T1E1.4/93-88

Standards Project: **T1E1.4: ADSL**

Title: **Recommended Procedures for Exchange of DMT Loading Information in ADSL**

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Abstract:

This paper is a continuation and an expansion of T1E1.4/93-022. It describes, in more, though not yet complete, detail, that part of the initialization procedure for an ADSL system implemented by DMT that is concerned with feedback to each transmitter of the calculated bits and powers.

Recommended Procedure for Exchange of DMT Loading Information in ADSL

1.Introduction

In order to achieve the best possible performance from a DMT ADSL system on a wide variety of subscriber lines, three essential parts of the initialization procedure are

(a) Measurement, in the two receivers, of the S"N"R* in all used sub-bands. The recommended procedure for this has been outlined in T1E1.4/93-022, and is described in detail in T1E1.4/93-087.

(b) Calculation of the optimum distribution of bits, and available transmit power among the sub-carriers (b_i and g_i, for i=1 to N_C, where N_C = 256 at the CO and 64 at the RT). Two algorithms have been described in [1,2], but neither is totally satisfactory. Better algorithms have been, and will continue to be, developed; since, however, they are not essential for the design of a compatible ADSL unit, they will probably remain proprietary.

(c) Communication of this "bits and gains" information from each receiver to each transmitter. This paper recommends a procedure for this communication.

2. Exchange of Bits and Gains Information

As shown in Fig. 5 of 93-083, the RTU transmits the random channel-analysis signal immediately after the periodic line-conditioning signal. Thereafter, the basic sequence of signals is as shown in Fig. 1 of this paper. It should be noted that the channel analyses are performed simultaneously (i.e., in a full-duplex mode); this is because unfiltered or uncancelled echo may be a significant part of the total "noise" seen by a receiver. The subsequent exchange of bits and gains, however, is most conveniently performed in a half-duplex mode.

Ultra reliability in the exchange of bits and gains information is very desirable, but at this stage of the initialization the two transmitters do not, of course, know how many bits each of their subcarriers can carry. Since, however, the amount of information to be sent is quite small (just 16 bits for each of the N_C carriers), a set of only four low-frequency carriers (those that would be expected eventually to carry up to eleven bits) is used with only QPSK on each. Two other safeguards are used: the information is repeated on a second set of fourcarriers, and a 16-bit CRC is appended to the data.

The bits and gains signal, which therefore consists of $2N_C$ symbols, is preceded by a header symbol and followed by the CRC (both formats to be recommended later) for a total of ($2N_C$ +4) symbols.

The format of the symbols is $[b_i,g_i] = [b1_i,b2_i,b3_i,b4_i,g1_i,g2_i,\ldots\ldots\ldots g12_i]$, and they are transmitted in ascending order of subcarrier number: that is, i = 1 to N_C*.

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* The N is enclosed in quotation marks to emphasize that the "noise" is the sum total of all impairments listed in Section 4.1 of T1E1.4/92-098.

The b1,b2,b3,b4 are encoded in conventional binary (0000 to 1011 for 0 to 11) onto a primary set of carriers 8-9 and a secondary set that is to be determined.

The g1,.......g12 represent the ratio of the gain to be transmitted to that used for channel analysis, with 0010 0000 0000 being normalized to unity. For example 0100 0000 0000 would indicate a 6 dB increase in power.

The symbols $[b_i,g_i]$ are transmitted on the primary set of carriers 8 - 11 and a secondary set N_{sec} - N_{sec}+3 in conventional QPSK as follows:

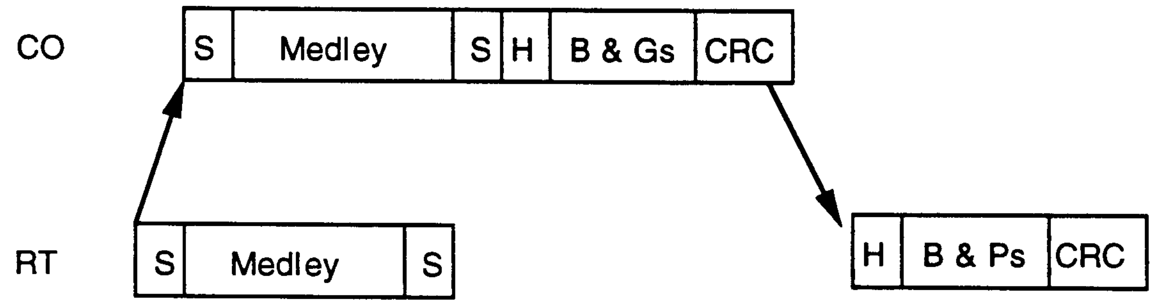
	b1b2	b3b4	g1g2	g3g4		g5g6	g7g8	g9g10	g11g12
First symbol:	8	9	10	11	Second symbol:	8	9	10	11
First symbol: N_{sec}+	0	1	2	3	Second symbol: N_{sec}+	0	1	2	3

This method of communicating the bits and gains information is extremely reliable, but there is, of course, a non-zero probability of error. If the CRC indicates an error then the "basic" procedure of Fig. 1 must be refined to allow for retransmission. Details of this have not been finalized. In the the present implementation a detected error would initiate a complete re-initialization: this is not necessary.

References.

[1] J.A.C. Bingham, "*The Theory and Practice of Modem Design*", John Wiley and Sons, 1988.

[2] D. Hughes-Hartogs, "Ensemble Modem Structure for Imperfect Transmission Media", U.S. Patent No. 4.679.227, July 1987.



S = Segue; H = Header (see 93-083)

Figure 1. Bits and Powers exchange.

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* Subcarrier 0 can never be used in a transformer-coupled system. Subcarrier N_c is at the Nyquist frequency, $f_s/2$; if used, which would be very rarely, it could be modulated only as BPSK: that is b_{N_c} may be 0 to 5.