AIRSPACE MEASUREMENT OF CATV SYSTEM CLI

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ABSTRACT

This paper discusses the signal leakage measurements made in the airspace above Dallas and Fort Worth, Texas to determine cable system Cumulative Leakage Index (CLI).

Discussed is the monitoring equipment used, the pre-flight and in-flight calibration tests, and the outfitting of the aircraft used in the flyover.

Cable systems with shielded and unshielded cable fittings, as well as new (quad shield) and old (60% braid), were included in the measurements. The systems with the best procedure to prevent leakage also had the most aggressive monitoring program and, as expected, had little problem complying. The systems with fewer precautions to prevent leakage had a more casual monitoring program and, judging by ground measurements, had more severe leaks.

The measurements were made at an altitude of 450 meters (1,476 feet) above average terrain and at Channel C carrier frequency. The purpose was to determine the compliance with anticipated FCC requirements for 10 uv/meter maximum leakage.

The first test (April, 1985) indicated that the best system had 2 uv/meter in the airspace, an intermediate system, --- i.e., shielded cable fittings, a monitoring program, but with some old house drops --- had approximately 4 to 8 uv/meter and a worst case system had higher than 20 uv/meter.

The test in December showed house wiring to be less of a factor than originally thought, with 3 uv/meter being a typical value for a good system, even those with some older drops.

It is concluded that a system with shielded fittings and an aggressive ground leakage monitoring program would easily comply with the future FCC requirements of 10 uv/meter at 450 meters above the cable system being tested.

INTRODUCTION

The use of aeronautical frequencies 105-136 MHz and 225-400 MHz by cable TV systems has always been carefully controlled by the FCC to avoid interference to aeronautical communication and navigation systems.

In locations where cable systems have been allowed to operate in these frequency bands prior FCC notification has always been required. Reduced power and offsets from standard channel frequencies have historically been used to avoid conflict with other services.

In the Opinion and Order 21006, the FCC authorizes the use of aeronautical frequencies without prior notification provided specified offsets are maintained and a ground-based leakage monitoring program is implemented. After July 1, 1990 systems will also have to show compliance with certain leakage criteria, either the ground-based CLI (Cumulative Leakage Index) or the maximum of 10 uv/meter in the airspace. Ground-based CLI measurements have been discussed in the literature; until the FCC Docket 21006 was published no limit of airspace leakage was widely circulated. This docket specifies a limit of 10 uv/meter field strength in the airspace 450 meters above the cable TV system.

When it was first believed that CLI measurements would be required for signal carriage, ground-based measurements were attempted by Sammons. Initial tests showed that the time required to cover 75% of the Metropolitan Fort Worth area could be as high as three man-months, especially if the levels measured in the street were converted to equivalent levels 3 meters from a possible source. In addition, the uncertainty in estimating distances between antenna and sources is high. Finally, ambiguous results can easily be obtained in locations where more than one high level leak may exist. For these reasons, it was decided that a flyover would provide the most definitive measurement of system airspace leakage.

Two tests were taken: one in April of 1985, covering Sammons' Fort Worth system and some just-acquired adjacent systems. The second test in December of 1985 covered the same areas plus those of a second acquisition. Overall, a good sampling of systems was measured: with and without cored cable fittings, with and without multiple shielded house drops, and with a variety of leakage monitoring programs.

EQUIPMENT AND CALIBRATION

Receiver

The receiver used was a Singer NM-37/57 (in the first test) and a Polarad ESV (in the second). The receiver criteria was:

Sensitivity: -108 dBm

Bandwidth: 25 KHz maximum

Calibrated output to drive Y-T chart recorder

Frequency Resolution: ± 1 KHz

Provision for internal battery or 12v operation

The receiver sensitivity was determined by the expected signal: 10 uv/meter will theoretically produce -98 dBm in a half-wave dipole antenna, and a minimum receiver sensitivity of -108 dBm would then provide a 10 dB margin. The receivers used actually had about -117 dBm maximum sensitivity, so the minimum detectable field strength was about 1 microvolt/meter.

Both also had proper output to drive an Y-T recorder and the required powering provision. The Polarad had a synthesized local oscillator which displayed frequency directly in 1 KHz increments; the Singer did not, but the local oscillator frequency was available at a test port so an external counter was used to accurately determine input frequency. Both were heavy - the Singer weighed 65 pounds with batteries. A separate input filter was found necessary to reduce interference generated from out-of-band signals.

To calibrate the measurement system, the FCC requires that a known 10 uv/meter field be established at the test altitude of 450 meters. This field is generated by an antenna and signal generator on the ground.

The FCC is specific about the calibration antenna. It is to be "... a well characterized antenna consisting of orthogonal resonant dipoles, both parallel to and one quarter wavelength above a ground plane of a diameter of 2 meters or more at ground level. The dipoles shall have centers co-located and be excited 90 degrees apart." [1]

This antenna produces circularly polarized signals. The antenna used in these tests was cut for Channel C (132 MHz) and required +15 dBmv excitation to generate 10 uv/meter 450 meters away. It should be noted that ground-based tests to verify proper operation are difficult to perform; the ground, and any structures, distort the generated field. It is best, if one chooses to verify operation before a flight, to use adjacent hills and raise the transmit and receive antenna as high off the ground as possible.

In contrast to the difficulty in obtaining good gound-based readings, the initial flyover of the calibration antenna produced results within 3 dB of calculated values. Since the aircraft fuselage was close enough to have a definite effect on the antenna response, this was considered a comfortably close correlation. We found it necessary to fly directly over the antenna to get the most consistent results.

Receiving Antennas

Two dipole receiving antennas were used on the aircraft; they were tied between the tail and the wing tie-down points on each side of the fuselage. The outputs were combined before entering the receiver. With two antennas it is believed at least one would pick up a signal should the aircraft fuselage shield the other. This advantage of wider coverage should outweigh any problems caused by 180° phase cancellation that would occur in some situations. The antenna array gave consistent results during the in-flight calibration, even though its field was probably distorted because of its proximity (two to three feet) to the metal fuselage. It is important that the pertinent channel frequencies be measured just before testing; a slight drift can place the signal out of the receiver's bandwidth.

TIME REQUIREMENTS

Preparation and Test

Approximately one man-month was required before the initial tests were taken; this time was used for equipment selection, calibration and receiving antenna design and construction, ground tests, and outfitting the aircraft. Only about one day of preparation was required before the second test. The plane flew at an airspeed of 75 to 90 knots (approximately 100 mph). The flying was done in one-mile grids; it took about one day to cover the entire Tarrant County area. Additional close systems could have been covered, if desired. An additional day was used to cover systems that were 30 to 40 miles away.

A street map was marked to guide the navigator when flying over the Fort Worth area. Visual estimations were used when flying over smaller towns (like Weatherford) where three or four passes were adequate.

TEST RESULTS

System	Date	Leakage uv/m		Monitoring Program	Shielded Cable Fittings	All Quad or Triple Drops
Benbrook	4-85	10	*	Yes	Yes	Yes
	12-85	3		Yes	Yes	Yes
Burleson	4-85	30		No	No	No
	12-85	3.2		Yes	Yes	No
Crowley	4-85	10		No	No	No
	12-85	3		Yes	No	No
Fort Worth	4-85	3		Yes	Yes	Yes
	12-85	22.3	**	Yes	Yes	Yes
Richland Hills	4-85	10		No	No	No
	12-85	3		Yes	Yes	No
Saginaw	4-85	14		No	No	No
	12-85	2.5		Yes	No	No
Watauga	4-85	8		No	No	No
	12-85	3		Yes	Yes	No
Weatherford	4-85	10		No	No	No
	12-85	3		Yes	Yes	No
White Settlement	4-85	4		Yes	Yes	No
	12-85	4		Yes	Yes	No

* Caused by one leak
** Two locations greater than 10 uv/meter

When the first test was taken, the data indicated a measurable difference between systems with some lower quality drop and house wiring (60% braid) and those with only high quality wiring (triple or quad shield). The December measurements indicate that the quality of house wiring may have less effect than originally thought. It is unlikely that lower quality house wiring will cause 10 uv/meter signals in the airspace; it can, of course, create other problems such as interference to amateur radio services and can allow devastating ingress to midband channels.

Although the airspace measurement is not designed to locate individual leaks, it did, on one occasion during the April test, indicate an unusually high level (10 uv/meter) in the Benbrook system. Ground tests in the area located a radial feeder crack.

The December test showed four locations of high leakage in Fort Worth, two higher than 10 uv/meter. A ground check of the area is occurring, but results are not available in time for inclusion in this paper. They will be presented at the technical session.

One question has been raised by the Fort Worth data: If, in an otherwise tight system, some isolated severe leaks are measured by the flyover, and if ground-based measurements are used to locate and correct the leak, can the improvement in airspace leakage be demonstrated without an additional flyover? Can we be sure that all the contributing leaks are found?

Not, of course, with absolute certainty, but a conscientious monitoring program of the affected area should provide reasonable assurance that the system is clean.

CONCLUSIONS

The following conclusions can be reached from the test data:

1. Average signal levels of 2 to 4 uv/meter will be measured from well maintained systems.

2. A routine leakage monitoring program is essential for maintaining this level.

3. Shielded cable fittings are helpful but not quite as necessary as a routine monitoring program.

4. Drops and house wiring quality are not critical for maintaining the leakage level of 10 uv/meter @ 450 meters.

5. A system with inadequate leakage monitoring programs will probably exceed 10 uv/meter @ 450 meters.

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REFERENCES

1. FCC Docket 21006
§ 76.611 (a) (2)