THE CUMULATIVE LEAKAGE INDEX (CLI) MADE EASY

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ABSTRACT

The Advisory Committee on Cable Signal Leakage developed the Cumulative Leakage Index (CLI) in an attempt to provide a simple, positive means to assure that cable television systems do not interfere with aircraft navigation or communications systems. The CLI represents the best combined efforts of the cable industry, the aviation industry, the Federal Aviation Administration (FAA), and the Federal Communications Commission (FCC) to develop a measurement technique that, when fully employed, will allow extreme freedom for the cable operators to use any desired carrier frequencies on their cables.

For a well-maintained, leak-free cable system, the CLI requires little effort to accomplish. Measurements may be made either on the ground or in the air. Once the CLI has been analyzed and found to be in compliance, the cable operator has a high degree of assurance that no interference will be caused in the airspace.

BACKGROUND

Beginning in the early 1970s, the FAA, the FCC, and the cable television industry became increasingly concerned about the potential for cable television systems to interfere with critical air navigation or communications frequencies. Such a potential exists when cable systems use carrier frequencies within the "aviation band" (108 MHz to 137 MHz) and such cable systems radiate excessively. Only rarely were actual cases of interference reported; however, considering the possible consequences, the interference potential could not be ignored.

On February 10, 1978, the FCC chartered The Advisory Committee on Cable Signal Leakage (Advisory Committee) to examine the nature of the interference mechanisms and to recommend a regulatory approach. Through several field tests, both on the ground and in the airspace, the Advisory Committee found that ground-based measurements could be used to predict signal levels that aircraft would encounter. This prediction method was fully described in the Advisory Committee's final report, dated November 1, 1978. The system became known as the Cumulative Leakage Index. Most basically, the CLI uses ground-based measurements to statistically predict electromagnetic fields in the airspace.

The Advisory Committee's final report developed a CLI for 3000 meters above the cable system (I_{3000}) and then generalized that result to a CLI for an infinite distance above the cable system (I_{inf}). Although I_{3000} may be useful for borderline cases, it requires much more work to analyze. The actual distances between each leak and an imaginary point 3000 meters over the center of the system must be calculated and entered into the formula, along with leakage levels and a percentage factor for the amount of the cable plant actually measured. I_{inf} requires only a summation of actual leakage levels found, divided by the percentage of the cable system actually covered. The method of collection of leakage data is the same for either CLI.

Once the raw CLI has been calculated, it must be shown that 10 log I_{3000} is less than -7 or that 10 log I_{inf} is less than +64. If either condition is met, the system can be assumed to be producing a field of no more than 10 uV/m at 1500 meters above the cable plant. This level should not cause harmful interference to aircraft.

The CLI ground-based measurement technique can generally be used where the cable plant does not extend well above ground level. For example, a community of single family dwellings or relatively low commercial buildings would be a prime candidate for ground-based CLI measurements. An area of skyscrapers would be more suited for "fly-over" type measurements, as the CLI measurements will be accurate only when the measurements are made in close proximity to the cable plant.

For complete details on the CLI, the description in the Final Report of the Advisory Committee on Cable Signal Leakage (Final Report) should be studied. This paper deals with one "simplified" method of making the ground based measurements, as described in the Final Report. Although other implementation methods could be considered, the one described herein allows checking relatively large systems in a matter of hours.

WHAT IS THE CLI?

The Final Report describes the CLI in terms of simple formulas. Because the calculation for I_{inf} is much easier than for I_{3000}, we will consider only I_{inf}. The formula provided in the Final Report is:

$$I_{inf} = (1/P)(E_1 + E_2 + \dots + E_n)$$

where,

P = Percentage of cable system examined (expressed as a decimal)
E = Leakage level at 3 meters (uV/m)

The values for leakage are theoretically actual measured levels at 3 meters from the cable, as measured in accordance with Section 76.609 of the FCC Rules and Regulations. This would involve using a calibrated field strength meter, a resonant dipole, and an actual physical measurement at each leakage location. Although this would provide the most accurate results, the Advisory Committee developed a "simplified" method to make the measurements. The Final Report indicated that the shorter method gave sufficiently accurate results, as compared to the physical measurements at each location.

SIMPLIFIED PROCEDURE

The simplified method basically involves calibrating an "S-meter" in a vehicle against several measurements with the field strength meter and dipole antenna. The participants in the Advisory Committee used a commercial cable leakage detector as the receiver and a magnetically mounted quarter-wave dipole on the vehicle for the tests. Although the Advisory Committee did not try to record the data digitally, that would be a further refinement to the procedure.

To conduct measurements for a CLI, the Advisory Committee recommended that at least 75 percent of the cable system be covered, and that the worst part of the plant be included. Initially, the cable kilometers would be driven, while listening for high leakage on the leakage detector. When leakage of 50 uV/m or greater at 3 meters from the cable was suspected, then the vehicle would be stopped and a physical measurement would be made. After this had been done several times, a calibration chart could be developed to relate the S-meter readings to actual field strengths. Once sufficient confidence had been gained in the S-meter readings, then it would no longer be necessary to stop at each leak and take a measurement. The readings of the S-meter could simply be converted to equivalent field strengths. This simplification would allow a cable plant to be driven, without stopping, in a short period of time. The person making the measurements would merely need to record the maximum S-meter level for any leak suspected of being over the limit. Once back at the office, the engineer could convert the S-meter readings to field strengths and compute the raw and final CLI values.

ACCURACY OF PROCEDURE

The first question related to the accuracy of the simplified leakage measurement technique involves the lack of known distances between the leaks and the vehicle. The Advisory Committee felt that over a large number of kilometers, the variations in distance would average out. That is, sometimes the vehicle would be close to a small leak and thus the leakage value would be distorted to the high side. Likewise, some larger leaks might appear small due to greater distances between the cable and the measurement vehicle. Additionally, assuming that reasonable distances always remained between the cable and the measurement vehicle, any egregious leaks should be found by the system scan.

Second, the accuracy of the prediction of no interference to aircraft could be questioned based on the chance that an egregious leak might be missed with the procedure. The Advisory Committee found that single leaks of relatively high magnitude did not appear to cause excessive interference in the airspace. For example, a single resonant, sleeved dipole fed at trunk level could not be detected at 450 meters above one of the cable systems examined by the Advisory Committee. So, unless a large number of medium to high intensity leaks were missed, the chances of interference would be minimal.

OTHER CONSIDERATIONS

The Final Report described a method of automating the ground-based field strength measurements. At the time of the Final Report, computers and magnetic storage media were fairly expensive, so the Advisory Committee did not envision use of this technique for routine CLI measurements by cable operators. Since 1979, computers have become readily available to the general public at low cost. An improvement on the above described manual procedure would be for the data to be collected by a computer. This would nearly completely automate calculation of the CLI, except for the person driving the measurement vehicle throughout the cable plant.

When using the automated technique, the Advisory Committee used a "fifth wheel" on the vehicle to cause a measurement to be taken every 24 centimeters of distance traveled. This provided several measurements per wavelength and avoided biasing the results by having numerous measurements made at stop lights and few measurements made at highway speeds.

There are perhaps other techniques that can be implemented in the future that will further simplify the CLI. For example, it may be possible to change the measurement location scheme to make data collection easier. In the mean time, the CLI can serve to allow cable operators more freedom in operation on aeronautical frequencies.

Even though offsets from aviation frequencies appear to be an easier solution to the interference question, offsets can provide only a temporary solution. The FAA has "split" the aviation channels several times before. Another split will cause cable carrier channels and aviation channels to be coincident in frequency. Clearly, at that time, low leakage will be the only means by which cable can safely continue to use aviation channels. The time to begin a leakage reduction program is now, not when your system comes in conflict with the FAA.

The views expressed in this paper are those of the author and do not represent an official policy statement of the Federal Communications Commission.