Noise Reduction

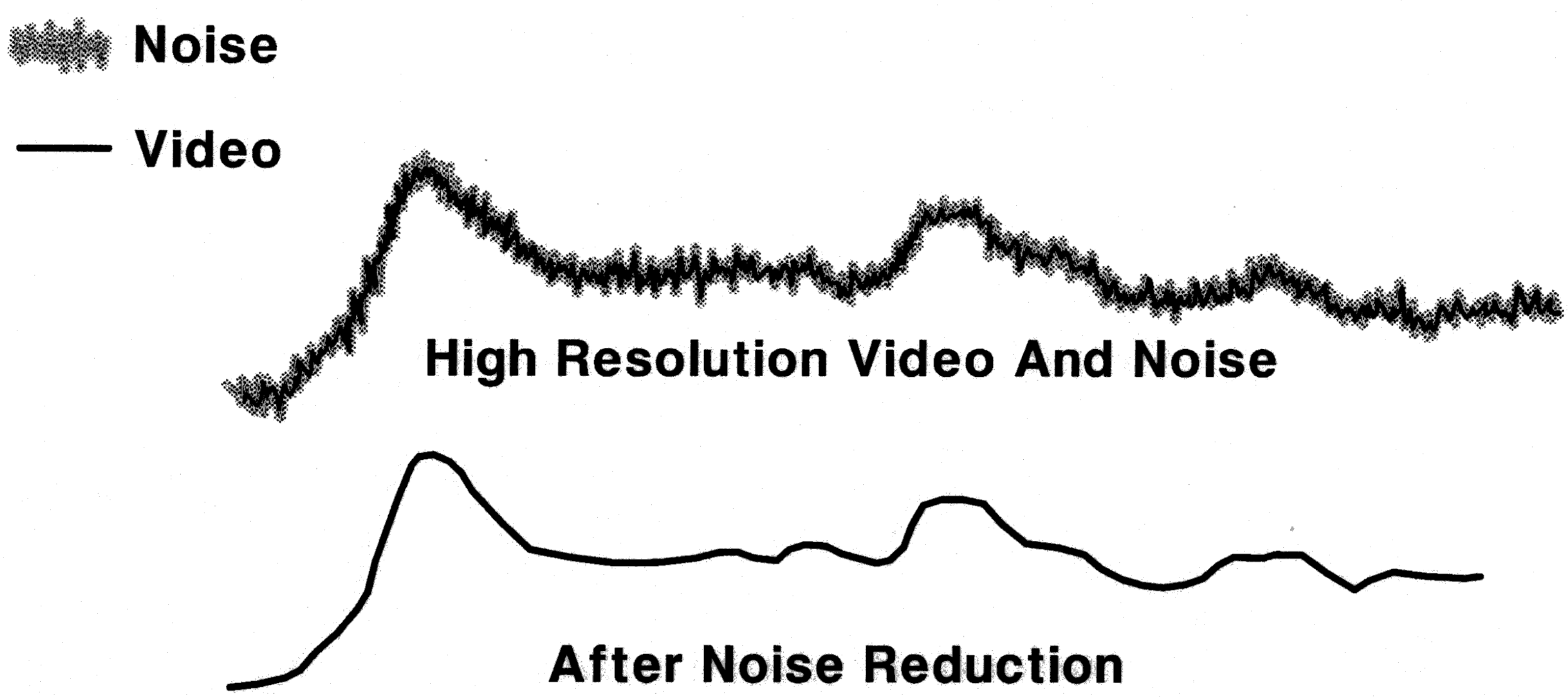

FIGURE 1.

Detail Resolution Test

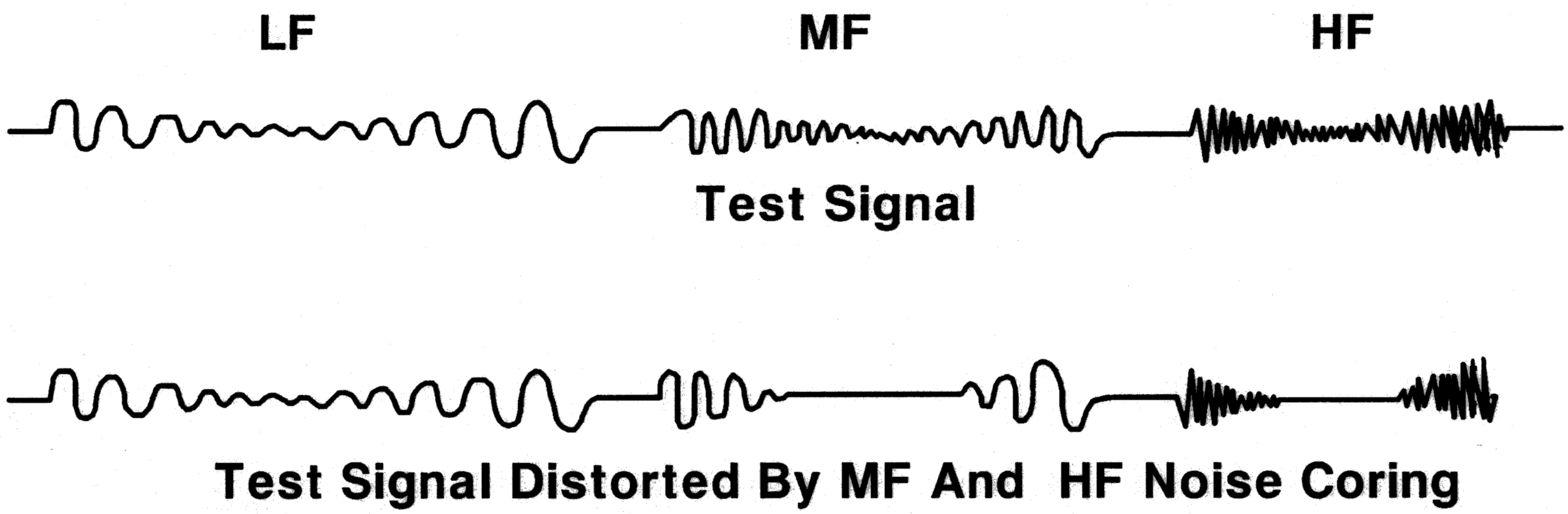

FIGURE 2.

Nonlinear Pre-Emphasis

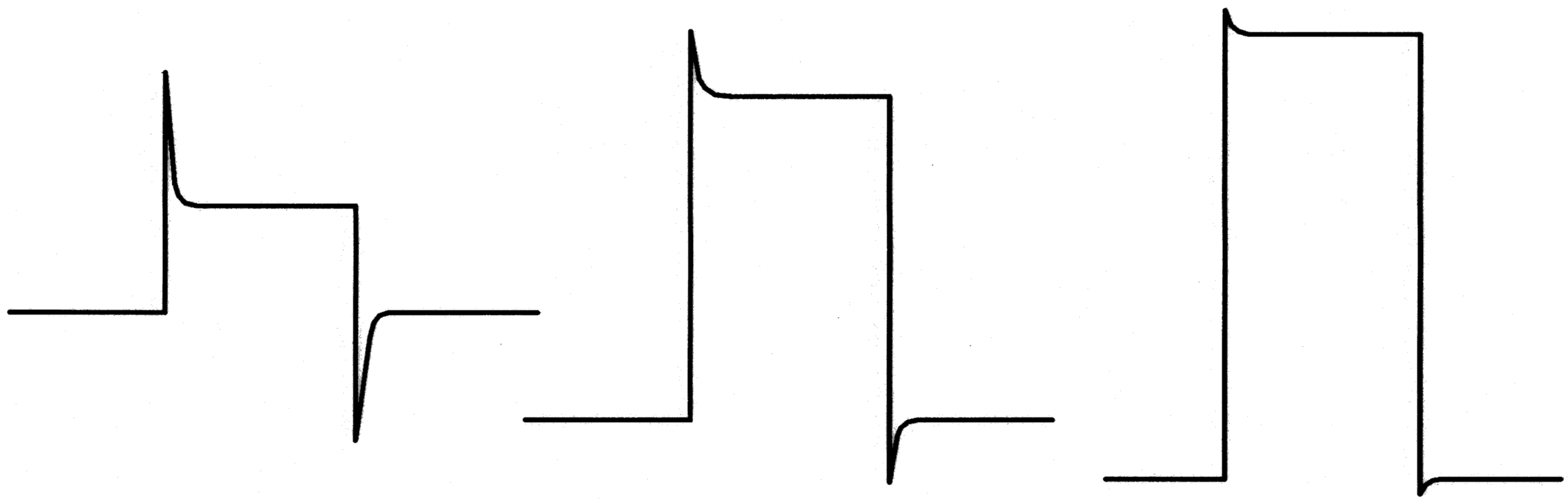

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FIGURE 3.

Subcarrier Trap

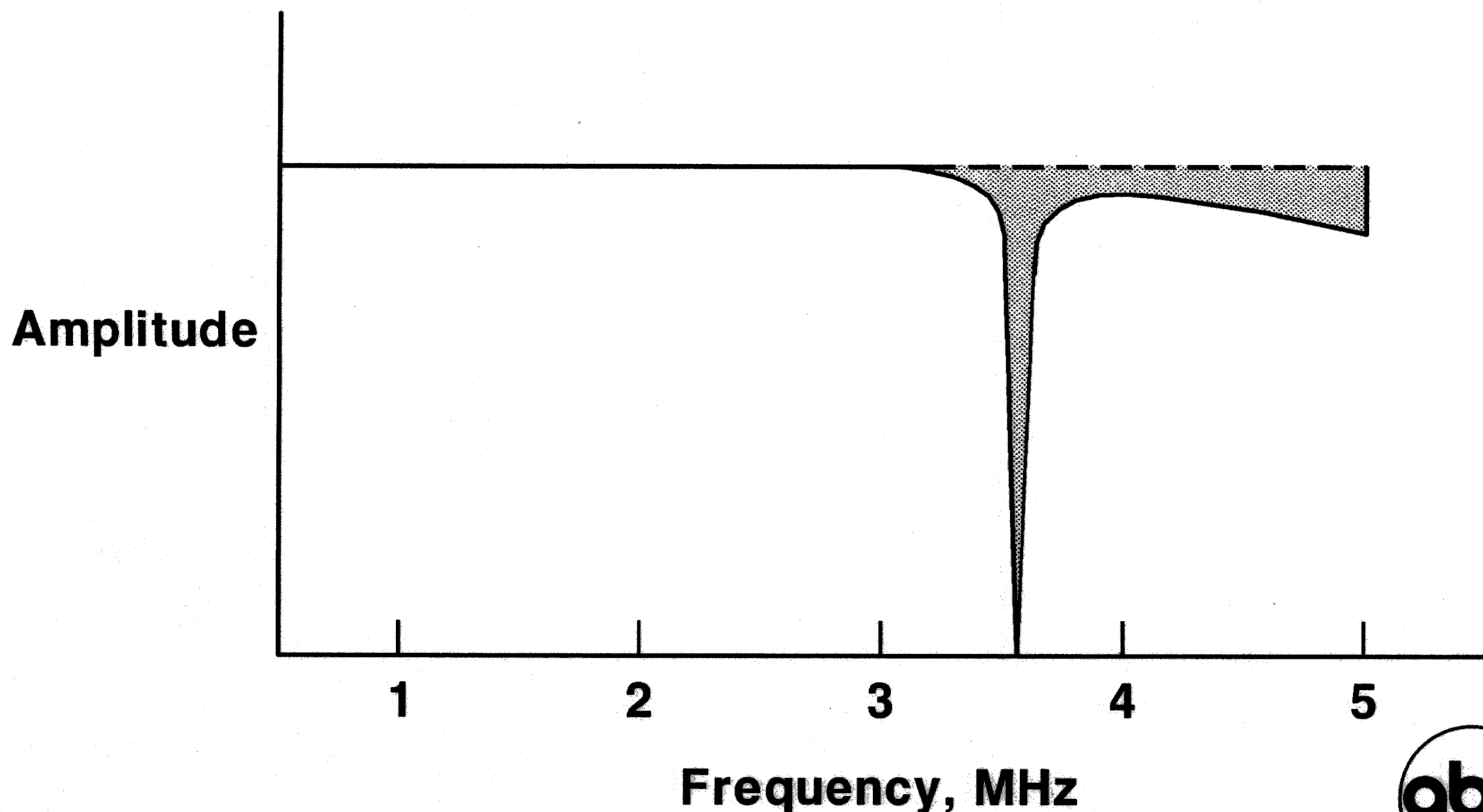

FIGURE 4.