Name of discipline:

Transmission systems of access networks (TSAN)

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Lecture 5

SIMMETRICAL DSL TECHNOLOGIES

Main terms and usage specifications

Basic version of the SHDSL (Single-pair High-speed Digital Subscriber Line – Recommendation ITU-T G.991.2) transmission system (TS) uses 16-level pulse amplitude modulation (PAM) with trellis coded – 16-TCPAM.

Using the trellis codes provide gain in 5 dB, thus reducing the error probability for transmission and increase the distance of communication. For decoding at the receiver using Viterbi algorithm is effective.

Additional gain in SHDSL TS gained through the use Tomlinson precoding – signal precoding at the transmitter based on knowledge of the channel impulse response.

As a result of the application of these algorithms SHDSL, compared with single-pair variant HDSL TS (Recommendation ITU-T G.991.1), using code 2B1Q, as demonstrated by the operation, thus increasing by 35 - 45% transfer rate for the same distance or increase distance on 15 - 20% at the same speed.

In order to ensure the provision of services at different levels in SHDSL TS lets you choose speeds ranging from 192 kbit/s to 2312 kbit/s in steps of 8 kbit/s. In order to reduce the transfer rate resort in cases where it is necessary to achieve an increase in transmission distance, and the regenerators installation is impossible or impractical. Length of digital SL in the SHDSL TS is about 2 km for maximum transfer rate (cable type ТП diameter cores 0.4 mm), for minimal – more than 6 km.

To increase the transfer rate of in SHDSL TS has the ability use to data transmission simultaneously to four pairs, which allows to provide transfer rate up to 9.248 Mbit/s.

Was put in the December 2003 edition of the Recommendations G.991.2 provides SHDSL TS option with the increased speed of information transfer one pair cable to 5696 kbit/s, with possible use as a modulation of 16-TCPAM, and 32-TCPAM. This allows SHDSL TS for work in four paired transmission mode reach rates of 22784 kbit/s.

In 2007 there were reports of further increasing the maximum transfer rate of one pair SHDSL TS to 15200 kbit/s by implementing 64-TCPAM and 128-TCPAM modulation techniques.

Frame structure of SHDSL

The largest element of the SHDSL signal structure is frame that consists of 4 blocks of useful data and service information (see. Fig. 5.1).

Frame synchronization	Service information	Useful data block	Service information	Useful data block	Service information	Useful data block	Service information	Useful data block

Fig. 5.1

Each data block contains 12 sub-blocks. The duration of the frame when the synchronous transmission mode is 6 ms, and if plesyochronous mode– $6 + 3/(k + 12)$ ms, where k – is the size of each block of useful information, $k = 12(i + 8n)$ bits. Information transfer rate is $64n + 8i$ kbit/s, where $3 \leq n \leq 36$ and $0 \leq i \leq 7$. For $n = 36$ i can take only two values: 0 and 1 The information transfer rate is set during initialization.

Block diagram of the SHDSL transmitter

The block diagram of the transmitter STU-C (SHDSL Transceiver Unit at the Central Office) or STU-R (SHDSL Transceiver Unit at the Remote End) is shown in Fig. 5.2.

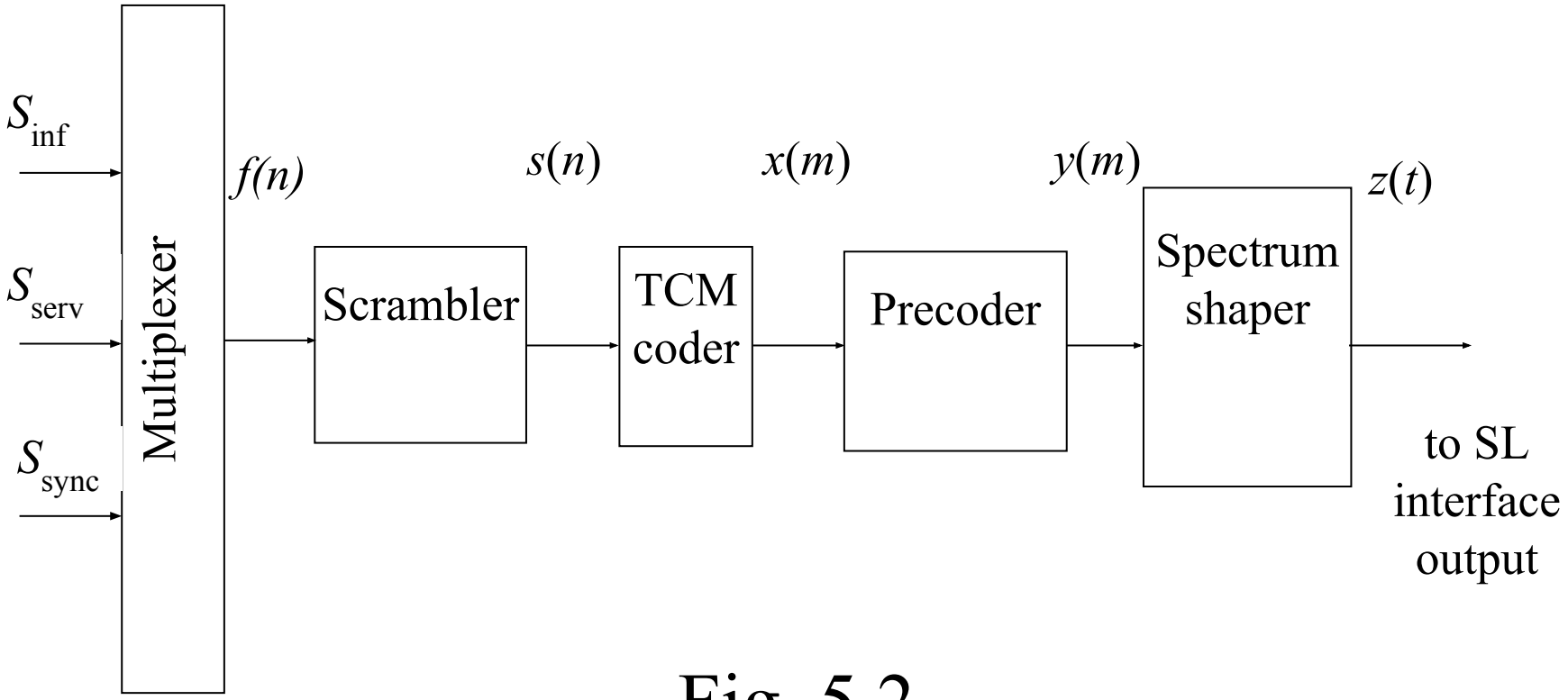

Fig. 5.2

The input multiplexer combines the information S_{inf} and service S_{serv} signal with synchronization and control signals S_{sync} into a single digital stream $f(n)$, $n = 1, 2, \ldots,$ (n − number of bits) according to the frame structure of the signal.

Formed digital stream is scrambling, and pseudorandom signal $s(n)$, $n = 1, 2, \ldots,$ the input of the encoder TCM (Trellis Coded Modulation).

Output signals TCM-encoder is K-bit information symbols− $x(m)$, $m = 1, 2, \ldots$ (m − number of symbols).

Then the symbols $x(m)$ lists the Tomlinson precoding algorithm in symbols $y(m)$, $m = 1, 2, \ldots$, and come in a spectrum shaper that provides a digital signal $y(m)$ to analog signal $z(t)$ to the desired spectral characteristics.

According to transferring K information bits per symbol duration PAM-symbol in K times greater than length of the bit.

Symbol rate f_{sym} (symbol/s) related to the rate of transmission of useful information R (bit/s) the following relation:

$$f_{sym} = (R + 8) / 3.$$

SHDSL signal power spectral density (PSD) masks

Spectrum shaper device creates the output signal power spectral density (PSD) masks which satisfies power shown in Fig. 5.3-5.4. One of the features of SHDSL TS is that the width of the spectrum of transmitted signal is proportional to the speed of information transfer.

In SHDSL TS assumed optional use of asymmetric (different to the station and subscriber side) PSD masks.

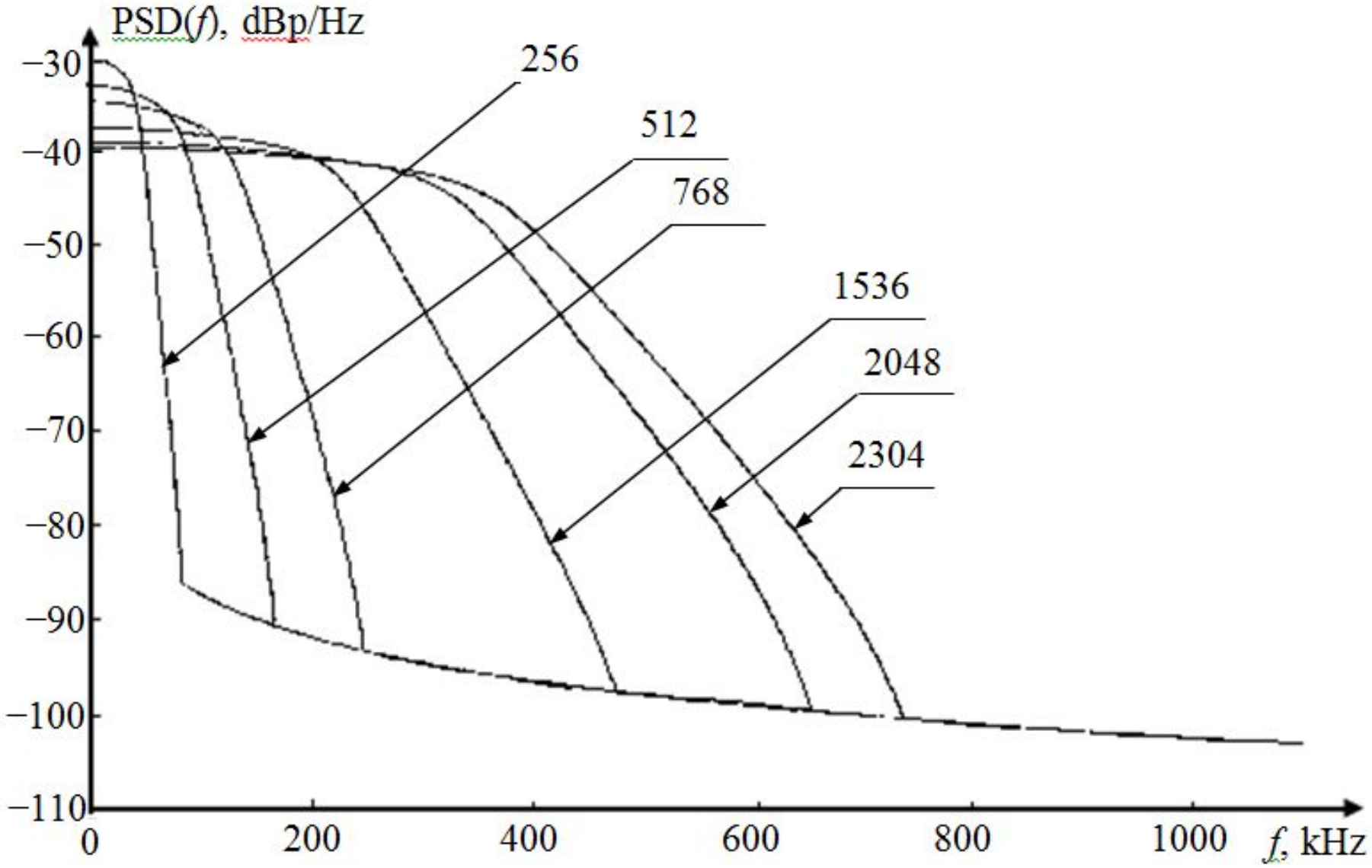

Fig. 5.3 − SHDSL PSD masks for bitrates: 256; 512; 768; 1536; 2048 and 2304 kbit/s (16-TCPAM)

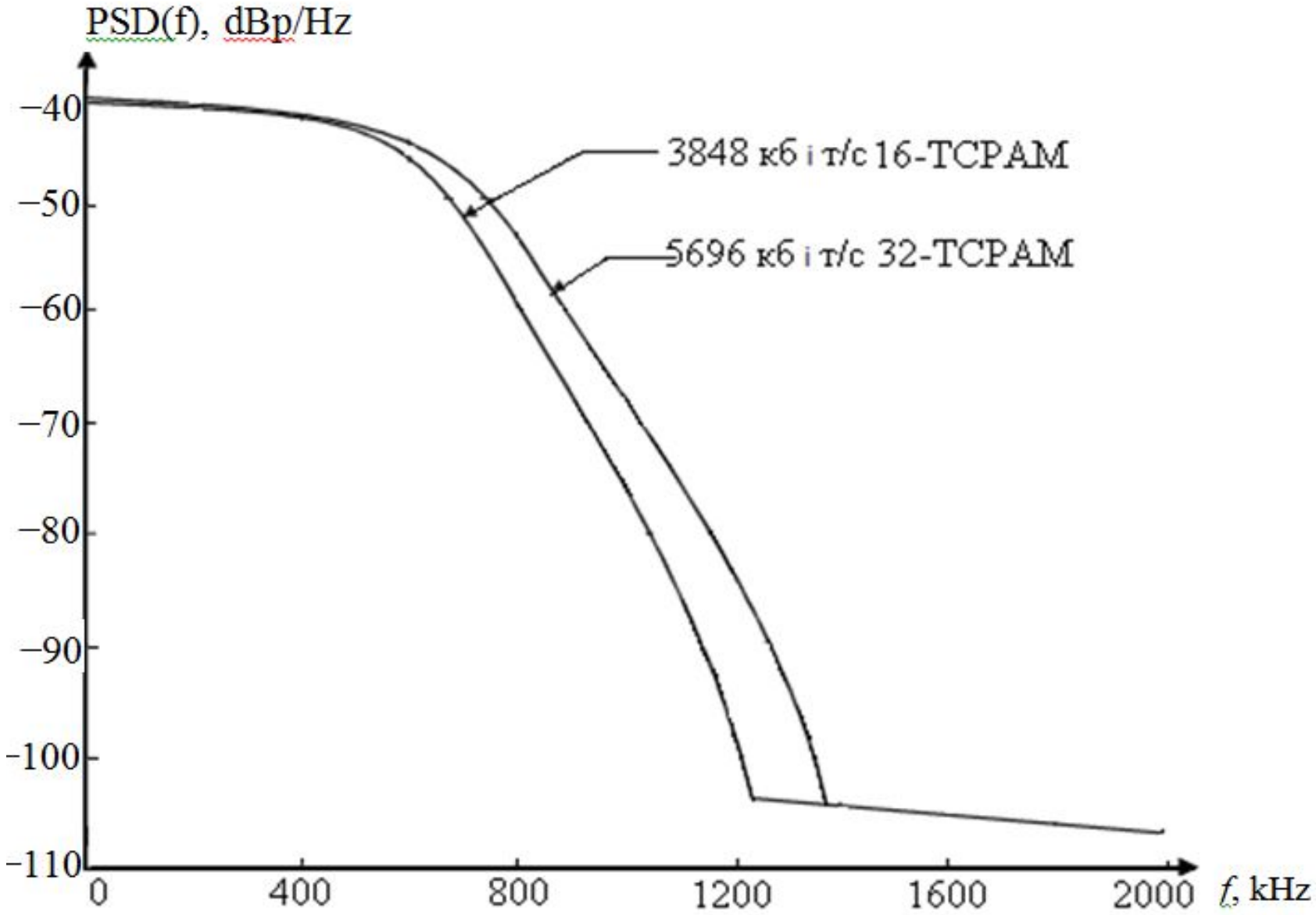

Fig. 5.4 − SHDSL PSD masks for bitrates: 3848 kbit/s (16-TCPAM) i 5696 kbit/s (32-TCPAM)

The maximum power level at the output of the transmitter is 15 dBp at speeds that are greater or equal to 2048 kbit/s and 14 dBp for speeds below the 2048 kbit/s.