Section-D
Lecturer-1

- Topic Covered:
- EQUALIZERS AND FILTERS
- Classification of Equalizers; Inverse Impedance and inverse Network; full series Equalizer, full shunt Equalizer and Bridge – T Equalizer; Lattice Equalizer; Characteristics of Equalizers; Equalizer for Transmission for Digital Data; Active Filters, First order and second order Butterworth filter; universal active filters.

ATTENUATORS:

- Symmetrical Attenuators, Symmetrical T-Attenuator, -Attenuator, Bridged T-Attenuator, Lattice Attenuators; A Symmetrical T-Attenuator, L-Attenuator, -Attenuator; Minimum loss
- Attenuator, Attenuator for variable load; Balanced and unbalanced Attenuators; Ladder Attenuators.

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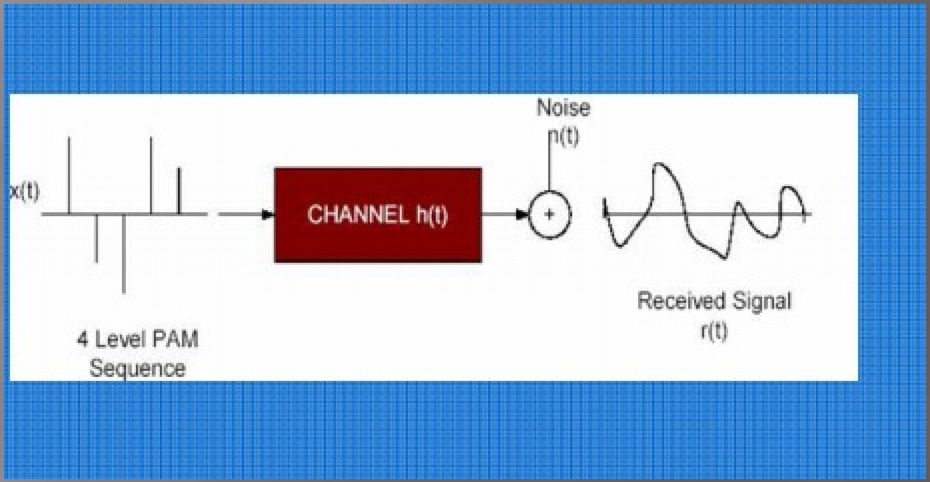
- The goal of equalizers is to eliminate inter symbol interference (ISI) and the additive noise as much as possible.

- • Inter symbol interference(ISI) arises because of the spreading of a transmitted pulse due to the dispersive nature of the channel.

- • In below Fig there is a four-level pulse
- amplitude modulated signal
- (PAM), x(t). This signal is
- transmitted through the channel
- with impulse response h(t). Then
- noise n(t) is added. The received
- signal r(t) is a distorted signal.


Noise
n(t)
x(t)
CHANNEL h(t)
+
4 Level PAM
Sequence
Received Signal
r(t)

Lecture-2

- Classification of Equalization
- • Equalization using
- – MLSE (Maximum likelihood sequence
- estimation)
- – Filtering

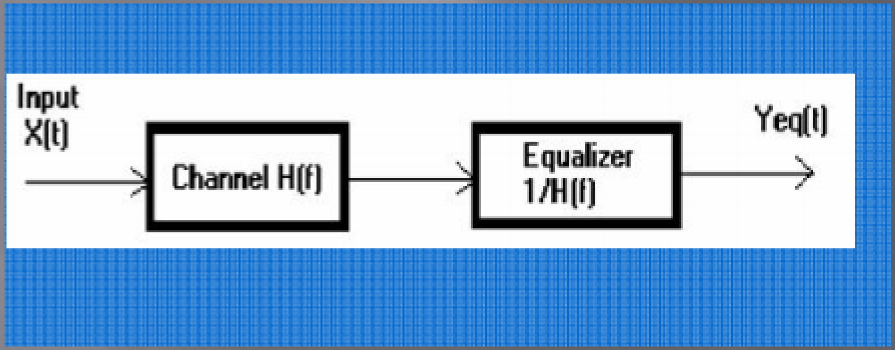
- • Transversal filtering
- – Zero-forcing equalizer
- – Minimum mean square error (MSE) equalizer
- • Decision feedback
- – Using the past decisions to remove the ISI contributed by them
- • Adaptive equalizer

Categories of Equalization

- • Equalizers are used to overcome then negative effects of the channel. In general, equalization is partitioned into two broad categories;
- Maximum likelihood sequence estimation (MLSE) which entails making measurement of channel impulse response and then providing a means for adjusting the receiver to the transmission environment.

- (Example: Viterbi equalization)
- 2. Equalization with filters, uses filters to compansate the distorted pulses. The general channel and equalizer pair is shown in below Figure.

Filter



- Depending on the time nature
- • These type of equalizers can be grouped as preset or adaptive equalizers.
- • Preset equalizers assume that the channel is time invariant and try to find H(f) and design equalizer depending on H(f).

- The examples of these ADAPTIVE EQUALIZERS are zero
- forcing equalizer, minimum mean square error equalizer,and desicion feedback equalizer.

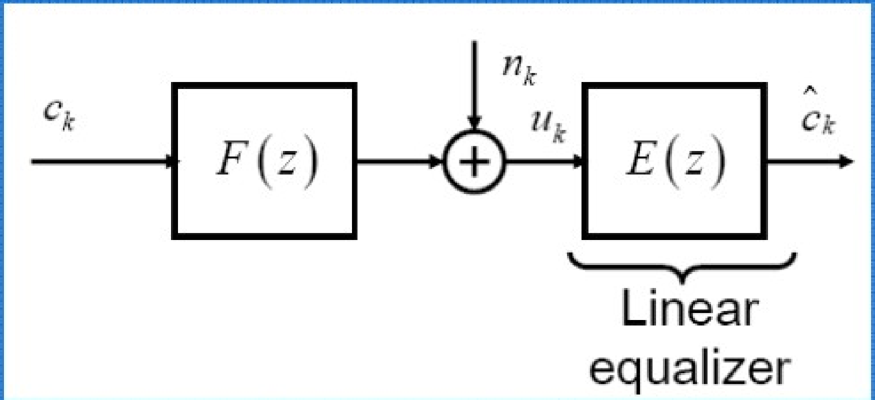
Lecture-3

- • Adaptive equalizers assume channel is time varying channel and try to design equalizer filter whose filter coefficients are varying in time according to the change of channel, and try to eliminate ISI and additive noise at each time.
- The implicit assumption of adaptive equalizers is that the channel is varying slowly

Linear equalizer:

- Zero-forcing
  - Design E(z) so that ISI is totally removed.
- Minimum mean square error (MMSE)
  - Design E(z) to minimize the mean square error (MSE)

$$MSE = \sum_k \varepsilon_k^2 = \sum_k \left(c_k - \hat{c}_k\right)^2$$

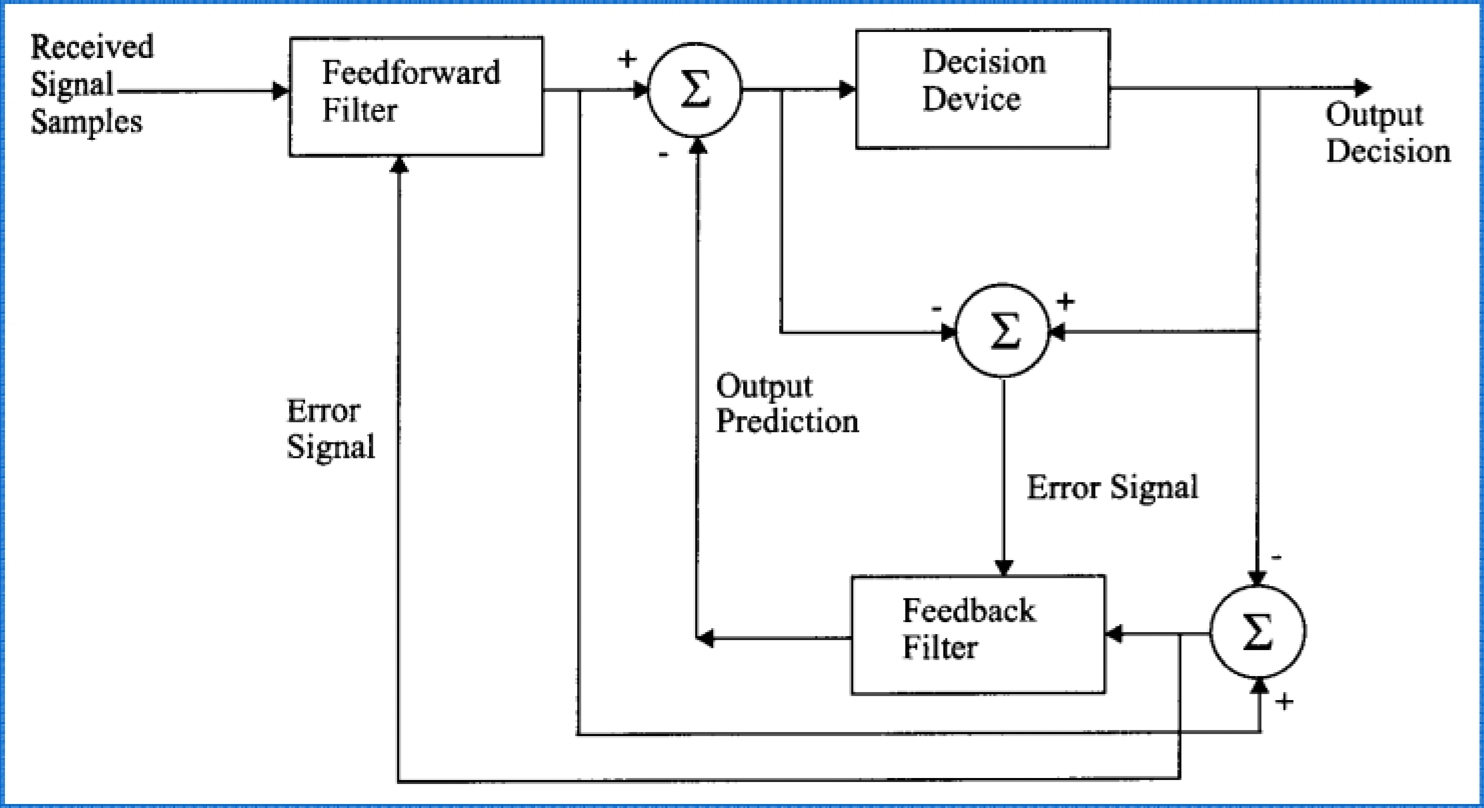


- Characteristics of Lattice Filter
- • Advantages
- ¾Numerical stability
- ¾Faster convergence
- ¾Unique structure allows the dynamic assignment of the most effective length
- • Disadvantages
- ¾The structure is more complicated

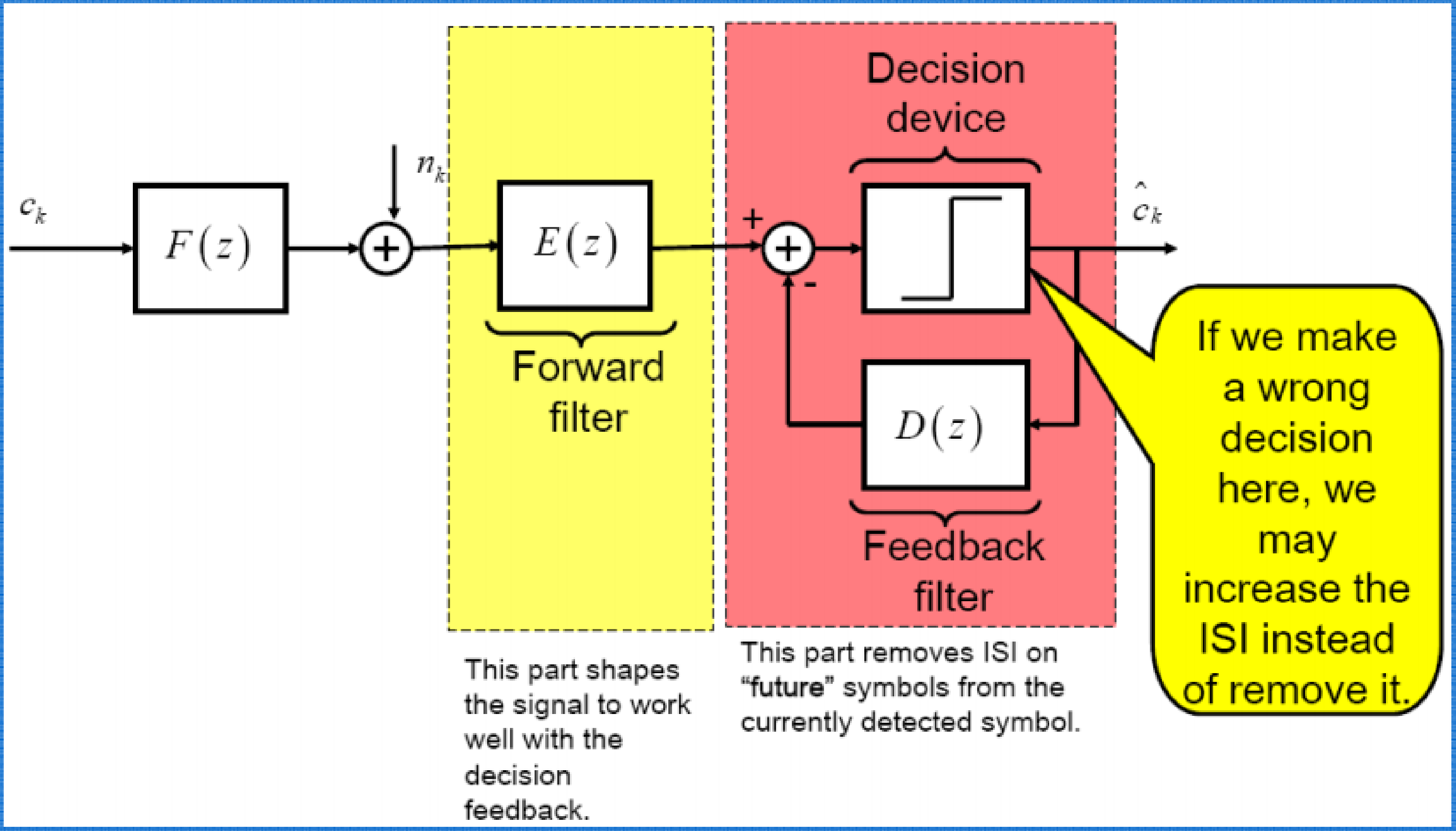
- Nonlinear Equalization--DFE
- •Predictive DFE (proposed by Belfiore and Park,
- •Consists of an FFF and an FBF, the latter is called a noise predictor
- •Predictive DFE performs as well as conventional DFE as the limit
- in the number of taps in FFF and the FBF approach infinity

- •The FBF in predictive DFE can also be realized as a lattice structure.
- The RLS algorithm can be used to yield fast convergence

Non linear equalizer:



- Decision feedback equalizer (DFE)



lecture-4
attenuator basics:

- Attenuator Basics An Attenuator is a special type of electrical or electronic bidirectional circuit made up of entirely resistive elements.
- An attenuator is a two port resistive network designed to weaken or "attenuate" (hence their name) the power being supplied by a source to a level that is suitable for the connected load

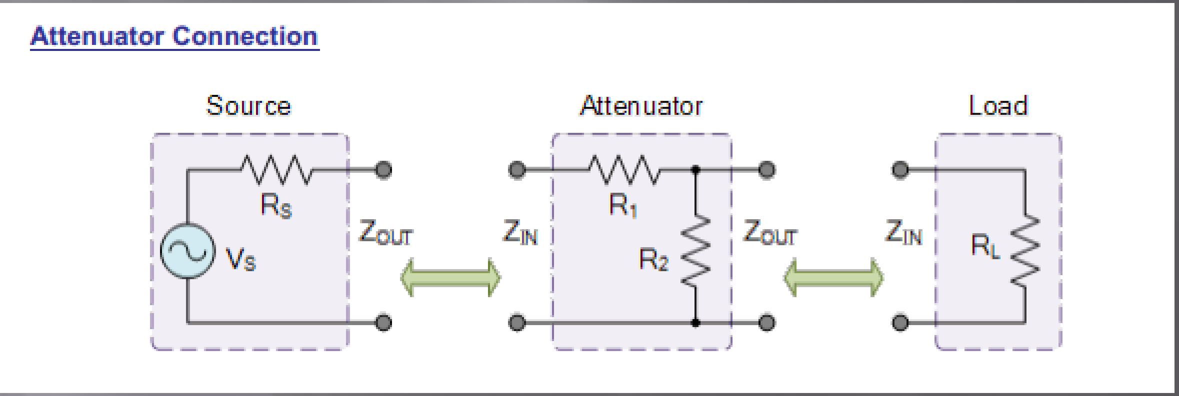
- The attenuator reduces the amount of power being delivered to the connected load by either a single fixed amount, a

variable amount or in a series of known switchable steps.

- Attenuators are generally used in radio, communication and transmission line applications to weaken a stronger signal.
- The attenuator is a purely passive resistive network (hence no supply) which is used in a wide variety of
- electronic equipment for extending the dynamic range of measuring equipment by adjusting signal levels,

- Toprovide impedance matching of oscillators or amplifiers to reduce the effects of improper input/output

terminations, or to simply provide isolation between different circuit stages depending upon their application


Attenuator Connection
Source
Attenuator
Load
R_S
V_S
Z_{OUT}
Z_{IN}
R_1
R_2
Z_{OUT}
Z_{IN}
R_L

- Simple attenuator networks (also known as "pads") can be designed to produce a fixed degree of "attenuation" or to give a variable amount of attenuation in pre-determined steps..

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- Standard fixed attenuator
- networks generally known as an "attenuator pad" are available in specific values from 0 dB to more than 100
- dB. Variable and switched attenuators are basically adjustable resistor networks that show a calibrated
- increase in attenuation for each switched step, for example steps of -2dB or -6dB per switch position

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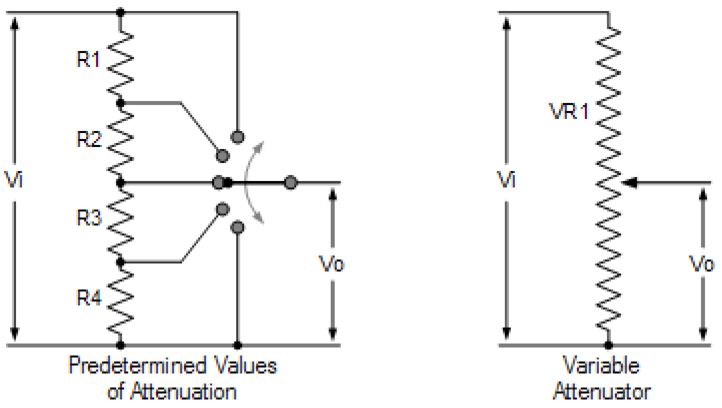
- Then an Attenuator is a four terminal (two port) passive resistive network (active types are also available which use transistors and integrated circuits) designed to produce "distortionless“ attenuation of the output electrical signal at all frequencies by an equal amount with no phase shift unlike a passive type RC filter network,

- and therefore to achieve this attenuators should be made up of pure non-inductive and not
- wirewound resistances, since reactive elements will give frequency discrimination.

Simple Passive Attenuator



- Attenuators are the reverse of amplifiers in that they reduce gain with the resistive voltage divider circuit being a typical attenuator. The amount of attenuation in a given network is determined by the ratio of:Output/Input.
- For example, if the input voltage to a circuit is 1 volt (1V) and the output voltage is 1 milli-volt(1mV) then the amount of attenuation is 1mV/1V which is equal to 0.001 or a reduction of 1,000th.

Degrees of Attenuation:

- An attenuators performance is expressed by the number of decibels the input signal has decreased per
- frequency decade (or octave). The decibel, abbreviated to "dB", is generally defined as the logarithm or "log"
- measure of the voltage, current or power ratio and represents one tenth 1/10th of a Bel.

In other words it takes 10 decibels to make one bel. Then by definition, the ratio between an input signal (Vin) and an output signal (Vout) is given in decibels as:

Decibel Attenuation

$$dB_v = 20\log_{10}\frac{Vout}{Vin} \quad (dB)$$

Passive Attenuator Designs:

- There are many ways in which resistors can be arranged in attenuator circuits with the Potential Divider Circuit being the simplest type of passive attenuator circuit.
- The potential or voltage divider circuit is

generally known as an "L-pad" attenuator because its circuit diagram resembles that of an inverted "L".

Contiii..

But there are other common types of attenuator network as well such as the "T-pad" attenuator and the "Pi-pad"

- (π) attenuator depending upon how you connect together the resistive components. These three common
- attenuator types are shown below.

Types of attenuator