

From Studio to Home — How Good Is The Electronic Highway?

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"A bird in the hand..": a picture in the home, "is worth two in the bush": is worth two in the studio. But this is only true if in transportation, the picture is not degraded appreciably. Present distribution techniques for NTSC television cannot reproduce studio quality. Improved pictures in the studio have little future application unless they can be delivered to the home while either retaining their intrinsic improvements or by being reconstructed by sophisticated receiver circuitry.

Our present electronic highway, then, is no six lane expressway, but more akin to a secondary road. Let us quickly review the degree of deterioration which does occur between studio and home.

Figure I lists typical quality factors such as signal-to-noise ratio (SNR), K-factor, and resolution to be found at various points in the system. Modern cameras can reproduce pictures with SNR around 55 dB, K-factor of 1%, and resolution of 500 to 600 lines. VTR's are capable of providing air-play dubs of 52 to 54 dB SNR, retaining a 1% K-factor, and resolution of 500 lines. Digital VTR's will do even better. At the studio output, typical values would be an SNR of 50 to 55 dB, K-factor of 2 or better, and resolution of 500 lines. And in future, the all-digital studio will improve these figures.

The studio signals may feed a transmitter directly, via terrestrial microwave, a network or at least an STL, or via a combination of microwave and satellite links. The overall quality would depend on a number of design or contractual decisions, -bandwidth, number and frequencies of aural sub-carriers, fade margins, diversity reception, and so forth. Typical at the transmitter input would be an SNR ranging from 48 to 52 dB, a K-factor between 2 and 3, and resolution of 450 to 500 lines. But now the real deterioration sets in.

The 6 MHz r.f. channel bandwidth used for NTSC is a serious constraint, and requires the video bandwidth to be reduced to a maximum 4.2 MHz, resulting in no better than 335 lines of resolution. The transmitter noise floor is only 48 to 50 dB below the video, and the best K-factor attainable is about 2 to 3 percent. The r.f. transmission is therefore between about 46 to 50 dB SNR, with a K-factor of 3-5% and 335 lines resolution, but even the professional quality transmitter demodulator can recover only some 320 lines after trapping out the aural carrier.

The typical receiver may recover the off-air signal directly, along with whatever deterioration due to noise, ghosting or interference the direct path provides. However, in Canada at least, the majority of receivers are connected to cable-TV systems, and very frequently with devices interposed between cable system subscriber terminal and the receiver itself.

As a consulting engineer, I had frequent opportunities to measure the performance of cable-TV systems. On average, in my opinion, the signal delivered to the typical subscriber would vary in SNR from 40 to 50 dB, with a K-factor of 4 to 6% and resolution of 300 to 320 lines. The receiver accessories, -converter, pay-TV descrambler or "address box" would have a wide range of effects, and frequently would reduce SNR by one or two dB, add about one % to K-factor, and lower resolution by perhaps 25 lines.

The receiver itself, in order to reduce colour crosstalk, usually rolls off 6 dB from maximum response at colour subcarrier, 3.58 MHz, and delivers a degraded picture of from 200 to 250 lines resolution, with a bad K-factor, and SNR in the 35 to 50 dB range. Video peaking, which adds overshoots to improve the detail subjectively, also adds noise to the picture. Colour saturation on the receiver is low because of the lowered response near colour subcarrier, and saturation must be increased, adding considerable noise to the colour display.

None of us can be very proud of the picture delivered at the end of the electronic highway. It is vastly inferior to the studio quality picture which started the journey.

And now we are promised substantially improved pictures at the source, enhanced definition, and high-definition TV. We are also being offered alternative methods of transporting our pictures to the home, and some of these can avoid the major constraint imposed by the 6 MHz r.f. channel bandwidth.

In some countries which have not yet exploited the UHF-TV band, it would be possible to increase channel bandwidths at UHF. This however, would call for a special breed of receivers, at increased cost, with dual-bandwidth I.F.'s for conventional and for wide-band TV, and probably requiring a split-sound design.

The direct-broadcasting satellite (DBS) offers a real opportunity for improvement, even on NTSC standards. The satellite links are nothing more than additional microwave hops, albeit long ones, and the Region 2 12 GHz plan provides for FM transmission in 24 MHz channels. The signal reaching the earth station receiver therefore can retain the quality typically delivered to our terrestrial TV transmitters. Baseband video and audio can be provided directly into the video and audio circuitry of component-style receivers. No doubt, though, an r.f. modulator will also be needed so as to feed an r.f. signal into receivers not so equipped. We will be hearing later in the session, from Mr. Whitworth and Mr. Gressman, current information on plans for DBS, and from Mr. Chouinard on the picture quality attainable over DBS in the presence of interference.

Though there are some difficulties in incorporating wider-band HDTV channels into the existing Region 2 DBS Plan, these are not insurmountable, and co-operative action on the part of at least the countries of North America can be anticipated.

The 12.2-12.7 GHz band in the ITU table of allocations to be used here for DBS also provides for terrestrial broadcasting. However, only in fairly large countries which do not institute DBS is there any chance that terrestrial alternatives would be possible.

There are other satellite bands 22.5 to 23 GHz and 40.5 to 42.5 GHz allocated for Broadcasting Satellites, along with other services, and it is thought that the former band offers a good alternative for HDTV distribution including all-digital service, despite the problems associated with attenuation due to rainfall at these frequencies.

Considering cable alternatives for wider-band channels, FM is already used for cable transportation of certain signals, and it would be possible to provide a subscriber service using FM. This could be compatible with the 12 GHz FM DBS signals. However, in most instances, a second cable would be necessary, with costs being very high. Present single cable systems have the capacity for some fifty 6 MHz channels, and could provide initially, a means to deliver improved signals using MAC technology. But in North America, at least, our off-air broadcasting spectrum is close to saturation. Broadcasters would need to retain their frequencies for compatible NTSC signals, and additional channels for a simultaneous, non-compatible MAC-type service are simply not available. Such signals would need to be provided directly to cable headends for distribution to the public, or alternatively, could use DBS or satellite-to-cable networks.

Regarding the capability of present cable system designs to transport better definition signals with minimum deterioration, we will be addressed by Israel (Sruki) Switzer during this session. Mr. Switzer has been involved at the cutting-edge of technology in cable system design for many years.

Fibre optics show great promise. Mr. Tsuboi will be describing advancements in this technology, particularly for the distribution of HDTV.

Up to the present, videocassettes and videodiscs for the home have not been designed to reproduce quality levels substantially different from those available through terrestrial off-air networks. Some do offer stereo sound, but little if any picture quality improvement. However, there is no major obstacle, particularly if an international standard emerges, to the provision of better quality magnetic or optical recordings for home use. Programs on these media could not replace broadcasting, but could supplement the choices available to viewers.

The all-digital studio provides the key for the generation of very high quality signals. Possibly ten years down the road, the electronic highway will provide for transportation of such signals to the home, using satellite or satellite to optical cable distribution, and the all-digital receiver will emerge as the eventual winner of the quality race. Mr. Lumbrink will be providing us information on digital development work at Bell Northern Research.

As the total revenues available for television expand, those based on advertising are being supplemented more and more by those based on subscription, and encryption methods become of greater interest. Mr. Keith Lucas will be describing techniques in this field.

To summarize, Figure II lists the presently-recognized distribution alternatives, together with their main attributes. It can be seen that we have little opportunity for major improvement in any of the schemes involving off-air terrestrial 6 MHz channels, and our crowded broadcasting spectrum offers little opportunity to reach the home using alternative

terrestrial off-air transmissions. Satellites, either by direct broadcasting, or by satellite-to-cable networks show promise, and optical fibres may well surpass coaxial cable as the preferred local terrestrial distribution network.

However, given the smart receiver, and in particular the digital frame store in the receiver, our opportunities expand substantially, since some of the obstacles imposed by the 6 MHz channel can be avoided.

Figure III summarizes our future delivery options using enhanced quality techniques. It would appear that quality can be improved to any extent that the market will permit. The sophistication and the pocketbook of the home viewer will determine the level, and not the limitations of technology.

**FIGURE I
SIGNAL QUALITY**

AT OUTPUT OF	SIGNAL-TO-NOISE RATIO dB	K-FACTOR %	RESOLUTION - LINES
CAMERA	55	1	500 - 600
VTR	52 - 54	1	500
STUDIO	50 - 55	2	500
MICROWAVE/SAT	48 - 52	2 - 3	450 - 500
TRANSMITTER	46 - 50	3 - 5	335
CABLE SYSTEM	40 - 50	4 - 6	300 - 320
RX. ACCESSORIES	38 - 48	5 - 7	275 - 300
RECEIVER	35 - 50	5 - 20	200 - 250

**FIGURE II
NTSC DELIVERY OPTIONS AVAILABLE TODAY**

SYSTEM	BANDWIDTH	RESOLUTION	S N R
Off-air	6	poor	poor to fair
Off-air to cable	6	poor	poor to fair
Microwave or Satellite to cable	6	poor	fair
DBS - remodulated	6	fair	good
DBS-direct video	--	good	good
Cassette or Disc	--	poor	fair to good

**FIGURE III
FUTURE DELIVERY OPTIONS**

SYSTEM	STANDARD	RESOLUTION	S N R
Off-air	NTSC-MAC	fair	fair
Off-air to cable	NTSC-MAC	fair	fair
Microwave or Satellite to cable	NTSC-MAC	fair to good	good
	HDTV	excellent	good
DBS-direct video	NTSC-MAC	good	good
	HDTV	excellent	good
Fibre Optics	NTSC-MAC	good	excellent
	HDTV	excellent	excellent
Cassette or Disc	any	excellent	excellent
All Digital	any	excellent	excellent



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