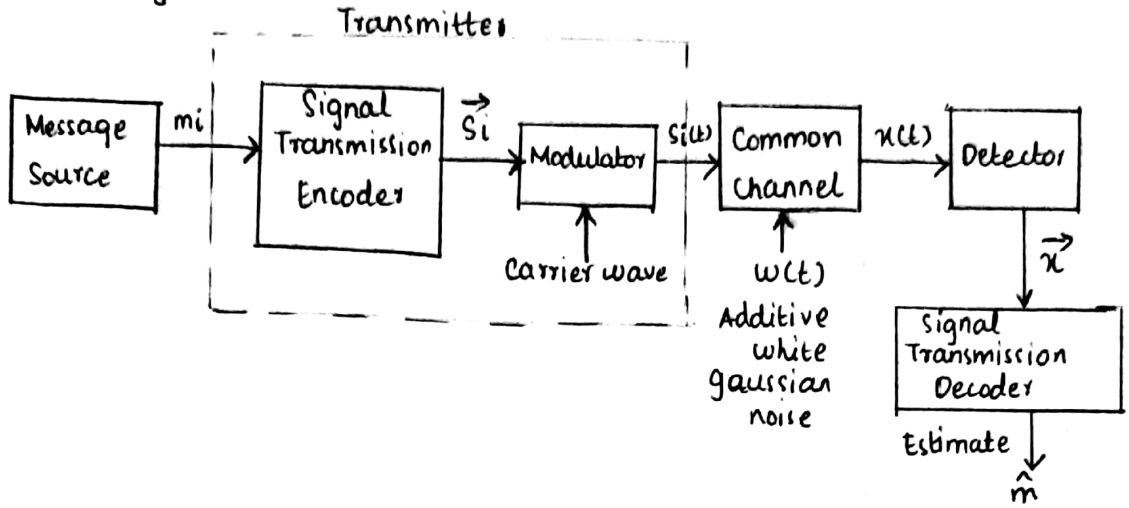
Detection and Estimation in Digital Communication System

Block Diagram of Digital Communication System:



Message source provide discrete message in the form of symbol denoted by mi. This discrete message is passed through transmitter where encoding & modulation takes place. The signal transmitter encoder convert discrete message mi to sequence of set of real no. in the form of vector $\vec{s_i}$. After encoding, this vector sequence get converted into signal s(t) comfortable for transmission purpose & having some finite energy. During transmission additive white gaussian noise w(t) is introduced with the information. The received signal is given as x(t), x(t) is converted into observation vector ($\vec{x}$) which further decoded, gets estimated symbol ($\hat{m}$).

Initially message source which contains 'M' number of symbols emits one symbol at a time i.e one symbol / Tsec $\{m_i\}$. These discrete message are called <u>m array output</u>, with each discrete message having corresponding probablities $P(m_1), P(m_2) \ldots, P(m_M)$ → called priori probablities. If These messages $m_1, m_2, \ldots m_M$ are equally likely, probablity of m array output message is $P_i = P(m_i) = \frac{1}{M}$ for all i

Now, M array output is $\{m_i\}$ is passed through vector transmitter, which is a type of Signal Transmission Encoder which encodes M array output into sequence of numbers (set of real no.) & having dimension $N \leq M$

$\{m_i\} \longrightarrow$ Signal Transmission Encoder $\longrightarrow \{\vec{s_i}\}$ (Dimension of $N \leq M$). sequence of N numbers (set of real no.) corresponding to each message $\{m_i\}$

Vector Transmitter

ex - We consider M array (discrete message) denoted by $\{m_i\}$ in the form of sequence $m_1, m_2 \ldots m_M$. Vector Transmitter encode each symbol $\{m_i\}$ into set of N real no. & called as Signal Vector $\{\vec{s_i}\}$. This signal vector is a sequence of $\{\vec{s_1}\}, \{\vec{s_2}\}, \ldots \{\vec{s_M}\}$, each vector having dimension $N \leq M$

In the transmitter itself, modulator converts, vector sequence $\{\vec{s_i}\}$ into sequence of finite energy signal $\{s_i(t)\}$ which is a function of time. which corresponds to continuous finite energy signal over symbol duration $0 \leq t \leq T$

$\{\vec{s_1}, \vec{s_2}, \ldots \vec{s_M}\} \longrightarrow$ Modulator $\longrightarrow \{\tilde{s_i}(t)\} = \{s_1(t), s_2(t), \ldots s_M(t)\}$

carrier wave

continuous finite energy signal over symbol duration $0 \leq t \leq T$

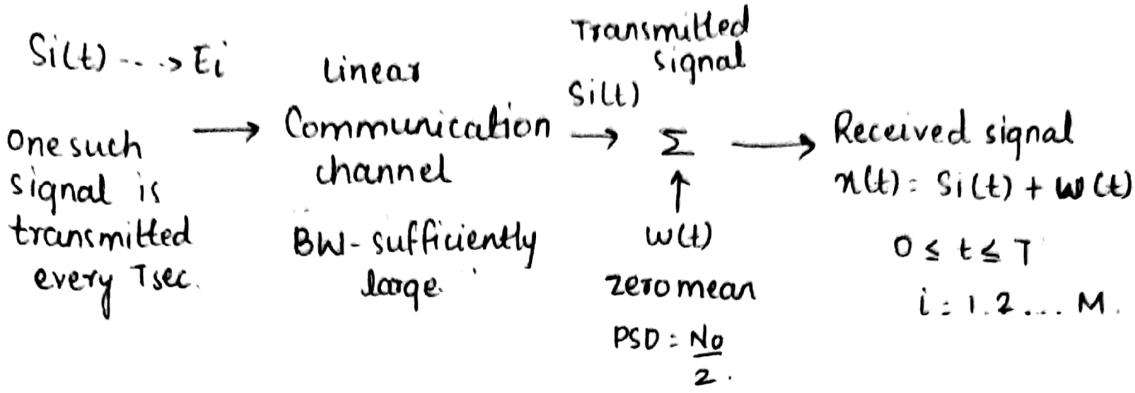
As the modulated signal $s_i(t)$ is necessary to be a real value energy signal & represented by expression

$$E_i = \int_0^T s_i^2(t)\,dt, \quad i = 1, 2, \ldots M.$$

During Transmission through the channel only one signal of E_i is transmitted per T sec.

We consider a linear channel with considerable large bandwidth

The transmitted signal $S_i(t)$ get added with additive white gaussian noise denoted by $w(t)$ with zero mean and Power Spectral Density, PSD = $\frac{N_0}{2}$ gives received signal $x(t)$.



At the input of receiver, $x(t)$ is received as one symbol for duration Tsec. Detector converts individual symbol into corresponding observation vector denoted by $\vec{X}$. Signal Transmission Decoder transform observation vector into estimated symbol $\hat{m}$. This Signal Transmission Decoder is a type of Vector receiver. The decision at receiver is based on the priori probablity of signal vector sequence denoted by $\{\vec{S_i}\}$.

This Signal Vector consists of sequence $\vec{S_1}, \vec{S_2}, \vec{S_3} \ldots \vec{S_M}$ which corresponds to individual message signal $m_1, m_2, m_3 \ldots m_M$ respectively. In order to make a decision priori probablity of {M array} symbol makes possibility to make decision & estimate $\hat{m}$.

While detection & estimation in digital communication System, additive white gaussian noise affect decision making process & gives rise to Symbol Error

To minimise Symbol Error, we use an optimum detection process, where optimum receiver is used to minimise average probablity of symbol error.

There are 2 types of optimum receiver based on coherent & non-coherent detection

1) Coherent detector:-

Receiver must be in phase synchonised with transmitted carrier

2) Non-Coherent detector :-

There is no requirement of phase synchronisation with transmitted carrier.