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# Calculating the impact of wireless services on cable TV

White paper

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# THE IMPACT OF WIRELESS SERVICES


## EXECUTIVE SUMMARY

Spectrum is in high demand and wireless services are increasingly using frequencies that are traditionally used by cable TV or may be used by cable TV in the future. This paper describes a method to calculate the injected voltages originating from a wireless service into a cable network.

Using the specified screening effectiveness of cable TV components, the distance from the wireless device to the cable TV component and the power output of the wireless device, an injected voltage can be calculated. Two examples for 4G/5G interference in the 700 MHz band are calculated and the results show that a screening effectiveness of more than 101 dB, or class A++, is needed in order to maintain signal integrity of a cable TV network.


## PROBLEM ANALYSIS

Wireless is an ever-growing service as consumers want to enjoy different types of media using handheld devices in the home as well as outside. Since usable spectrum is a limited resource, more spectrum traditionally used in cable TV will also be used by wireless services. Wireless services have a cellular architecture using handheld devices and base stations.

The handheld wireless devices are battery operated and are therefore limited in radiated power, usually ranging from a few hundred milliwatts to 1 or 2 Watt. Base stations however, service a whole cell and the power of these is much higher, going up to 1,000 Watt of radiated power for a 4G macrocell, for example. With the introduction of 5G more frequencies will be used. 4G and 5G technology will integrate and use bandwidth in the 700 MHz, 1400 MHz, 2100 MHz, 3500 MHz and 26 GHz bands. Although the last two will probably not interfere with cable TV signals in the foreseeable future, the first three do have the potential to do so.

Handheld devices are also used in the home and will be in close proximity (< 1 metre) of the in-home cable TV network. Although their radiated power is relatively low, the signals on the cable TV network are many times lower, so screening effectiveness is expected to be of the upmost importance in order to guarantee signal integrity.

Base stations are usually mounted on rooftops or towers and the distance of the base station to the cable TV network will be much larger in general, reducing the risk of interference. However, the radiated power of base stations is much higher than handheld devices, so an evaluation of the impact of base stations is also needed.

Finally, an injected interfering voltage higher up in the network (either by a base station or a handheld device that happens to be close by) could influence the cable TV service of many more customers than a single home.

## MATHEMATICAL RECIPE

The interaction between a wireless device and cable TV component is a transmission path with the wireless device being the transmitter and the cable TV network the receiver. The radiated power from the wireless device is known and the screened cable TV component can be regarded as a receiver with a (bad) antenna. The better the screening effectiveness, the lower the antenna gain.

The Friis transmission formula is used to calculate the received voltage from the wireless device. Known inputs:

- Effective Isotropic Radiated Power (EIRP) of the wireless device [ Pt in Watt ]
- Distance between wireless device and cable TV component [ L in metre ]

From those two inputs the power flux density [ W/m$^2$ ] coming from the wireless device at the distance L can be calculated:

**Power flux density:**

$$p = \frac{Pt}{4\pi L^2}\ [\,W/m^2\,] = \frac{(Vrms/m)^2}{120\pi}$$

*(with 120 π being the approximate impedance of free space)*

The next step is to calculate the antenna effect of the cable TV component with respect to the received frequency. This is called Effective Antenna Aperture (AER) [ m$^2$].

**Effective Antenna Aperture:**

$$AER = \frac{\lambda^2}{4\pi} \cdot Gri\ [\,m^2\,]$$

With λ [metre] being the used wavelength and Gri [no dimension] being the antenna gain of the cable TV component with respect to an isotropic radiator. The antenna gain Gri can be calculated from the specified screening effectiveness of the cable TV component. Screening effectiveness is specified in dBs with respect to a dipole so a correction of 2.15 dB must be added to calculate the isotropic antenna gain.

**Antenna gain:**

$$Gri = 10^{\left(\frac{SE+2.15}{10}\right)}$$

With SE [dB] being the specified screening effectiveness.

As an example, the calculated antenna gain Gri of a cable TV component with a screening effectiveness of 75 dB (class A) is:

$$Gri = 10^{\left(\frac{-75+2.15}{10}\right)} = 5.18 \cdot 10^{-8}$$

From the calculated power flux density ρ and the AER, the received power Pr [W] can be calculated.

**Received power:**

$$Pr = \rho \cdot AER\ [\,W\,]$$

The received power Pr [W] is the interfering RF power from the wireless device into the cable TV component and can be easily calculated into a voltage in an impedance of 75Ω.

**Figure 1**_Measurement of screening effectiveness using the clamp method.

# EXAMPLES

**Example 1**

The impact of 4G/5G handheld devices using 790 MHz with a cable TV component with a class A (75 dB) screening effectiveness is calculated.

The inputs:

- Handheld 4G/5G device
- Radiated power (EIRP) 200 mW
- Class A cable TV component, screening effectiveness 75 dB
- Frequency 790 MHz, $\lambda = 0.38$ m
- Calculated AER = $5.9 \cdot 10^{-10}$ m$^2$

| Distance handheld deivice CATV component | Generated EM field | Received power ( W ) | Injected voltage Class A | Minimum screening effectiveness for 10 dBµV injected voltage |
|---|---|---|---|---|
| 0.5 m | 4.8 V/m | $3.6 \cdot 10^{-11}$ | 34 dBµV | 99 dB |
| 1 m | 2.4 V/m | $3.6 \cdot 10^{-11}$ | 28 dBµV | 99 dB |
| 3 m | 0.8 V/m | $3.6 \cdot 10^{-11}$ | 19 dBµV | 99 dB |
| 6 m | 0.4 V/m | $3.6 \cdot 10^{-11}$ | 13 dBµV | 99 dB |

**Figure 2**_Results for a 4G/5G handheld device

With a cable TV signal level of 0 dBmV, it becomes obvious that class A screening effectiveness is simply not enough to maintain signal integrity. Carrier-to-interference ratio can be as low as 26 dB (at a distance of 0.5 metre only), at a distance of 6 metres or more the carrier-to-interference ratio starts to become useable. It should also be noted that the interference does not necessarily originate from one's own handheld device, it could also be the a neighbouring device.

The same scenario is, of course, true for outdoor handheld devices that are in close proximity to outdoor cable TV components. In that case the interference might influence many more customers than a single home.

The last column shows the calculated minimum screening effectiveness for a carrier-to-interference ratio of 50 dB. It is obvious that, for safe interference free operation, a minimum screening effectiveness of 99 dB is needed. This exceeds class A+, so class A++ is needed as a minimum specification.

## EXAMPLES

**Example 2**
The impact of a macrocell 4G/5G base station at 790 MHz on a cable TV component with a class A (75 dB) screening effectiveness is calculated.

The inputs:

- Macrocell base station
- Radiated power (EIRP) 1000 W
- Class A cable TV component, screening effectiveness 75 dB
- Frequency 790 MHz, $\lambda$ = 0. 38 m
- Calculated AER = $5.9 \cdot 10^{-10}$ $m^2$

| Distance 4G/5G station / CATV | Generated EM field | Received power ( W ) | Injected voltage Class A | Minimum screening effectiveness for 10 dBµV injected voltage |
|---|---|---|---|---|
| 30 m | 5.8 V/m | $5.2 \cdot 10^{-11}$ | 36 dBµV | 101 dB |
| 60 m | 2.9 V/m | $1.3 \cdot 10^{-11}$ | 30 dBµV | 95 dB |
| 100 m | 1.7 V/m | $4.7 \cdot 10^{-11}$ | 25.5 dBµV | 90.5 dB |

**Figure 3**_Results for a 4G macrocell base station

As can be seen the distances between the macrocell and cable TV component are much larger. It is highly unlikely that a 4G/5G base station, with such massive radiated power, is mounted directly on top of a cable TV component.

With a cable TV signal level of 0 dBmV it becomes obvious that class A screening effectiveness is simply not enough to maintain signal integrity. Carrier-to-interference ratio can be as low as 24 dB at a distance of 30 metres, even at a distance of 100 metres the carrier-to-interference ration is a meagre 35 dB.

Again, a minimum screening effectiveness is well over class A+, class A++ is needed as a minimum specification.

Of course, this is all true for a cable TV signal level of 0 dBmV. If the signal level is increased to a higher level than the carrier-to-interference ratio will also increase, and the minimum needed screening effectiveness can be decreased.

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