Implications of Ghost Cancelling to the Cable Industry

Gary Chan

Rogers Engineering
Toronto, Canada

Abstract

The ghost cancelling effort is steadily migrating from a developmental stage to commercial applications and will eventually target to a wider application - into consumers' television sets and VCRs. The influx of ghost cancelling into the cable industry is imminent. This paper will examine the issues that are important to the cable industry; it is based on earlier experiences on testing ghost cancellers done in: Vancouver - British Columbia (B.C.), Kitchener - Ontario, and the CableLabs' tests in Washington, D.C.

Introduction

Multipath is one of the major impairments cable companies encounter in receiving over-the-air television signals. Traditionally, RF cancellation technique (sometimes baseband technique) is used. However, it requires trimming long lengths of cable to match the appropriate delays or adjusting sensitive phase-

Figure 1 Ghost Cancelling Crew Investigating at a System Location.

shifting networks and matching precisely the amplitude of the reflections. In addition, the resultant signal suffers a signal-to-noise degradation during signal recombination and, most often, 100% cancellation cannot be achieved. Rogers Cablesystems initiated the ghost cancelling project in early January of 1990. A prototype ghost canceller was tried in Salt Spring Island, B.C. on April 6 & 7, 1990 immediately after the NAB convention. A month later, the first ghost canceller was put into full operation serving subscribers in Vancouver and its vicinities. Figure 1 shows a photograph of the Vancouver ghost cancelling crew investigating at a system location in Victoria, B.C.

ATSC's Effort to Establish a GCR Signal Standard

In 1989, the Advanced Television Systems Committee formed a specialist group on Ghost Cancelling called T3S5 to examine the various ghost cancelling techniques. There were five systems - AT&T, BTA, NA Philips, Sarnoff and Samsung - submitted to the ATSC for consideration. It was hoped that with a succession of field test, cable test and laboratory test, a single voluntary standard could be established for the television industry in North America. Six organizations were involved in this effort. The broadcast field test was conducted in mid-September of 1991. It took place in the Washington D.C. area. Three television stations, one in the VHF and two in the UHF bands, were used for the test. Over a hundred and fifty test locations were visited.

The cable test followed immediately after the field test. It consisted of two parts: the cable impairment test and the cable system test. The impairment test encompassed a series of cable impairment simulations which was carried out in the CableLabs HDTV testing facility in Alexandria, Virginia. The cable system test was performed on four cable systems in the vicinity of Washington D.C. and comprised of thirty-three subscriber locations. Measurements were made at headends, AML hubs, distribution taps and within subscribers' homes. The subscriber locations were carefully selected with a balanced mix of AML, trunk and optical link.

The laboratory test was carried out at the Communications Research Center in Ottawa last January. The test consisted of computer simulations of the different GCR signals being impaired by ten different combinations of ghosting and noise conditions; observations were focused on each proponent's GCR signal and its software implementations, such as, its ability in characterizing the transmission channel, the duration required to obtain a good approximation of the channel response, and the number of iterations necessary to achieve convergence. The laboratory test also used segments of the CCIR test tape, originally prepared to assess video codecs, to subjectively evaluate the picture quality improvement. Ghosts and random noise were introduced at IF and RF frequencies. The laboratory test was concluded at the end of January.

The results of the field test, the cable test and the laboratory test will be submitted to the ATSC. ATSC will recommend a standard to its membership for a vote in April of 1992. At the same time, a line in the vertical blanking interval will be determined for the transmission of Ghost Cancel Reference (GCR) signal. The tabulation of the vote will be disclosed in June of 1992.

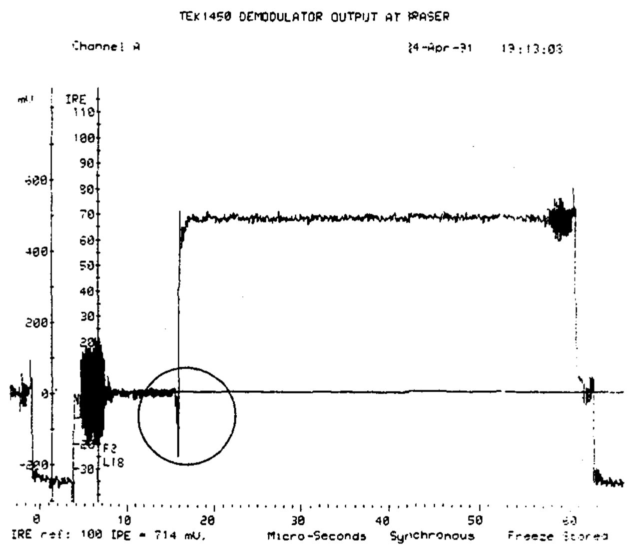


Figure 2 GCR Signal Received at the Fraser Hub.

Vancouver Test

Vancouver was the initial test site chosen for the ghost canceller test. There were a few important findings in the Vancouver test that prompted further investigations into the impact of ghost canceller to a cable system. For example, AM and FM microwave systems are widely used for cable television distribution. However, if they are not well maintained, non-linearity introduced by AM and FM microwave links can adversely affect the ghost cancellation performance and convergence time. Figure 2 shows the received GCR at the Fraser AML receive site. The GCR signal was inserted before the AML transmitter in Burnaby on channel 32. Notice that there was considerable undershoot but no overshoot on the integrated (sin x)/x signal. Under normal circumstances, the undershoot did not create any problems because it was blacker than black. However, when the GCR signal was captured and processed by the ghost canceller, the ghost canceller interpreted the undershoot as a ghost and tried to cancel it. The net result was that a ghost was introduced by the canceller itself.

Kitchener Test

Prior to the commencement of the Kitchener test, there were many uncertainties about ghost cancellers operating in a cable environment:

- Group delay caused by duplex filter and mop-up equalizers often cause chrominance to luminance delay inequality. Could these ghost cancellers be able to improve these distortions and to what extent?
- How would these ghost cancellers perform in a typical cable subscriber's environment, with the presence of a variety of cable distortion products, which satisfied the specifications outlined in

the FCC rules Part 76?

- Microreflection is one of the major concerns for in-house wirings that do not conform to CATV standards. Would these ghost cancellers be as effective as to cancel ghosts which were distinct and far apart than to cancel ghosts which were clustered very close together near the picture carrier?

In August of 1991, a test was launched in Kitchener, Ontario to investigate the effectiveness of a ghost canceller operating in a modern and well maintained cable system with AML distribution. Two test channels were used: one on channel 2 and the other on channel 48. A total of nineteen test points were selected giving thirty-eight sets of data consisting of subjective picture quality evaluations and objective channel waveforms. Since different brands of ghost canceller react differently to the signal that was contaminated by ghosting and other distortions, to simplify the analysis, it was decided that only one ghost canceller would be used.

There were a few specific findings as a result of the Kitchener test. From the subjective data, the results indicated the process through the ghost canceller did not alter the picture quality. However, assisting the judgement with the objective channel waveforms reviewed that 89% of the test points actually showed an improvement and only 11% indicated that the picture quality was degraded after the ghost cancelling process. Figure 3 shows a demodulated cable signal at a distribution tap and Figure 4 illustrates the same signal after it was processed by the ghost canceller. Notice the small improvement on the 2T pulse and

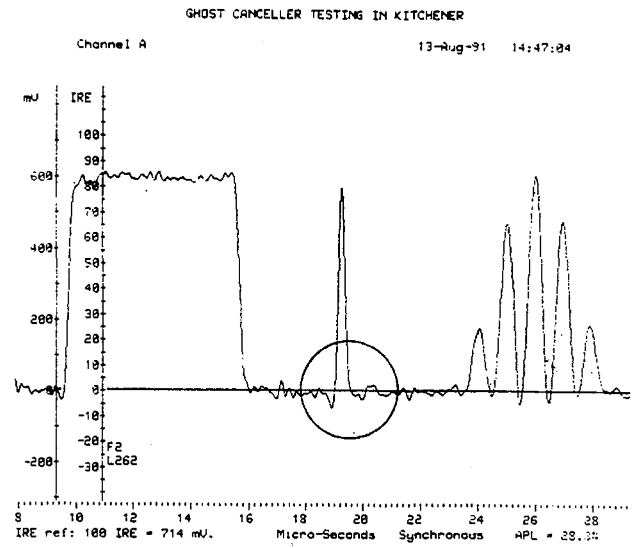


Figure 3 Demodulated Signal at Distribution Tap.

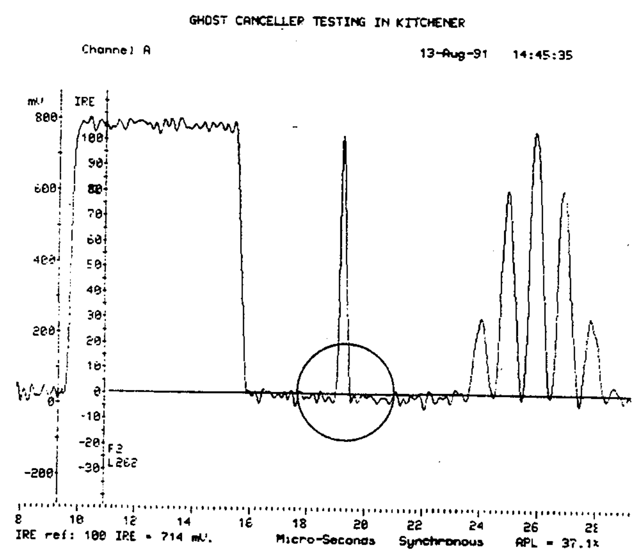


Figure 4 Demodulated Signal Processed by Canceller.

subjectively, it is difficult to perceive the difference by merely observing the pictures shown on the television set.

Contrary to the result of the Fraser hub in Vancouver, the Kitchener data indicated that AML equipment, if well maintained, did not impose any restriction on the ghost cancelling equipment to perform.

Suggestions on purchasing Ghost Canceller

The technology to implement ghost cancelling system clearly exists. Japan introduced the ghost cancelling system as part of the ClearVision implementation in 1988. North America will have a GCR signal standard this year. It is believed that commercial ghost cancellers will be introduced to the broadcast and cable industries even before the 1992 NCTA Convention. Yet, what does a cable company need to consider before buying a ghost canceller? Rogers Engineering would like to share some of our experiences:

- These devices exhibit some peculiar characteristics and, quite often, require a software reset to cure the condition. Therefore, it is highly desirable if a front panel as well as a remote reset (for unmanned antenna sites) functions are available.
- Occasionally, broadcasters may necessitate the removal of the GCR signal for maintenance or trouble-shooting purposes. Normally, a ghost canceller updates the ghosting conditions by continuously captured and processed the GCR signal. However, it may exhibit an instability state due to the loss of GCR signal. Thus, there is a need for ghost cancellers being able to freeze the last set of filter coefficients during which the GCR signal is missing.
- If electrical interference (or sometimes called impulse noise) is present on the received signal, here is another feature to ask for: its robustness to electrical interference. Figure 5 shows the BTA GCR signal corrupted by electrical interference. As a result, there may be momentary loss of the picture for a short duration. If the impulse noise happens often enough, the momentary loss of picture becomes very annoying.

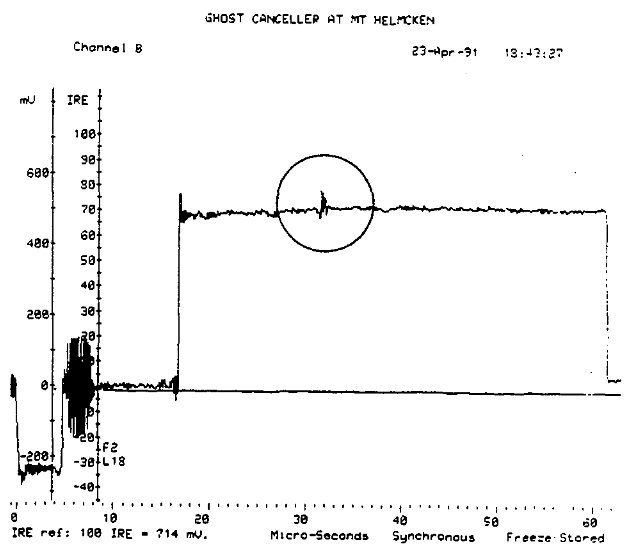


Figure 5 GCR Signal Corrupted by Electrical Interference.

- Under certain circumstances such as a deep signal fade or equipment failure, there may be a need to by-pass the ghost cancelling process. Therefore, front panel as well as remote by-pass switches are useful.
- Ghost cancellers are

baseband devices. If channel processors are presently used to process over-the-air signals, one may want to ask ghost canceller manufacturers whether there is an IF interface option available.

- Lastly, line 19 on the vertical blanking interval is being proposed by the ATSC for the transmission of GCR signal and, as a consequence, the usage of line 18 and line 20 may be restricted to time invariant test signals only. But, line 20 is being used by some cable operators for conditional access and the information on this line is time-varying. Cable operators may want to solicit ghost canceller manufacturers to incorporate GCR signal deletion circuitry once the television signal has gone through the ghost cancelling process. And, maybe, there are other alternatives than deleting the GCR signal.

Conclusions

The list of suggestions presented on buying a ghost canceller is by no means complete. It is the intention of Rogers Engineering to share the experiences of our ghost cancelling system development effort with other cable companies and, via the sharing of ideas, to stimulate more discussions and generate more ideas on the implementation and deployment of ghost cancellers.

Acknowledgement

The author would like to thank Rogers Cable TV in Vancouver, British Columbia and in Kitchener, Ontario for their assistance in conducting the field tests. The evaluation of ghost cancellers is sponsored by CableLabs. The cooperation of Tektronix, KOMO, KIRO and KING stations, Communications Research Center, and the support of various ghost canceller manufacturers is vital to this project. Their help and support are most appreciated.

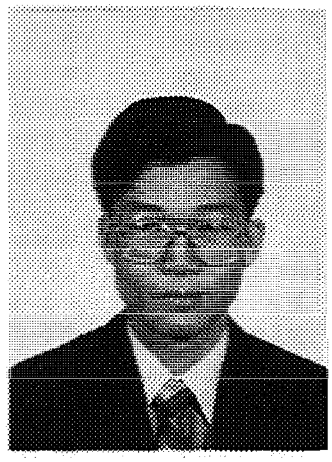
References

"Field Tests of Ghost Canceling Systems for NTSC Television Broadcasting", by National Association of Broadcasters and Association for Maximum Service Television, January 31, 1992.

"Results of Computer Simulations and Laboratory Tests of Proposed Ghost Cancelling Systems", by Bernard Caron - Communications Research Center, (preliminary) February 1992.

"Shades of Ghost Canceling", by Wendell Bailey, pp.18, Communications Engineering and Design, December 1991.

"Ghost Cancelling and Cable", by Nick Hamilton-Piercy and Gary Chan, pp.113, NCTA Technical Paper, March 1991.



Gary Chan is a Staff Engineer at Rogers Engineering, Toronto Canada. He received his B.Sc.E.E. degree in 1980 from the University of Manitoba and Master of Engineering (Electrical) degree in 1986 from the University of Alberta. Since his graduation in 1980, he has engaged in CATV design, operation, maintenance, research and development of advanced cable television technologies. Most recently, he leads the PCN test on using the cable plant as a transport media in Toronto. He is a member of the IEEE and a registered Professional Engineer of Ontario.