The Most Standardized Aspect of International Television Is The Lack Of Standardized Standards.

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INTRODUCTION

For the past few years, then has been a considerable amount of interest in the color television systems to be used throughout the world. In writing about color systems, there is an immediate difficulty because of the lack of standardization in the meaning of the word "Systems". The International Radio Consultative Committee (CCIR) recognizes a number of different television systems and each system is clearly defined. In this paper the various methods of transmitting color television, such as NTSC, PAL, and SECAM, will also be referred to as "Systems" to indicate the general scheme used that can be modified for use with different monochrome standards. It is hoped that the two meanings used for the word system will not be too confusing.
It has always been impossible to obtain international agreement on television standards, and it is interesting to review what has happened in the past, in order to understand some of the reasons for the present difficulties with standardization.

HISTORY

The first scheduled broadcasting of monochrome television, as we know it today, was started by the British Broadcasting Corporation (BBC) in 1936. Even in 1936 when television first started with only one station a single TV system was not enough. The broadcast started using two different systems on alternate days. One system, known as the Baird System, used a 250-line non-interlaced scanning raster with a frame rate of 50 Hz; the other known as the EMI system, used a 405-line interlaced raster with a frame rate of 25 Hz. Receivers were switchable for both standards and with the help of a calendar and a certain amount of manual dexterity, it was possible to obtain quite a reasonable picture on either system.

After about a year of operation, the 250-line Baird System was discontinued. The 405-

line system, now CCIR System A, was retained. It has remained substantially unaltered to this day and is at present in use throughout Great Britain on all VHF channels. Prior to 1936, there were lengthy technical discussions to decide whether vertical or horizontal polarization should be used for the radiated signals. Finally, one of the national Fine Arts Councils decided that the receiving antennas for vertical polarization were more beautiful than those for horizontal polarization, so vertical polarization was used. Much later, in the mid 50s, some stations were built using horizontal polarization in order to reduce co-channel interference by about 8 dB.

The direction of modulation of the vision transmitter was positive because flywheel synchronizing circuits had not been developed and automobile ignition interference was so great that, if negative modulation were used, the picture would breakup for a substantial portion of the time. If people had had radio receivers in their cars in the early 30s, negative modulation might have been chosen.

In the United States of America, television broadcasting really started on 30 April 1939, concurrently with the opening of the New York World's Fair. The standards used at this time were those recommended by the Radio Manufacturers Association (RMA). The RMA standards specified a 441-line system that had been developed by the radio industry over a number of years. It was thought by the majority of people in the industry that these standards would be adopted by the Federal Communications Commission (FCC). Contrary to this expectation, the FCC did not accept the RMA's standards and the National Television System Committee (NTSC) was formed in 1940. This Committee was charged with recommending standards to the FCC.

The NTSC's recommendations for monochrome television standards were accepted by the FCC in March 1941 and are now designated System M by the CCIR. The standards for monochrome recommended by the NTSC were substantially the same as the RMA standards. The only really significant difference was the number of scanning lines in each frame which was changed from 441 to 525. This change was not recommended by the NTSC until after the meetings of the panel concerned were formally closed and the NTSC had sent the FCC a preliminary copy of its recommendations.

Since the total resolution of System M, the American System, is the same as System A, the British System, the question might well he asked, 'Why are the two systems different in almost every respect?' The only significant answer to this question is that the power-line frequency in the United States was mostly 60 Hz, whereas in England it was mostly 50 Hz. At the time the standards were drawn up, it was thought to he very difficult to prevent noticeable interference from the power system if the power

and television frequencies were not the same. This fear has since proved to he unfounded and all the TV systems recognized by the CCIR are now capable of working satisfactorily when not locked to the power line. In addition, there are many geographical areas that use a 60 Hz field frequency for TV and 50 Hz power-line frequency. However, time has shown that the use of a 60 Hz field frequency is a very significant advantage of System M over all other TV systems. This is because modern technology has produced kinescopes with high levels of light output and the 60 fields per second rate gives much less flicker than the 50 field per second systems. Although people do get used to the 50 Hz flicker of European TV if the picture brightness is not too great, the 50-field systems do limit the picture brightness that can be used. This is the one big advantage of the American System.

With the beginning of the second World War, in 1939, television development in Europe stopped and did not get going again until well after the end of the war. After the war the CCIR attempted to obtain international agreement on monochrome TV standards but this proved to he impossible. The attempt to standardize was given up completely in about 1951 when France announced, just before an international meeting on standards, that TV in France would he on an g19-line 50-field standard. As a result of the lack of standardization, there are now four different scanning standards in use:

405 lines 50 fields System A
525 lines 60 fields System M
625 lines 50 fields System B, C, D, 0, H, I, K, L, N
8l9 lines 50 fields System E, F

There are also six different spacings between sound and vision carriers, namely: 3.5, 4.5, 5.5, 6.0, 6.5 and 11.15 MHz. In addition, there is the use of AM or FM for the audio modulation and positive and negative modulation for the picture carriers. Table I shows the important characteristics of the various systems.

Table 1: Monochrome TV Systems.

CCIR Sys	Lines	Fields/sec	Video Mod	Sound Mod	Spacing	Color Stan.
A	405	50	+	AM	3.5	6
B G H	625	50	-	FM	5.5	2
C	625	50	+	AM	5.5	2
D K	625	50	-	FM	6.5	2

E	819	50	+	AM	11.15	4
F	819	50	+	FM	5.5	5
I	625	50	-	FM	6.0	2
L	625	50	+	AM	6.5	2
M	525	60	-	FM	4.5	1
N	625	50	-	FM	4.5	3

At about the same time that the CCIR was trying to get agreement on monochrome TV, color TV was being investigated vigorously in the USA. After a great deal of work by industry and many demonstrations, the FCC adopted the CBS field-sequential system in 1950 .The National Television Systems Committee was reformed in 1950 because the majority of the television equipment manufacturers thought that the field-sequential system was not the best, and if agreement could be reached by all manufacturers it would he possible to have the standards changed.

The field-sequential system was not compatible with the monochrome TV system and it is difficult to see how color TV could ever have grown in popularity with this system. Fortuitously, the war in Korea caused a shortage of copper which prevented color receivers being built at this time, so it was possible for the FCC to adopt the present NTSC system in 1953 without any public outcry from the people who had purchased field-sequential receivers.

COLOR TELEVISION SYSTEMS

The NTSC color television system, as used in the USA since 1953, was the only system used in broadcasting until mid-1967. At present, England and Germany use the PAL system and France uses the SECAM system. Again it maybe asked, 'Why is there not some international standardization?' Again there is no technical argument in favor of more than one system.

In the early days of NTSC color broadcasting, there were some technical difficulties which at that time resulted in unsatisfactory color pictures on certain occasions. These difficulties were all due to shortcomings of the apparatus in use at the time and have been completely overcome in modern equipment.

The three important difficulties in the early days of NTSC were:

1. Errors in hue due to differential phase in equipment.
2. Errors in saturation due to differential gain.
3. Errors in hue due to the phase of the color subcarrier burst being inconsistent in relation to the color information in the picture.

These shortcomings were, of course, known to engineers in Europe and a large number of different color systems were developed to overcome the difficulties. Very little work was done in Europe to eliminate the cause of problems in the NTSC system, but this has been done quite successfully in the United States.

All the color TV systems developed in Europe were the same as NTSC except for the method of encoding the color-difference signals. They are:

I. TSC-The two subcarriers systems.
2. FAM-The frequency and amplitude modulation systems.
3. DST-The FM subcarriers system with an additional subcarrier on the color subcarrier.
4. ART-The added reference transmitter system.
5. NIR-The Russian system that is the same as NTSC except that the phase modulation, but not the amplitude modulation, of the subcarrier is omitted on alternate lines.
6. SECAM-Sequentlal with memory.
7. PAL-Phase alternation by lines.

Of these seven systems, only the last two have been extensively tested by members of the European Broadcast Union (EBU), and are in use at this time. France and the USSR were using the SECAM system, while most of the other countries of Europe were using, or have stated they will use PAL.

The PAL signal is the same as the NTSC signal except that the phase of the "I" component of the color subcarrier is reversed (changed by 180) every line. The claimed advantages of this system are that it has good immunity to phase and differential phase errors, and also that ghosts do not change the color of the received pictures and are visible only as a change of brightness. The important disadvantage of PAL is the increase in cost of the home receivers. To achieve the advantages of PAL, each receiver must have a delay line (64ps).

SECAM uses an FM color subcarrier that carries the color difference signals sequentially R-Y on one line and BY on the next line. A delay line in the receiver provides the necessary storage for making R-Y and B-V available for display at the

same time. The SECAM system has greater tolerance to differential gain and differential phase than NTSC, but it also has many shortcomings compared with NTSC, the important ones being: reduced resolution of color in both the vertical and horizontal direction; poor compatibility with monochrome receivers greater sensitivity to noise, and difficulty of mixing signals in the studio. Also, of course, the receivers must have a delay line.

The NIR system, sometimes called SECAM IV, is the same as NTSC except that the phase of the color subcarrier is held constant at a reference value on alternate lines. The amplitude modulation of the subcarrier is the same as NTSC on all lines. The only advantage of NIR appears to be that it is not the same as NTSC, PAL, and SECAM. The NIR system was strongly recommended by a few people at the 1966 meeting of the CCIR, because they thought that it might provide a compromise to which all the countries of Europe could agree.

INTERNATIONAL EXCHANGE OF PROGRAMS

All the TV systems, both monochrome and color, can operate from movie film and, at present, this is the only really satisfactory method of program exchange between all systems.

Monochrome programs can also he exchanged by video tape, microwave, and satellites between countries using the same scanning standards. In some cases there will he a reduction in picture quality because of the difference in video bandwidth between the systems.

Very satisfactory electronic standard converters are also available for converting between systems having the same field frequency, and these are used quite extensively in Europe at the present time. Only one satisfactory standard converter has been built for converting between 50 and 60 field systems. At present, optical converters that consist of a camera focused on a picture monitor are used, but they have poor resolution and also introduce substantial noise. In addition, there is usually some 10-cycle flicker observable in the output

International exchange of color programs is more complex. Even if there were only one color system, say NTSC, throughout the world, there would still have to he six different standards for the chrominance signals if color were to he used with all the monochrome systems. These different standards are indicated by arbiirary numbers in

the right-hand column of Table I. Fortunately, agreement has been reached in the CCIR that color TV will he confined to 625-line systems in Europe; thus only three color standards would he necessary if only one color system were to he used.

For exchange of color programs between countries to he accomplished easily, other than by means of film, not only must the scanning standards he the same, but the color standards must also he the same. The CCIR has obtained agreement that the color sub-carriers frequency will he 4.43 MHz in Europe for the 625line 50-field systems, but this frequency is not suitable for System "N" which is used in some South American the vision-to-sound carrier spacing is only 4.5 MHz, so special transcoding apparatus must he used to change the color subcarrier frequency in order to exchange programs between System N and Systems B, D, C, 0, H, I, K and L. In addition, there may he some lesser difficulties in the exchange of programs where the same color systems, color subcarrier frequency and scanning standards are used due to differences in the bandwidth allowed for the upper sideband of the color subcarrier, which is not the same for Systems B, I and L.

Exchange of programs between countries using the same scanning standards but different color systems is, of course, possible
by transcoding the color information. However, this transcoding will reduce the resolution of the luminance signal to some extent, because of the filtering required to prevent the incoming color subcarrier from interfering with the outgoing signals.

Exchange of color programs between systems having different scanning standards is difficult, and no very attractive scheme has yet been suggested. At present, it does not appear to make much difference to the difficulties if the two color Systems are the same or different, if the scanning standards are different.

RECEIVER COMPATIBILITY

Monochrome receivers designed for System N can he used on System M and vice versa. If NTSC is used with System N, color receivers would also he interchangeable. This is the only case where the same receivers can he used on systems having different scanning standards.

The same receivers are used on Systems B and G. The only difference between these systems is the channel width (7 and 8 MHz respectively). The same receivers can he used on System D and K. Again the only difference is the radio frequency bandwidth

(8 and 8.5 MHz respectively). Receivers designed for Systems B and 0 can he used on System H, but not the other way around. This is because System H has 1.25 MHz of vestigial sideband, whereas Systems B and 0 have 0.75 MHz.

Because of the many different TV standards for monochrome, there are large areas of Europe where it is necessary for the viewer to have a multiple standard receiver if he is to he able to make use of all the signals arriving at his antenna. In England he must have a receiver for Systems A and I; in France for Systems E and L, etc.; in the Benelux countries 4 and 5 standard receivers are not uncommon.

When the different color systems are added to the monochrome systems, the receiver designing engineers will he busy for many years.

The AUTHOR

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Eric M. Leyton was born and educated in England. After graduating in 1938, he worked at the Research Laboratories of the British General Electric Company where he participated on the development of radio transmitters and radar. In 1945, he joined Rediffusion Ltd. (Rediffon) as Chief Engineer and was concerned primarily with the production of RE. heating equipment. He also was responsible for the development of television transmitters which were supplied to the British Broadcasting Corporation. In 1953, Mr. Layton came to the United States to join the staff of the RCA Research Laboratories. In 1959, he joined the Staff of Dr. 0. H. Brown, Executive Vice President of Research and Engineering for RCA. He is a Fellow of the Institute of Electrical and Electronics Engineers a Fellow of the Institution of Electrical Engineers and a member of the Society of Motion Pictures and Television Engineers.