Technology to the Core

Proposal for Definition of Preemphasis

Dimitry Taich, Dr. Ze'ev Roth
Mysticom

Overview

- Nomenclature
- Three alternative definitions
- Equivalence
- Summary

A Word on Nomenclature

- Pre-emphasis is a well know terminology for a high-pass filter function performed before some other operation
  - In speech coding, prior to performing LPC analysis one high passes the signal - this filter is called pre-emphasis
- From "Principle of Communication Systems"
  - "The premodulation filtering in the transmitter, to raise the power spectral density of the baseband signal in its upper-frequency range. is called *preemphasis* (or predistortion). The filtering at the receiver to undo the signal preemphasis and to suppress noise is called *deemphasis*."
    - by H. Taub and D.L. Schilling (Second edition, McGraw-Hill International Edition 1986 p382) - quote relates to preemphasis and deemphasis in FM systems.

Proposal 1 for Pre-Emphasis Definition

- Pre-emphasis filter
  - pre-emphasis specified by β

$$y_n = (1-\beta)x_n - \beta x_{n-1}$$

- Maximal and minimal filter outputs

$$x_n = V_{peak}\ ,\ x_{n-1} = V_{peak} \quad \Rightarrow V_{Low} \equiv (1-2\beta)V_{peak}$$
$$x_n = V_{peak}\ ,\ x_{n-1} = -V_{peak} \quad \Rightarrow V_{High} \equiv V_{peak}$$

- Frequency response

$$H_M(z) = (1-\beta) - \beta z^{-1}$$
$$|H_M(\theta)|^2 = (1-\beta)^2 + \beta^2 - 2\beta(1-\beta)\cos\theta$$
$$|H_M(0)|^2 = (1-2\beta)^2 \qquad |H_M(\pi)|^2 = 1$$

Proposal 2 for Pre-Emphasis Definition

- Pre-emphasis filter
  - pre-emphasis specified by α

$$y_n = \frac{1}{1+\alpha} x_n - \frac{\alpha}{1+\alpha} x_{n-1}$$

- Maximal and minimal filter outputs

$$x_n = V_{peak}\,,\, x_{n-1} = V_{peak} \quad \Rightarrow V_{Low} \equiv \frac{(1-\alpha)}{(1+\alpha)} V_{peak}$$

$$x_n = V_{peak}\,,\, x_{n-1} = -V_{peak} \quad \Rightarrow V_{High} \equiv V_{peak}$$

- Frequency response

$$H_B(z) = \frac{1}{1+\alpha} - \frac{\alpha}{1+\alpha} z^{-1}$$

$$|H_B(\theta)|^2 = \frac{1 - 2\alpha\cos\theta + \alpha^2}{(1+\alpha)^2}$$

$$|H_B(0)|^2 = \frac{(1-\alpha)^2}{(1+\alpha)^2} \qquad |H_B(\pi)|^2 = 1$$

Proposal 3 for Pre-Emphasis Definition

- Pre-emphasis filter form: $$y_n = ax_n - bx_{n-1}$$
- Pre-emphasis $$Pre\_Emphasis = \left(1 - \frac{V_{Low}}{V_{High}}\right)$$
  - Where the high and low relate to the maximal and minimal filter outputs

One to One Correspondence of Pre-emphasis value and filter

- Pre-emphasis filter $y_n = a x_n - b x_{n-1}$
- Minimal and maximal output $V_{Low} = (a-b) V_{peak}$ $V_{High} = (a+b) V_{peak}$
- Pre-emphasis definition $$Pre\_Emphasis = \left(1 - \frac{V_{Low}}{V_{High}}\right) = \left(1 - \frac{(a-b)}{(a+b)}\right) = \frac{2}{1+\frac{a}{b}}$$
- Filter's frequency response

  at π $$H(\theta) = a - b\exp(-j\theta) \Rightarrow H(\pi) = a + b$$
- Require unity gain at π $$a + b = 1$$
- Filter coefficients $$b = \frac{1}{2} Pre\_Emphasis \qquad a = 1 - \frac{1}{2} Pre\_Emphasis$$

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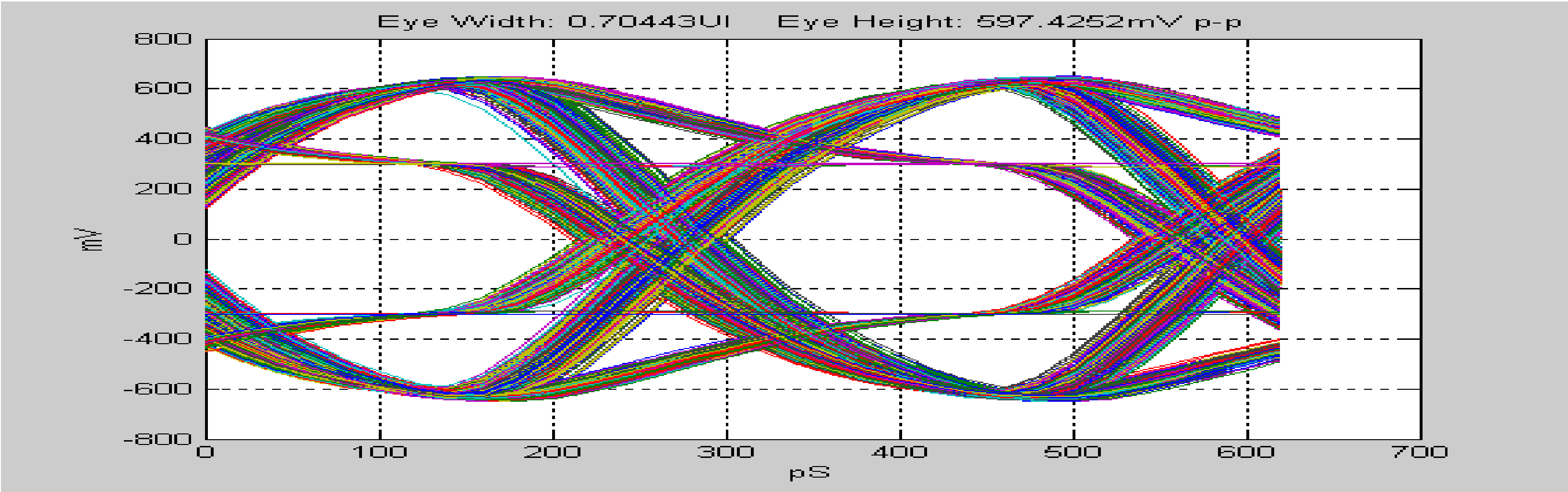
Correspondence of pre-emphasis definitions

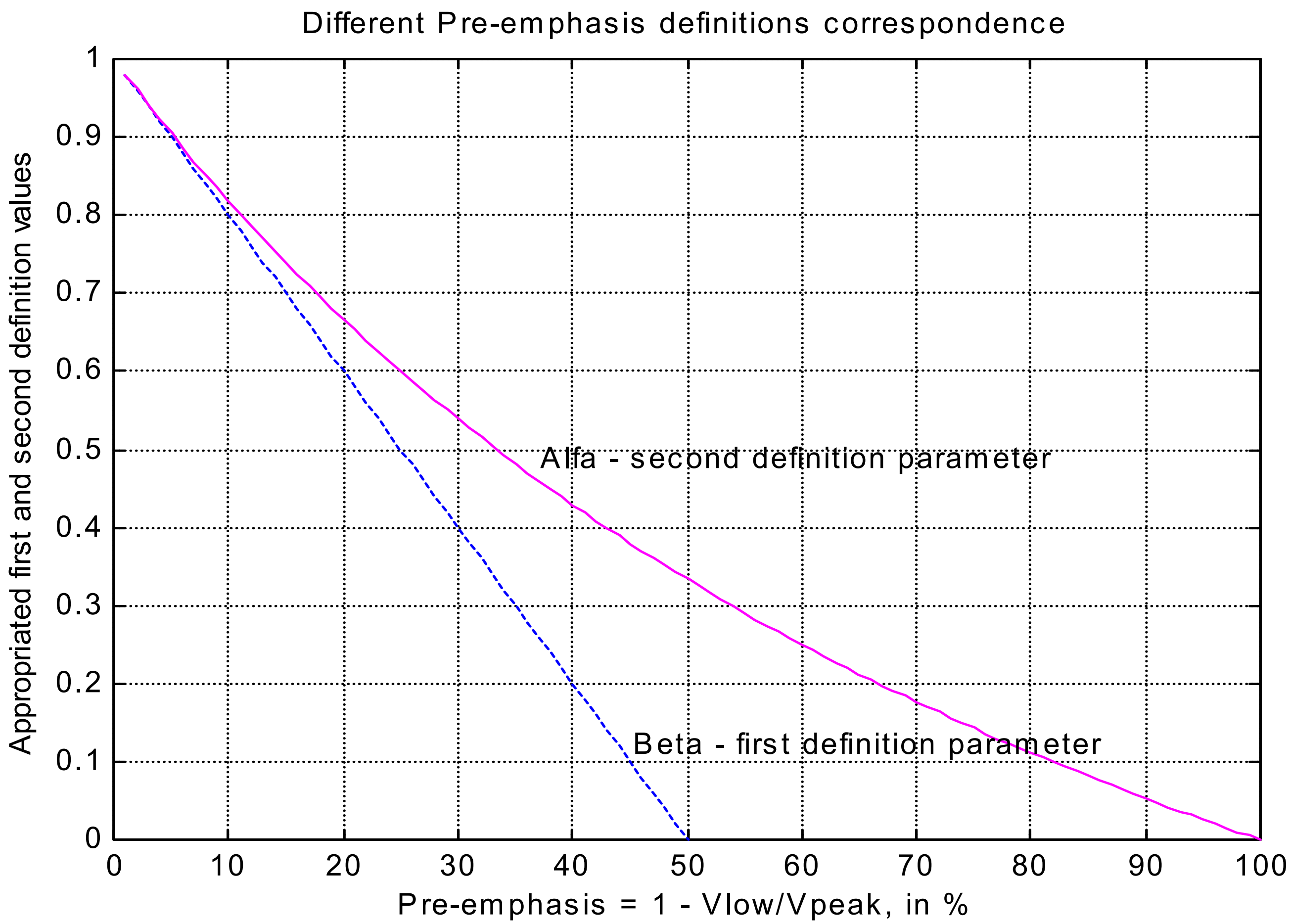
- Different definitions correspondence:

  Pre-emphasis = $1 - V_{low}/V_{peak} = 1 - 2\beta = (1-\alpha)/(1+\alpha)$



- Example: Pre-emphasis =50% according to 3rd definition, then $\beta = 0.25$, $\alpha = 0.33$

Correspondence of pre-emphasis definitions (cont)



Summary

- All three definitions are essentially equivalent
  - Simple mapping between the different definitions
- Definition #2 was used in CFI
- Recommend we adopt a single definition in standard development