High Quality on Cable TV Including MDS

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'IMAGE QUALITY' CONSIDERATIONS IN CABLE SYSTEMS

Background

'QUALITY' considerations in cable systems have concerned themselves almost exclusively with noise and distortion. In common with other frequency division multiplexed (FDM) transmission systems, cable systems tread a narrow path between noise and distortion. Signal levels which are too low result in excessively low C/N and S/N, while signal levels which are too high produce excessive distortion Inadequate C/N results in 'snowy' pictures. The limiting distortion in multi-channel cable systems is now third order intermodulation. This results in 'waterfall' effects in non-coherent carrier systems and 'cross-talk' in coherent carrier systems. All of these effects are, of course, objectionable.

The cable systems business has evolved in a market environment in which variety, i.e. the number of signals, is more important than image quality. Systems operate with adjacent channels to cram the most signals into the least system bandwidth. Coherent carrier techniques are used to reduce distortion both by reducing peak composite signal levels and by reducing the subjective impairment effects of intermodulation. Video signal synchronization is being used by some systems to further reduce subjective effects of transmission distortions. Manufacturers of the thin film hybrid gain modules which are almost universally used in cable television repeater amplifiers are producing gain modules with remarkably good specifications for noise, distortion and flatness of frequency response.

Notwithstanding the remarkable sophistication of the equipment and the transmission technology, cable television image transmission must be considered mediocre by the standards employed by the television production industry. The cable television industry understandably tends to stretch the capabilities of the available equipment to the utmost. The FCC rules allow C/N as low as 36 dB. C/N in cable systems is measured in a 4 MHz bandwidth. It turns out that C/N in 4 MHz bandwidth translates almost directly to video weighted S/N with only minor numerical correction. Most recently designed cable systems aim for C/N of 43 dB. Although many cable subscribers, particularly those close to the distribution 'head-end', enjoy higher C/N ratio, many accept what video professionals would consider mediocre S/N. There is a similar pressure on intermodulation distortion, cable systems pushing for maximum economic efficiency and accepting image quality compromises.

This situation has arisen because cable television systems, by and large, do not serve professional viewers. Most subscribers served by mediocre cable systems have mediocre receivers - by professional standards - and would not know a really good picture if it popped out of the screen and offered to make coffee. The present cable television market judges the value of the service by the number and variety of television program services, provided practical standards of 'barely perceptible' impairment are achieved.

Cable transmission engineers have generally overlooked one major parameter which, in my view, also affects transmission quality. The effect of multiple, closely spaced reflections is not fully understood. I believe that these reflections, arising from the small impedance mismatches caused by the myriad of connectors and devices in the transmission path, and the small imperfections of the coaxial cable itself, cause a slight 'smearing' of picture detail - a loss of 'crispness'. The visual effect is that of a reduction of transmission bandwidth, even though we know that the broadband transmission system has not itself directly reduced the transmission bandwidth. Our operations engineers get complaints from subscribers who have a chance to compare good quality local television signals as received direct from a local broadcaster and as received through the cable system. There is a small but noticeable impairment in this circumstance which does not have to do with C/N, intermodulation or signal processing considerations. I attribute the impairment, as I have said, to multiple, low level reflections in the cable system.

High Quality Transmission of NTSC Signals

I consider this a topic of major importance. I am concerned that the new DBS services will point out picture quality 'disabilities' in cable service. I am told that COMSAT is designing an 'all-digital' origination center (Las Vegas) with the objective of providing absolute state-of-the art program origination for their DBS service. I believe that DBS service will be capable of providing higher quality image transmission than the present terrestrial television broadcasting system and certainly better than present cable systems. Cable television systems must anticipate this competitive pressure and respond with significant improvements in the cable distributed image quality.

HIGH DEFINITION TELEVISION (HDTV - 1125 line) has excited a great deal of interest in the professional television community and is starting to get some attention from the popular press. The present HDTV concept originated with NHK and has been implemented to the present demonstration level by several Japanese equipment manufacturers - SONY, MATSUSHITA, NEC. The May, 1983 International television symposium in Montreux, Switzerland had a large scale HDTV demonstration with demonstration programs taped by CBS and several European (including USSR) broadcast authorities. SONY staged an impressive HDTV demonstration at the 1983 NCTA convention in Houston.

HDTV is 'spectacular', particularly when projected onto a large screen by a good quality projector. Images closely approximate 35mm movie quality. The HDTV screen, as proposed by NHK, has a 5:3 aspect ratio compared to the 4:3 aspect ratio of conventional 525 line systems. The 5:3 aspect ratio approximates current 'wide-screen' motion picture presentation. Frame/field rate remains 30/60. The improvement in definition results in a significant increase in video bandwidth - about

20 MHz compared to the 4.2 MHz used by present broadcast systems. The system has, of course, high-fidelity stereo sound.

All of these attributes -

- 1125 scan lines
- increased video bandwidth
- high fidelity stereo sound
- 5:3 aspect ratio
- non-NTSC color encoding

result in a serious incompatibility with present broadcast television receivers. There is general acknowledgment that it will take many years to introduce HDTV as a broadcast service.

Just before going to Montreux I read an account of Joe Flaherty's presentation on HDTV at the NAB convention earlier this year. I am sure you know Joe Flaherty as chief engineering executive at CBS. Flaherty was complaining that there hadn't been any major improvement in television program origination quality in the last few years. HDTV was a new breakthrough in this area. This report moved me to write to Flaherty. I pointed out that 99.9% of the television audience in this country has yet to see a 'good' 525 line picture.

I believe that we will experience a 'generation' (10 years) of improved 525 line television before HDTV (1125 line) becomes a major factor in television broadcasting. It might turn out that improved 525 services actually delay introduction of 1125 line HDTV services because of the renewed investment in high quality 525 line receiving equipment. HDTV can follow as a cable service in due course. We will have to invent a new 'superlative' to market it.

Americans have a long standing reputation for not caring much about television picture quality. I believe that there is a 'quality' market in America which can be 'sold' on quality video, and that they will pay a reasonable price to get it. I believe that this 'quality' market segment subscribes to cable and that cable is the best way to reach them.

There was a similar situation in phonographs thirty years ago. CBS developed the LP microgroove record. Recording engineers were able to produce records with much better audio quality than had ever been produced before. The existing phonographs just could not reproduce the sound quality that the recording artists and engineers were putting into the new records. People had LP players but the pick-ups, the amplifiers and the loud speakers just weren't good enough. Improved phonograph components were developed and found a ready market as 'high fidelity' audio. There has been a continuing market for improvements in audio equipment over the last thirty years. We may finally have achieved the end of the technology chain in audio as PCM techniques provide 'ultimate' recordings, and amplifier and loudspeaker engineers find it increasingly difficult to wring out the last minor imperfections in audio reproducing equipment.

'High-Fidelity' 525 Line Video

There are two aspects of providing high quality 525 line service -

improvement of color encoding technique,

improvement of transmission.

Enhanced Video

Cable television represents a unique opportunity to introduce new color encoding techniques. Most cable systems firmly control subscriber terminal equipment - the addressable programmable converter/descramblers which are provided to control access to cable television services. The equipment is owned by the cable system and provided to the subscriber as part of the overall cable service. Much of this equipment operates in a baseband mode, i.e. they consist of complete demodulators which presently provide a composite video output. These baseband subscriber terminal units could just as easily provide improved color decoding with RGB output to the subscribers video monitor. This improved decoding could be improved decoding of NTSC encoded color or it could be optimum decoding of a new, more sophisticated color encoding system, such as the C-MAC component system which has been proposed.

Program originators, such as national Pay-TV networks, could originate in both conventional NTSC video and an improved 525 line mode. Cable systems could similarly distribute in both modes - most have spare channel capacity during a changeover period. When a cable system has completed a changeover of all of its subscriber terminal equipment it would distribute in the improved mode only, although program originators would have to distribute in dual mode to allow for a longer period of changeover in all of their affiliates. Alternately a cable network operator could provide head-end decoding and transcoding equipment for those affiliates who were not immediately prepared to change from NTSC distribution. Cost and complexity would be comparable to the video encyphering that some of these network operators will be providing soon.

Television broadcasters would have a more difficult conversion since they do not have the dual service transmission capability that many cable systems have. The market created by cable systems would, however, speed the introduction and acceptance of new-standard receiving equipment. Local broadcasters would, however, be under competitive pressure since the cable distributed networks would be taking advantage of the improved transmission technologies. Local broadcasters could meet this competition by setting up local area direct feeds of enhanced video to cable systems in their service area.

I am not an expert in the detail of various enhanced 525 line video systems which are being proposed, but I do perceive that they offer a significant enhancement potential and that cable systems can speed the introduction of a worthy enhanced video proposal.

Improved Cable Transmission - PERFECT PICTURE

The cable television industry is substantially committed to its present plant. It would be a very expensive and difficult task to replace amplifiers or other major components in existing or 'under-construction' cable systems. Feed-forward amplifiers, with significantly reduced distortion (at least 16 dB reduction in third order intermodulation) are on the brink of widespread acceptance and availability. Widespread retrofit of existing systems will, however, be quite expensive. Use of feed-forward amplifiers in cable system trunks would improve system C/N but would still leave the system with the problem of multiple, low level reflections.

Most new cable systems have 'spare' bandwidth available. I am proposing to several of my client systems that this bandwidth be traded for 'quality' in the traditional way, by use of frequency modulation (FM) transmission. In the first phase of an image quality improvement program the cable system would use FM transmission of ordinary NTSC video. FM transmission in a cable system would require 18 MHz of spectrum. Most new urban cable systems have enough spare spectrum to provide conventional VSB-AM transmission (6 MHz per channel) and high quality FM transmission (18 MHz per channel) at the same time. I call the service 'PERFECT PICTURE'. The FM video service would also have high quality stereo sound, probably in the form of discreet L and R subcarriers, but possibly in PCM digital format.

FM transmission would remove S/N as a quality compromise in cable system transmission. Other quality degradations in cable systems, such as intermodulation and 'reflections', have different, less visible, less objectionable manifestations in FM video transmission (intermodulation in the baseband and as small degradations in differential phase and gain).

Subscribers who opt for the 'PERFECT PICTURE' service would be provided with a special FM video receiver which would tune the desired FM video channel, demodulate and descramble it, and provide both composite and RGB outputs (as well as baseband stereo L and R sound outputs). 'PERFECT PICTURE' subscribers would be expected to have a high quality video monitor or projector in order to enjoy the benefits. It wouldn't make much sense to remodulate 'PERFECT PICTURE' to NTSC VSB/AM for an ordinary receiver. The special FM video receivers would be adapted from the DBS receivers which will now be manufactured in fair volume. The principal difference will be the tuner. The DBS receivers tune 12 GHz. The cable version will, of course, tune cable FM video channels in the 50 - 550 MHz range.

Major cable television services are now distributed by satellite. Most broadcasting networks now (or will soon) distribute their servce by satellite as well. Another way to look at my proposal is that it 'splits' the satellite receiver. These satellite-based video transmission systems are designed to provide 'professional' grade transmission. PERFECT PICTURE places the satellite downconverter at the cable system head-end and places the rest of the receiver in the subscriber's home in order to maximize transmission quality. It puts the TVRO right in the living room!

The second phase of a transmission improvement program would introduce enhanced color encoding with compatible optimum decoding in the subscriber terminal box.

HIGH DEFINITION SERVICES

HDTV creates special problems for cable transmission. 'Raw' HDTV has significantly increased video bandwidth. Transmission, even by spectrum conservative VSB-AM, will require substantially increased bandwidth compared to 525 line video. For purposes of discussion I will assume 20 MHz of bandwidth for noise calculation purposes.

It has become customary to calculate cable system noise (for NTSC transmission) in a 4 MHz bandwidth. The random 'KTB' noise in a 75 ohm system in a 4 MHz bandwidth is 1.1 microvolt or -59 dBmV. Overall transmission noise is calculated by taking into account amplifier noise figures and system operating levels. As I have said, the FCC minimum

standard is 36 dB C/N. A C/N of 43 dB would be considered more usual for a 'good' cable system. This 43 dB C/N degrades by 7 dB to 36 dB C/N in the 20 MHz bandwidth of a HDTV transmission. HDTV service subscribers will probably have increased service quality expectations and the 43 dB S/N that we consider good for NTSC images might very well not be acceptable for HDTV images. I have not seen any published figures for S/N corresponding to various grades of HDTV transmission.

Frequency modulation might not be an available noise reduction option for HDTV transmission. We can realistically talk about 18 MHz transmission channels for enhanced 525 line PERFECT PICTURE service. FM for 20 MHz HDTV video would probably require at least 60 MHz per channel. This would cut our newest 500 MHz systems down to eight channels per cable. This kind of channel capacity reduction might be acceptable in Europe but is not acceptable here.

Some kind of bandwidth reduction technology would be very desirable. Feedforward amplifier technology might produce the 7 dB improvement in cable system C/N that conventional transmission would require. Some reduction in amplifier loading because of a reduction in the number of channels would also help somewhat. All in all, I fear that large scale, multi-channel HDTV service on cable will not be feasible without significant bandwidth reduction technology. I am sure that HDTV proponents are aware of this problem and that practical HDTV proposals will come forward with accompanying practical bandwidth reduction technologies.

CONCLUSION

I believe that image transmission improvement in cable will come about through a new interest in high quality video. It will first take the form of enhanced 525 line video, which will be followed some considerable time later by HDTV services. Cable systems will lead in the introduction of enhanced 525 line transmission by providing FM trnamssion along with improved color encoding techniques.

Israel Switzer is a graduate of the University of Alberta (Physics, 1949). He has been active in cable television engineering since 1954 with concurrent and prior experience in petroleum geophysics, television broadcast transmission engineering and electronic computer systems. Mr. Switzer is a resident of Palm Springs, California and Toronto, Ontario, and is a frequent contributor to cable television trade magazines, journals and technical programs. He is a member of SMPTE and IEEE, and is a registered Professional Engineer and designated Consulting Engineer in Ontario. He has significant engineering responsibility for the recent expansion of cable system channel capacity from 36 channels to the present 60 channel level. He has current engineering consulting responsibility for very large cable systems under development in the Virginia suburbs of Washington, D.C. and the north-west suburbs of Chicago.