# Evaluation of high definition digital video signal over coaxial transmission lines

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**Abstract-**. In this paper, the propagation of two different digital video transmission standards have been evaluated over fifteen different coaxial cables. The frequency dependence of the attenuation for each cable and the maximum cable length for each standard have been obtained. The results show that the propagation properties improve with the inner conductor thickness and it is better to use coaxial cable with an inner conductor based on several filaments.

## 1. INTRODUCTION

The Society of Motion Picture and Television Engineers (SMPTE) defined the SMPTE292 and SMPTE424M to transmit high definition digital video and audio over coaxial cables at 1.485 Gbits/s [1] and 2.970 Gbits/s [2], respectively. In both cases, the amplitude of the signal should be between 720 mV and 880 mV (800mV ± 10%), the rise/fall time and unit intervals are 270 ps and 673.4 ps for SMPTE292. In case of SMPTE424 these values are reduced to 135 ps and 336.7 ps, respectively. On the one hand, these signal requirements require good conductors to guarantee the correct level of video transmission. On the other hand, the current cooper price has increased the cost of coaxial cables and, thus, a trade-off between the quality of connections and the cost of the installation appears. Therefore, in order to select the correct transmission line for one particular installation, an analysis of signal quality / installation cost should be done. In this work, the high definition video signal transmission has been evaluated for several coaxial transmission lines with the aim to determine the optimum cable configuration for specific installations. The remainder of the paper is organised as follows. Section 2 describes the cables under test and the measurement procedure. In Section 3 the experimental results are shown and discussed. Finally, in Section 4 the main conclusions are drawn.

## 2. MATERIALS AND METHODS

### 2.1 Cables under test

In this work, fifteen different coaxial cables have been evaluated: eight coaxial cables with rigid inner conductor and seven with flexible inner conductor. In all cases the inner conductors are oxygen-free copper (OFC), the dielectric materials are foam high density polyethylene (FHDPE) and the jacket materials are Polyvinyl Chloride (PVC). Table 1 and Table 2 summarize the properties of rigid and flexible coaxial cables under test, respectively.

**Table 1**. Properties of rigid coaxial cables under test

| Cable | # Inner conductors /diameter (mm) | AWG | Outside dielectric diameter (mm) | Shield | Jacket diameter (mm) |
|---|---|---|---|---|---|
| **1R** | 1/0.41 | 26 | 1,9 | Foil & Braid | 3,5 |
| **2R** | 1/0.51 | 24 | 2,40 | Foil & Braid | 3,81 |
| **3R** | 1/0.584 | 23 | 2,77 | Foil & Braid | 4,5 |
| **4R** | 1/0.80 | 20 | 3,75 | Foil & Braid | 6,0 |
| **5R** | 1/1.00 | 18 | 4,60 | Foil & Braid | 7 |
| **6R** | 1/1.40 | 15 | 6,60 | Foil & Braid | 9,2 |
| **7R** | 1/1.60 | 14 | 7,10 | Foil & Braid | 10,3 |
| **8R** | 1/2.05 | 14 | 8,20 | Foil & Braid | 11,1 |

**Table 2.** Properties of flexible coaxial cables under test

| Cable | # Inner conductors /diameter (mm) | AWG | Outside dielectric diameter (mm) | Shield | Jacket diameter (mm) |
|---|---|---|---|---|---|
| **1F** | 7/0,10 | 30 | 1,5 | Spiral | 2,8 |
| **2F** | 19/0,10 | 26 | 2,55 | Braid | 4,3 |
| **3F** | 7/0,254 | 22 | 3,4 | Braid | 6,0 |
| **4F** | 19/0,20 | 20 | 4,2 | Double Braid | 6,20 |
| **5F** | 80/0,10 | 20 | 4,9 | Foil & Braid | 8,0 |
| **6F** | 7/0,40 | 18 | 5,0 | Double Foil & Braid | 7,0 |
| **7F** | 19/0,254 | 18 | 5,2 | Double Braid | 7,20 |

## 2.2 Experimental setup

Each cable has been subjected to two different tests. On the one hand, the frequency responses of each cable have been simulated in order to obtain the attenuation and the maximum cable length for one specific digital video standard. On the other hand, the maximum cable length has been experimentally evaluated with a video signal generator *DeckLink Studio 4K* and a *Tektronix WVR8200* video analyser, as it is shown in Fig. 1.

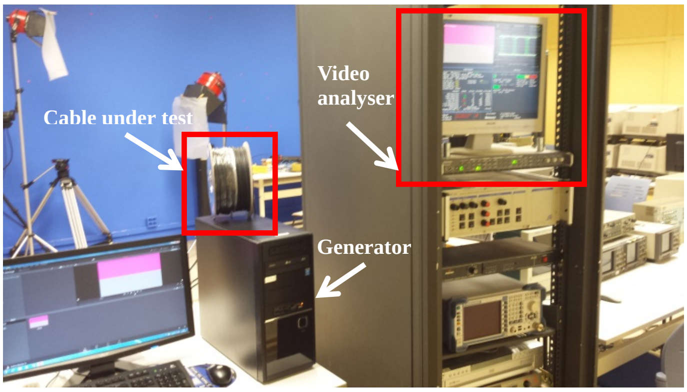
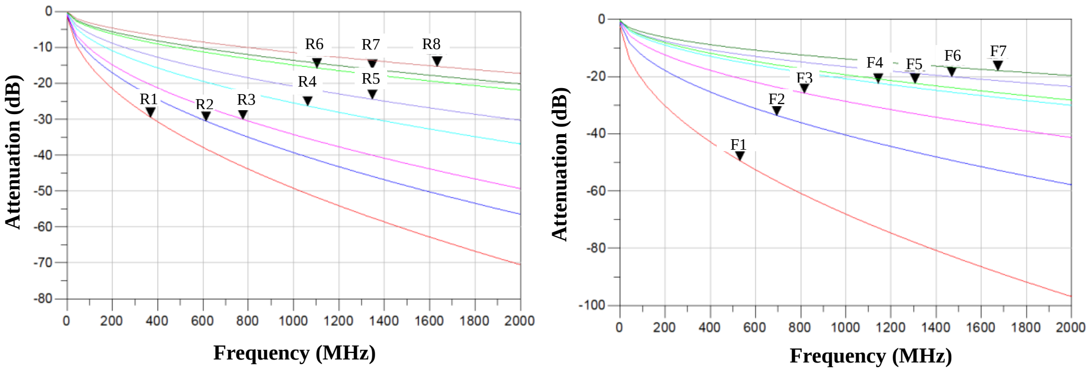



**Fig. 1.** Experimental setup to evaluate the maximum cable length of digital video.

## 3. RESULTS AND DISCUSSION

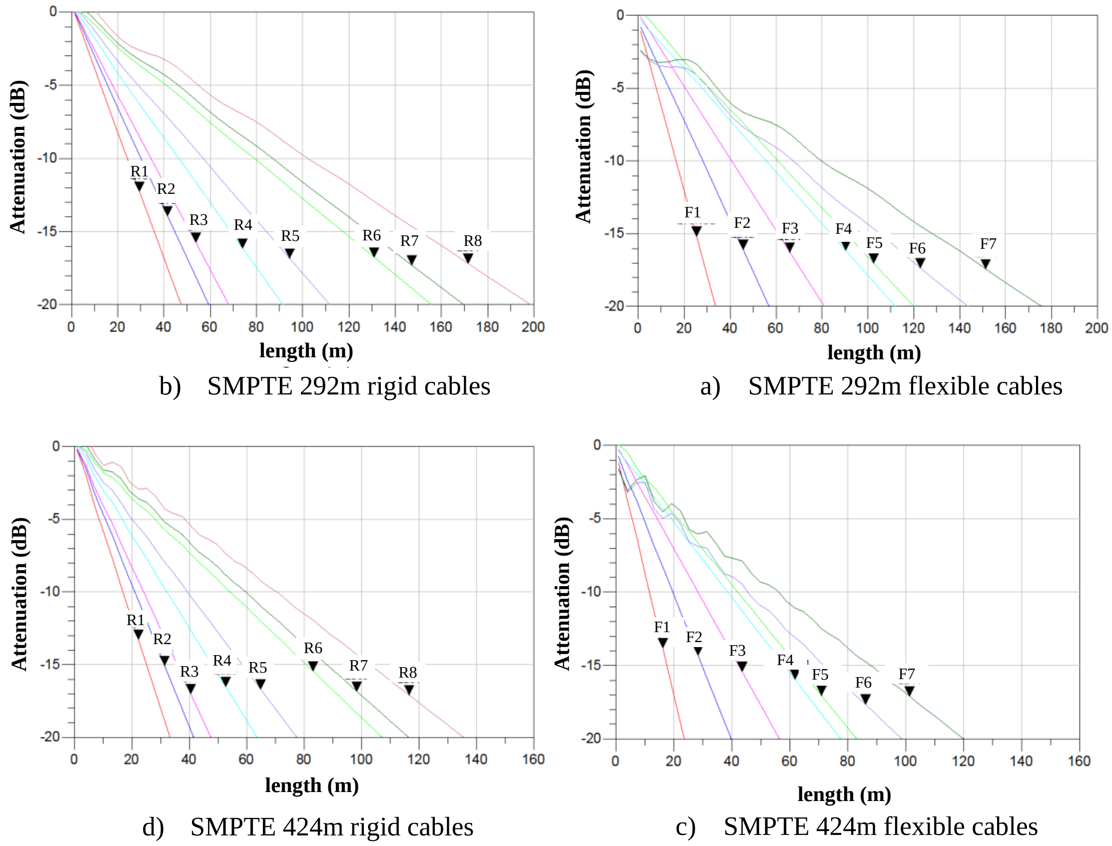
Fig. 2 shows the frequency dependence of the attenuation for a cable length of 100 m. It is observed that the attenuation increases with the frequency, as expected. At the same frequency, higher attenuation value is obtained for thinner cables. For instance, at 1 GHz the attenuation for the thinner rigid cable (R1) reached 50 dB whereas the attenuation for thicker rigid cable (R8) is about 11 dB. For similar American Wire Gauge (AWG), the attenuation is lower in flexible coaxial cables. As an example, at 1 GHz and AWG of 26 the attenuation of rigid cable (cable R1) it is 50 dB meanwhile this value decreases at 40 dB for flexible cable (cable F2). The flexible cable inner conductor is composed of several filaments and, therefore the lower attenuation on flexible cables can be due to the lower impact of skin effect.




a) b)

**Fig. 2**. Attenuation frequency responses for a cable length of 100 m. a) rigid cables, b) flexible cables.

Fig. 3 compares the dependence of the attenuation with the cable length (for rigid and flexible coaxial cables) and two different digital video transmission standards; SMPTE 292m and SMPTE 424m, with a bit-rate 1.485 Gbps and 2.970 Gbps, respectively. For the same attenuation (*i.e.* 20 dB), the maximum cable length is higher for ticker cables in all cases. The maximum cable length increases from 48 m for cable R1 to 198 m for cable R8 for SMPTE 292m and from 33 m to 137 m for SMPTE 424m. For similar gauge and attenuation, better performance is achieved for flexible cables. For instance, for SMPTE292 standard, AWG 26 and 20 dB attenuation, the cable length increases from 48 m to 58 m for cable R1 and cable F2 respectively. For SMPTE 424m standard (attenuation 20dB), the cable length values move from 33 m (cable R1) to 40 m (Cable F2). The SMPTE 292m and SMPTE 424m define that the typical loss amount which would be in the range of up to 20 dB at one-half of the clock frequency. Taking into account this reference, it is possible to predict the maximum length for one specific cable and standard. Table 3 summarizes the maximum coaxial length for the fifteen cables under test and the two standards under investigation.




b) SMPTE 292m rigid cables

a) SMPTE 292m flexible cables

d) SMPTE 424m rigid cables

c) SMPTE 424m flexible cables

**Fig. 3.** Dependence of attenuation with the cable length for two different digital video formats.

**Table 3.** Maximum cable length (m) in order to guarantee the high definition digital video transmission.

| | | Cable | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **R1** | **R2** | **R3** | **R4** | **R5** | **R6** | **R7** | **R8** | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** |
| **SMPTE** | **292M** | 48 | 60 | 69 | 92 | 103 | 155 | 170 | 198 | 33 | 58 | 80 | 111 | 120 | 142 | 176 |
| | **424M** | 33 | 41 | 48 | 62 | 78 | 109 | 118 | 137 | 22 | 40 | 56 | 78 | 82 | 100 | 120 |

## 4. CONCLUSIONS

In this work, the maximum length of several coaxial cables to transmit a high definition digital video under the standards SMPTE 292m and SMPTE 424m had been evaluated. The results show that the maximum cable length increases with the inner conductor thickness and due to the skin effect, for similar cable gauge, it is better to use cables with inner conductor base on multifilament. Taking into account the results it is possible to determine the optimum cable type for one specific installation requirement.

## ACKNOWLEDGEMENT

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## REFERENCES

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