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# Detecting and Locating Signal Leakages from Cable TV Networks – A Case Study

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***Abstract*—Since the digitalization of terrestrial television, many countries have discontinued television broadcasting in the UHF band. The freed-up frequencies are now available as digital dividends for mobile and fixed wireless access communication networks (MFCN), particularly for 4G/5G and public safety services in broadband called BBPPDR. Since cable TV still uses the UHF band, leakage from cable TV networks is the most common cause of interference in MFCN networks. Insufficient containment of the radio frequency signals transmitted through a cable system results in cable signal leakage. This article investigates the significance of controlling electromagnetic signal leaks from cable TV networks and how they impact authorized and standardized MFCN networks in the digital dividend bands. The periodic drive-test approach to detect and measure electromagnetic leakage from a cable TV system in the 700 MHz band at a site is detailed. The causes of the detected leaks and offered the appropriate procedure to repair them are also discussed. Additionally, the current measures taken in Hungary to address cable television signal leakage in the digital dividend bands are also discussed and alternative strategies for the adopted test drive approach are proposed.**

***Keywords*— MFCN; cable TV; signal leakage; drive test; digital dividend bands; 700 MHz**

## I. Introduction

CABLE television systems have the technical ability to deliver television programs, voice, and internet services to paying subscribers via radio frequency (RF) signals transmitted through the closed coaxial cable networks or the hybrid fiber-coaxial (HFC) network.

Over the last few years, the signals sent across the cables have virtually covered the whole ultra-high frequency (UHF) spectrum. Numerous crucial services are available over the air in the same frequency range, including radiocommunication services, such as program-making and special events (PMSE), broadcasting TV signals, mobile communications, broadband public protection and disaster relief (BBPPDR) services, governmental communications, and navigation systems [1].

On the other hand, based on the GE06 regional agreement, analog television transmissions were replaced by digital television broadcasting in UHF and VHF bands [2],[3]. The switch to digital TV broadcasting allowed for the release of a valuable spectrum known as “digital dividend bands”. To address the increasing demand for frequencies suitable for mobile broadband services, the International Telecommunication Union (ITU) reallocated these digital dividend bands for MFCN, particularly for 4G/5G networks and public safety services, in two phases. The decision to allocate the first digital dividend band (800 MHz band extending from 790 to 862 MHz) was taken at the world radiocommunication conference (WRC) in 2007. The decision to allocate the second digital dividend band (700 MHz band extending from 694 to 790 MHz) was announced at WRC in 2015 [1],[4],[5]. Figure 1 depicts how current channels are assigned in the UHF spectrum for ITU Region 1.

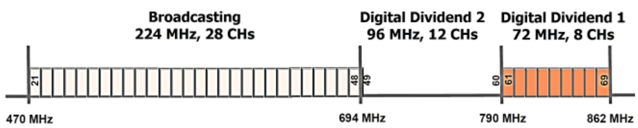


Fig. 1. Allocation of frequency channels in the UHF spectrum for ITU Region 1

According to the present spectrum allocations, MFCN are considered the primary authorized users of the spectrum. Cable TV systems are not mentioned since the coaxial cable and other components of the cable TV system constitute a closed network. Nevertheless, suppose any part of the shielding integrity of the cable TV network is damaged or deteriorated. In that case, the signals inside the cable network might leak out and potentially interfere with over-the-air services, referred to as signal leakage/egress interference. Vice versa, cable TV networks may suffer interference from over-the-air signals that leak into the network, referred to as ingress interference.

MFCN operating in the digital dividend bands is technically capable of detecting interference to their services and determining that the interference is caused by cable signal leakage. As a result, international and national spectrum regulators and public interest management, must ensure that interference from cable signal leakage is avoided for authorized users of the spectrum. In this regard, several technical standards have been issued that ensure the commitment of cable TV providers to monitor and repair any electromagnetic leakage from cable networks. Figure 2 presents the 700 MHz band agreement in Hungary as a case study in this regard. Figure 2 indicates that three mobile network operators, in addition to broadband public safety services, are granted licenses in the 700 MHz band in Hungary. Cable TV systems operate in the adjacent band, which spans 470 MHz to 694 MHz [6],[7]. Although the two systems appear to be independent in principle, there is mutual overlap between them in practice under certain conditions.

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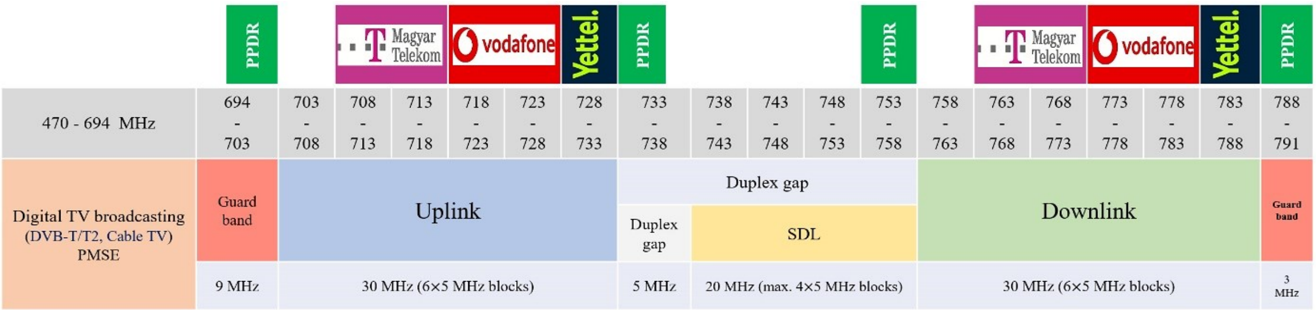


Fig. 2. 700 MHz frequency band: Rights of Use in Hungary

The National Media and Infocommunications Authority (NMHH) is responsible for spectrum management and ensuring the functioning of Hungary's various networks and services [8]. NMHH seeks to ensure as much as possible the availability and usability of the limited resource frequency and its technical and economical optimal usability in a harmful interference-free environment. To achieve that, on-demand measurements and interference analyses shall be provided for MFCN applications operating in the digital dividend bands [9].

Although the issue of monitoring and repairing leakage from cable TV systems is important, it is relatively rarely discussed. Our last article is a state-of-the-art review of most research studies on the mutual interference between cable television networks and MFCN in the digital dividend bands [10]. The Society of Cable Telecommunications Engineers (SCTE) members offered a workable framework for operational procedures to reduce UHF leakage from cable TV networks [11]. In [12], SCTE investigated the effect of QAM signal leakage on LTE using laboratory tests in a controlled setting. In [13], ARCOM equipment were used to identify QAM signal leakage from cable TV networks in high and low frequencies. The authors of [14] emphasized the need to monitor leakage in both aeronautical and broadband frequencies. In [15], leakage from cable TV network components was measured using a monitoring receiver and an active directional antenna.

In the studies mentioned above, the cable TV provider was responsible for monitoring and repairing cable leakages. In Hungary, the procedure is different since the NMHH oversees monitoring the leaks, whereas repairing leaks is the responsibility of the cable TV provider. This paper describes the NMHH's periodic drive test approach for detecting and measuring electromagnetic leakage from a cable TV system across a range of frequencies in the 700 MHz band in the village Pilisszentlászló north of Budapest.

The rest of this article is structured as follows: Section II highlights the reasons for monitoring cable leakage and how it affects mobile network operators and public safety services. The leak detection and measurement approach followed by the NMHH is described in section III. Section IV presents the results of leakage measurements, discusses the causes of leaks, and provides measures to repair the detected leaks. Section V discusses current solutions in Hungary to address the cable TV signal leakage issue and presents alternative proposals to enhance the adopted leakage monitoring approach. This article is concluded in section VI.

## II. Reasons to Monitor for Cable TV Leakage

### A. *Prevent Off-air Interference*

Cable TV providers must avoid interfering with the licensed over-the-air users who are the protected users of the frequencies in the UHF spectrum.

The leaking signals from cable TV networks may block or degrade cellular reception and transmission. The leaking signals might be stronger or equal to the cell device signal. The power transmissions from cell devices to the base station may have very low amplitudes or be equal to local leakage. A cable leak might be substantially worse if the leaks are located close to the mobile base station or if there are several leaks in the coverage area. The effects of cable leakage on mobile communications would manifest as dropped or blocked calls, poor voice quality, variable data rates, and no data connection. The statistical information offered by the base stations is an initial indication of harmful interferences in cellular communications, such as a low signal-to-noise ratio (SNR) or high level of received signal strength index (RSSI).

On the other hand, the leaking signals might interfere with public safety communications and hamper the security personnel's efforts to do their duties. For instance, the radiated emissions from a leaky point may degrade or block the intended communications from a nearby police car.

### B. *Regulatory Compliance Requirements for Spectrum*

The need for regulatory compliance for spectrum management and public interest is the second justification for leakage monitoring. The Leakage might result in significant fines being imposed by spectrum regulatory agencies. Federal Communications Commission (FCC) and SCTE have issued many regulations applicable to cable systems. These included several technical standards about how to perform signal leakage measurements and the maximum leakage limits that apply to all parts of the cable TV network [16],[17]. Table I shows acceptable signal leakage limits versus frequency as per FCC and SCTE [16],[17]:

Table I
ACCEPTABLE SIGNAL LEAKAGE LIMITS AS PER SCTE

| Frequencies | Limits of signal leakage | Distance (in meters) |
|---|---|---|
| 216 MHz < Analog signals ≤ 54 MHz | 15 μV/m | 30 |
| 216 MHz < Digital signals ≤ 54 MHz | 13.1 μV/m | 30 |
| 216 MHz ≥ Analog signals > 54 MHz | 20 μV/m | 3 |
| 216 MHz ≥ Digital signals > 54 MHz | 17.4 μV/m | 3 |

Furthermore, the clause in [18] requires the elimination of "harmful interference", irrespective of any detected level of cable signal leakage from the network. Therefore, UHF leakage monitoring must become part of a continuous program of operation and maintenance. In this regard, the FCC has also instituted several methods of testing that cable operators are required to perform to ensure compliance, such as quarterly leakage monitoring and measuring the annual ground-based cumulative leakage index (CLI) [19],[20]. CLI is defined as the overall effect of all system leaks combined, which leads to the formation of an undesired RF energy cloud over the cable system [19].

On the one hand, the regulations in [21] organize cable network operations near specific emergency frequencies. On the other hand, the regulations in [22] describe who is responsible for leakage inside and outside the home.

### *C. Improve the Physical Condition of the System*

Leakage monitoring improves the performance of both the cable TV system and MFCN operating in the digital dividend bands. The immediate and long-term benefits of adopting leakage monitoring are locating physical problems, reducing the mean time to repair, reducing customer care calls, increasing the spectral efficiency, updating and/or eliminating certain legacy equipment, and centralization monitoring of network.

### *D. Eliminate Ingress Interference into Cable TV Networks*

It should be recognized that any egress/leakage location is a potential ingress location as well. Over-the-air signals can leak into each portion of the cable system, which can radiate an electromagnetic field outward. These unwanted signals may interfere with both the forward and reverse signals of the cable TV system and cause deterioration of the quality of the signal coming to the subscriber. It is another reason why cable TV providers and spectrum management agencies must regulate network stability and the quality of the transmitted signals.

## III. Methodology

There are three primary methods currently available in the industry to monitor and measure electromagnetic leaks from cable TV networks in field measurements [10],[11].

These methods vary in workload and equipment need. The simplest and most cost-effective technology is inserting narrowband non-interfering test signals at a specific frequency between two adjacent QAM channels and then measuring the leakage at that frequency. The second method determines if there is a correlation between a reference signal that is acquired at the headend of the cable TV system and a leakage signal captured using an antenna of a correlation detector at a field location. The third method is the most flexible approach that can provide a comprehensive snapshot of the leakage signal using portable spectrum analyzers paired with high-gain directional antennas. The reference [10] compares these approaches based on each approach's features, methodology, and detecting system components and indicates manufacturers of equipment compatible with each technology.

NMHH adopts a drive test strategy in addition to spectral analysis employing a spectrum analyzer and an active high-gain directional antenna for cable leak monitoring. In order to accurately characterize the adopted approach by NMHH, we have participated with the NMHH team in the periodic drive test procedure for a cable TV system that employs mainly coaxial cables in the distribution part in the village Pilisszentlászló near Budapest. The objective was to detect, locate, and measure digital QAM leakages across a range of frequencies in the 700 MHz band.

Figure 3 shows the measurement set used for the driving test; a vehicle equipped with high-frequency digital leak detection equipment. Table II lists those technical specifications of the equipment used that are relevant to the topic of this study [23],[24],[25].

The measurement was performed in two steps. Initially, the electric field intensity was measured during driving using the compact multirole spectrum-monitoring system (SkyScan7). Upon detection of digital QAM leakages, the handheld Narda spectrum analyzer with the active high-gain directional antenna was used to identify and locate the sources of the leaks. All measured data were collected, recorded, and forwarded to the cable TV provider serving the same village to repair leakages.

We easily identified and localized leaks in the 700 MHz band at distances up to 3 meters. The spectral display presented the leakage measurements (amplitude versus frequency).


Fig. 3. Measurement set used for the drive test; the devices are denoted by orange numbers and are also listed in Table II

TABLE II
TECHNICAL SPECIFICATIONS OF THE EQUIPMENT USED IN THE DRIVE TEST

| Device | Technical Specifications |
|---|---|
| 1. Monitoring receiver | R&S®EB500 made by Rohde & Schwarz.<br>Wide frequency range: 8 kHz to 6 GHz.<br>20 MHz Realtime bandwidth. |
| 2. Compact multirole spectrum-monitoring system | GEW® SkyScan7 made by HENSOLDT South Africa.<br>Instantaneous receiver bandwidth: up to 80 MHz.<br>Emitter location methods supported: AoA (Angle of Arrival), TDOA (Time Difference of Arrival), Hybrid (AoA+TDOA).<br>Native demodulation modes: CW, AM, FM.<br>ITU-R compliance: SM.377, SM.1268, SM.443, SM.1880 |
| 3. Direction-finding system | MRA7067 Watson-Watt antenna made by HENSOLDT South Africa.<br>Frequency range is 1 MHz to 6 GHz. |
| 4. Portable spectrum analyzer | IDA2 3106 made by Narda.<br>Frequency range is 9 kHz to 6 GHz.<br>Modulation Types: AM, FM, LSB, USB, CW. |
| 5. Active directional wideband antenna | Made by Narda.<br>Directional antenna (3100/13).<br>Automatically detected.<br>Frequency range is 400 MHz to 6 GHz. |

European standards for the EN 50083 and EN 60728 series have been adopted to deal with cable TV networks, including equipment and associated measurement methods, as well as to define the maximum permissible levels of radiated emissions [26],[27]. These standards state that for broadband signals, the maximum allowable level of radiated emission at a distance of 3 meters from the devices is 27 dBµV/m [26],[27]. The acceptable signal leakage limit set by the FCC and SCTE is somewhat lower than this limit [16],[17]. According to the FCC and SCTE standards, Table I above shows that the digital signal leakage limit for broadband transmissions at 3 meters is 17.4 µV/m, which is equal to 24.8 dBµV/m.

However, it is essential to adhere to the FCC clause [18] that mandates the removal of "harmful interference", regardless of what level of cable signal leakage from the network is detected. Furthermore, licensed mobile operators often consider any detectable level of egress as interference with their networks.

## IV. RESULTS AND DISCUSSION

Detecting signal leakage in the 694-790 MHz frequency range was quite simple using the measurement set described in the previous section. Numerous leaks from the cable network serving the village Pilisszentlászló were detected in the digital dividend bands. Figure 4 shows the distribution of leak points detected on the map of the village Pilisszentlászló.

This section will provide sample measurements of the leaks detected, along with the associated diagnoses and the proper repair procedures. The measurement data show that there is a frequency response associated with the leaks which are represented in the spectral display.

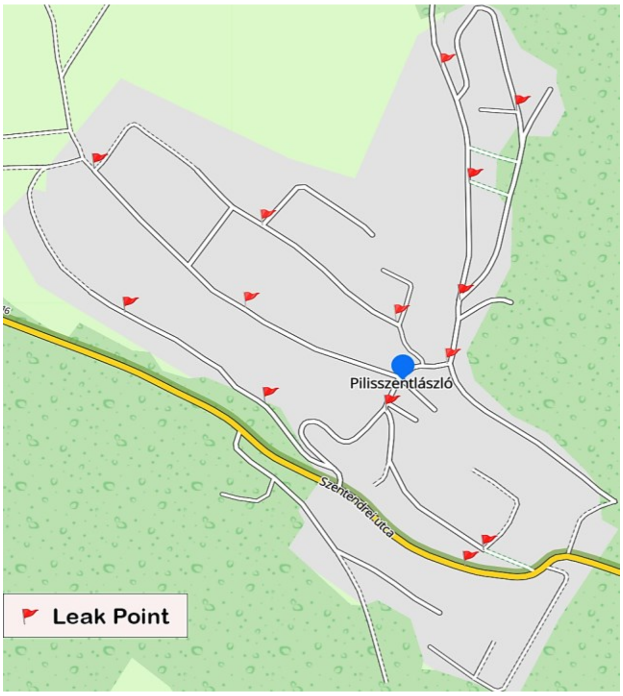


Fig. 4. Detected leak points in the village Pilisszentlászló

Figure 5 shows the leakage detected at one of the locations in a screenshot captured from the portable spectrum analyzer.

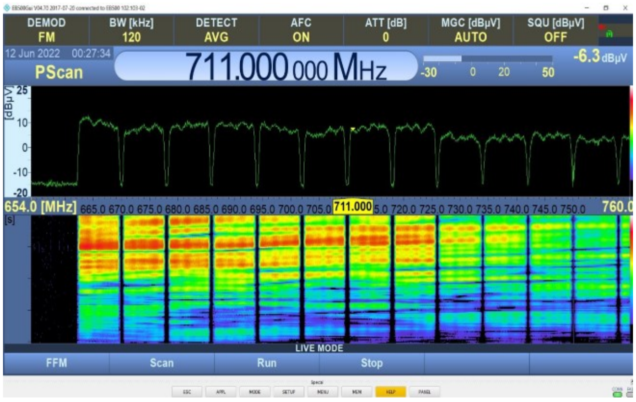


Fig. 5. Screenshot captured from the portable spectrum analyzer of the measured spectrum at a leak point

At the top of the screenshot, the measured spectrum (amplitude versus frequency) is shown. High-level QAM signal leakage is evident across the spectrum range of digital TV broadcasting and digital dividends bands. While the lower part of the screenshot is a waterfall display that presents visually sporadic effects of signal intensity within the sweep frequency range over time. The waterfall display creates a line across the targeted frequency spectrum when it is started, showing the percentage of time a signal is present as a color gradient. Then a growing stack of previous signal activity with varied colors is created by stacking one spectrum time slice line on top of the following time slice that is captured. The color gradients distinguish the signal intensity such that whenever a more frequently a specific frequency and power pixel in the display contains RF energy, that pixel will be "brighter" or "redder". This indicates that the uplink part of the 700 MHz band is most critical for cable TV signal leakage.

Consequently, the frequency center of the portable spectrum analyzer was set to 706 MHz, which is in the uplink part of the 700 MHz band and is the frequency center of TV channel 50 (702 -710 MHz).

Thanks to all the data displayed, users are able to understand the behavior of the RF environment within the sweep range, identify the source of interference, and analyze the signals.

Figure 6 displays the leakage values at the frequency center 706 MHz and the corresponding GPS data in a screenshot captured from the portable spectrum analyzer.

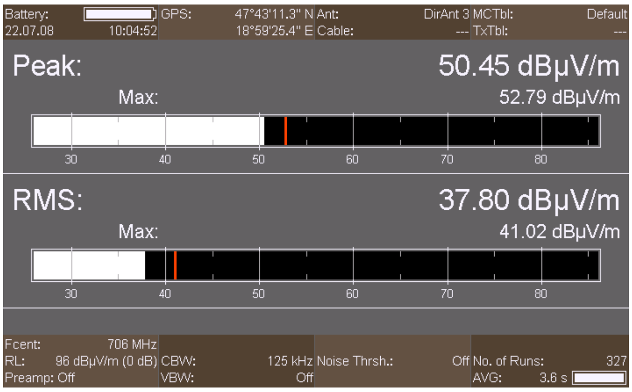


Fig. 6. Screenshot captured from the portable spectrum analyzer of the leakage values at 706 MHz

The peak value of the leakage signal was very high 50.45 dBμV/m, which refers to the maximum value that the leakage signal intensity can reach whereas the (root-mean-square) RMS value was 37.80 dBμV/m, which refers to the effective value of the total waveform. In this study, only the peak value was considered because the technical standards adopted in the assessment specify the maximum permissible levels of radiated emissions. In this sample, the source of the leakage might be the faulty amplifier or/and hardline connector that is not tightened all the way or over-tightened, as indicated in Fig. 7a.

The digital leakage at the frequency center of 706 MHz was identified and measured for every leak point detected in the village using the same method. Thus, the measurement results can be summed up as follows. Figure 7 indicates the potential leakage sources for several leak points detected in the village. Table III list the measured peak values of the leakage signals that correspond to the leak points shown in figure 7, along with their associated diagnoses.

The measurement results lead to conclude that digital leakage in the 700 MHz band is highly prevalent, despite the target area being a small rural village. In every case observed, the leakage field strength was more than the acceptable leakage limit of 27 dBμV/m at 3 meters. Most leakage spots were the amplifiers, taps, and hardline coax connectors, which are essential for providing service to a subscriber's home. Therefore, ensuring that connectors and cables are correctly prepared and installed is essential for the performance of the cable TV network and prevents any potential leakage.

To conclude the case study, we recommend examining and analyzing the hardline connector strategy before conducting any node alterations or installs. Ensure the amplifiers, taps, and connectors are of the best quality and properly installed. Sometimes tightening loose components in the pedestal, terminating the open ports on the tap, or properly tightening the tap screws is sufficient. We also advise creating a highly skilled

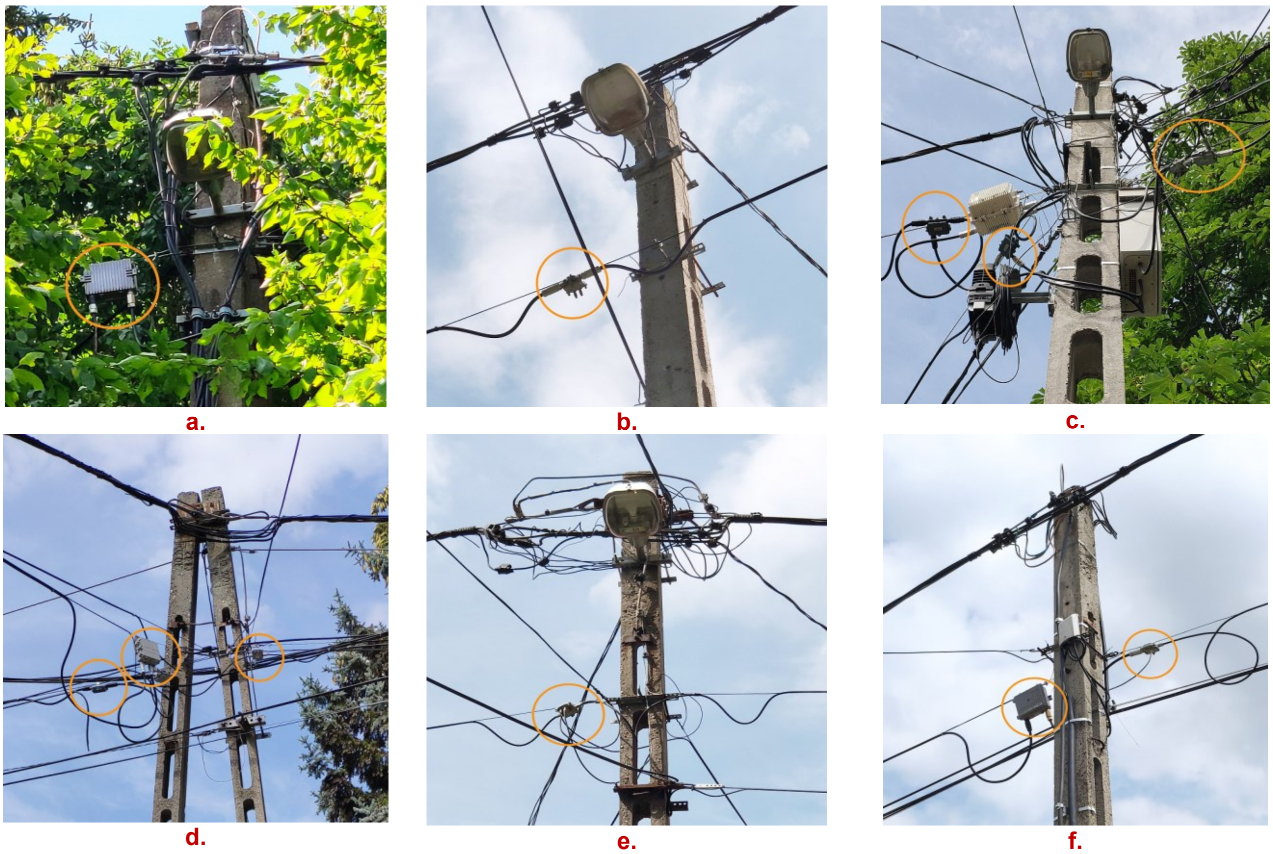


Fig. 7. Potential leakage sources of measurement samples; they are denoted by orange circles and are also listed in Table III

TABLE III
PEAK VALUES OF THE LEAKAGE SIGNALS CORRESPONDING TO THE LEAK POINTS SHOWN IN FIGURES 7A-7F, ALONG WITH THEIR ASSOCIATED DIAGNOSES

| Leak Point | Peak Value | Diagnosis |
|---|---|---|
| a) | 50.45 dBμV/m | Faulty amplifier or/and hardline connector that was not tightened all the way or over-tightened. |
| b) | 35.93 dBμV/m | Loose tap plate screws, tap's unterminated ports, or loose housing-to-housing connector. |
| c) | 32.26 dBμV/m | Loose tap plate screws, tap's unterminated ports, or loose housing-to-housing connector |
| d) | 41.37 dBμV/m | Faulty amplifier and hardline connector, loose tap plate screws, or tap's unterminated ports. |
| e) | 44.24 dBμV/m | Tap was not properly installed or bad connectors at the tap. |
| f) | 35.02 dBμV/m | Faulty amplifier and hardline connector, or tap's unterminated port. |

and experienced technical team for the initial installation to avoid having to go back and fix leakage issues.

## V. MANAGING THE SIGNAL LEAKAGE ISSUE

This section discusses the current measures taken in Hungary to handle the signal leakage from cable TV networks in the digital dividend bands and proposes alternative strategies to the adopted drive-test approach.

### A. The Current Measures

Through participation in the periodic test drive and discussions with the specialized team in the Radio Monitoring and Interference Investigation Department at NMHH, the current solutions taken in Hungary to address the signal leakage from cable TV networks in the digital dividend bands can be derived, as follows.

An expert team from NMHH conducts routine drive testing in several locations to ensure there are no harmful interferences in the digital dividend bands. The cable TV provider checks the leaks' locations and works to repair them. The most common procedure is to check the cable network components and tightening and replacing suspect connectors that cause leakage.

Suppose the leaks are widespread throughout the village or city. In that case, the cable TV provider will usually abandon the current frequencies and retune the system to other frequencies that do not interfere with the digital dividend bands. The NMHH justifies this process as simple and cost-effective. However, at best, this is a short-term solution because it is impractical to abandon or avoid utilizing cable channels in valuable RF spectrum whenever leakage or ingress is problematic. Eventually, the problem would need to be fixed for the abandoned frequencies to be usable.

Another measure taken in Hungary is that an optical system is replacing the whole coaxial system. NMHH justifies this procedure as more cost-effective over the long term and devoid of leakages; thus, no periodicals or measurements are required. However, upgrading the coaxial network to fully fiber optic system (FTTH: fiber to the home) is still rather expensive. Additionally, network operators must consider multiple factors while planning a transition to FTTH network, such as future demand, deployment challenges, high costs, additional equipment, and several decisions that determine whether the project will be success or fail [28],[29].

Using a combination of optical fibers and regular coaxial cables in so-called hybrid fiber coaxial (HFC) networks is somewhat less expensive, thus it is a more plausible alternative. HFC networks ensure the reliability of the two-way communications and enable the delivery of more channels to the subscribers [30]. However, leaks from the coaxial part of the entire hybrid network are still possible. Additionally, only a few cable providers currently use HFC, particularly in urban areas, while many other cable TV providers still use conventional coaxial cables throughout the network.

As a result, the issue of coaxial network leakage in the digital dividend bands will continue to be challenging. Thus, coaxial networks require periodic preventative maintenance and entail ongoing energy and cost expenditures since any signal leakage must be detected, measured, and repaired.

### B. The Suggested Strategies

In order to make the signal leakage monitoring approach more efficient in terms of cost, time, and human resources, we propose alternative strategies for the periodic drive-test approach adopted in Hungary.

The first strategy is based on organizing cooperation between NMHH and cable TV providers and mobile operators operating in the 700 MHz band. Since most cable TV providers are parts of the mobile operator companies in Hungary, coordination between them to preserve the reliability of services for each is simple to establish.

We recommend that basically the mobile operators operating in the digital dividend bands monitor and troubleshoot interference in their networks. Since each cell tower's coverage is segmented into sectors, the mobile operator could be alerted if there are any indicators of poor downlink or uplink performance in the sector. The SCTE technical report, which summarizes the results of the tests carried out to determine the effect of cable leakage on changes in LTE's downlink and uplink performance, clearly refers to some of these indications [12]. A signal-to-noise ratio (SNR) and a channel quality indicator (CQI) are used to monitor cellular downlink performance. The CQI is reported to the base station (BS) by the user equipment (UE). CQI carries information on the quality of the communication channel and indicates an appropriate downlink transmission data rate. Two parameters can be monitored in the base station to monitor changes in uplink performance: the SNR and the received signal strength indicator (RSSI). An RSSI measurement at a cellular site represents the signal plus the cumulative noise floor.

Consequently, poor SNR, lower CQI, or higher RSSI than the typical operating values in the sector is usually due to interference within the sector area. Thus, the mobile operator isolates the affected sector. Once the general affected area is located, the mobile operator notifies the regulatory authority NMHH. Then the cable TV provider serving the area is asked to isolate the sources of the interference/leakage and repair them.

This strategy will save the cost, time, and resources needed for the periodic driving tests carried out by NMHH.

Regarding the second proposed strategy for addressing the leakages issue, we recommend adopting the injected narrowband carrier technique instead of the periodic drive tests. This approach is regarded as the simplest and most cost-effective technique. In this strategy, a non-interfering low-level test signal is injected at a specific frequency between two adjacent TV channels at the headend or hub directly. Then the field leakage is monitored and measured at that frequency by the corresponding field-detection units. To cover cable leakage in the 700 MHz range, we recommend that the cable TV provider inject the test signal between TV channels 50 (702-710 MHz) and 51 (710-718 MHz). The next step is to utilize relatively low-cost receivers for automatic and continuous monitoring of leakage field strength. In the cable TV provider's service area, a partnership agreement with fleets vehicles of other companies is possible to install antennas, receivers, and GPS. For instance, field equipment can be installed in the garbage trucks that cover most, if not all, streets in the area. As a result, the cable TV network is monitored while the vehicles are being driven without any intervention from technicians. The collected data is then automatically transmitted through Wi-Fi to the cable provider frequently for analysis and action.

The products from these manufacturers – CPAT, VIAVI, ComSonics, and Effigis – are compatible with this methodology [10]. Adopting this strategy in place of periodic driving tests will save cost, time, and resources.

The third suggestion to address the leakage issue is derived from the research results presented in Section IV. It is obvious that the cable network in the target area was hanging from poles in the air and vulnerable to the effects of severe climatic conditions. Thus, any weakness in cable shielding or conductors' installation will cause harmful interference with MFCN operating within the digital dividend bands. It seems plausible that we recommend laying coaxial cables underground. To ensure the efficiency of the underground cabling system, a variety of factors must be taken into consideration. These factors depend on the proper laying method of the coaxial cables, how well the cable joints are made, and how the branch connections at the distribution points that emerge from the ground are made.

In comparison to overhead cables, underground cable systems have several advantages. They are not visible to the unaided eye and hence retain the aesthetic beauty of the location, guarantee a long service life, and require less maintenance than aerial cables exposed to external factors and climatic conditions. Additionally, installing underground cables is a faster and wiser long-term investment. However, there are challenges with laying underground cables, including high initial installation costs, the need for permits and approvals for the digging process, cumbersome modifications to the coaxial cables, and obstructions in the cables' path.

Adopting the underground cabling approach reduces the cable networks' ground-based cumulative leakage index (CLI). Distribution points protruding from the ground and the part leading to subscribers' houses remain as potential leakage points.

It should be highlighted that adopting the underground cabling approach is a responsible alternative concerning choosing underground coaxial cables or going directly to buried optical cables. As stated previously, network operators must consider many factors while planning the transition to an optical network. When making this decision, it is wise to trade-off between buried and aerial fiber deployments. As a result, careful planning is critical to determine the choice of implementation. In most cases, either maintaining the already existing overhead coaxial cable or investing in underground optical networks are reasonable choices. Transitioning from overhead coaxial cables to underground coaxial cables is rarely an alternative.

## VI. Conclusion

The issue of monitoring and repairing leakage from cable TV networks in the digital dividend bands is a concern of many spectrum management authorities, cable TV providers, and radio communications operators.

To truly represent this issue, we followed the drive test methodology adopted by the NMHH authority in Hungary to monitor and measure electromagnetic leakages from cable TV networks in the 700 MHz band. The measurement results showed that the digital leakages in the 700 MHz band were very widespread in the target area. The main causes of the leakage were mainly related to the quality of the work performed during the initial network installation.

Several alternative leakage monitoring and measuring strategies were analyzed based on cost, time, and human resource efficiencies. The most sensible of these approaches is to include mobile operators in the leakage monitoring tasks. On the one hand, mobile operators are eager to operate their services without interference. On the other hand, most mobile operators also provide cable TV service along with their services. Consequently, coordination is essential to maintain the reliability of all services. Injecting a narrowband test signal at a specific frequency between two adjacent TV channels and monitoring the leakage at that frequency is one of the simplest and most cost-effective approaches. Vital factors and careful planning must be considered before deciding whether to replace the overhead cables with underground coaxial cables or implement directly buried optical cables.

In general, leaks are more common in older cable TV networks and their attached connectors, which deteriorate over time. Thus, if low-level leaks are not fixed, they will eventually become high-level leaks. As a result, simply complying with the accepted limits of signal leakage is insufficient. To minimize signal leakage, comprehensive and updated operational practices must be developed. The use of high-quality materials and components with adequate shielding effectiveness must be encouraged. Following quality inspections and efficient maintenance programs are also essential.

Finally, the ITU, based on the preliminary agenda item for WRC-23, is seeking to make a new co-allocation for the mobile service in the 470-694 MHz band in ITU Region 1. As a result, MFCN and cable TV providers will encounter additional challenges, emphasizing the significance of managing their mutual interference.

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