IMPROVING NTSC IN A CABLE TELEVISION FACILITY

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INTRODUCTION

In the early 1950's, when the parameters of the NTSC color television system were established, the theoretical performance of the system was completely unachievable by the television technology existent at that time. Unstable vacuum tubes, drifting components, bandwidth limitations and hue shifts due to phase errors in the equipment, or the transmission path, were quite objectionable. Constant readjustment of the home receiver to maintain a tolerable, if not perfect, image was a fact of life then. However, the visionary pioneers, who laid down those brilliantly conceived NTSC parameters, gave to color television a remarkable potential that, in today's world of solid-state precision, can finally come into its own.

NTSC's basic advantages are almost self-evident. It is the most efficient use of the available spectrum through the interleaving of the luminance and chrominance signals, and it was and continues to be fully compatible with monochrome television. This inherent simplicity obviously makes it the most cost effective system in use as well. Millions of viewers, who live in areas where NTSC is the Cable TV color standard, can now receive acceptable quality color images in their homes, coming from NTSC transmissions.

However, if one sees an original RGB image on a studio monitor, sitting next to the best home NTSC receiver with a cable feed of the same picture, the difference in image quality is still significant, even if the basic colorimetry is accurate. These differences are due to an approach to the NTSC encoding and decoding process which, in spite of the last decade's improvement, still suffers from intermodulation between the luminance and chrominance components in the video signal, NTSC's major disadvantage. The spectrum overlap, which plagues the present encoding process, produces this unwanted cross color and cross luminance, and in no small measure relies on the psycho-physical characteristics of the human eye/brain interaction to act to diminish these annoying NTSC artifacts by adaptive mental filtering.

This paper describes new approaches to NTSC encoding and decoding which virtually eliminate the effects of cross color and other undesirable artifacts, thus rendering a final NTSC image to the home viewer of near RGB quality. The use of this completely compatible technique will not only render better NTSC images on existent color receivers, but when combined with other currently proposed techniques, will enhance future TV services, and will ultimately rival presently proposed HDTV systems without imposing the higher line rate and wider transmission paths they require.

The goal of this system is to make full use of those technological advances that are available today, namely, more intelligent processing circuitry, and inexpensive memories in line and frame store form. The new hardware can replace the eye/brain filter in removing artifacts, and can even eliminate visual fatigue by providing an NTSC image that looks like RGB. In the opinion of the authors, this can be accomplished without increased demands on our least available resource, RF spectrum bandwidth.

Cable companies employing these new encoding techniques will soon be delivering better NTSC images to their subscribers, regardless of the type of color television receiver they now have.

OBSERVANCE OF SPECIFIED NTSC RULES AT THE HEAD END

There are two general areas where observance of NTSC rules usually apply in varying degrees.

At the transmission level adherence to rules is almost automatic because of the built-in limitations of the equipment. Little complex signal processing is done at the transmitter, and as a result the quality of the distributed NTSC signal may be a function of the few elements that modify it at that site, the final encoder and the hopefully precision sideband filters that shape the selected channels response curve.

However, the NTSC signal path through the studio is a much more convoluted one. Here the signal is routed, switched, recorded, and processed through successive devices in both its analog and often digital form.

Within the studio or production facility, there may not be any regulations for common practices to maintain the NTSC baseband video at its optimum, and each of the devices used to manipulate the signal may indeed contribute some unwanted deterioration to the overall system.

As an example of some studio devices which contribute to this growing problem, consider the proliferation of character generators, computer-graphic systems, color keyers and digital effects systems. Most of these systems, which have entered into the mainstream of program production, use such fast rise time video signal edges that they generate illegal sidebands when they are applied to the chroma channels of an encoder. It is not unusual when watching a cable channel carrying news and data, in the form of scrolling text, to see breakup or tearing due to overmodulation from these hard-edged signals.

The I & Q (or R-Y and B-Y) chroma bandwidth bounds are exceeded, and the resultant signals, full of intermodulation overlap, can never be properly decoded by even the best comb filter decoder in a monitor or receiver. Obviously the careful control of these factors at the source would contribute greatly to the betterment of the NSTC images received by the home viewer.

EXPRESSION OF IMPLIED RULES

Throughout the complex studio chain, the NTSC signal finds itself submitted to a variety of sampling mechanisms which are subject to the Nyquist criteria. The techniques for minimizing these effects have been described by researchers in America, Japan and West Germany. In fact recent articles in the SMPTE Journal, by Dr. Wendlund and his colleagues, and in the IEEE Communications Journal, by Takahiko Fukinuki, et al., give good theoretical analyses of these phenomena.

The answer to the problem lies in the use of very careful multi-dimensional Nyquist pre- and post-filtering. This would result in the elimination of aliasing caused by line scanning, and by the 2:1 interlace in normal television. It would also reduce the motion artifacts and the chroma/luminance spectral overlap that creates visual disturbances in the image when certain kinds of fine details are present.

When NTSC was first developed the cameras of that era were incapable of rendering any useful MTF at luminance frequencies above 4.0 MHz, therefore, the notch filter used in the home receiver to filter out the color subcarrier did little harm to the overall resolution of the image. That is no longer the case, and modern cameras do have useful high frequency output above 6.0 Mhz, therefore, requiring that the upper luminance frequencies be recovered after comb filtering of the chroma signals. Again, this implies adherence to operational practices that retain the full quality of a proper NTSC signal.

COMPATIBLE RULE CHANGES

It is also possible to make some beneficial changes to the current NTSC rules which still maintain full compatibility with the present system. To make this clear, "compatible" in this case means full forward and reverse compatibility with no degradation if any new element is introduced in the chain, either at the transmitter or the receiver. The level of any improvement will increase if both sides are implemented.

It has already been adequately demonstrated that the use of 2H comb filtering in the encoder and decoder, in combination with some additional adaptive logic circuitry, can indeed produce a near RGB result in the home receiver. That technique has by no means been taken to its limit, and laboratory tests have shown that further improvements can be made with more than 2H combs. So far, the 2H comb is a cost effective means of getting a considerable improvement in NTSC images without burdening the system with greater complexity and cost.

Another proposal is to replace the currently differing I and Q bandwidths with equal 1.0 MHz baseband channels, which would also have very sharp roll off characteristics incorporated into them. This would definitely help to eliminate the effect of cross luminance in the decoder. If at the same time the transitional characteristics of the chroma channel were very strictly defined, there would be a significant reduction in those well known deficiencies of NTSC, chroma ringing, chroma/luminance delay and the fast rise time pulse handling. These high quality NTSC signals, radiated by a transmitter that has good filters, will certainly make a visible improvement even on old notch filter receivers.

Speaking of transmission, that may very well be the weak link in the chain, and we would propose very strict performance regulations for filters used in the video channel of the transmitter. This would assure that what is actually transmitted on the air would not negate all of the good practices adopted in the studio to improve NTSC image quality.

SUMMARY

In summary, it is clearly evident that the implementation of these steps for the originated and trasmitted NTSC signal would greatly improve the quality of the signal, and would greatly simplify the design of more efficient home receivers.

Line doubling at the receiver is made easier and better if the transmitted signal has been properly pre-filtered in the scanning process; sophisticated comb filter decoding, making use of adaptivity in the horizontal and vertical domains, and of chroma bandwidth expansion, is made easier if chroma luminance spectral overlap is not allowed in the transmitter.

In conclusion, it is believed that an NTSC signal, fully compatible with the present standard, can be displayed as a 525 line, 60 Hz progressive scan image. This image will be free of ringing, cross color, cross luminance, and have all appearance of a 7 MHz RGB signal.

These changes in quality, reasonably easy to implement, will give to NTSC a longer lease on life as it was previously expected, and will give to this industry enough time to design, without unnecessary haste, the proper high definition television system of the future.

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