AVERAGE LEAKAGE INDEX

ALI

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ABSTRACT

The implications of signal leakage from a cable television system have changed as dramatically as the cable industry. In the earliest days a cable operator was concerned with radiation simply as it provided a mechanism for unauthorized reception. Today we have regulations which prescribe the conditions by which we may use certain frequencies and require affirmative actions to control system leakage and ongoing record keeping, yet we still tend to refer to our systems by subjectively saying "a good tight system", "a lotta leakage" or so forth.

The Average Leakage Index (ALI) was developed to rank system leakage and access repair effectiveness. ALI serves as a repeatable, objective method which yields an 'executive summary' of leakage within a system.

INTRODUCTION

The Average Leakage Index is a simple, straight-forward method of determining the relation of leakage in a particular system to others in the same universe. The process is fully random, and since it is conducted under similar circumstances and not (hopefully) subject to operator interpretation, unbiased. The process conducts two measurements for each mile of plant and classifies each site as shown:

1. Unlikely to exceed FCC limit.
2. 50/50 chance of exceeding FCC limits.
3. Likely to exceed FCC limits.

The total samples in each category are then related to the overall total (100%) and expressed as a percentage.

Finally, the actual ALI for the system is determined by adding the total scores together and dividing by the number of samples. While a more statistical astute method might be applied, it is felt that the under-lying objective of ranking is met by the process. The ALI technique will provide clues to the nature of leakage problems, better focus repair efforts and evaluate the effectiveness of a repair project.

It is important to remember the ALI is only a ranking tool. It does not assure compliance with the Commission rules. Systems with very low ALI's should not forget about radiation monitoring. The Commission rules are inflexible, and any leakage can result in Commission action.

THE PROBLEM

Assume you have a leakage detector adjusted to indicate a "fail" condition when detecting a leakage source of 20 uV/M at 10 feet. Now drive down a street; a drop passes overhead, perhaps 5' from your antenna; the plant is on the other side of the street, now 30' away; or its in the back lot, 130' distant. Unless you can identify each source of leakage--no matter how small--and then evaluate it based on your distance from that source, the survey will provide misleading data. The leakage from a back lot distribution plant could be 10-12 dB above the allowed level and be seen as less than the source of a "legal" nearby drop. Any system wide survey testing will be subject to this effect. Understanding this limitation, let's look at what ALI offers.

CONDUCTING AN ALI

The total mileage of the system should be determined. A street map should be marked showing the boundaries of the plant. All test locations should be within the confines of the system.

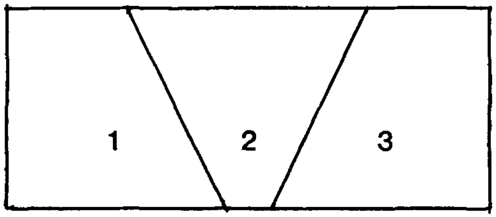
The number of test locations should be equal to twice the number of plant miles. So, a 50-mile system will have 100 test locations. The locations should be consecutively labeled and as the actual testing progresses, tests should be made about every one-half mile. On the average, about 25 to 30 tests can be made for each working hour.

The ALI testing conducted by Capital Cities personnel used the Comsonics Sniffers operating in the vicinity of 108 MHZ. Other units could be used, however, unless the meter display of the substitute unit followed the same sensitivity curve, the comparison between these ALI's and others would be distorted. The 'Sniffer' is essentially linear to mid scale and compresses toward the upper end. If a system were employed which were linear the resultant ALI samples would be higher.

The following procedure relates to the

calibration of the sniffer:

The equipment should be calibrated to the Internal Standard so 20 uV/M at 10 feet equals mid scale. At this point the calibration dot will be near the 12 o'clock position. Install the monopole antenna on the roof of the test vehicle so as to be away from other antennas, lights and ladder racks. Install the clear overlay on the face of the Sniffer.



ALI METER OVERLAY

The test vehicle should be driven to the reference point and stopped without any attempt to optimize or diminish the reading of the detector. This would be best accomplished by turning down the testing device's audio and covering the meter. This is very important.

When the vehicle is fully stopped, the relative indication of the meter (1, 2, or 3) should be logged along with the location number (See Figure 1) which is also marked on the survey map. This provides a method of returning to locations displaying high leakage indications. When the survey is complete, the Average Index may be calculated. Total the value of all measurements and divide it by the total number of measurements actually made (See Figure 2).

Newer well maintained systems will be capable of ALI values very close to 1.0 (i.e. 1.005 1.01 etc.). In our experience a value of 1.2 is not uncommon in a 5 year old aluminum cable system with casual maintenance. ALI's of 2.05 have been recorded in 15 year old systems using foil type trunk and distribution cables. After an extensive maintenance effort the particular system demonstrating 2.05 was reduced to below 1.1. This proves the effectiveness of the repair process. As a practical matter, in a system with severe leakage it may be very difficult to isolate individual leak sources. A technique of trapping out the radiation transmitter from down stream amplifiers may be employed to control the amount of system 'illuminated'.

Capital Cities has been using the ALI test since July, 1983, and to date conducted approximately 100 full ALI's on its 55 systems.

AUTOMATED ALI

After using ALI for a few months we found that while it was a quantum leap over the old emotional 'good system' or 'leaky' expression, the present system has some shortcomings in the area of testing convenience and the use of a single spot frequency for measurements. This paper will conclude with the concept of Automatic ALI which is presently under evaluation by a major CATV Equipment Manufacturer.

The process utilizes several techniques which are new to leakage measurements. The principle features of this technique include:

- Non-Additive Multi-Frequency Leakage Detection.

- Automated Logging of Measurement Samples.

The nature of leakage sources within coaxial cable inherently create highly reactive networks. Because of the large reactive component, a leakage point may offer a low radiation resistance at certain frequencies and a high resistance at others. Because of this effect, a leakage source may generate substantial fields at frequencies removed from the survey frequency yet present virtually no fields at the survey frequency itself. This disparity can cause major leakage sources to be missed. The reactive component of a leak is controlled by mechanical variables. As physical cable plant conditions change due to movement such as vibration, wind sway or temperature, points of grounding between the cable and strand can change. These changes and other effects alter the nature of the reactance at the leakage source and consequently its frequency selectivity. This effect may account for the heretofor unexplained appearance of 'new leaks' on a system just repaired. Simply stated, the leaks were always there but were simply hidden from the single frequency detection equipment.

The proposed system utilizes three frequencies which due to their harmonic relationship, increase the probability that any leakage source will present a low radiation resistance at one of these frequencies. The actual frequencies may differ slightly to accommodate on-going cable signals and regulatory considerations.

When a signal is detected by the appropriate antenna, the output of the respective receiver increases. It is further believed that multi-frequency techniques will tend to smooth out the cyclical (grating lobe) effect experienced while passing a leakage source with a single frequency detector. This improvement is due to the contribution from the other two frequencies effectively filling the propogational nulls of any single frequency. Each of the three receivers and its respective antenna is reconciled to some nominal field sensitivity. This is accomplished considerate of the differential in path loss to the leak due to frequency and the gain of the individual antennas.

The display meter shows an indication of the amount of signal received from the predominant receiver. The vehicle is equipped with a 'Fifth Wheel' and at predetermined intervals loads the measurement into memory.

Concurrent with the sync and data packets being loaded two other components are present. A voice operated microphone is mixed with a continuing audio sample of the output of all three receivers. The mike circuit allows for noting significant reference points along the survey route. The audio component of the receivers identifies the particular receiver dominant in the audio summation as the three source transmitters having distinctively different audio tones.

The magnitude of every sample may be determined by inspection of the record. The Average Leakage Index is determined by dividing the total of all recorded levels by the total samples. An operator knowing the distances between samples, survey path and reference points, can identify the approximate distance from a reference point to any sample point.

While some enhancement is bound to occur when this system is prototyped and eventually used in the field, it is felt the essential features of the system will prove to be a valuable contribution to continued CATV plant maintenance.

CONCLUSION

A logical relation exists between the regulatory environment and ALI. A process like or similar to ALI could serve as the gateway for the utilization of more sensitive frequencies in a "closed system". The operator who through diligence maintains a nearly perfect closed system should be rewarded for this effort by the right to re-use critical frequencies. Those who ignore the consequence of operating leakage-prone or poorly maintained systems should bear the brunt of Commission's Enforcement actions. Until some economic reward fuels leakage management, it is likely to remain an 'also ran'.

It is our belief that a measurement system that makes the distinction between good and bad plants will be at least useful and in all probability pivotal in future years.

Example of field log

fig. 1

LOCATION	LEVEL
1	3
2	1
3	2
4	1

Total of Levels - 7
Number of Samples - 4

$$\frac{7}{4} = \text{ALI } 1.75$$

Example of test results

fig. 2