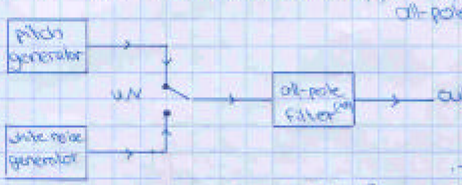
עיבוד קול דיבור

8.1 LPC Speech Synthesis

[illegible] של המערכת יצור דיבור [illegible]: בדיבור <u>voiced</u> ה-vocal chords [illegible] [illegible] ב-pitch. [illegible] ה-vocal tract, [illegible] resonates בתדרים [illegible] [illegible], ולכן [illegible] ה-pitch [illegible].
בדיבור <u>unvoiced</u> ה-vocal chords לא vibrate אך ה-vocal tract [illegible]:
[illegible] ה-vocal tract [illegible]
vocal tract) [illegible] ע"י פילטר all-pole



switch v/u בוחר בין 2 מקורות
[illegible]
[illegible] pitch generator [illegible]
[illegible] white noise generator [illegible]
[illegible] AR.
[illegible]
[illegible] T [illegible]
[illegible] ה-AR [illegible] T [illegible].
[illegible] voiced או unvoiced [illegible] voiced [illegible]
[illegible] ה-pitch [illegible]
[illegible] ה-AR [illegible]
[illegible]
[illegible] T [illegible] 32 [illegible] ה-pitch,
[illegible] 8 [illegible] 3. [illegible] ה-LPC [illegible]
[illegible] embellishment [illegible]
[illegible] ה-pitch [illegible] gain [illegible]
[illegible].
[illegible] ה-pitch [illegible]
[illegible] AR [illegible] yule-walker [illegible]
[illegible] 4 [illegible] 8 [illegible]
[illegible].

LPC - Linear Predictive coding

- $\sum a_i x_{n-i} = \hat{x}_n$
- $e_n = x_n - \hat{x}_n$

[illegible]
[illegible]
CELP - Code Excited Linear Prediction: [illegible]
[illegible].

8.2 PCM

[illegible]:
[illegible]
[illegible] A/D [illegible]
[illegible] linear PCM [illegible] Nyquist-1, [illegible]
[illegible] 4KHz [illegible]
[illegible] 14 [illegible] 8 [illegible]
[illegible] 8-bit [illegible] 16 [illegible]
[illegible] 4KHz [illegible]
[illegible] 40×16 [illegible]
[illegible].
[illegible] 2 [illegible].
[illegible] MOS [illegible] 1-5 [illegible] 4 - Toll quality [illegible]
[illegible] 3KHz
[illegible] 4KHz [illegible] 4KHz [illegible] Nyquist
[illegible] 3000 [illegible] 8000 × 16 = 128Kbit/s [illegible] 8 [illegible]
[illegible] 256 [illegible]
[illegible] 14 [illegible]

[illegible] $\sum(x(n)-\hat{x}(n))^2$ [illegible]

[illegible] $8 \cdot 8000$ [illegible] 256 [illegible]

[illegible] ITU-ב [illegible] G.711 [illegible] A-law ו-μ-law [illegible] PCM [illegible] μ-law [illegible] A-law [illegible]

[illegible] PCM [illegible]

μ-law [illegible]

$$\hat{s} = \operatorname{sgn}(s)\, s_{max}\frac{1+\mu\frac{|s|}{s_{max}}}{1+\frac{|s|}{s_{max}}}$$

[illegible] s_{max} [illegible] μ [illegible]

[illegible] μ [illegible] μ-ב [illegible]

[illegible] $\frac{\Delta I}{I}$ [illegible]

19.8 DPCM, DM and ADPCM

[illegible] auto-correlation [illegible] 8kHz [illegible] low-pass [illegible] voiced [illegible] pitch [illegible]

[illegible] DPCM [illegible] (Δ-modulation) [illegible]

[illegible] DPCM [illegible] Delta Modulation (DM) [illegible] DM [illegible] Sigma-delta converter [illegible] DM [illegible] oscillate [illegible] decelerate [illegible] 0 [illegible] 1 [illegible] slope-overload [illegible]

[illegible] low-pass [illegible] DPCM [illegible] E_n [illegible] feedback [illegible]

[illegible] A [illegible] open-loop [illegible] $32kHz = 4 \times 8000$ [illegible]

[illegible] open-loop [illegible]

[illegible] closed-loop [illegible] loop [illegible]

ADPCM: [illegible] quality [illegible] 32kb/s [illegible]

[illegible] DM [illegible] Δ [illegible]

[illegible] slope overload [illegible]

[illegible] Δ [illegible] 'granular noise' [illegible]

[illegible] DM [illegible] DPCM [illegible]

[illegible] DM [illegible] Δ [illegible]

[illegible] DPCM [illegible] Δ [illegible] digitize [illegible]

[illegible] Δ [illegible]

[illegible] 64 [illegible]

[illegible] 2 [illegible]

[illegible] 4 [illegible]

19.11 [illegible] APC [illegible]

19.12 CELP Coders [illegible]

18.2 Analog Modulation types

[illegible] carrier [illegible] carrier [illegible] modulated signal [illegible] modulator [illegible] demodulator [illegible]

- $x(t) = A\cos(2\pi f_c t + \phi)$ [illegible] carrier [illegible]

[illegible] carrier [illegible] Baudot [illegible]

on-off keying (OOK): $S_{OOK}(t) = A(t)\cos(2\pi f_c t)$

[illegible] $A(t)$ [illegible] f_c [illegible] carrier [illegible]

[illegible] acoustic modulating $x(t)$ [illegible] $x(t)$ [illegible]

- $S_{AM}(t) = A_0(1 + m_{AM}x(t))\cos(2\pi f_c t)$ [illegible] carrier [illegible]

[illegible] $|x(t)| \le 1$ [illegible] Amplitude Modulation (AM) [illegible] $0 \le m_{AM} \le 1$

[illegible] f [illegible] ϕ

Frequency Shift Keying (FSK): [illegible] Baudot [illegible] encoded text

- $S_{FSK}(t) = A\cos(2\pi f(t)t + \phi)$ [illegible] 2 [illegible]

[illegible] 2 [illegible] 2 [illegible]

Phase Shift Keying (PSK):

- $S_{PM}(t) = A\cos(2\pi f_c t + \phi(t))$

[illegible] 2 [illegible] 180° [illegible] FM [illegible] PM

[illegible] [illegible]

13.3 AM

13.4 FM and PM

13.5 Data Communications

Information Theory 186

[illegible]

Non Return to Zero (NRZ): [illegible] T [illegible]

[illegible]

Return to Zero (RZ): [illegible] NRZ [illegible] $0 = -\frac{A}{2}$, $1 = \frac{A}{2}$ [illegible]

[illegible] RZ [illegible] T [illegible] NRZ [illegible]

[illegible]

[illegible] T [illegible] $\frac{1}{T}$ [illegible]

[illegible]

• $H(x) = -\log_2 p(x) = -\sum p(x)\log p(x)$

[illegible]

AMI: [illegible] NRZ [illegible] +1 [illegible] -1 [illegible] 3 [illegible] $\frac{1}{2}$ [illegible] $\frac{1}{2}$ [illegible]

Communications Theory 187

(1) [illegible]

(2) [illegible]

(3) [illegible]

• [illegible]

[illegible]

[illegible]

[illegible] bit correction [illegible]

(1) [illegible]

• [illegible] bandwidth [illegible]

• [illegible]

(36)

(2) [illegible] קידוד המקור: [illegible]

(3) [illegible] קידוד הערוץ: [illegible] -
[illegible]

מקרה 1: [illegible]

מקרה 2: [illegible] channel encoder

מקרה 3: [illegible] N [illegible] $(-\frac{N}{2} , +\frac{N}{2})$

[illegible]

נקבל:

- $\frac{S+N}{N} = \frac{S}{N} + 1 \Rightarrow \log_2(\frac{S}{N}+1) = \log_2(SNR+1)$ (SNR)

ניתן להעביר $BW \log_2(\frac{S}{N}+1)$

- $C = BW \cdot \log_2(SNR+1)$

[illegible]

[illegible] channel encoder

[illegible]

[illegible] framework [illegible]

[illegible] source coding - channel coding

source encoding: [illegible]

[illegible]

channel encoding: [illegible]

[illegible] source decoding, "channel decoding" [illegible]

[illegible]

- channel coding [illegible] error correction coding - line coding

error correction code: [illegible] corruption [illegible] abstraction

line coding: [illegible] channel code - error correction code [illegible] line code [illegible] (19.18)

[illegible] capacity theorem [illegible]

188 Channel Capacity

[illegible]

channel capacity: [illegible]

[illegible] 0.0101 [illegible]

[illegible]

[illegible] signal-plus-noise-to-noise ratio

$SNNR = SNR+1$

[illegible] peak-to-peak [illegible]

[illegible] time varying signal [illegible]

[illegible] jump discontinuities [illegible]

[illegible] piecewise [illegible]

[illegible]

The channel capacity Theorem

[illegible]

(1) [illegible]

$C = BW\log_2(SNR+1)$

(2) [illegible]

(3) [illegible]

$C = BW\log_2(SNR+1) \approx BW\log_2 SNR = BW\frac{SNR_{dB}}{10\log_2 10} \approx BW\frac{SNR_{dB}}{3}$

[illegible]

PAM and FSK 18.12

[illegible]

Alternate Mark Inversion (AMI)

[illegible]

[illegible]

[illegible] digital modem signal [illegible]

[illegible] baseband [illegible] (BW of DC) [illegible]

[illegible] passband [illegible] NRZ [illegible]

[illegible]

[illegible] bandpass [illegible]

On off keying (OOK)

OOK [illegible]

Frequency shift keying (FSK)

[illegible] OOK [illegible]

[illegible] FSK [illegible]

[illegible] band-pass (matched) [illegible]

[illegible]

Phase shift keying (PSK)

[illegible]

[illegible] PSK [illegible] OOK [illegible]

[illegible]

[illegible] NRZ [illegible] multilevel PAM [illegible]

[illegible] baud [illegible]

[illegible] misdetection [illegible]

[illegible] noise intensity [illegible]

[illegible] multilevel PAM [illegible] multifrequency FSK [illegible]

Modem Spectra 10.14

[illegible] NRZ [illegible]

[illegible] baud [illegible]

[illegible] Wiener-Kinchine [illegible]

[illegible] NRZ [illegible] baud [illegible]

[illegible] sinc squared [illegible]

[illegible] PAM [illegible] baud [illegible]

[illegible] baud [illegible] (PSK to OOK) [illegible]

[illegible]