

Receiving Circuit for Transmission Systems with Copper Cables

The present invention relates to a receiving circuit for transmission systems with copper cables in accordance with the precharacterising part of Claim 1.

Making full use of the capacities of copper cables, which still predominate in the service areas of telecom networks, enables services involving broad-band data transmission via the existing cable network. Therefore major investments in the expansion of existing cable networks are unnecessary at least for medium time intervals. Data transmission rates of about 2 Mbit/sec are obtained with the HDSL technique (high bit rate digital subscriber line according to ETSI standard ETR 152) in data transmission via copper cables (see, e.g., COMTEC, Technische Mitteilungen der CH-Telecom [Technical Communications of Swiss Telecom], 2/1997, page 29, or SIEMENS, telecom report CH-Edition 3/95, page 11).

In some instances, when HDSL transmission links are set up, there are noticed problems which make the use of newly developed HDSL components questionable or which require refitting work within the transmission system. In particular, it was noted that building up HDSL transmission links with copper cables is not possible or possible only when selected components are employed or when expensive matching work is carried out. In view of the volume of the HDSL applications to be expected in the future in the service areas of telecom networks, such refitting work, which in most cases requires a lot of time, must be definitely avoided.

Therefore, the problem underlying the present invention is to devise measures which make it possible - without individually required refitting work - to build transmission links for high data transmission rates on the basis of copper cables of the type present in the service areas of communication networks.

The solution of this problem is achieved with the measures recited in the characterising part of Claim 1.

The measures according to the invention, which can be implemented at low cost, make it possible to use copper cables of various lengths and diameters, as they are present in the service areas of communication networks, for erecting HDSL transmission links without need for matching additional components of the transmission system with the characteristics of the cables. In addition, the use of commercially available components of the transmission system (e.g., conventional HDSL components) is possible with practically all copper cables which in view of their lengths and diameters can be employed for HDSL transmission links.



In what follows, the invention is explained in detail by way of an example and with reference to a drawing. There show:

Figure 1, frequency-dependent forms of the signal attenuation of three copper cables of different lengths and wire diameters;

Figure 2, a possible embodiment of a filter provided for dynamic limiting;

Figure 3a, the basic circuit of a known HDSL transmission link;

Figure 3b, the basic circuit of an inventive HDSL transmission link for simplex operation;

Figure 3c, the basic circuit of an inventive HDSL transmission link for duplex operation; and

Figure 4, frequency-dependent forms of the signal attenuation of two copper cables of identical lengths and identical wire diameters.

In the service area of telecom networks there are copper cables which differ in regard to length, insulating materials, and spacing and diameter of the conductor pairs and which, hence, have various transmission characteristics (resistance, inductance, capacitance, dielectric conductance per unit length, and wave impedance). In the service area of communication networks, there are typically copper cables with lengths of up to 7 km and diameters from about 0.4 mm to 1.4 mm. Problems which arise when HDSL transmission links with standard components are set up to date have been solved from case to case by adaptation to the copper lines to be employed. Depending upon the conditions, after tests a suitable line was selected from a plurality of lines.

By analysing the problems encountered, it could be unexpectedly established that the problem does not originate generally from the attenuation of a transmission line but from the nonuniformity of the attenuation which, surprisingly, is particularly significant in copper cables of increased wire diameter (e.g., 1.4 mm) which, because of their reduced attenuation per unit length, are employed for building HDSL transmission links of increased length. For example, by contrast to a copper line with smaller diameter and higher attenuation, a copper line of greater diameter and lower attenuation may cause problems. It could be established when copper cables of various diameters and lengths were checked, that copper cables of greater diameter and greater lengths have a greater nonuniformity of the attenuation than copper cables of smaller diameter and approximately the same average attenuation.

Figure 1 shows the form of the nonuniform attenuation (attenuation as a function of the frequency) of copper cables SL1, SL2, and SL3 having diameters of 0.4 mm, 1.0 mm, and 1.4 mm, respectively, the lengths of which are chosen so that they have the same attenuation at a frequency

of about 220 kHz. Of course, the 1.4 mm cable SL1 has at a particular length a lower attenuation than the 0.4 mm cable SL3 in the entire frequency range, as shown in Figure 4. It follows from the diagram of Figure 1 that the 1.4 mm cable SL1 has a substantially lower attenuation at lower frequencies ($< 10^4$ Hz) and a substantially higher attenuation at higher frequencies ($> 10^5$ Hz) than the 0.4 mm cable SL3. At 1000 Hz, the 0.4 mm cable SL3 has a by 10 dB higher attenuation than the 1.4 mm cable SL1. A signal transmitted via the 1.4 mm cable SL1 therefore has a dynamic range which is by about 10 dB greater than a signal transmitted via the 0.4 mm cable SL3 (see $\text{dyn1} < \text{dyn2}$). Even if the 1.4 mm cable SL1 were shorter by a few hundred meters and had a lower attenuation, this feature may cause problems. The attenuation differences of the copper lines SL1, SL2, SL3 are in the receiver of a transmission system in most instances compensated by amplification control which, however, does not affect the nonuniformity of the attenuation. Therefore, when copper cables of increased diameter are employed, the line arrangements or the components provided for the digital signal processing must be capable of processing signals of a greater dynamic range. Known digital HDSL receiver modules satisfy these conditions often only marginally so that problems may arise in some instances. The dynamic range of signals transmitted and to be processed determines the resolution required for the digital section of the receiver circuitry (digital/analog converter, equaliser). Therefore, the signals transmitted via the 1.4 mm cables SL1 require a substantially greater dynamic reserve which corresponds to zone z indicated in Figure 1.

According to the invention, for HDSL communication links there is therefore provided a filter FR which reduces the signal components at lower frequencies ($< 10^4$ Hz) by about 10 dB. For this purpose, the filter FR, which, for example, is a filter composed in known fashion of capacitors Cf and resistors Rf as shown in Figure 2, has preferably an attenuation dependence as shown in Figure 1 (see line fkl). This puts into evidence that signals in the range of up to 1000 Hz are reduced by about 10 dB by the filter FR. By using the filter FR, the dynamic range of the signals transmitted via the 1.4 mm cable SL1 is made to match the dynamic range of the signals transmitted via the 0.4 mm cable SL3. But if a 0.4 mm cable SL3 is connected to the filter FR, the signal components at lower frequencies ($< 10^4$ Hz) are not reduced below the signal amplitude of the signal components at higher frequencies (10^4 Hz - 10^5 Hz), whereby a reduced signal-noise spacing would be generated. For the copper cables of the smallest diameter in the network, in the selection of the filter characteristics care must be taken that the attenuation at lower frequencies does not exceed the value corresponding to the value of the maximum attenuation occurring at

higher frequencies. The circuit arrangement according to the invention therefore can be used for all laid copper cables SL1, ..., SL3 without that inadmissibly high attenuation would occur in copper cables SL3 of smaller diameter.

Figure 3a shows the basic circuit diagram of the HDSL transmission link which is known from COMTEC, Technische Mitteilungen der CH-Telecom (Technical Communications of Swiss Telecom), 2/1997, page 28, and which is reduced to two (SL1 and SL2) in place of three subscriber cables connecting a line terminal HDSL/LT at a G.703/G.704 interface with a net termination HDSL/NT, with individual lines for data transmission at transmission rates of 64 kbit/sec emanating from the net termination. The output of the net termination HDSL/NT, like the line terminal, can be provided with a G.703/G.704 interface (2 Mbit/sec).

Figure 3b shows the basic circuit diagram of an inventive HDSL transmission link for simplex operation. Data are transmitted by a transmitter unit TX in simplex operation from the line terminal LTSX via the subscriber cable SL1 to the network termination NTSX or to a filter FR provided for dynamic equalisation and, following the same, to a receiver unit RX. Data are transmitted in the same fashion in the inverse direction via the subscriber cable SL2.

In the basic circuit diagram according to Figure 3c, the data transmission between the line terminal and network terminal LTDX and NTDX is effected in known fashion in duplex operation via terminating sets GS, with a filter FR for dynamic equalisation provided between each terminating set GS and the associated receiver unit RX.

Furthermore, the filter FR may be used advantageously together with integrated receiver units RX which, as the case may be, are part of a transceiver. For example, the circuit components SK70704/SK707070 of the company LEVEL ONE are suitable; these have been described in the corresponding data sheet "1168kbps HDSL, Data Pump Chip Set" of May 1996.



Claims

1. Receiving circuit for setting up transmission systems with copper cables which may have dissimilar cable characteristics, particularly lengths and diameters, characterised in that there is provided a receiver unit (RX) serving for digital signal processing, which receiver unit is adapted to be connected via a filter (FR) and a copper cable (SL1, SL2) to a transmitter unit (TX), which filter (FR) for compensating nonuniformity of attenuation is provided with a high-pass characteristic such that signal components at lower frequencies are attenuated to an extent such that the dynamic range of the signals transmitted via copper cables (SL1, SL2) with the greatest possible wire diameter is reduced to an extent such that the resolution of the digital section of the receiver unit (RX) suffices for their processing and that signal components at lower frequencies are at most attenuated to an extent such that, in the case of copper cables (SL1, SL2) with the smallest possible wire diameter, the maximum attenuation arising in the frequency range used without application of the filter (FR) is practically not increased following application of the filter (FR).

2. The receiving circuit according to Claim 1, characterised in that the filter (FR) has an attenuation between 5 dB and 15 dB in the range of the first 10 kHz when the bandwidth of the transmission channel amounts to a few 100 kHz and the copper cables (SL1, SL2) employed have wire diameters between 0.4 mm and 1.4 mm.

3. The receiving circuit according to Claim 1 or 2, characterised in that the receiver unit (RX) for data transmission in simplex operation is connected to a transmitting station (TX) via the filter (FR) and a copper cable (SL1, SL2,) having a diameter of the range for which the filter (FR) has been designed.

4. The receiving circuit according to Claim 1 or 2, characterised in that the receiver unit (RX) for data transmission in duplex operation is connected to a transmitting station (TX) via the filter (FR) and a copper cable (SL1, SL2,) having a diameter of the range for which the filter (FR) has been designed.

5. The receiving circuit according to Claim 1, 2, 3 or 4, characterised in that the receiver unit (RX) and the transmitter unit (TX) are structured in accordance with HDSL standards.

6. The receiving circuit according to Claim 1, 2, 3 or 4, characterised in that the receiver unit (RX) and the transmitter unit (TX) are designed for the transmission of data with up to 2 Mbit/s.



7. The receiving circuit according to any one of Claims 1 - 6, characterised in that the receiver unit (RX) is provided for controlling the signal amplitude and for analog/digital conversion of the input signals.

8. The receiving circuit according to any one of Claims 1 - 6, characterised in that the receiver unit (RX) is an integrated circuit of the type SK70704 of the company LEVEL ONE.