AUTOMATED SIGNAL LEAKAGE MEASURING SYSTEMS

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Abstract

This paper deals with the FCC requirements for monitoring and measurement of signal leakage in conjunction with the cable operator's need for a leak free system. Moving from the basically cumbersome methods now employed, possible integration of various techniques and hardware is considered to accomplish ground and air monitoring, measurement, data reduction, display and hard copy generation. The paper suggests a "better way" to approach this very important aspect of cable system maintenance.

Introduction

During the mid 70's, the attention of the cable industry was forced to focus upon signal leakage as a result of the concerns of various users of over-the-air communication services as well as a few instances of interference by signal leakage from CATV systems. The now famous Docket 21006 was generated and FCC/FAA/Industry "Advisory Committee on Cable Signal Leakage" was formed, worked and reported. Part 76 of the FCC Regulations was modified several times leaving us today with specific regulatory responsibility for controlling CATV leakage, This requires constant vigilance in the form of continuous monitoring to detect the same, plus the task of ongoing repair. This is all in order to protect not only safety-of-life services, but all over-the-air users of the frequencies utilized "within the cable". It took the cable industry some time to come up to speed on this new perspective, however, today most cable operators have instituted monitoring and repair programs which have resulted in reduction of cable system leakage. The job of clean-up is far from complete. In 1990, the regulations require qualification of performance by way of the "Cumulative Leakage Index" or fly-over measurement of the leakage fields within the air space above the cable system. This move toward protection of over-the-air communications services will result in better cable systems since where less energy leaks out, less interference to CATV product can be expected to leak in.

It is most sobering to consider that even the best CATV components operating in the outside environment, cannot be counted upon to maintain leakage integrity indefinitely. The bottom line is that monitoring and repairing (and probably verification for the FCC) will go on indefinitely in the forseeable future. A great deal of money will be spent upon continuing labor plus equipment to perform this quality control task. Due to the labor intensive nature of this job, it would behoove us to seek more efficient methods of leak detection, location and repair as well as qualification of our results.

Perhaps, a better way...

This is certainly a situation where we need the proverbial "better way" to ease our task and improve our results. It is well to attempt to quantify that way and direct our attention toward better methods lest we become "slaves of the system". It is our objective here to suggest directions to proceed in weaning ourselves from signal level meters, handheld dipoles and tedious routines.

We seek a systematic approach, not only for monitoring and leak location but for data-taking to satisfy the FCC requirements. Such an approach must be one which takes meaningful and accurate data but does not become highly labor intensive due to the care required to take the data or the volume of data which must be assembled. In other words, we need a system which can automatically sample all necessary parameters and store large volumes of data for later reduction. The equipment must be easy to handle, install and operate and leave little room for omission and error. We are talking about a task which needs to be done both in the air and on the ground and combines leakage detection and location with the FCC qualification measurements.

After the measurements are done, it is absolutely necessary to produce good records and documentation along with flexible displays so that the leakage situation may be viewed from the perspective of the entire system as well as observation of single leaks.

While we are about it, we should leave some flexibility for "esoteric" items like multifrequency measurements which will surely enhance our understanding of leakage phenomona and hopefully lead to better practices in both construction and measurement.

Approach

With the above considerations in mind, let's dream a little about the configuration of such an integrated signal leakage measurement package. There certainly is a need for an automated and continuous data gathering device which can be used in vehicles utilizing DC power, etc. There are really two distinct vehicular requirements. The first is in an aircraft to accomplish the measurement of leakage fields in the airspace above the cable system, while the second is a ground vehicle configuration.

Airborne measurements must be done with a carefully thought-out and executed procedure. In order to satisfy the FCC requirements (Section 76.611), the overflight must be made at approximately 1500 feet above the average terrain. A grid pattern should be flown with a spacing of approximately one-half mile between passes. When you are flying in the airspace above the cable system, you must employ some system of geographical reference in order to assure the desired flight path. There are various ways of accomplishing this, the traditional one being to preselect landmarks which can be used to establish the grid pattern and visually fly by these landmarks. It is reasonable to assume that careful scrutiny of your data may be undertaken by the FCC and would require definitive notes on the landmarks employed, how the passes were flown and any discrepancies or anomalies in the flight path which might be caused by terrain obstacles, drifting off course, changing course to avoid other aircraft traffic, etc.

Ultimately, your flight path should be overlaid on a map of the area. Presentation of early flight tests included a transparent overlay of the flight path attached to a map of the system.

In terms of the flight path, a constant check on the altitude should also be maintained. Since the flight path is specified relative to the average height above the terrain, flying a constant barometric altitude (the altitude indicated by a standard calibrated aneroid altimeter) is indicated and a running check or repeated spot check of the actual altitude should be recorded. Careful consideration of the above requirement shows that maintaining the prescribed flight path and recording exactly where you've been is more than a trivial task under realistic flight conditions. It certainly would be nice to have some magic position indicating device which would feed in the actual position, including the altitude, for each datapoint taken thereby eliminating all of the problems associated with the above.

Considering data points, it behooves us to have a lot of them so that there is little chance of missing a peak in the leakage intensity during the run. The FCC regulations provide for either analog or digital data collection. Analog collection might be obtained by using a continuous chart recorder and logging the amplitude of the AGC voltage from a calibrated receiver while a digital method might utilize the same detection scheme with at least several samples per second for each frequency being monitored. In either situation Section 76.611 instructs us how to handle the data. Analog data should be smoothed "by good engineering practice" while the digital scheme uses the 90th percentile for the criterion, i.e., the level equal to or greater than 90% of the data points.

When you look at the above tasks, including the full time job of flying the airplane, it does not seem necessary to exhaustively display or attempt to analyze the data while in the air. It is also far more convenient to bring it all back to your office and then work it over from several different angles and to arrive at specific conclusions as to the magnitude and distribution of the leakage fields.

It is, however, necessary to have enough indication in the aircraft to assure you that measurements which you are taking are really measurements of the proper carrier and that you are not being overridden by spurious noise or interference. To avoid overlooking these conditions, an audio output is very useful since the ear can often detect changes in the sound which are related to spurious effects. A chart recorder output can also be useful so that unusual and unexpected occurrences can be noted and those areas be reflown if there is sufficient doubt that the data is valid. For instance if there are long periods of no measurable leakage, or extremely high signal there are reasons to question the results and probably to take another look.

The last several paragraphs describing in-flight measurements illustrate that there are many important tasks to be accomplished in airborne gathering of data. Many of these, if attempted manually, can be expected to give at best, crude results. Now sit back and imagine a "magic box" which can be hand carried to the airplane, quickly connected to power and antenna and flown in a "hands-off" manner. This box should have the audio and visual indications to assure that the data being taken is valid, but other than that, there need be little more than a "start" and "stop" button.

Position indication is magically derived and inserted along with the data, as well as indication of current altitude. If you really want to do it right, imagine a connection to the aircraft autopilot which accomplishes flying of the predetermined course at the predetermined altitude. The entire setup can be operated by a pilot who has very little knowledge of the technicalities of the test and spends virtually all of his time flying the aircraft.

This hypothetical box which we have been describing would also be very handy to install in a service vehicle and drive throughout the system. We must understand that the conditions on the ground are somewhat different from those in the overflight situation. Here we deal with single or a few leaks at any one time rather than the combined effects of many leaks. In the air, with the exception of a very clean system with a few remaining leaks, there is little indication of the location of any single leak. On the ground, however, the only leakage signals received are generally those within the immediate proximity of the vehicle. It is normal to have frequent periods of no leakage signal and distinct peaks as one drives near to specific leaks. However, problems arise in connection with those leaks which are not directly on the right-of-way which you are driving, i.e. those leaks which occur in the alleys, easements, high-rise buildings, etc. There is a dual problem here. First, a leak of minimum intensity may be 30 meters or even 100 meters away rather than the 3 meters specified as the measuring distance. The received signal then varies inversely as the distance so that a 20 microvolt per meter at 3 meters leak will produce only 2 microvolts per meter at 30 meters making the requirements for receiver sensitivity much more stringent.

When monitoring leaks on the ground, the job is incomplete unless the leak can be found. When the leak occurs on the strand overhead of the vehicle, finding it is fairly routine. However, when the leak is in the alley, easement or high-rise, some means of direction and range finding is required for location or else the whole exercise becomes futile. This is the place for a little more magic to aid in actual leak location. The availability of position data to tie to the leakage data is extremely valuable along with distance and directional information for location of remote leaks. In the ground case, immediate readouts of distance and direction will facilitate efficient leak location.

Results

Now that we've taken this magic box and run it through its paces both in the air and on the ground, what can be derived from the mass of data accumulated? We must first verify compliance with the FCC regulations and second aid in the overall assessment of the cable signal leakage. Obviously we can easily compile tables of leakage versus location in terms of the route (simply the chart recorder plot) and attempt to (laboriously) relate this back to the actual system map. Given location information for each data point, it is possible to program a computer to reduce this data and produce a contour presentation of the system leakage patterns. Why not pop this whole thing into the PC on your desk and be presented with plots or signal leakage contours relative to an actual system map? You can even produce a color display to highlight levels, etc.

It is easy to see that such a presentation is easier said than done particularly in matters of "where does the map come from?", or "how do you get it into the computer?" In general, "how do you put the whole thing together so that the presentation is useful and informative?" It is evident that hardware and software can be assembled to achieve all of these tasks. Described above is sort of "what the world needs" which may not be too far from practical realization.