NEW TECHNOLOGY FOR CABLE TELEVISION

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Abstract

Four new technologies are presented. They are: Digital Television, Multiplexed Analog Components, High Definition Television and CCD Cameras. Each of these new technologies is explained and its application to cable television is described.

INTRODUCTION

A number of new technologies are emerging that will make profound changes in cable television. These changes range from entirely new kinds of television to new methods of signal processing to improved television signal sources. They will be found in the subscriber's home, in the cable head-end and at the point of original picture production. Four new technologies have been selected for this discussion: namely, digital television, multiplexed analog components, high definition television and CCD cameras.

DIGITAL TELEVISION

Digital television includes more than just the use of digital circuitry in television equipment. We are all familiar with the digital processing in TV receivers and set top converters for remote control, for on-screen display, and for frequency synthesized tuning. However, these are not digital television. Digital television refers to the representation of a television waveform as a series of discrete digital words called pixels, rather than as a continuous analog waveform.

The advantages of digital over analog processing in television are the same as those that led to the use of digital processing in other fields. For example, digital circuits have smaller parts counts because they do not require passive resistors, capacitors and coils. Moreover, adjustments for gain, level, bandwidth and so on can be eliminated and performance does not gradually degrade as parts age. Software can be used to conveniently test subsystems during and after manufacture; control of digital television processors by other digital equipment is natural; and computer-aided design can be applied to digital integrated circuit design. Finally, new functions can be done digitally that could not be done at all in analog.

The growth of digital television is driven by advances in three kinds of semi-conductors. A/D converters, memories, and very large scale integrated circuits [VLSI] High speed A/D converters capable of digitizing real time television signals have dropped in price from $15,000 in 1975 to about $50 today. They are expected to drop by another order of magnitude within the next two years. Semi-conductor memories have dropped in price from a penny per bit with 4K dynamic rams in 1976 to about 10^{-2} cents per bit with 64K dynamic rams today. With further improvements in semi-conductor density, a single chip will be capable of storing an entire television frame. VLSI has advanced to the stage where vast amounts of logic can be built on a single chip. High-speed gate arrays with more than 10,000 gates per chip are presently available to the digital television designer. Use of such large gate arrays combined with sophisticated logic simulation techniques permit complex digital television IC's to be developed reliably and within a reasonable time frame.

Digital television will bear on cable in a number of ways. New high definition television services will depend on digital processing for their operation. In addition, picture improvement methods such as noise reduction and ghost cancellation can be done digitally. However, the most important impact of digital television on cable will be in advanced video encryption. It is possible with digital processing to design encryption systems that cannot be broken by pirates. These encryption systems will not depend on hardware that must be physically protected from a subscriber, but rather they will

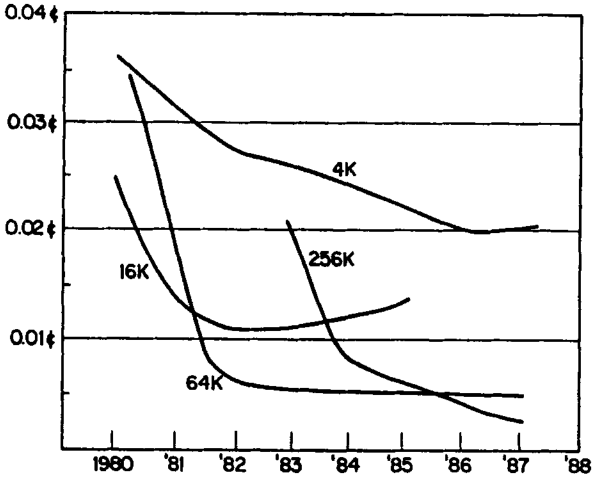

Fig. 1. The price per bit of memory of dynamic RAMs has been driven down sharply by each fourfold increase in memory size. By mid-1985, the price per bit of 256K RAMs is expected to drop below that of 64K RAMs (Fortune Magazine, May 26, 1983, page 154).

depend on software that can only be received by authorized subscribers. The authorization of subscribers is also controlled by encrypted software. In short, digital processing can lead to that elusive ideal: a foolproof method of controlling pay TV revenues for the system operator.

MULTIPLEXED ANALOG COMPONENTS

Multiplexed Analog Components (often abbreviated MAC) refers to a new kind of television signal that uses a different method of encoding color from NTSC. As we know, NTSC uses a subcarrier at 3.58 MHz to encode color. MAC on the other hand does not use a subcarrier, but instead the chrominance and luminance components for each line are compressed in time and transmitted serially during each line time. Another difference between MAC and NTSC is in the way audio is encoded. For the MAC signals likely to be used on cable, audio will be encoded digitally with pulses in the horizontal blanking interval. In the event that the MAC signal is encrypted, addressability data to control subscribers' access will also be included in the horizontal and vertical blanking intervals. In the MAC systems, sync would also be digitally encoded and included in the blanking intervals along with the audio and addressability data.

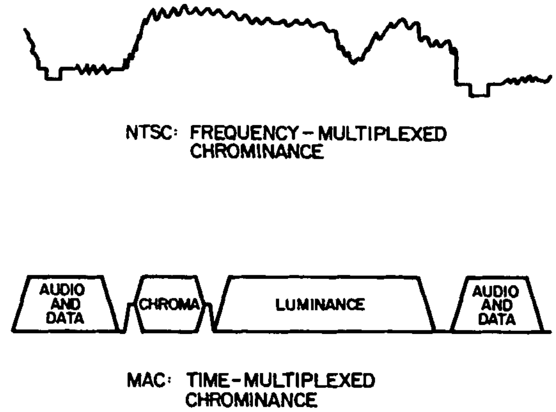

Fig. 2

MAC has a number of advantages as a signal format. Since a subcarrier is not used to encode color, none of the effects of the subcarrier that are visible in NTSC are visible on a MAC picture. In particular, there is no dot crawl, there are no hanging dots and there is no luminance/chrominance crosstalk. Because luminance and chrominance are not combined in MAC, but rather transmitted separately (time-multiplexed) the picture is completely clean and free from any color subcarrier visible artifacts. The second advantage of MAC for cable use is that the digital audio provides multiple channels of high fidelity sound. The third advantage of MAC applies to transmission over an FM channel such as a satellite used for distribution of programs to cable headends. Because the satellite's FM noise spectrum increases with higher frequencies, the lack of color subcarrier in a MAC signal results in a lower chrominance signal-to-noise for MAC than for NTSC, thus producing a quieter picture.

MAC can be part of the cable delivery chain, either over the satellite or on the cable itself. In direct broadcast by satellite on K-band, some companies have already announced the use of the MAC signal format. A possible business scenario for cable operators would be to receive DBS signals and redistribute them on the cable. In this case, the MAC signal format would be used both over the satellite and on the cable. MAC could also be used for C-band satellite distribution and indeed may be the format selected by some satellite channel distributors for scrambled service. On the cable, the MAC signal, which has neither sound nor chrominance subcarriers, will be less susceptible to intermodulation with the carriers of other channels. In addition, because MAC has no analog sync, the full dynamic range will be available for the picture and audio parts of the signal.

In summary, the MAC signal format offers a higher quality picture, multiple channels of high fidelity sound, compatibility with encryption of both video and audio, fewer intermodulation problems and better use of the dynamic range.

HIGH DEFINITION TELEVISION

There is no single definition of high definition television. Many HDTV systems have been proposed. They work in different ways, are designed for different purposes and have differing amounts of improvement in picture quality. Furthermore, some HDTV systems require more bandwidth than others and some require more complex processing circuitry than others do.

Although HDTV cannot be precisely defined, certain characteristics can be expected. For example, the NTSC sub-carrier artifacts such as dot crawl, hanging dots and luminance/chrominance crosstalk could be removed from the picture. A method of removing these artifacts would be the use of the MAC signal format as described above. In addition, line crawl and 30 Hz interlace flicker caused by 2-to-1 raster interlace could be removed by use of progressive scan in the display. Another improvment in the picture that high definition could yield, would be elimination of vertical aliasing caused by the discrete nature of the 525 scanning lines in the camera. This aliasing could be removed by the use of more scanning lines in the camera followed by interpolation down to 525 lines. A number of methods hve been proposed to increase both horizontal and vertical resolution including use of more than one channel for each transmitted program. Still another aspect of HDTV would be wider display aspect ratio, from 4-to-3 to 5-to-3 or perhaps even higher.

An important aspect of any high definition television system is the degree to which it is compatible with NTSC. There are three levels of compatibility. The first is HDTV that is fully compatible with NTSC. By fully compatible is meant that both a HDTV receiver and an NTSC receiver could display pictures from the same signal. Of course the HDTV picture would have a better quality picture. An example of such a fully compatible HDTV method would be the use of a sophisticated frame store NTSC decoder in a TV receiver. The second level of compatibility is HDTV that is easily transcodable into NTSC. A good example of this level of compatibility would be the MAC signal format, which has the same number of scanning lines as NTSC has and differs only in how chrominance and audio are encoded. The third level of compatibility is HDTV that is not easily transcoded to NTSC. This generally refers to HDTV systems that employ more than 525 lines for transmission and display. HDTV systems of this type would be costly in terms of bandwidth and are therefore expected to be limited in use to video production.

One interesting possibility for HDTV on cable is the use of extra bandwidth for signal transmission. Unlike the TV broadcaster, who is confined to a 6 MHz channel, a cable operator is in principle free to use as much bandwidth per channel as he desires. Future cable HDTV systems are conceivable that use more than 6 MHz for improved resolution and wider aspect ratio. Another possibility is the use of FM modulation so that a cable operator can distribute scrambled HDTV signals from a satellite directly to the subscribers' home without decoding or remodulating.

Although it is not now clear which of the many HDTV possibilities will emerge first, it is clear that the cable TV industry will soon have the technology to deliver pictures that are superior to those that we are now watching.

CCD CAMERA

A number of new all solid state TV cameras have recently been introduced to both the consumer and the broadcast markets. The broadcast CCD camera has three silicon CCD imagers instead of three photoconductive pick-up tubes. Each solid state imager has discrete pixels on each line which are read out serially in a manner analogous to beam scanning in a camera tube.

A CCD camera is more flexible than a tube camera because it is smaller in size, lighter in weight and consumes less power. It is physically rugged and has no microphonic distortion due to vibration of delicate electrodes. There are no components inside a CCD camera that require periodic adjustment or replacement. In addition to these practical advantages, the CCD camera has better dynamic resolution. Dynamic resolution refers to the ability to see detail in objects that are moving rapidly. In tube-type television cameras there is partial retention (called lag) of previous images mixing with and blurring new images falling on the tube surface. The CCD on the other hand, retains no memory of the previous image, so as in a film camera, each exposed frame is independent of the previous frame. Because the CCD inherently has no lag, a scene consisting of a moving bright light on a dark background will not leave a trailing smear. Furthermore, the camera can be pointed at a light of any brightness without causing either permanent or temporary burn-in or damage of any kind. And finally, the CCD camera has a greater dynamic range than that of any tube camera. Consequently, it can be used to shoot scenes under very low-light conditions.

The features of a CCD camera will offer the cable operator many advantages. The camera itself is less sensitive to mis-handling, can make good quality pictures under less critical lighting conditions, it requires less frequent maintenance and lower skill levels for maintenance that is required. In short it will offer the cable operator a versatile camera for a wide variety of cable production needs.

CONCLUSION

In conclusion we have looked at four new technologies that will provide for cable TV better quality pictures, more reliable equipment in the home and in the studio, multi-channel high-fidelity audio and secure scrambling. All of these new technologies add up to making our product more desirable to our customers.