ABSTRACT

The objective of the Ph. D. work is to study Electromagnetic Interference (EMI) produced by AC Power lines and its effect on communication/ networking cables. Different causes of EMI and different techniques used for reduction of EMI are pointed out. The main aim of the study is to investigate and analyze the effect of AC Power line on UTP cable. The contents of the thesis have been tried to logically organized and spread over eight chapters.

Chapter 1 describes networking and the current trend of cabling in the networking world. UTP cables, the most popularly used copper based cables are described with their types, requirements, advantages, disadvantages and also including specifications. There are two types of networking cables-one is copper based networking cables and the other is optical fiber cables. Copper based cables, specially UTP cables are very sensitive to EMI and optical fiber are insensitive to EMI. But still today, UTP cable is the most popularly used networking cable supporting the standards up to Ten Gigabit Ethernet. It is because of its high speed of data transmission capabilities and also from the point of view of cost and installation. The study tries to outline the current trend of cabling in the networking world and to give an overview of all categories of current UTP cables. UTP cable is always preferred by the network users for wired LANs for high speed of data transmission. Quantitative performances against different significant parameters and against different types of UTP cables are analyzed. Critical parameters are studied for significant performance differences across the types of cables.
Chapter 2 reviews different literatures and documents available regarding the problem of study. Installing cabling without regard to sources of EMI can be detrimental to network performance and transmission quality. In this chapter, different available literatures and documents are reviewed and the problem of study has been defined. The problem of study is the effect of AC power line on UTP cable. The chapter tries to focus on all the available accepted standards regarding the distance between the power lines and UTP cables.

Chapter 3 gives deals with the components of different networking cables and their important characteristics. A network’s performance is depended upon the different characteristics of the used networking cable. For developing a successful network, it is important to understand the different characteristics of all types of cables and how they are related to a particular type of network. The chapter represents a detailed analysis of the significant characteristics of different copper cables. Analysis and study are supported by qualitative and quantitative evaluations of critical parameters in regards to performance.

Chapter 4 covers the different aspects of Electromagnetic Interference (EMI) EMI produced by AC Power lines and its effect on communication/networking cables are described. Data transmission through UTP cabling system is effected by EMI from a nearby Power line through the coupling mechanisms. By maintaining a proper separation gap between Power cable and UTP cabling, we can reduce the effect of EMI to a minimum. This chapter discusses in detail different kinds of coupling effects, and analyses different parameters associated. The effect reduction strategies are also discussed. The aim of the chapter is to investigate and analyse the effect of AC Power line on
UTP cable. Today, effect of Electromagnetic Interference (EMI), is becoming an exceptionally crucial issue in the design of electronic and electric systems. Electromagnetic Interference (EMI) is an undesirable phenomenon, which can degrade the performance of a system due to the electromagnetic fields making up the electromagnetic environment. Designing and Installing UTP cabling infrastructure without regard to EMI can be detrimental to Network Performance and Signal Transmission Quality. Today, though UTP cable is the most preferred cabling supporting 10G Ethernet, but it is also the mostly influenced cable by EMI, since it is unshielded. Shielding and Physical Separation are the two most effective methods to avoid EMI. By maintaining a proper separation gap between Power cable and UTP cabling, we can reduce the effect of EMI to a minimum.

Chapter 5 elaborates different types of coupling mechanisms by which noise voltage can be created on a networking cable from a power line cable. Electromagnetic Interference is caused by coupling mechanisms between source of interference and receptor circuits. This chapter analyses and models different couplings using lumped circuit components and electric circuit analysis considering power cable as the source of interference and networking cable as the receptor circuit of EMI. Noise coupling channels can be represented as equivalent lumped component networks, whenever possible. A time varying electric field existing between two conductors can be represented by a capacitor between the two conductors. Similarly, a time varying magnetic field coupling two conductors can be represented by the mutual inductance between the two circuits. The condition for the validity of this type of approach is that the physical
dimensions of the circuits must be small compared to the wavelengths of the signals involved.

Chapter 6 describes the model used as the Test-Bed for the experimental observation with the descriptions of the used instrument and the pin configurations of the UTP cable. A 10/100 Fast Ethernet model at its simplest form is used as the Test- bed for observing the effect of EMI on UTP cable. Two personal computers are connected directly by using an UTP crossover cable (10m) without a hub. A file is shared between the two computers for running video and file transfer between them. Experiments are conducted for different categories of UTP cable currently used. During the time of file transfer, the voltage and frequency of the signal through the UTP cable (both transmitted and received) are measured using Digital Storage Oscilloscope (DSO).

The aim of the experiment is to measure the signal voltages of the UTP cable sharing LAN under data carrying conditions. Signal voltages of the UTP cable for both transmitted pair and received pair are measured by placing the UTP cable near power lines (230V, 50 Hz) and with no power lines. Readings are taken by placing the power lines at different distances from the UTP cable (varying in inch). The experiment is repeated by changing the values of the loads of the power lines. Signal voltages are measured by placing different current trend of UTP cables at different distances near different loaded power lines.

Chapter 7 contains all the experimental data in tabular form and analysis and result of the experimental observations. It includes 15 tables measuring the
signal voltage of the UTP cable with three variables. The three variables are: i) types of UTP cable, ii) the distance (d) between the cable and power line and iii) the value of the used load on the power line. Three types of UTP cables have been used in the experiments. They are CAT5e, CAT6 and CAT6e. The second variable is the distance between UTP cable and AC power line, which is varied from zero inch to ten inches. The third variable is the value of the used load on the power line. The used loads are 100W, 200W, 400W, 1KW and 2KW respectively.

Analysis of the experimental data of the present work shows that under the effect of AC Power Line, the signal voltage level through the UTP cabling varies in mV. The variations of the voltage levels of UTP cable becomes more with small separation gaps and vice versa. Again, the variations of the voltage levels of UTP cable become more with the increase of used loads of the power line and vice versa. Maximum voltage change occurs when the AC power line is placed near the UTP cable with 0 inch separation gap i.e. when UTP cable and power cable are in physical contact. The signal variation is more prominent to a distance of 2 inch between UTP cable and power cable.

Signal voltage of CAT5e is more affected by EMI than CAT6 or CAT6e and signal voltage of CAT6 is more affected by EMI than CAT6e. Therefore, CAT6e is more immune to EMI compared to CAT5e and CAT6. Maximum voltage change is 0.2V for both transmitted and received pairs for UTP cables. Distance between the source of interference and receptor plays an important role in controlling the effect of EMI. The result of the experimental observations reveals that.
Chapter 8 is the last chapter of the thesis with the conclusion of the Ph. D. work also including its limitations, problem faced and further scope of the study. The study is solely based on the value of the induced voltage generated by nearby power line on UTP cable signal or LAN signal during data carrying condition and why and how. The study is limited to see the effect of EMI on UTP cable produced by coupling mechanisms (Near Field) only. Effect of EMI on UTP cable produced by radiation mechanisms (Far Field) has not studied. Problems were faced during the period of experimental study, but every problem was tried to overcome. Realizing the limitations and problem faced of the present study, the result obtained from the experimental observations could be considered valuable for further study. This study can be considered as a starting point of a detailed analysis of this type of work.

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