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AWR-047

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NEW PROVISIONAL APPLICATION TRANSMITTAL LETTER

Sir:

Transmitted herewith for filing is the Provisional Patent Application of Inventor(s):

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For: Characterization of Transmission Lines Using Broadband Signals In A Multi-Carrier DSL System

Enclosed are the following papers required to obtain a filing date under 37 C.F.R. §1.53(c):

— Sheets of Informal Drawings
33 Pages of Specification, Drawings & Tables
— Claims

The following papers, if indicated by an ☒, are also enclosed:

☐ A Declaration and Power of Attorney
☐ An Assignment of the invention
☐ An Information-Disclosure Statement, Form PTO-1449 and a copy of each cited reference
☐ A Small-Entity Declaration
☒ A Certificate of Express Mailing, Express Mail Label No. EE437022773US

Basic Fee: $150

☒ A check in the amount of $150 is enclosed to cover the Filing Fee.

Please address all communications and telephone calls to the undersigned.

Respectfully submitted,

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AWR-047

UNITED STATES PROVISIONAL PATENT APPLICATION

of

Murat Belge
Michael A. Tzannes
and
Halil Padir

for a

Characterization of Transmission Lines Using Broadband Signals In A Multi-Carrier DSL System

References Cited

[1] Provisional patent by D. Krinsky and R. Pizzano, "*Multicarrier Modulation System with Remote Transmission Mode*", serial no: 60/174,865, date filed: 1/7/2000.

[2] Provisional patent by M. Belge, "*Estimation of the Loop Length and Bridged Tap Length of a Transmission Line*", serial no: 60/174,866, date filed: 1/7/2000.

1 Background of the Invention

Rapid developments in the computer industry and the availability of affordable hardware created the internet where any user having a communication link between his/her home and the computers in centralized locations can access publicly available information. Users of the internet are connected to the communication network through a link that includes a telephone line from the customer premises (CPE) to a telephone company central office (CO). A computer user requesting data transfer from an internet server is faced with the limited bandwith of the connection between the his/her home and the central office. As more and more information is being created and stored in digital format, the demand from users to access large data files is increasing making it crucial to find new and faster ways of transferring data. One way of achieving faster data transmission is to increase the bandwith of the transmission line between users and the CO by replacing the current metallic conductors with fiber or using better quality metallic conductors with increased bandwith. But such an approach is costly and requires a substantial investment by the telephone companies.

Recent developments in digital signal processing and telecommunications have resulted in the digital subscriber line (DSL) technology enabling a high speed data link over existing twisted pair telephone lines. Alhough a couple of different DSL systems had been proposed multi-carrier systems have quickly gained popularity and been standardized. Multi-carrier DSL systems operate on the principle of frequency division multiplexing where seperate frequency bands are used to transfer data from the CPE to the CO and vice versa. The portion of the bandwith allocated for transmitting data from the user's computer to the CO is called the up-stream (US) channel and the portion of the bandwith allocated for passing data from the CO to the user's computer is called the down-stream (DS) channel. Since in a typical internet session the amount of data being transmitted from the CO to the user's computer is much larger than the amount of data transmitted from the user's computer to the CO, the bandwith allocated for the DS channel is usually much larger than the bandwith allocated for the US channel (typical ratios are 4 to 1 or 8 to 1). The bandwith allocated to the US and DS channels are partitioned into a large number of sub-bands which are sufficiently narrow so as to allow the distortions introduced by the line to be described as an attenuation and a phase shift. These parameters can be measured in a training session prior to establishing the data link by sending and receiving a predefined signal on each subband. The amount of data that can be sent in a sub-band is limited by the signal to noise ratio (SNR) in that sub-band which is the signal strength described by the line attenuation divided by the noise power. Each of the sub-bands in the multi-carrier DSL system is used to transmit data that is consistent with the SNR on that sub-band and maximum allowable error bit rate. Multi-carrier DSL

system operating with the described principles are able to achieve data rates as high as ten million bits per second.

Although the multi-carrier DSL systems are promising because they offer a cost effective way of opening current telephone lines to high speed data transmission traffic, there are important problems in the installation and maintenance phases of DSL deployment that prevents rapid wide spread deployment. Existing telephone lines were initially installed for voice only transmission which can be done by using only a small bandwith. Multi-carrier DSL system require utilizing a bandwith much larger than that required by the voice transmission. At high frequencies line conditions that don't affect the voice transmission become important factors limiting the digital data transmission rate. For example, the line attenuation is related to the loop length. The strength of the signals sent from either CO or user's computer decreases with distance. Small open circuited twisted pairs, called bridged taps (BT), connected in shunt with working twisted pairs, while not effecting voice transmission, cause periodic dips in the attenuation function of the line at certain sub-bands and hence degrade the performance of the DSL service. Telephone lines are usually bundled as 25 or 50 twisted pairs in a cable. Close proximity of the twisted pairs in the cable causes the signals generated by various DSL services carried by a specific telephone line to be picked up by the remaining telephone lines in the bundle. These signals are perceived as additive noise components because they are unpredictable and meaningless for all but one of the telephone lines carrying the service. The interference entering the telephone lines through some coupling path with other telephone lines are called crosstalk. There may be other sources of noise in a telephone line which are caused by the reception of electromagmetic (EM) waves transmitted by various sources such as AM stations or electrical devices such as hair dryers, dimmer switches, alarm systems etc. The most detrimental of these EM sources are generally AM stations. Since no two telephone lines are the same and the availibility and the quality of a DSL link depend on the conditions of the line as described above, it is very important to be able to qualify telephone lines for DSL service and maintain the link once the service is established. It is a challenge to ease the installation and maintenance issues. To decrease the cost associated with service qualification and maintenance, it is preferrable to qualify and maintain telephone lines remotely without sending a technician to the customer premises.

It is the object of the present invention to provide a system for the qualification, maintenance and monitoring of telephone lines for DSL service by taking advantage of the DSL tranceivers in the CO and the CPE sites.

2 Summary of the Invention

Establishing a digital data link between the computer in user's home and the servers connected to the backbone of the central office requires DSL tranceivers handling the data transmission with the basic principles outlined in the previous section. Each of the tranceivers at either side of the link, the CO and the CPE, are called modems. The CO and the CPE modems consist of some analog harware to perform analog signal transmission and reception and a digital section which consists of a digital signal processing (DSP) chip and

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