NORTH ATLANTIC TREATY ORGANIZATION

ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD

MILITARY AGENCY FOR STANDARDIZATION (MAS)
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MAS/55-EL/4198
13 February 1984

To : See distribution overleaf

Subject : STANAG 4198 EL(EDITION 1) - PARAMETERS AND CODING CHARACTERISTICS THAT MUST BE COMMON TO ASSURE INTER-OPERABILITY OF 2400 BPS LINEAR PREDICTIVE ENCODED DIGITAL SPEECH

Reference : AC/302-D/186 dated 7 January 1982

Enclosure : STANAG 4198(Edition 1)

1. The enclosed NATO Standardization Agreement which has been ratified by nations as reflected in page iii is promulgated herewith.

2. The reference listed above is to be destroyed in accordance with local document destruction procedures.

3. AAP-4 should be amended to reflect the latest status of the STANAG.

ACTION BY NATIONAL STAFFS

4. National staffs are requested to examine page iii of the STANAG and, if they have not already done so, to advise the Defence Support Division of the International Staff, through their national delegation as appropriate, of their intention regarding its ratification and implementation.

P.J. MITCHELL
Major-General, CAAR
Chairman, MAS

STANAG 4198
(Edition 1)

NORTH ATLANTIC TREATY ORGANIZATION

(NATO)

MILITARY AGENCY FOR STANDARDIZATION

(MAS)

STANDARDIZATION AGREEMENT

SUBJECT: PARAMETERS AND CODING CHARACTERISTICS THAT MUST BE COMMON TO ASSURE INTEROPERABILITY OF 2400 BPS LINEAR PREDICTIVE ENCODED DIGITAL SPEECH

Promulgated on 13 February 1984

P.J. MITCHELL
Major-General, CAAR
Chairman, MAS

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature
1-4		3/11/00	[illegible]

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Chairman MAS under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

DEFINITIONS

4. Ratification is "The declaration by which a nation formally accepts the content of this Standardization Agreement".

5. Implementation is "The fulfilment by a nation of its obligations under this Standardization Agreement".

6. Reservation is "The stated qualification by a nation which describes that part of this Standardization Agreement which it cannot implement or can implement only with limitations".

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page iii gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page iv (and subsequent) gives details of reservations and proprietary rights that have been stated.

STANAG 4198
(Edition 1)

NAVY/ARMY/AIR

NATO STANDARDIZATION AGREEMENT (STANAG)

PARAMETERS AND CODING CHARACTERISTICS THAT MUST BE COMMON TO ASSURE INTEROPERABILITY OF 2400 BPS LINEAR PREDICTIVE ENCODED DIGITAL SPEECH

Annexes:
A. Description of Linear Predictive Coding.
B. Voice Digitizer Characteristics.
C. Interoperable Coding and Decoding Tables.
D. Performance Characteristics (for information only).

Related Documents:
(1) STANAG 4197, Modulation and Coding Characteristics that must be Common to Assure Interoperability of 2400 Bps Linear Predictive Encoded Digital Speech Transmitted Over HF Radio Facilities

(2) STANAG 4291, Modulation and Coding Characteristics that must be Common to Assure Interoperability of 2400 Bps Wireline Modems for use in Narrow Band Secure Voice Systems

AIM

1. The aim of this agreement is to define the voice digitizer characteristics, the coding tables and the bit format requirements to ensure the compatibility of digital voice produced using Linear Predictive Coding (LPC).

AGREEMENT

2. Participating nations agree to use the characteristics contained in this STANAG for their equipment used to provide narrow-band digital speech using Linear Predictive Coding (LPC).

GENERAL

3. A description of Linear Predictive Coding is at Annex A. Voice Digitizer Characteristics are at Annex B. Interoperable Coding and Decoding Tables are at Annex C. Performance Characteristics are at Annex D for information only.

IMPLEMENTATION OF THE AGREEMENT

4. This STANAG is considered implemented by a nation when all such equipment to be used in its forces are manufactured in accordance with the specifications detailed in this agreement and are placed in service.

DESCRIPTION OF LINEAR PREDICTIVE CODING

1. Linear Predictive analysis is based on the fact that a speech sample can be approximated as a linear combination of past speech samples. By minimizing the sum of the squared differences (over about 20 milliseconds) between the actual speech samples and the linearly-predicted ones, a set of prediction coefficients can be determined.

2. The theory of linear prediction is intimately related to the basic speech model. Speech can be modelled as the output of a linear, time-varying system, excited by either quasi-periodic pulses (during voiced speech) or random noise (during unvoiced speech).

3. Figure 1 is a block diagram of the transmitter portion of a typical Linear Predictive Coder (LPC) system.

(a) The input bandwidth must be as wide as possible, consistent with a sampling rate of 8 kHz. It is desirable that the pass band be flat within 3 dB from 100 to 3600 Hz. Table 1 is the input filter response used in the telephone company T-1 carrier equipment and is a typical input filter.

(b) After first order pre-emphasis ($1 - .9375Z^{-1}$) 10 predictor coefficients are determined by linear predictive analysis.

(c) For pitch and voicing analysis, 60 pitch values are calculated over the frequency range of 50 to 400 Hz. A two-state voicing decision is made twice per 22.5 milliseconds frame.

(d) The excitation and spectrum parameters are then coded and error corrected for transmission at 2400 Bps.

(e) A fully loaded input Analog to Digital Converter, independent of the number of bits used in the A/D Converter, should produce a fully loaded RMS Coded value of 63 in the Table 5 RMS Coding Table on Page C-4. The maximum 5 bit index transmitted will be 31.

4. Figure 2 is a block diagram of the receiver of a typical Linear Predictive Coder.

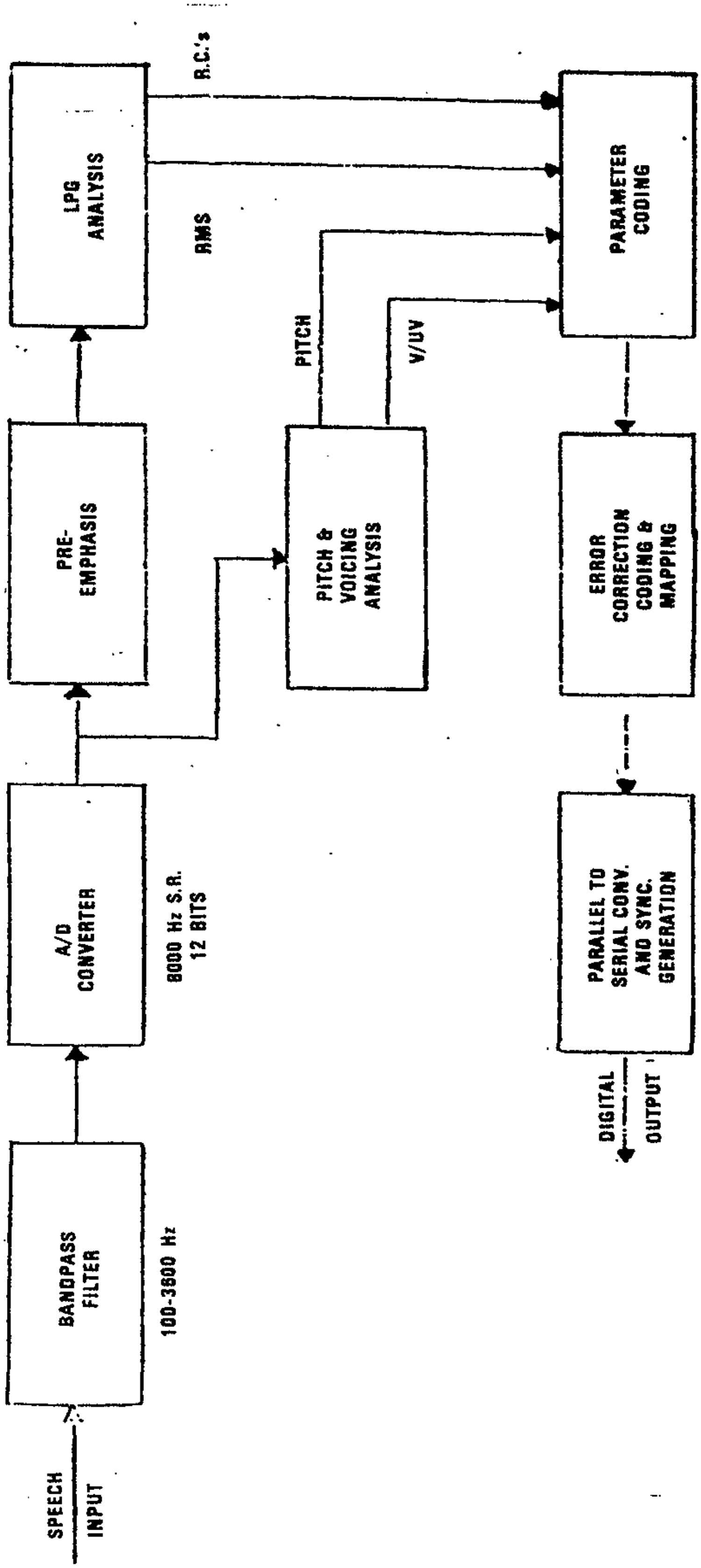

FIGURE 1: LINEAR PRODUCTIVE CODER TRANSMITTER (TYPICAL)

40 Hz	-32 dB
60 Hz	-18 dB
80 Hz	- 8 dB
100 Hz	- 3 dB
200 Hz	0 dB
500 Hz	0 dB
1000 Hz	0 dB
1500 Hz	0 dB
2000 Hz	0 dB
2500 Hz	0 dB
3000 Hz	0 dB
3600 Hz	- 3 dB
3800 Hz	-13 dB
4000 Hz	-23 dB
4200 Hz	-33 dB
4400 Hz	-46 dB

Table 1. Input Filter Response (Typical)

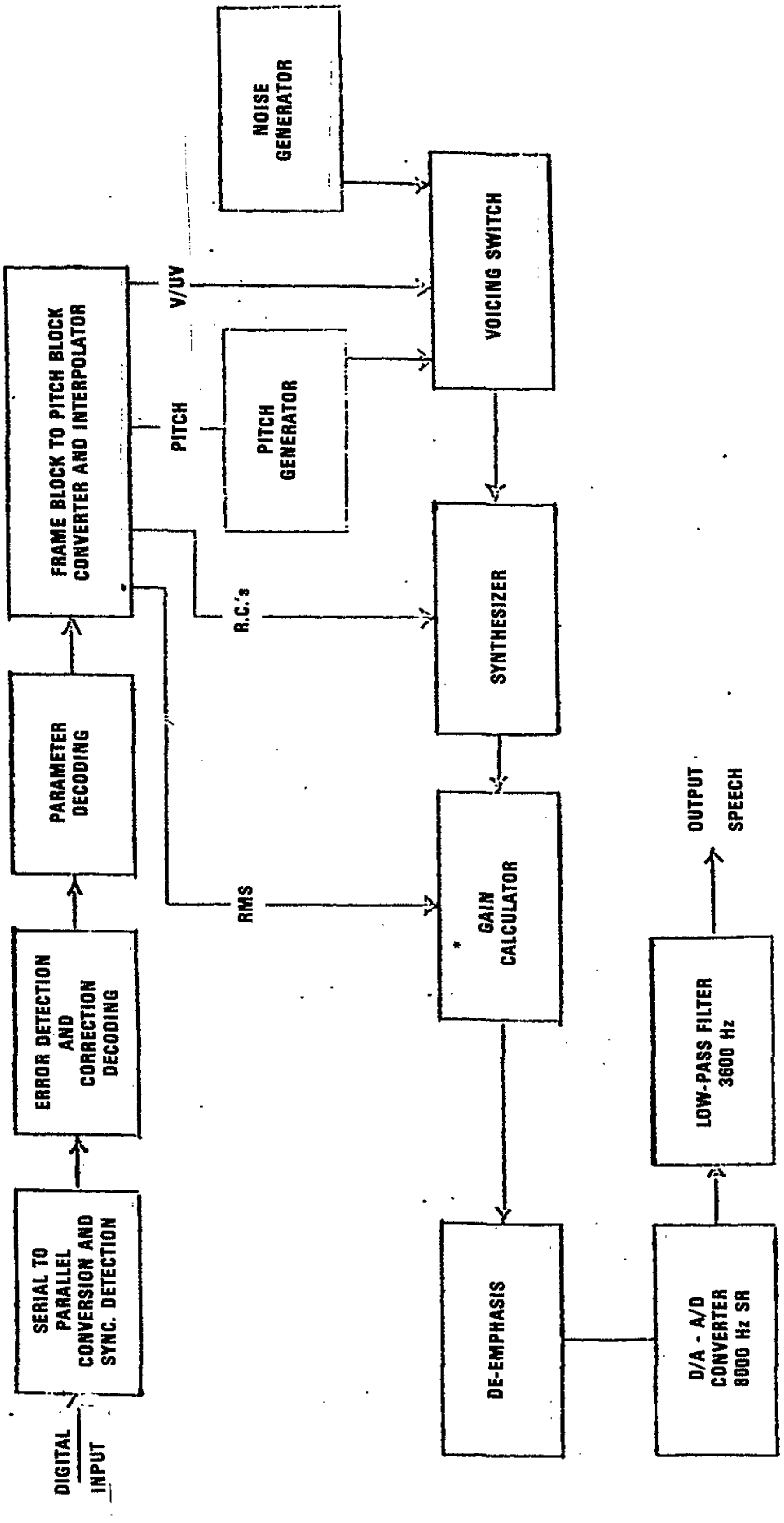

FIGURE 2. LINEAR PREDICTIVE CODER SYNTHESIZER (TYPICAL)

* GAIN CONTROL COULD BE INCLUDED IN SYNTHESIZER BOX

VOICE DIGITIZER CHARACTERISTICS

Sampling Rate:	8 kHz ± .1%
Predictor Order:	10
Transmission Data Rate:	2400 b/s ± .01%
Frame Length:	22.5 ms (54 bits per frame)
Excitation Analysis	
Pitch	50-400 Hz, semi-logarithmic coding (60 values)
Voicing	A two-state voicing decision is made twice a frame
Amplitude	Speech root-mean-square (rms) value, semi-logarithmic coding (32 values)
Spectrum Analysis	
Pre-emphasis	Typical first order digital transfer function $1 - .9375Z^{-1}$
Spectrum Approximation	10th order all-pole filter
Spectrum Coding	Log area ratio for the first two coefficients and linear reflection coefficients for the remainder
Transmission Data Format	
Synchronization	1 bit
Pitch/Voicing	7 bits
Amplitude	5 bits
Reflection Coefficients	41 bits for 10 coefficients if voiced, or 20 bits for 4 coefficients with 20 error protection bits if unvoiced (plus 1 unused bit, see Table 1)

Error Detection and Correction

Voicing Decision	(1) Full-frame unvoiced decision encoded as a 7-bit word having a Hamming weight of zero (7 zeros)
	(2) Half-frame voicing transition encoded as a 7-bit word having a Hamming weight of seven (7 ones)
Unvoiced Frame Parameters	Hamming (8,4) codes to protect most significant bits of amplitude information and first 4 reflection coefficients.
Voiced Frame Parameters	(1) 60 pitch values mapped into 60 of 70 possible 7-bit words having a Hamming weight of 3 or 4
	(2) Typically for good performance under error conditions an adaptive smoothing algorithm should be applied to pitch, amplitude and first 4 reflection coefficients for eradication of gross errors based on the respective parameter values over three consecutive frames

Synthesis

The synthesis filter must be a 10th order all-pole filter with appropriate excitation signals for voiced and unvoiced sounds capable of satisfying the speech intelligibility requirements as specified in Annex D.

The typical de-emphasis transfer function is $\frac{1}{1 - .75Z^{-1}}$

A recommended 40 sample all-pass excitation for voiced speech is given in Table 2.

SAMPLE	VALUE	SAMPLE	VALUE
1.	249	21.	-82
2.	-262	22.	-123
3.	363	23.	-39
4.	-362	24.	65
5.	100	25.	64
6.	367	26.	19
7.	79	27.	16
8.	78	28.	32
9.	10	29.	19
10.	-277	30.	-15
11.	-82	31.	-29
12.	376	32.	-21
13.	288	33.	-18
14.	-65	34.	-27
15.	-20	35.	-31
16.	138	36.	-22
17.	-62	37.	-12
18.	-315	38.	-10
19.	-247	39.	-10
20.	-78	40.	-4

Table 2. Voiced Excitation

INTEROPERABLE CODING AND DECODING TABLES

1. The RMS, reflection coefficients, pitch and voicing are coded to 2400 Bps. The frame length is 22.5 milliseconds. Table 3 gives the bit allocation for the voiced and non-voiced frames. Table 4 gives the specified transmitted bit stream for voiced and non-voiced frames. Synchronization is an alternating 1, 0 pattern. RMS is coded logarithmically using nominal .773 dB steps between 2 and 512 as in Table 5. The table has 64 values instead of 32 to allow for logarithmic interpolation at the receiver.

2. The reflection coefficients are coded and decoded in the following manner:

(a) the sign convention used is that $K_1 = R_1/R_0$, where R_0 = autocorrelation of Si on itself (o delay) and R_1 = autocorrelation of Si and Si + 1 (1 delay). The same sign convention is used for all reflection coefficients;

(b) the receiver decodes K_1 and K_2 using Table 6. K_1 and K_2 are Log-Area-Ratio encoded by table look-up. See Table 7;

(c) for voiced frames, K_3 through K_{10} are coded in accordance with Tables 8 through 15;

(d) for voiced frames, K_3 through K_{10} are decoded in accordance with Tables 8 through 15;

(e) for non-voiced (unvoiced and transition) frames, only the first four Ks are transmitted. Error correction and detection is provided by (8,4) Hamming Codes which protect the most significant 4 bits of the four Ks and RMS. See Table 16.

3. The Pitch Encoder Table 17 gives the relationship between pitch code (period) pitch frequency and Pitch Code.

4. The 60-pitch values are Gray type coded as Hamming weights 3 and 4 of a 7-bit word. For unvoiced frames, a 7-bit zero vector is transmitted while for voicing transition frames 7 ones are transmitted. Table 18 decodes the pitch and voicing word, where 0 is unvoiced, 1 is transition, 3 is invalid pitch received and all other numbers are pitch period values.

	Voiced	Unvoiced
Pitch/Voicing	7	7
RMS	5	5
Sync	1	1
K(1)	5	5
K(2)	5	5
K(3)	5	5
K(4)	5	5
K(5)	4	
K(6)	4	
K(7)	4	
K(8)	4	
K(9)	3	
K(10)	2	
	54	33
Error Correction	0	20
Unused bit D/C		1

Table 3. Bit Allocation for LPC

BIT	VOICED	UNVOICED	BIT	VOICED	UNVOICED
1	K1-0	K1-0	28	K2-4	K2-4
2	K2-0	K2-0	29	K7-0	K3-5 *
3	K3-0	K3-0	30	K8-0	R-5 *
4	P-0	P-0	31	P-4	P-4
5	R-0	R-0	32	K4-4	K4-4
6	K1-1	K1-1	33	K5-0	K1-5 *
7	K2-1	K2-1	34	K6-0	K2-5 *
8	K3-1	K3-1	35	K7-1	K3-6 *
9	P-1	P-1	36	K10-0	K4-5 *
10	R-1	R-1	37	K8-1	R-6 *
11	K1-2	K1-2	38	K5-1	K1-6 *
12	K4-0	K4-0	39	K6-1	K2-6 *
13	K3-2	K3-2	40	K7-2	K3-7 *
14	R-2	R-2	41	K9-0	K4-6 *
15	P-2	P-2	42	P-5	P-5
16	K4-1	K4-1	43	K5-2	K1-7 *
17	K1-3	K1-3	44	K6-2	K2-7 *
18	K2-2	K2-2	45	K10-1	D/C
19	K3-3	K3-3	46	K8-2	R-7 *
20	K4-2	K4-2	47	P-6	P-6
21	R-3	R-3	48	K9-1	K4-7 *
22	K1-4	K1-4	49	K5-3	K1-8 *
23	K2-3	K2-3	50	K6-3	K2-8 *
24	K3-4	K3-4	51	K7-3	K3-8 *
25	K4-3	K4-3	52	K9-2	K4-8 *
26	R-4	R-4	53	K8-3	R-8 *
27	P-3	P-3	54	Sync	Sync

Note 1 - Bit 0 is LSB
Note 2 - Order of transmission is bit 1 to bit 54
Note 3 - P is pitch
- R is RMS
- K is reflection coefficients

Note 4 - Bit 0 is LSB of data
- Bit 5 is LSB of parity for RMS and reflection coefficient

Note 5 - D/C unused bit
Note 6 - * indicates Error Correction Bits

Table 4. Transmitted Bit Stream

0 - 0	16 - 8	32 - 32	48 - 135
1 - 0	17 - 8	33 - 35	49 - 147
2 - 1	18 - 9	34 - 39	50 - 164
3 - 1	19 - 10	35 - 42	51 - 176
4 - 2	20 - 11	36 - 46	52 - 192
5 - 2	21 - 12	37 - 51	53 - 210
6 - 3	22 - 13	38 - 55	54 - 230
7 - 3	23 - 15	39 - 60	55 - 251
8 - 4	24 - 16	40 - 66	56 - 275
9 - 4	25 - 17	41 - 72	57 - 300
10 - 5	26 - 19	42 - 79	58 - 328
11 - 5	27 - 21	43 - 86	59 - 359
12 - 6	28 - 23	44 - 94	60 - 392
13 - 6	29 - 25	45 - 103	61 - 428
14 - 7	30 - 27	46 - 113	62 - 468
15 - 7	31 - 30	47 - 123	63 - 512

Table 5. RMS Coding Table

INDEX	DECODE
-15	-.9844
-14	-.9688
-13	-.9531
-12	-.9375
-11	-.9218
-10	-.8906
-9	-.8438
-8	-.7812
-7	-.7187
-6	-.6406
-5	-.5625
-4	-.4688
-3	-.3593
-2	-.2500
-1	-.1406
0	+.0313
1	.1406
2	.2500
3	.3593
4	.4688
5	.5625
6	.6406
7	.7187
8	.7812
9	.8438
10	.8906
11	.9218
12	.9375
13	.9531
14	.9688
15	.9844

Table 6. Log Area Ratio Decoder

FROM	TO	CODE	INDEX
-.9999	-.9844	10001	-15
-.9843	-.9688	10010	-14
-.9687	-.9531	10011	-13
-.9530	-.9375	10100	-12
-.9374	-.9063	10101	-11
-.9062	-.8750	10110	-10
-.8749	-.8281	10111	-9
-.8280	-.7656	11000	-8
-.7655	-.6875	11001	-7
-.6874	-.6094	11010	-6
-.6093	-.5313	11011	-5
-.5312	-.4219	11100	-4
-.4218	-.3125	11101	-3
-.3124	-.2032	11110	-2
-.2031	-.0938	11111	-1
-.0937	+.0937	00000	0
.0938	.2031	00001	1
.2032	.3124	00010	2
.3125	.4218	00011	3
.4219	.5312	00100	4
.5313	.6093	00101	5
.6094	.6874	00110	6
.6875	.7655	00111	7
.7656	.8280	01000	8
.8281	.8749	01001	9
.8750	.9062	01010	10
.9063	.9374	01011	11
.9375	.9530	01100	12
.9531	.9687	01101	13
.9688	.9843	01110	14
.9844	.9999	01111	15

Note that the negative coded values are the index numbers expressed in binary "twos complement". Also, sign convention is such that RC1 = R_1/R_0, where R_1 and R_0 are autocorrelation functions with sample delays of 1 and 0 respectively. These conventions are used for all reflection coefficients.

Table 7. Log Area Ratio Encoder

FROM	TO	CODE	INDEX	DECODE
-.9999	-.5891	10000	-16	-.6033
-.5890	-.5456	10001	-15	-.5598
-.5455	-.5019	10010	-14	-.5164
-.5018	-.4583	10011	-13	-.4729
-.4582	-.4148	10100	-12	-.4295
-.4147	-.3712	10101	-11	-.3860
-.3711	-.3726	10110	-10	-.3426
-.3275	-.2840	10111	-9	-.2991
-.2839	-.2404	11000	-8	-.2557
-.2403	-.1967	11001	-7	-.2122
-.1966	-.1532	11010	-6	-.1687
-.1531	-.1096	11011	-5	-.1253
-.1095	-.0660	11100	-4	-.0818
-.0659	-.0224	11101	-3	-.0384
-.0223	.0212	11110	-2	.0051
.0213	.0648	11111	-1	.0485
.0649	.1139	00000	0	.0920
.1140	.1575	00001	1	.1355
.1576	.2011	00010	2	.1789
.2012	.2447	00011	3	.2224
.2448	.2883	00100	4	.2658
.2884	.3318	00101	5	.3093
.3319	.3755	00110	6	.3527
.3756	.4191	00111	7	.3962
.4192	.4626	01000	8	.4396
.4627	.5062	01001	9	.4831
.5063	.5499	01010	10	.5266
.5500	.5934	01011	11	.5700
.5935	.6370	01100	12	.6135
.6371	.6807	01101	13	.6569
.6807	.7242	01110	14	.7004
.7243	.9999	01111	15	.7438

Table 8. RC(3) Encoding and Decoding Table

FROM	TO	CODE	INDEX	DECODE
-.9999	-.7627	10000	-16	-.7774
-.7626	-.7236	10001	-15	-.7383
-.7236	-.6846	10010	-14	-.6993
-.6845	-.6455	10011	-13	-.6602
-.6454	-.6065	10100	-12	-.6211
-.6064	-.5674	10101	-11	-.5821
-.5673	-.5283	10110	-10	-.5430
-.5282	-.4893	10111	-9	-.5040
-.4892	-.4502	11000	-8	-.4649
-.4501	-.4112	11001	-7	-.4258
-.4111	-.3721	11010	-6	-.3868
-.3720	-.3330	11011	-5	-.3477
-.3329	-.2940	11100	-4	-.3086
-.2939	-.2549	11101	-3	-.2696
-.2548	-.2158	11110	-2	-.2305
-.2157	-.1768	11111	-1	-.1914
-.1767	-.1329	00000	0	-.1524
-.1328	-.0938	00001	1	-.1133
-.0937	-.0548	00010	2	-.0734
-.0547	-.0157	00011	3	-.0352
-.0156	.0234	00100	4	.0039
.0235	.0624	00101	5	.0429
.0625	.1015	00110	6	.0820
.1016	.1405	00111	7	.1211
.1406	.1796	01000	8	.1601
.1797	.2187	01001	9	.1992
.2187	.2577	01010	10	.2382
.2578	.2968	01011	11	.2773
.2969	.3359	01100	12	.3164
.3360	.3749	01101	13	.3554
.3750	.4140	01110	14	.3945
.4141	.9999	01111	15	.4336

Table 9. RC(4) Encoding and Decoding Table

FROM	TO	CODE	INDEX	DECODE
-.9999	-.6047	1000	-8	-.6358
-.6046	-.5324	1001	-7	-.5635
-.5323	-.4600	1010	-6	-.4912
-.4599	-.3877	1011	-5	-.4190
-.3876	-.3153	1100	-4	-.3467
-.3152	-.2430	1101	-3	-.2744
-.2429	-.1707	1110	-2	-.2022
-.1706	-.0984	1111	-1	-.1299
-.0983	-.0214	0000	0	-.0577
-.0213	.0509	0001	1	.0146
.0510	.1232	0010	2	.0869
.1233	.1955	0011	3	.1591
.1956	.2679	0100	4	.2314
.2680	.3403	0101	5	.3037
.3404	.4126	0110	6	.3759
.4127	.9999	0111	7	.4482

Table 10. RC(5) Encoding and Decoding Table

FROM	TO	CODE	INDEX	DECODE
-.9999	-.7011	1000	-8	-.7315
-.7010	-.6328	1001	-7	-.6631
-.6327	-.5645	1010	-6	-.5948
-.5644	-.4962	1011	-5	-.5264
-.4961	-.4279	1100	-4	-.4581
-.4278	-.3596	1101	-3	-.3897
-.3595	-.2913	1110	-2	-.3213
-.2912	-.2230	1111	-1	-.2530
-.2229	-.1505	0000	0	-.1846
-.1504	-.0822	0001	1	-.1162
-.0821	-.0139	0010	2	-.0479
-.0138	.0544	0011	3	.0205
.0545	.1227	0100	4	.0888
.1228	.1910	0101	5	.1572
.1911	.2593	0110	6	.2256
.2594	.9999	0111	7	.2939

Table 11. RC(6) Encoding and Decoding Table

FROM	TO	CODE	INDEX	DECODE
-.9999	-.5474	1000	-8	-.5762
-.5473	-.4809	1001	-7	-.5098
-.4808	-.4145	1010	-6	-.4434
-.4144	-.3480	1011	-5	-.3770
-.3479	-.2816	1100	-4	-.3106
-.2815	-.2152	1101	-3	-.2442
-.2151	-.1448	1110	-2	-.1778
-.1487	-.0824	1111	-1	-.1114
-.0823	-.0117	0000	0	-.0450
-.0116	-.0547	0001	1	.0214
.0548	.1211	0010	2	.0878
.1212	.1875	0011	3	.1542
.1876	.2540	0100	4	.2206
.2541	.3204	0101	5	.2870
.3205	.3869	0110	6	.3534
.3870	.9999	0111	7	.4198

Table 12. RC(7) Encoding and Decoding Table

FROM	TO	CODE	INDEX	DECODE
-.9999	-.6242	1000	-8	-.6539
-.6241	-.5568	1001	-7	-.5865
-.5567	-.4895	1010	-6	-.5191
-.4894	-.4221	1011	-5	-.4517
-.4220	-.3548	1100	-4	-.3843
-.3547	-.2874	1101	-3	-.3169
-.2873	-.2201	1110	-2	-.2496
-.2200	-.1527	1111	-1	-.1822
-.1526	-.0811	0000	0	-.1148
-.0810	-.0138	0001	1	-.0474
-.0137	.0536	0010	2	.0200
.0537	.1209	0011	3	.0874
.1210	.1883	0100	4	.1548
.1884	.2556	0101	5	.2222
.2557	.3230	0110	6	.2895
.3231	.9999	0111	7	.3569

Table 13. RC(8) Encoding and Decoding Table

FROM	TO	CODE	INDEX	DECODE
-.9999	-.3077	100	-4	-.3634
-.3076	-.1908	101	-3	-.2462
-.1907	-.0738	110	-2	-.1290
-.0737	.0432	111	-1	-.0118
.0433	.1638	000	0	.1054
.1639	.2807	001	1	.2226
.2808	.3977	010	2	.3398
.3978	.9999	011	3	.4570

Table 14. RC(9) Encoding and Decoding Table

FROM	TO	CODE	INDEX	DECODE
-.9999	-.3117	10	-2	-.4043
-.3116	-.1203	11	-1	-.2129
-.1202	.0743	00	0	-.0215
.0744	.9999	01	1	.1699

Table 15. RC(10) Encoding and Decoding Table

0 -	0	8 -	16
1 -	7	9 -	11
2 -	13	10 -	5
3 -	14	11 -	2
4 -	15	12 -	3
5 -	12	13 -	4
6 -	6	14 -	10
7 -	1	15 -	17

NOTE: The 4 data bits to be protected are used as index.
The 4 bit table output (octal) are the parity bits.

Table 16. Parity Bit Encoding

Pitch Period	Pitch Frequency	Code	Pitch Period	Pitch Frequency	Code	Pitch Period	Pitch Frequency	Code
20	400	19	40	200	53	80	100	77
21	381	11	42	190	49	84	95	73
22	364	27	44	184	51	88	91	75
23	348	25	46	174	50	92	87	74
24	333	29	48	167	54	96	83	78
25	320	21	50	160	52	100	80	70
26	308	23	52	154	60	104	77	71
27	296	22	54	148	56	108	74	67
28	286	30	56	143	58	112	71	99
29	276	14	58	138	26	116	69	97
30	266	15	60	133	90	120	67	113
31	258	7	62	129	88	124	65	112
32	250	39	64	125	92	128	63	114
33	242	38	66	121	84	132	61	98
34	235	46	68	118	86	136	59	106
35	228	42	70	114	82	140	57	104
36	222	43	72	111	83	144	56	108
37	216	41	74	108	81	148	54	100
38	210	45	76	105	85	152	53	101
39	205	37	78	103	69	156	51	76

Table 17. Relationship between Pitch Period and Pitch Frequency

0 - 0	32 - 0	64 - 0	96 - 3
1 - 0	33 - 3	65 - 3	97 - 116
2 - 0	34 - 3	66 - 3	98 - 132
3 - 3	35 - 3	67 - 108	99 - 112
4 - 0	36 - 3	68 - 3	100 - 148
5 - 3	37 - 39	69 - 78	101 - 152
6 - 3	38 - 33	70 - 100	102 - 3
7 - 31	39 - 32	71 - 104	103 - 3
8 - 0	40 - 3	72 - 3	104 - 140
9 - 3	41 - 37	73 - 84	105 - 3
10 - 3	42 - 35	74 - 92	106 - 136
11 - 21	43 - 36	75 - 88	107 - 3
12 - 3	44 - 3	76 - 156	108 - 144
13 - 3	45 - 38	77 - 80	109 - 3
14 - 29	46 - 34	78 - 96	110 - 3
15 - 30	47 - 3	79 - 3	111 - 1
16 - 0	48 - 3	80 - 3	112 - 124
17 - 3	49 - 42	81 - 74	113 - 120
18 - 3	50 - 46	82 - 70	114 - 128
19 - 20	51 - 44	83 - 72	115 - 3
20 - 3	52 - 50	84 - 66	116 - 3
21 - 25	53 - 40	85 - 76	117 - 3
22 - 27	54 - 48	86 - 68	118 - 3
23 - 26	55 - 3	87 - 3	119 - 1
24 - 3	56 - 54	88 - 62	120 - 3
25 - 23	57 - 3	89 - 3	121 - 3
26 - 58	58 - 56	90 - 60	122 - 3
27 - 22	59 - 3	91 - 3	123 - 1
28 - 3	60 - 52	92 - 64	124 - 3
29 - 24	61 - 3	93 - 3	125 - 1
30 - 28	62 - 3	94 - 3	126 - 1
31 - 3	63 - 1	95 - 1	127 - 1

Table 18. Pitch Decoder

PERFORMANCE CHARACTERISTICS
(for information only)

1. The performance of LPC-10 speech processors has been measured in terms of intelligibility test and free conversation test.

2. The voice intelligibility of the voice processor has been measured using the Diagnostic Ryme Test (DRT-IV). For the DRT, English, American and French versions are available. The talkers and listeners are to be familiar with the language in each case. The input analogue tapes used were for the American DRT and the minimum acceptable scores used in that test, are given below:

Acoustic Environment	Talkers	Tapes	Bit Error Rate	Microphone	Minimum Acceptable Score
Quiet	6M	E-1-A	0	Dynamic	86
Office	3M	G-4-A	0	Dynamic	84
Shipboard (Saipan)	3M	K6-1.2-A	0	H250	85
Aircraft (P-3C)	3M	K7-1.2-A	0	EV985	82
Jeep	3M	K8-1.2-A	0	H250	82
Tank	3M	K9-1.2-A	0	EV985	82
Quiet	3M	E-1-A	2.0%	Dynamic	82
E3A	3M	K1-11A	0	215-330	82
F15	3M	K-10-1	0	M101	75
F16	3M	1C-11-1	0	M101	75

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3. The Free Conversation Test should be carried out using at least 6 pairs of subjects who should have no undue difficulty in conversing over a normal telephone circuit. A mean opinion score of at least 2.5 should be obtained when the speech is transmitted between typical office environments and with zero bit error rate.