Correlation Receiver :

For an AWGN channel (Additive White Gaussian Noise Channel) and for the case when the transmitted signals $S_1(t), S_2(t), S_3(t) --- S_M(t)$ are equally likely, the optimum receiver consists of 2 subsystems:

a) Detector : It consists of a bank of M-product integrators or correlators supplied with a corresponsing set of coherent reference signals or orthonormal basis functions $\phi_1(t), \phi_2(t), \phi_3(t) --- \phi_N(t)$ that are generated locally. $(N \leq M)$ This bank of correlators operate on the received signal $x(t)$, $0 \leq t \leq T$ to produce the observation vector x.

b) Vector Receiver : The second part of the receiver namely, the vector receiver is shown in as fig (b). It is implemented in the form of a maximum-likelihood detector that operates on the observation vector x to produce an estimate $\hat{m}$ of the transmitted symbol m_i where $i = 1,2,3, -- M$ in a way that would minimize the average probability of symbol error. In accordance to the maximum likely hood equation a vector x lies inside region Z_i if

$$\sum_{j=1}^{N} x_j s_{kj} - \frac{1}{2} E_K \text{ is maximum for } K = i.$$

where E_K is the energy of the transmitted signal $S_K(t)$.

$$E_K = \sum_{j=1}^{N} s_{kj}^2 .$$

In the vector receiver, the N elements of the observation vector x are first multiplied by the corresponding N elements of each of the M signal vectors $s_1, s_2, s_3 -- s_M$ and the resulting products are successively summed in accumulators to form the corresponding set of inner products $\{(x, s_K)\}$, $K = 1, 2, 3, -- M$. Next, the inner products are corrected for the fact that the transmitted signal energies may be unequal. Finally the largest in the resulting set of numbers is selected and a corresponding decision on the transmitted message is made.

Matched filter Receiver.

Each of the orthonormal basis function $\phi_1(t), \phi_2(t)$ --- $\phi_N(t)$ is assumed to be zero outside the interval $0 \leq t \leq T$, the use of multipliers shown in correlation of Receivers may be avoided. This is desirable because analog multipliers are hard to build.

Consider a linear filter with impulse response $h_j(t)$, . With the received signal $x(t)$ used as the filter input, the resulting filter o/p $y_j(t)$ is defined by the convolution integral.

$$y_j(t) = \int_{-\infty}^{\infty} x(\tau) h_j(t-\tau)\, d\tau. \quad -①$$

Suppose we now set the impulse response.

$$h_j(t) = \phi_j(T-t) \quad -②$$

Then the resulting filter o/p is.

$$y_j(t) = \int_{-\infty}^{\infty} x(\tau) \phi_j(T-t+\tau)\, d\tau \quad -③$$

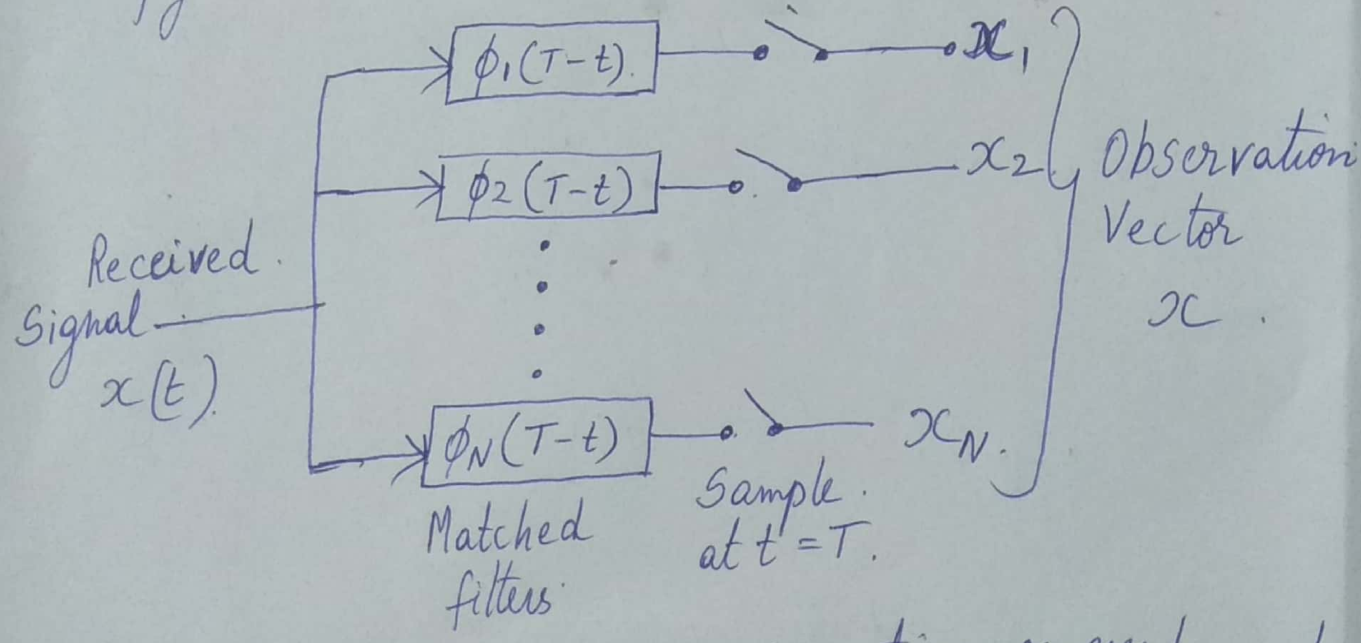
Sampling this o/p at time $t = T$ we get.

$$y_j(T) = \int_{-\infty}^{\infty} x(\tau) \phi_j(\tau)\, d\tau. \quad -④$$

and since $\phi_j(T)$ is zero outside the interval $0 \le t \le T$, we finally get

$$y_j(T) = \int_0^T x(\tau)\phi_j(\tau)\, d\tau. \quad -⑤$$

We note that $y_j(T) = x_j$ where x_j is the j^{th} correlator o/p produced by the received signal $x(t)$. Thus the detector part of the optimum receiver may also be implemented as in fig below.



A filter whose impulse response is a time reversed and delayed version of some signal $\phi_j(t)$ as in eq ② is said to be matched to $\phi_j(t)$. Correspondingly the optimum receiver based on the detector of shown above is refered to as matched filter receiver.