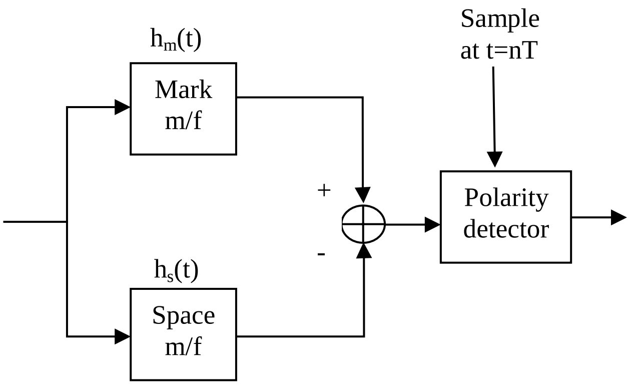
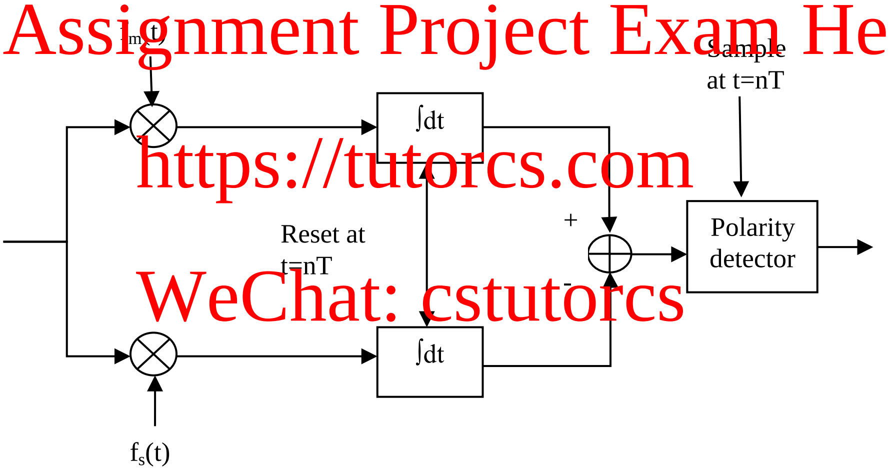
Coherent detection of FSK(ρ=0)

As in PSK, FSK can be detected by either a matched filter or a correlation detector.

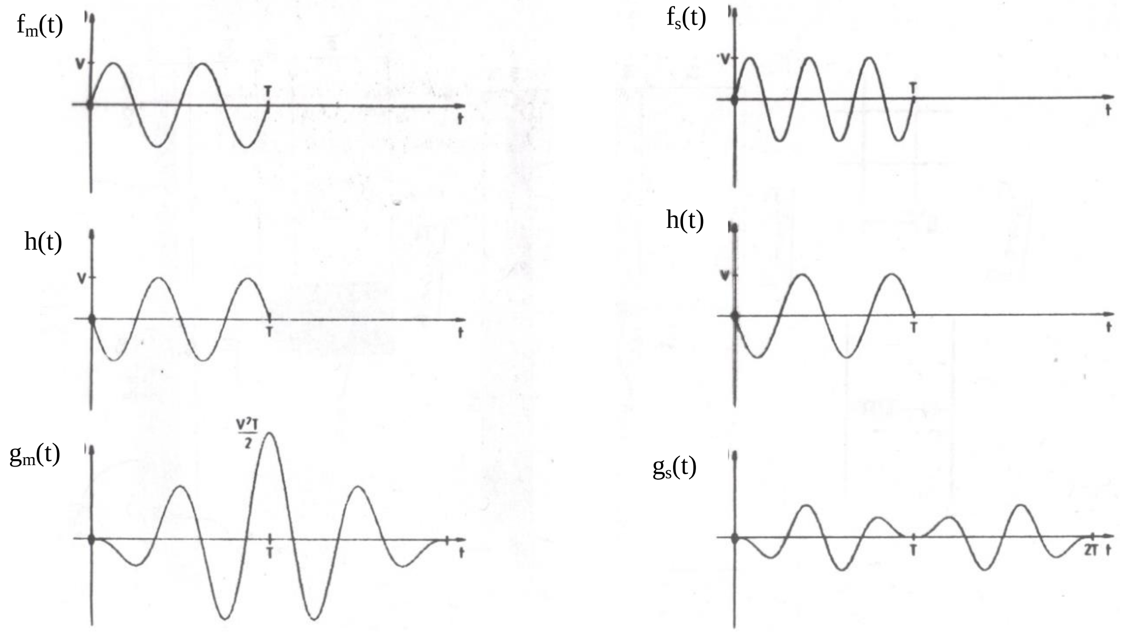
a) Matched detector:



b) Correlation detector:

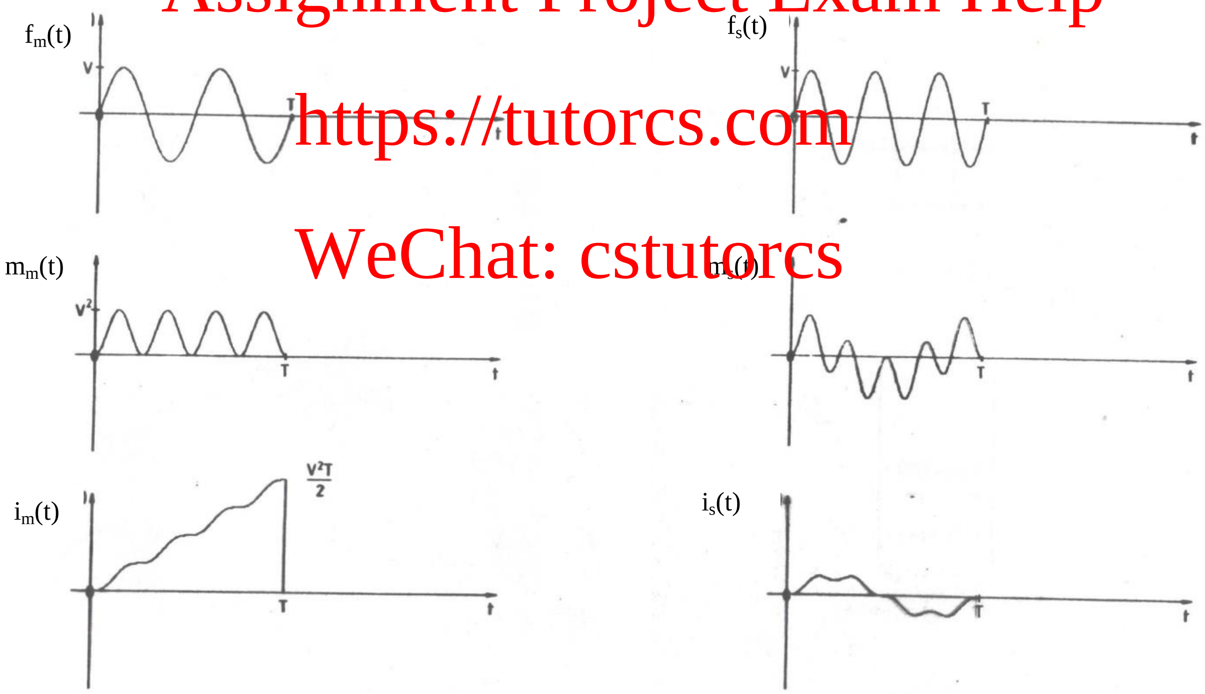


Similar to the case of PSK, the outputs of the two detectors are not identical at all times but have the same value at the sampling instant as shown in the figures below for the two detectors.



(a) (b)

Matched filter output (a) due to mark signal, (b) due to space signal



(a) (b)

Correlation detector output (a) due to mark signal, (b) due to space signal

Output of correlation detector can be expressed as

$$= \int_0^T f_m^2(\tau)d\tau + \int_0^T n(\tau) f_m(\tau)d\tau - \int_0^T f_s(\tau) f_m(\tau)d\tau - \int_0^T n(\tau) f_s(\tau)d\tau$$

To ensure that the third term does not subtract from the sampled value at t=T, we would need the third term to be equal to zero i.e.

$$\int_0^T f_s(\tau) f_m(\tau) d\tau = 0$$

That is the mark and space signals have to be orthogonal.

For the two signals to be orthogonal:

We can choose

$$f_m(t) = \cos \omega_1 t,$$
$$f_s(t) = \cos \omega_2 t \qquad (23)$$
$$\int_0^T \cos \omega_1 t . \cos \omega_2 t dt = 0$$

From Fourier series analysis for ω_1, ω_2 to be orthogonal they have to be harmonically related and both have an integer number of cycles within T

That is $\omega_1 = m\omega_o, \ \omega_2 = n\omega_o$

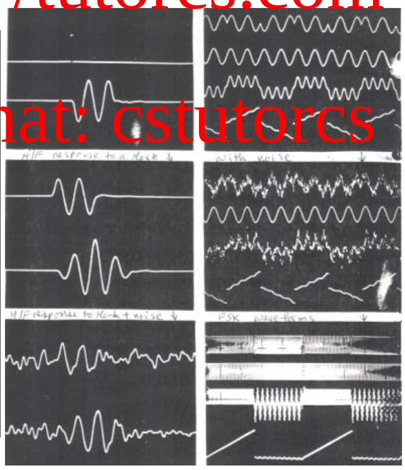
where $\omega_o = 2\pi / T$, where T is the keying rate or pulses/sec. This implies that

$$f_2 - f_1 = k / T \qquad (24)$$

Matched filter impulse response

Matched filter response to mark

Matched filter to mark plus noise



Correlation detector response to PSK signal

Correlation detector response to PSK signal with noise

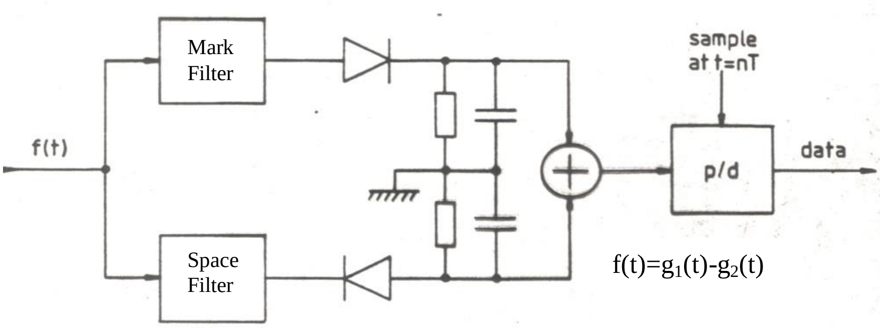
Correlation detector response to FSK signal

Figure illustrating the outputs of the matched filter and correlation detector outputs for PSK and FSK with and without the presence of noise

Non coherent detection

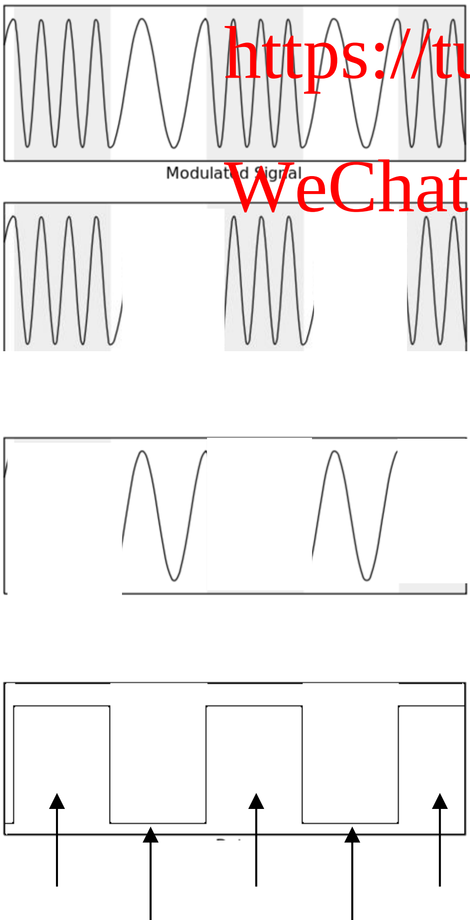
Coherent detectors require synchronous operation i.e. for a matched filter a precise sample instant is required, and for a correlation detector precise frequency and ϕ are required. Thus, sub-optimum, non-coherent detection might be preferred.

a) Non-coherent envelope detected FSK (very popular)



$f(t)=g_1(t)-g_2(t)$

Waveforms:



FSK data

Output of mark filter

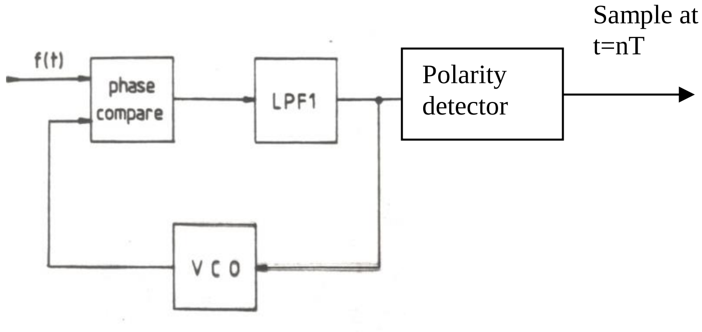
Output of space filter

f(t): Envelope detected output

Sampling instants

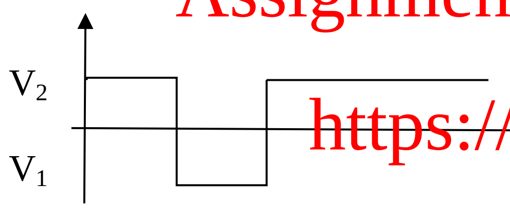
Here the requirements are as those for baseband i.e. we only need clock (ck) recovery. The performance is not of course as optimum as the matched filter.

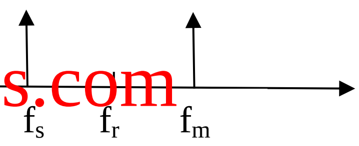
b) Non-coherent (PLL) FSK



Here the free running frequency of the PLL f_r is midway between f_1, and f_2.

It is set up to lock up very quickly to either tone. If $f(t)$ is $f_m(t)$ then the phase detector output should be such that to change the VCO frequency, f_{vco} from f_s to f_m $\Rightarrow$ +ve voltage. To change it from $f_m(t)$ to $f_s(t)$ the voltage should be in the opposite direction.





DC voltage to adjust VCO frequency gives the baseband data

Free running frequency w.r.t. mark and space frequencies

Differential phase shift keying DPSK (-1955)

To overcome the synchronisation problem i.e. having exact phase and frequency at the demodulator, in DPSK the correlation detector at the receiver uses the transmitted signal for a reference.

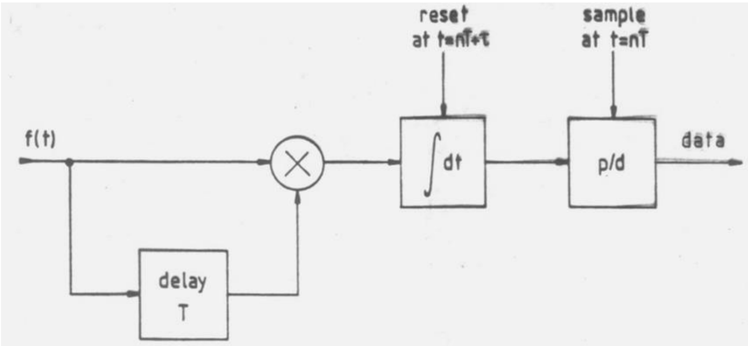
In this case the data are given in the relative phase of adjacent signal elements.

Example:

PCM code	1	0	0	0	1	1	0
Phase change	π	0	0	0	π	π	0

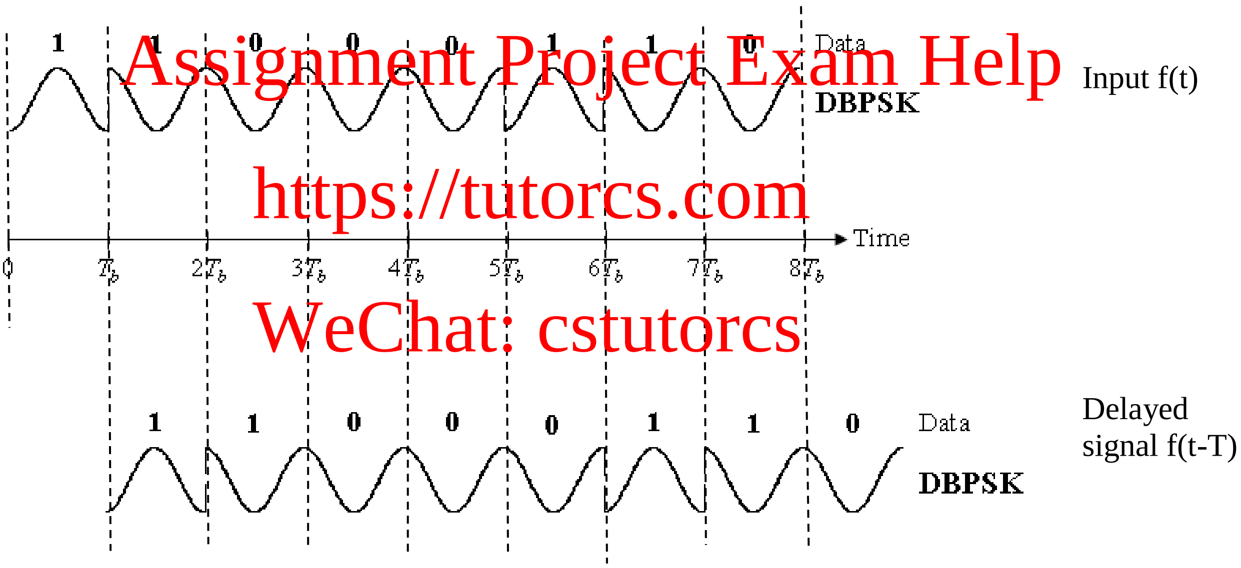
Differential code: If the PCM bit is 1, change the phase by π.
If the PCM bit is 0, the phase change is 0 i.e. the phase remains un-changed.

To detect DPSK we use the following block diagram where the incoming data stream is delayed by one bit duration to use as the reference:



The performance of DPSK detector is worse than the ideal correlation detector because the reference signal is noisy, but generally the degradation is small for large SNR.

Waveforms:



Comparing the phases of *f*(t) with *f*(t-T) the output of the multiplier followed by the integrator we get the following signs for the outputs

-ve, +ve, +ve, +ve, -ve, -ve, +ve which corresponds to the original data of
1, 0, 0, 0, 1, 1, 0