Digital and Analog Signals in Telecommunications

by

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Telecommunications signal transmissions can be accomplished via analog signals or digital signals. Analog signals are the older, and still more common mechanism. Despite the growing use of digital technologies such as voice over internet protocol (VoIP), Audin (2009) tells us that the analog legacy systems are still quite common. Engdahl (2004) gives a thorough analysis of that analog signal. Analog telephone signals are generated via a 48 volt battery which is located in one of the central telephone offices. 48 volts is used, according to Engdahl (2004), because voltages under 50 volts are considered safe, therefore 48 volts is not considered hazardous to human beings, but is still powerful enough to propagate through the miles of phone lines to the destination. 48 volts is the standard for phone lines in the United States, however some countries the telephone line will use between 36 and 60 volts. The typical telephone line in the United States has a direct current resistance in the 400 to 800 ohm range, according to Engdahl (2004).

Engdahl (2004) further explains the details of the analog phone wiring. Standard analog telephone sets have 2 wires to carry the speaker and the microphone signals. However the signal path between two telephones requires amplification using a 4-wire circuit. Engdahl (2004) explains that due to cost factors the 2 wire cabling was connected to 4-wire trunk circuits using a device called a "hybrid".

The analog telephone system, referred to as POTS (Plain Old Telephone Service) has a bandwidth of 3kHz, according to Engdahl (2004). A normal POTS line can transfer the frequencies between 400 Hz and 3.4 Khz. This is true in both the United States phone system and the European phone Systems.

One question the presents itself, is how are internet related transmissions sent over an analog phone line? For many years the standard mechanism for creating wide area networks, was to utilize the existing phone lines. And that legacy system is still used in many places. Phone systems, for many years, utilized their own packet switching protocol called X.25 (Cisco 2009). The Cisco (2009) paper goes on to explain that X.25 network use three types of devices. Those devices are data terminal equipment (DTE), data circuit-terminating equipment (DCE), and packet-switching exchange (PSE). Data terminal equipment devices are end point systems that communicate across the X.25 network. An X.25 DTE could be terminals or computers and are located on the premises of individual end users. DCE devices are communications devices, such as modems provide the interface between DTE devices and a PSE, and are generally located in the carrier's facilities. PSEs are switches that compose the bulk of the carrier's network. So, as the Cisco (2009) paper explains, X.25 communication begins with data terminal equipment that the end user has, the communications are translated to X.25 by that end users data circuit-terminating equipment and sent through the packet-switching exchange, ultimately arriving at the other end points data terminal equipment. This process is how packet switching wide are networks are established using the analog phone systems.

Even though digital systems are becoming much more common, Audin (2009) explains that there are still many applications for analog lines. A few examples that Audin (2009) mentions are analog fax lines, alarm systems, and point of sale credit card processing systems. All of these systems commonly utilize analog phone lines. Therefore, according to Audin (2009) when an organization is moving from a legacy analog phone system to a digital phone system utilizing voice over IP, it is important to be aware that some analog lines might still be needed.

Wotel (2004) explains the differences between analog phone lines and digital phone lines. In digital transmissions the signal is divided into binary units, a series of 1s and 0s, and then sent through the transmission medium. Wotel (2004) points out that digital signals use lower voltages than analog lines, thus decreasing power consumption. This can be critical in large organizations and can lead to significant savings. It is also true that digital signals can carry more data than analog signals, according to Wotel (2004). However Wotel (2004) states that current digital technology does not deliver the same quality of sound for voice operations as analog signals do.

One issue with digital signals is that since they can carry a diverse range of transmission types, it is an engineering challenge to differentiate the varied signals. For example an analog phone transmission will always be a voice or fax transmission. But a digital transmission could be voice, fax, video, or data. Differentiating those signals is imperative to successfully handling digital transmissions. The details of how digital signals are handles require a certain level of mathematics. Sewell and Cockburn (1999) discuss the issues of classifying digital signals using low complexity discriminant functions. The detailed mathematics of such functions are beyond the scope of this paper, however Stockburger (2009, explains the essentials of discriminant functions. The main purpose of a discriminant function analysis is to predict group membership based on a linear combination of the interval variables. Sewell and Cockburn (1999) explain the use of these functions to determine what type of signal a digital transmission is carrying based on assigning groups for each type of signal.

It is clear that digital signals and analog signals have many differences. Aside from the nature of the signal itself, the digital signal utilizes less power and can transmit more data as well as a wider variety of types of signals. However this also introduces the problem of differentiating the various signal types. This problem is best handled utilizing the mathematics of discriminant functions.

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