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# Comparison of a Variety of Cables for Real Time Data Transmission

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**Abstract:** The access to seamless multimedia services, browsing on internet, high speed and wide band data transmission are the basic requirements for the research and development. The cables play a pivotal role in getting the benefits from all these advancements in communication technology. To study various characteristics of cables, an extensive research has been carried out on a variety of cables. A variety of physical, electrical and numerical techniques have been utilized to characterize coaxial, twisted pair and twin lead cables. It has been revealed that coaxial cables are more suitable for real time data transmission due to their low attenuation, high velocity of propagation and their immunity to physical and environmental hazards. The main advantage of coaxial cables is its high bandwidth. The significance of other data cables cannot be ruled out but from different analytical techniques Radio Guide (RG)7/U has been proved to be the best cable for data transmission.

**Key words:** Cable characteristics, cable comparison

## INTRODUCTION

Modern houses as well as offices and factories are equipped with numerous multimedia terminals. Today's consumers want to utilize seamless multimedia services wherever they are, for example, some want to watch movies in their bathroom, others want to explore the Internet in their kitchen. These are made possible through the in-home ubiquitous multimedia network cables. Small diameter coaxial, twisted and twin lead cables with diameter smaller than 1 mm are widely used in multimedia networks, small electronic equipment, particularly mobile and wireless ones. These cables show low crosstalk, noise suppression, high-speed and wide band signal transmission, precise control of the characteristic impedance and low insertion loss. With the recent tremendous increase in the rate of production of cables and new devices used for video-frequency transmission, the measurement of attenuation of the cable and propagation delay has generally been the main issues (Kim and Lee, 2006; Unno *et al*., 2003; Batra *et al*., 2004).

Different cables with specific parameters are precise for different requirements. Technological advances in insulation, shielding, jacketing and sheathing materials as well as new cable designs have been taken into consideration in properly selecting and categorizing cables for the specific job (Shaukat and McKinlay, 1999).

The main objective of the research carried out is to categorize different cables for real time data transmission. A systematic research has been performed to characterize different cables and very encouraging results have been obtained. Technical concerns that include cable diameter, dielectric material, inductance, video signal attenuation and impedance are reviewed as well, as these parameters relate to the cable technology and play a significant role in high speed data transmission.

## MATERIALS AND METHODS

In this research different cables for real time data transmission have been studied. Various physical, electrical and numerical techniques are used to categorize 6 cables of different specifications. The main emphasis in characterizing the cables has been on impedance, capacitance, inductance, velocity of propagation and attenuation in video transmission. All the measurements were performed using channel three of PAL system, from 54 to 61 Mhz. These six cables are numbered in sequence in Table 1 and 2 and are acronymed as coaxial cable Radio Guide (RG) 7/U, RG 6/U, RG 59/U, twisted pair cable CAT5e, twin lead parallel line 'KULLU' cable and twin lead antenna cable (Vetterl and Brob, 2002).

The twin lead cable has low attenuation and high velocity of propagation. But it has a very high

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Electromagnetic Interference (EMI) and it can not bear the environmental effects. Another major disadvantage of this type of cable is low bandwidth for transmission and impedance mismatching. So it is not suitable for long distance transmission. These cables are suitable for the specific tasks such as dipole antenna and landline for telephone network.

Twisted-pair cables are used in telephone lines to provide voice and data channels. The DSL lines that are used by the telephone companies to provide high data rate connections also use the high-bandwidth capability of unshielded twisted-pair cables. Now a day's twisted pair cable is widely used in CCTV applications. Impedance matcher is used for impedance matching between cable and devices.

## RESULTS AND DISCUSSION

All the measurements are carried out on one meter length of cable having the physical characteristics mentioned in Table 1.

First of all the outer diameter of the inner conductor and inner diameter of the outer conductor are measured with the digital vernier caliper. The dielectric materials used in the cable with the specific dielectric constant are noted. The dielectric constant values are utilized to determine one of the important electrical parameters of the cables, the impedance from the Eq. 1 (Unno *et al*., 2003; Kennedy and Davis, 1992; Owusu, 2000);

$$Z = \frac{138}{\sqrt{\varepsilon}} \times \log\left(\frac{D}{d}\right)\Omega \quad (1)$$

Here:
ε = The dielectric constant.
D = The diameter of outer conductor and
d = The diameter of inner conductor.

The capacitance and inductance of coaxial cable are determined from the Eq. 2 and 3, respectively;

$$C = \frac{7.36 \times \varepsilon}{\log\left(\frac{D}{d}\right)} \frac{pf}{ft} \quad (2)$$

$$L = 0.140 \times \log\left(\frac{D}{d}\right)\frac{\mu H}{ft} \quad (3)$$

The velocities of propagation of all the cables are measured with the following relation between velocity of propagation and the dielectric constant, as described in Eq. 4 (Kennedy and Davis, 1992).

$$v = \frac{1}{\sqrt{\varepsilon}} \quad (4)$$

The most significant parameter in the characterization of cables is the attenuation factor of the video signal. This has been determined using the spectrum analyzer (GW Instek GSP-827 with 20Ghz) for different cables as described in Table 2. The attenuation is measured in the range of 54 to 61 Mhz as in PAL system channel. It is channel three with the bandwidth of 7 Mhz including picture carrier, picture sub carrier, sound carrier and channel spacing (Chen, 2004).

In case of the second category of cables under investigation, the parallel line (twin lead) cable, the diameter of the conductor with its insulation and distance between the conductors are measured. The dielectric materials used in the cable with the specific dielectric constant are noted. From these physical measurements, one of the important electrical characteristics, the impedance has been calculated from the Eq. 5 (Unno *et al*., 2003).

$$Z = \frac{276}{\sqrt{\varepsilon}} \times \log\left(\frac{2a}{d}\right)\Omega \quad (5)$$

The capacitance and inductance of twin lead cable are determined from the Eq. 6 and 7, respectively and are mentioned in Table 2.

$$C = \frac{\pi \varepsilon_r \varepsilon_0}{\ln\left(\frac{2a}{d}\right)} f\,m^{-1} \quad (6)$$

$$L = \frac{\mu_r \mu_0}{\pi} \times \ln\left(\frac{2a}{d}\right) H\,m^{-1} \quad (7)$$

Table 1: Physical parameters of a group of coaxial, twin lead and twisted pair cables

| Cable | Length of cable (m) | Diameter of conductor (mm) | Diameter of outer conductor (mm) | Separation between conductor (mm) | Dielectric Constant |
|---|---|---|---|---|---|
| RG 7/U | 1 | 0.78 | 4.75 | - | 2.20 |
| RG 6/U | 1 | 0.57 | 3.70 | - | 2.26 |
| RG 59/U | 1 | 0.50 | 3.70 | - | 2.60 |
| UPT Cat5e | 1 | 0.60 | - | 1 | 2.23 |
| KULLU paralle line cable | 1 | 1 (with insulation) | - | 3 | 1.70 |
| Antenna cable | 1 | 1.65 (with insulation) | - | 12.12 | 1.45 |

Table 2: Electrical characteristics of a group of coaxial, twin lead and twisted pair cables

| Cable | Impedance (Ω) | Inductance (μH/ft) | Capacitance (pf/ft) | Velocity of propagation (% of c) | Attenuation (dB 100 m) |
|---|---|---|---|---|---|
| RG 7/U | 73.00 | 0.1090 | 20.63 | 67.4 | 3.30 |
| RG 6/U | 74.56 | 0.1130 | 20.45 | 66.5 | 5.30 |
| RG 59/U | 74.40 | 0.1220 | 22.00 | 62.0 | 7.80 |
| UPT Cat5e | 97.00 | 0.0037 | 0.39 | 69.0 | 13.40 |
| KULLU cable | 164.00 | 0.3713 | 8.05 | 77.0 | 6.50 |
| Antenna cable | 277.00 | 0.4800 | 4.57 | 83.0 | 4.60 |

Here:

$\varepsilon_r$ = The relative dielectric constant,

$\varepsilon_0$ = The permittivity of free space ($8.8542\times10^{-12}$ fm$^{-1}$).

a = The space between two conductor,

d = The diameter of the inner conductor,

$\mu_0$ = The permeability of vacuum ($4\pi\times10^{-7}$ Hm$^{-1}$),

$\mu_r$ = The relative permeability of the medium (air = 1).

Similarly in case of twisted pair (Cat5e) cable, the diameter of the conductor and distance between the conductors are measured. The dielectric materials used in the cable have the specific dielectric constant. By measuring these values characteristic impedance of coaxial cable is determined from Eq. 8 (Kennedy and Davis, 1992).

$$Z = \frac{120}{\sqrt{\varepsilon_r}}\ln\left(\frac{2a}{d}\right) \quad (8)$$

The capacitance and inductance of twisted pair cable have been determined from the Eq. 9 and 10, respectively.

$$C = \left(\frac{0.7065\times10^{-12}}{\ln\left(\frac{2a}{d}\right)}\right)\varepsilon_r\ \text{fm}^{-1} \quad (9)$$

$$L = 10.16\times10^{-9}\ln\left(\frac{2a}{d}\right)\text{Hm}^{-1} \quad (10)$$

All these physical and numerical measurements give rise to the electrical characteristics of impedance, inductance, capacitance and attenuation of all the 6 types of cables and are shown in Table 2.

It has been revealed that the inductance and attenuation parameters of RG7/U cable are the minimum as compared with the rest of the five other cables as described in Table 2. This proves the uniqueness of RG7/U cable and hence it is one of the best cables.

It is divulged from this research work that the electrical characteristics are dependent on dielectric constant, capacitance and inductance. It has been observed that the values of inductance and capacitance are dependent on the relationship of the separation between the two conductors and the radius of the conductors. Impedance is dependent on capacitance and inductance of the cable. The velocity of propagation is mainly dependent on the dielectric material. Characteristic Impedance matching is very important issue in the video transmission. Standing waves are propagated, in case of mismatch in impedance between two different cables or between cables and the interfacing devices and consequently results in power attenuation. Impedance mismatch does not allow the maximum power transfer, which can be determined by Voltage to Standing Wave Ratio (VSWR). Different types of impedance matcher are in practice for matching the impedance of different cables. It has been noted that the impedance of the cable is independent of the length of the cable. It has been noted that the dielectric constant is inversely proportional to the propagation speed of the data signal, as shown in Fig. 1.

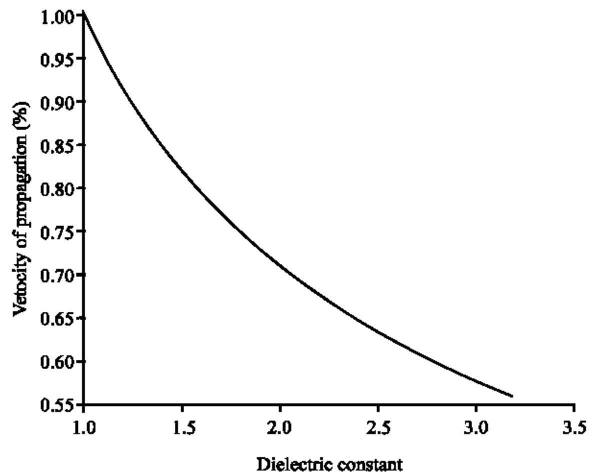


Fig. 1: The relation between dielectric constant and the velocity of propagation of video signal

It has been reveled from this research work that the capacitance is dependent on the dielectric medium and the distance between the separations of the two conductors. If the capacitance of a one meter cable is known the capacitance of the whole cable can be determined. The attenuation of the cable has been determined by the spectrum analyzer. The attenuation of the cable is dependent on the length.

All these measurements have been performed at room temperature, the effect of temperature on the cables quantum efficiency cannot be ruled out. Further research is being planned for the measurement of all the physical, electrical and numerical characteristics of these cables and even the fiber optics at different temperatures.

Most of the data transmission cables have been studied individually by previous researchers but not the comprehensive analysis of a variety of cables have been mentioned before in the literature (Chang, 2006). This research uniquely describes a number of characteristics and the comparison of a variety of data transmission cables collectively.

## CONCLUSIONS

A variety of physical, electrical and numerical techniques have been performed to categorize coaxial, twisted pair and twin lead cables for real time data transmission.

It has been revealed that coaxial cables are more suitable for real time data transmission due to their low attenuation, high bandwidth, high velocity of propagation and their immunity to climate changes and physical damages. The importance of other data cables cannot be ruled out but from different analytical techniques RG7/U is found the best cable. It has been noticed that the dielectric constant is inversely proportional to the propagation speed of the data signal. It has been reveled as well from this research work that the capacitance is dependent on the dielectric medium and the distance between the separations of the two conductors.

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