Equalization

Young W. Lim

November 29, 2013

The Band-limited Baseband Transmission

Efficient Transmission Techniques

- Discrete PAM (Pulse Amplitude modulation)
  - to use a discrete set of possible amplitude level
- Linear Modulation
  - to conserve the bandwidth

The Band-limited Baseband Reception

1. demodulated
2. synchronously sampled
3. decision

- when high SNR
  - the number of detectable amplitude level (a discrete set)
  - depend on isi rather than channel noise
- for a known channel characteristics
  - always possible to minimize isi
  - by using a proper pair of transmit and receive filters
  - to control the pulse shape

Why Equalization

In practice,

- no prior knowledge of the exact channel characteristics
- the imperfection of the implemented pulse shaping filters
- there will be always be some residual distortion
  - the isi is the limiting factor on the max possible data rate
- To cope with the intrinsic residual distortion
  - euqalization is used

The Traversal Filter

Two Linear Functions

1. pulse shaping
2. equalization of residual distortion

The Trasversal Fitler

- the combined and adjustable filter structure
- Delay Line - T second apart (symbol duration)
- Adjustable Weights - connected to the delay taps
- Summer - adding successively delayed and weighted input signal

Zero-Forcing Equalization

Two Subsystems

1. the impulse response $c(t)$:
   combined transmit filter and communication channel
2. the impulse response $h_{eq}(t)$:
   pulse shaping and residual distortion equalization

The Trasversal Fitler

- the structural symmetry - $(2N+1)$ points
- $w_{-N}, \cdots, w_{-1,} w_0, w_1, \cdots, w_N$: filter coefficients

Discrete Convolution Sum

- $h_{eq}(t) = \sum_{k=-N}^{+N} w_k \delta(t - kT)$
- $p(t) = c(t) \star h_{eq}(t) = c(t) \star \sum_{k=-N}^{+N} w_k \delta(t - kT)$
- $p(t) = \sum_{k=-N}^{+N} w_k c(t) \star \delta(t - kT) = \sum_{k=-N}^{+N} w_k c(t - kT)$
- $p(t = iT_b) = \sum_{k=-N}^{+N} w_k c((i - k)T)$
- $p_i = \sum_{k=-N}^{+N} w_k c_{i-k}$

Simultaneous Equations

- $h_{eq}(t) = \sum_{k=-N}^{+N} w_k \delta(t - kT)$

Reference

[1] S. Haykin, M Moher, “Introduction to Analog and Digital Communications”, 2ed