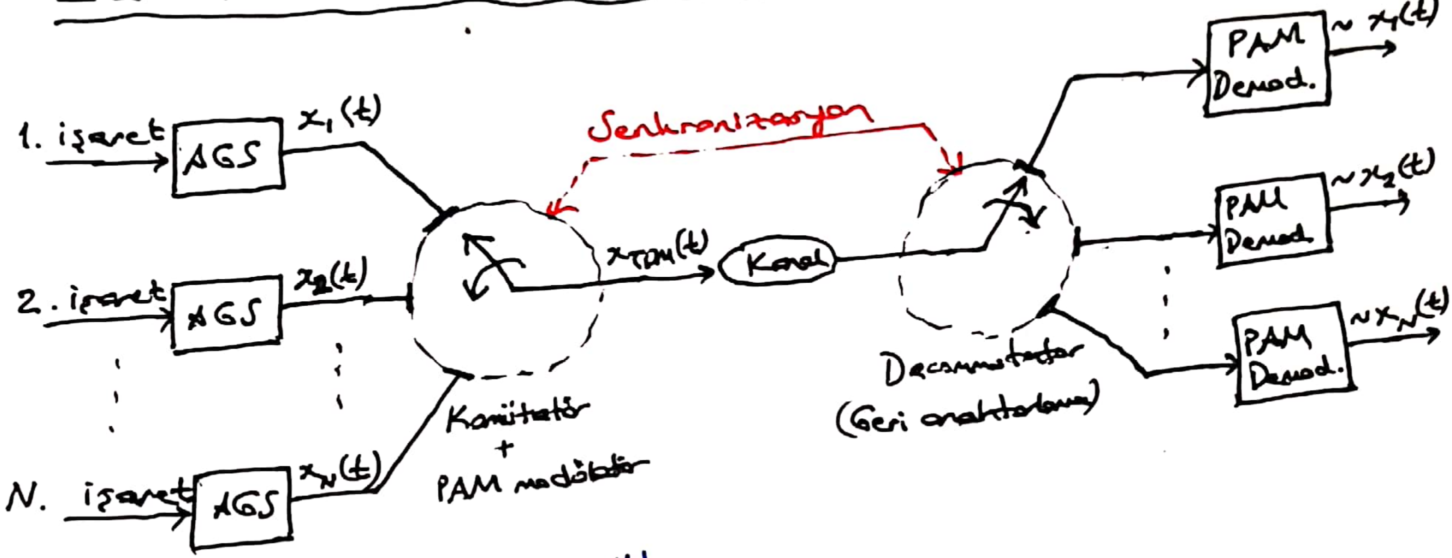
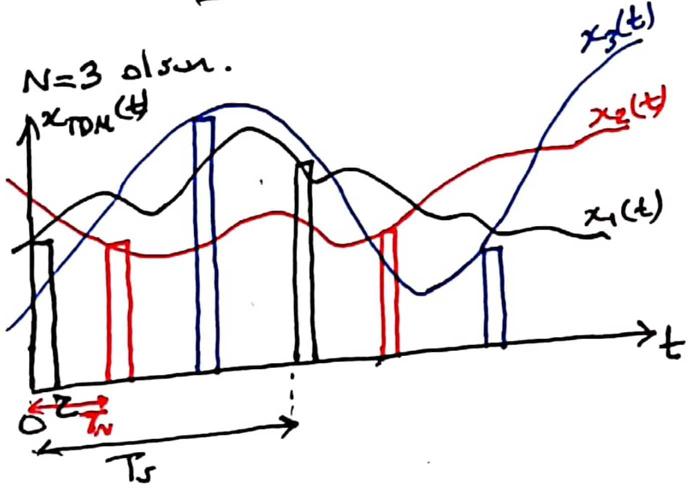
Zaman Bölmeli Çoğullama (Time Division Multiplexing, TDM)



N=3 olsun.



$x_i(t)$'lerin maks. frekansı W olsun.

$f_s \geq 2W$

$T_N = \frac{T_s}{N}$ (Örnekte $T_N = T_3 = \frac{T_s}{3}$)

T_s: Örnekleme periyodu

T_N: TDM işarette darbeler arası uzaklık

$f_s = \frac{1}{T_s}$

$f_N = \frac{1}{T_N}$: TDM işaretin frekansı ya da hızı

$f_N = \frac{N}{T_s} = N f_s \geq 2NW$

TDM işaretin band genişliği B_T olsun.

$f_N = 2B_T$ olmalı. $\Rightarrow$ $\boxed{B_T = \frac{f_N}{2} = \frac{1}{2T_N}}$

$B_T = \frac{f_N}{2} \geq \frac{2NW}{2} = NW$

Eğer işaretlerin band genişlikleri aynı değilse,

$x_i(t) \longrightarrow W_i \quad , \; i = 1,2,\dots,N$

$$W_{maks} = \underset{i}{\text{maks}}\, W_i$$

$$f_s \geq 2W_{maks}$$

$$f_N = N f_s \geq 2N W_{maks}$$

Örnek:

$N = 3$

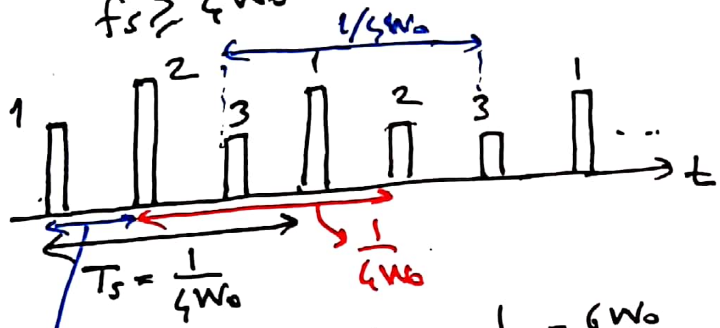
$x_1(t)$, $x_2(t)$, $x_3(t)$

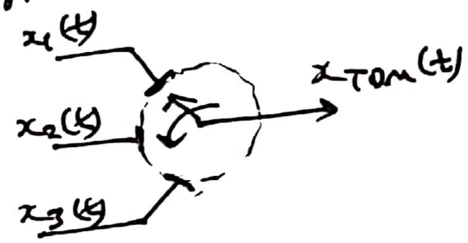
$2W_0$ $\quad W_0$ $\quad W_0$

$W_{maks} = 2W_0 \qquad \left(T_s \leq \frac{1}{4W_0}\right)$

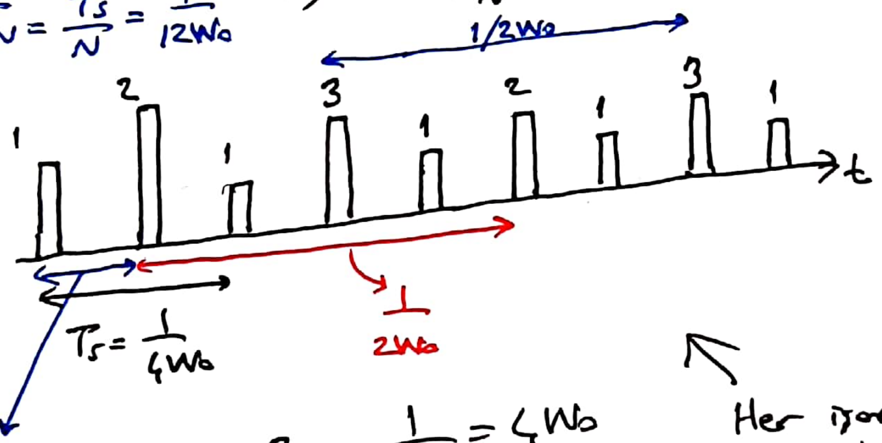
$f_s \geq 4W_0$

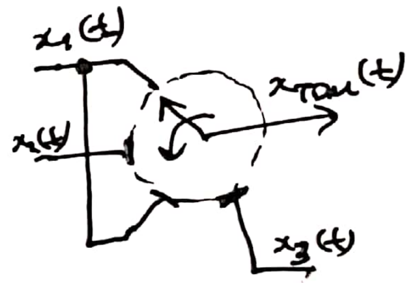
Örnekleme $4W_0$'da (frekans ile) yapılırsa.





$$T_N = \frac{T_s}{N} = \frac{1}{12W_0} \Rightarrow B_T = \frac{1}{2T_N} = 6W_0$$





$$B_T = \frac{1}{2T_N} = 4W_0$$

$$T_N = \frac{1}{8W_0}$$

Her işaret kendi Nyquist frekansında örneklenirse.

③

Principles of Electronic Communication Systems, L.E. Frenzel, McGraw-Hill, 4th Ed., 2016

Frame rate

One complete revolution of the commutator switch is referred to as a *frame*. In other words, during one frame, each input channel is sampled one time. The number of contacts on the multiplexed switch or commutator sets the number of samples per frame. The number of frames completed in 1 s is called the *frame rate*. Multiplying the number of samples per frame by the frame rate yields the commutation rate or multiplex rate, which is the basic frequency of the composite signal, the final multiplexed signal that is transmitted over the communication channel.

In Fig. 10-14, the number of samples per frame is 4. Assume that the frame rate is 100 frames per second. The period for one frame, therefore, is 1/100 = 0.01 s = 10 ms. During that 10-ms frame period, each of the four channels is sampled once. Assuming equal sample durations, each channel is thus allotted 10/4 = 2.5 ms. (As indicated earlier, the full 2.5-ms period would not be used. The sample duration during that interval might be, e.g., only 1 ms). Since there are four samples taken per frame, the commutation rate is 4 × 100 or 400 pulses per second.

Electronic Multiplexers. In practical TDM/PAM systems, electronic circuits are used instead of mechanical switches or commutators. The multiplexer itself is usually implemented with FETs, which are nearly ideal on/off switches and can turn off and on at very high speeds. A complete four-channel TDM/PAM circuit is illustrated in Fig. 10-15.

The multiplexer is an op amp summer circuit with MOSFETs on each input resistor. When the MOSFET is conducting, it has a very low on resistance and therefore acts as a closed switch. When the transistor is off, no current flows through it, and it therefore acts as an open switch. A digital pulse applied to the gate of the MOSFET turns the transistor on. The absence of a pulse means that the transistor is off. The control pulses to the MOSFET switches are such that only one MOSFET is turned on at a time. These MOSFETs are turned on in sequence by the digital circuitry illustrated.

Figure 10-15 A time-division multiplexer used to produce pulse-amplitude modulation.

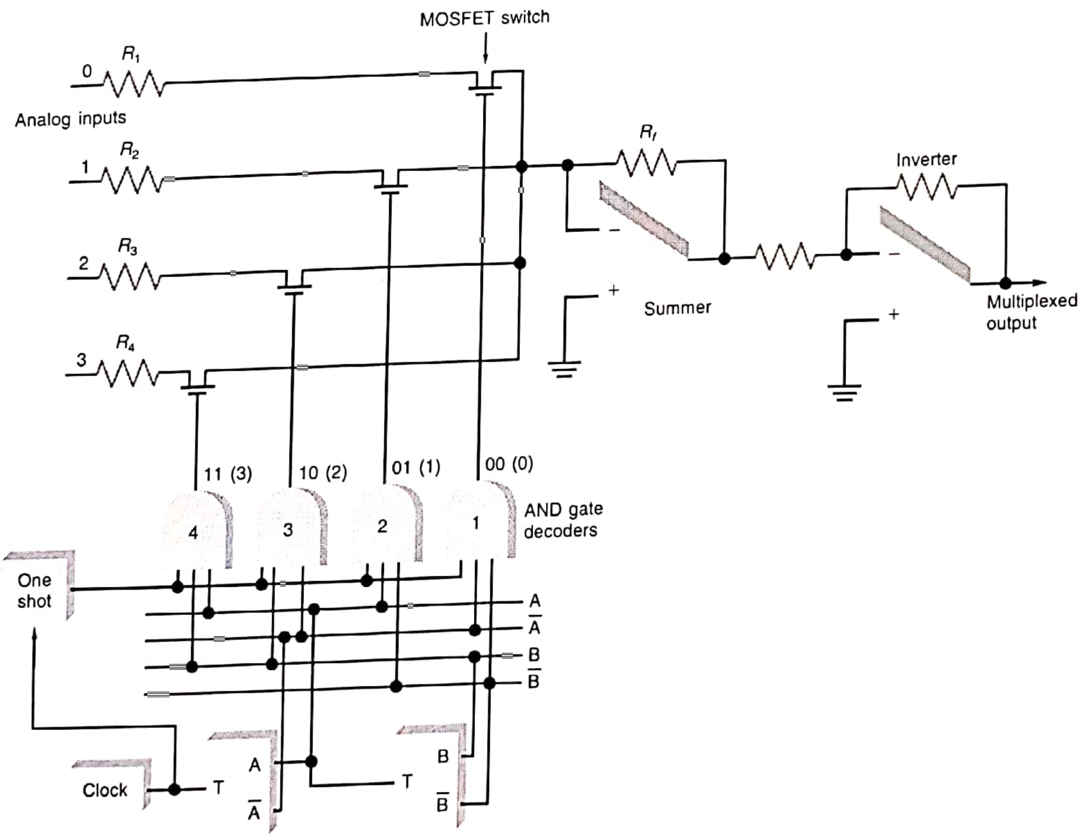
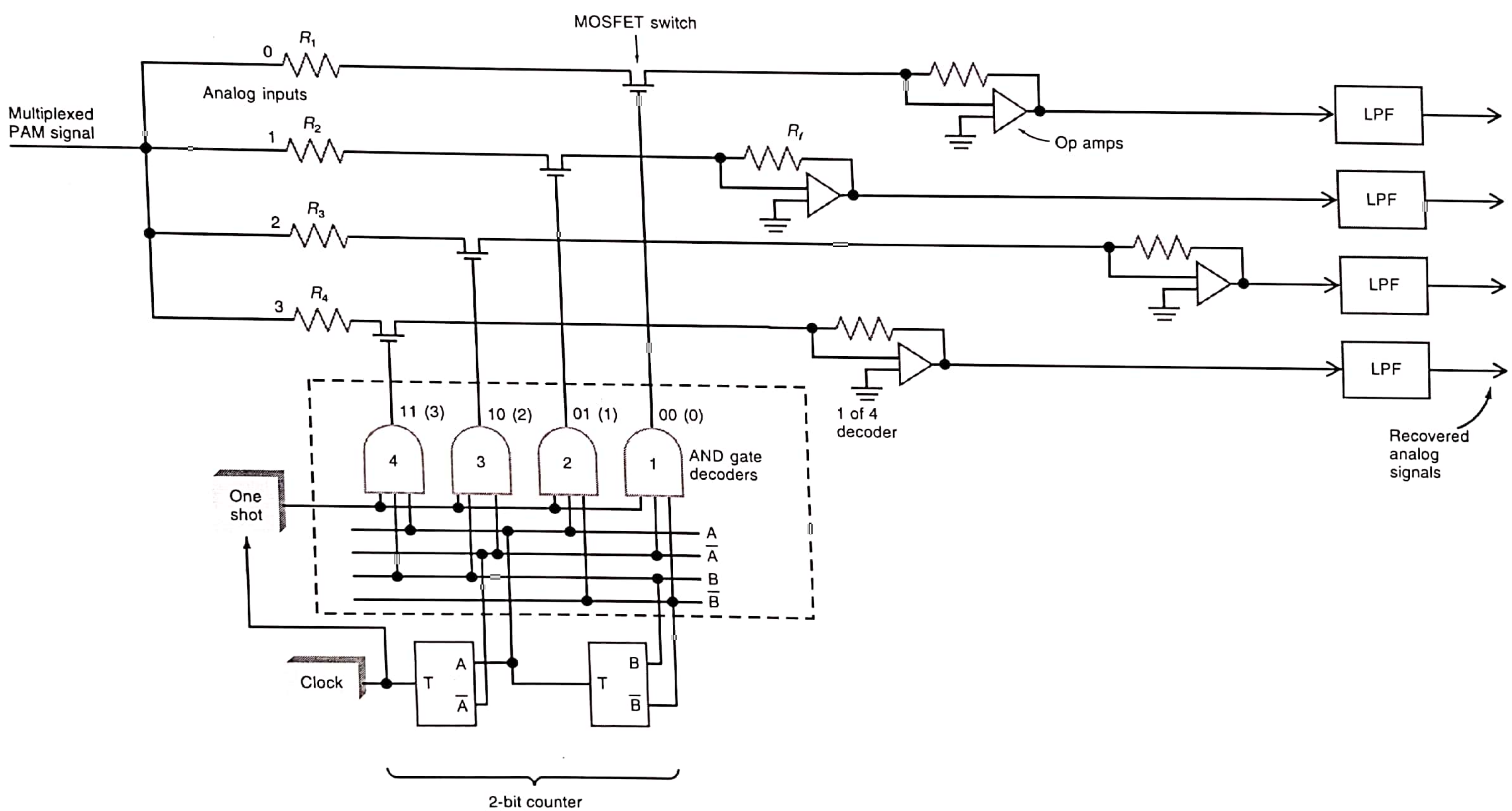


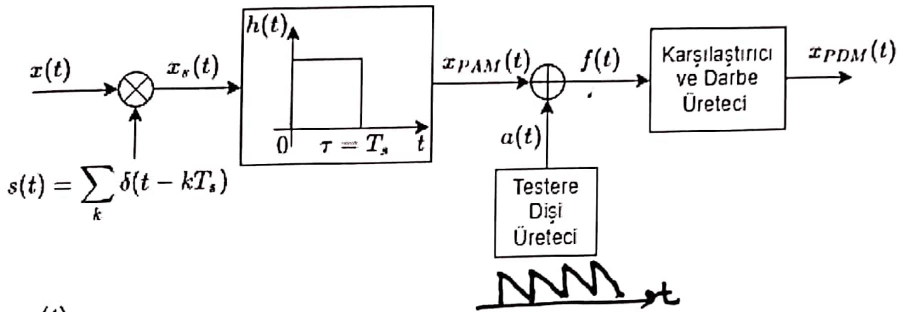
Figure 10-17 A PAM demultiplexer.

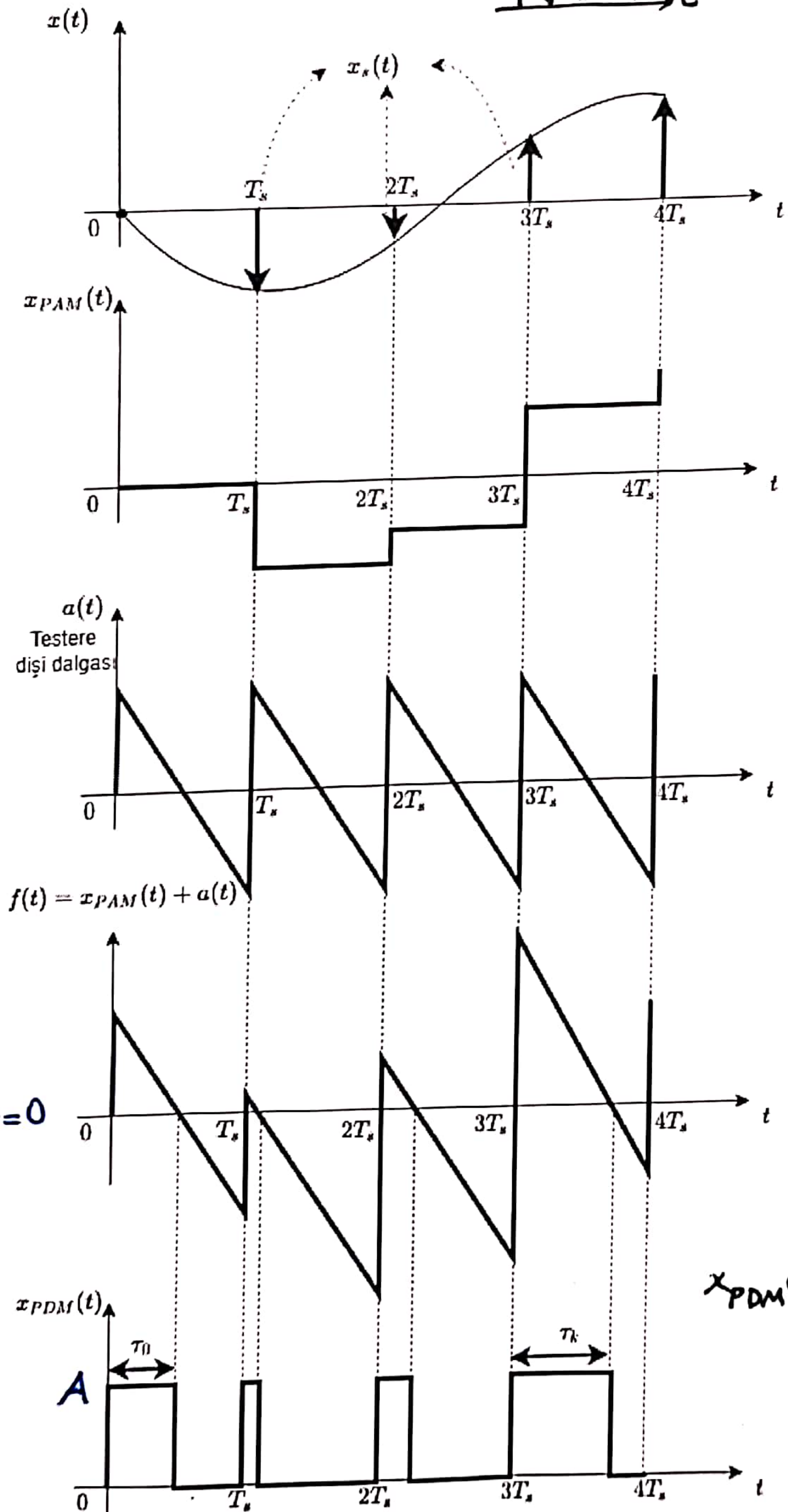


(4)

Darbe Zaman Modülasyonu (Pulse Time Mod.)

1) Darbe Süresi Modülasyonu (Pulse Duration Mod, PDM) ≡ PWM, PLM





Eşik değer=0

$$P_T = \langle x^2_{PDM}(t)\rangle_{T_{obs}}$$

$$= \lim_{T_{obs}\to\infty} \frac{1}{T_{obs}} \int_{-T_{obs}/2}^{T_{obs}/2} x^2_{PDM}(t)\,dt$$

$$T_{obs} = (2M+1)T_s$$

$$\Rightarrow P_T = \frac{A^2}{T_s}\lim_{M\to\infty} \underbrace{\frac{1}{(2M+1)}\sum_{k=-M}^{M}\tau_k}_{\langle\tau_k\rangle}$$

$$= \frac{A^2\langle\tau_k\rangle}{T_s}$$

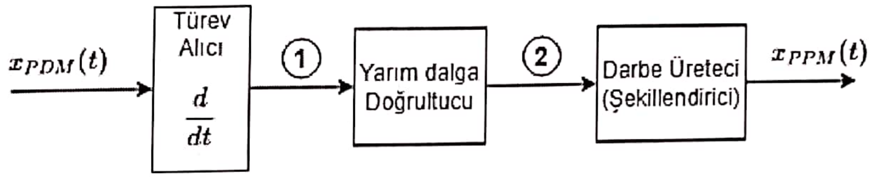
$$x_{PDM}(t) = A\sum_{k=-\infty}^{\infty}\Pi\left(\frac{t-kT_s-\tau_k/2}{\tau_k}\right)$$

Doğrusal olmayan bir mod.

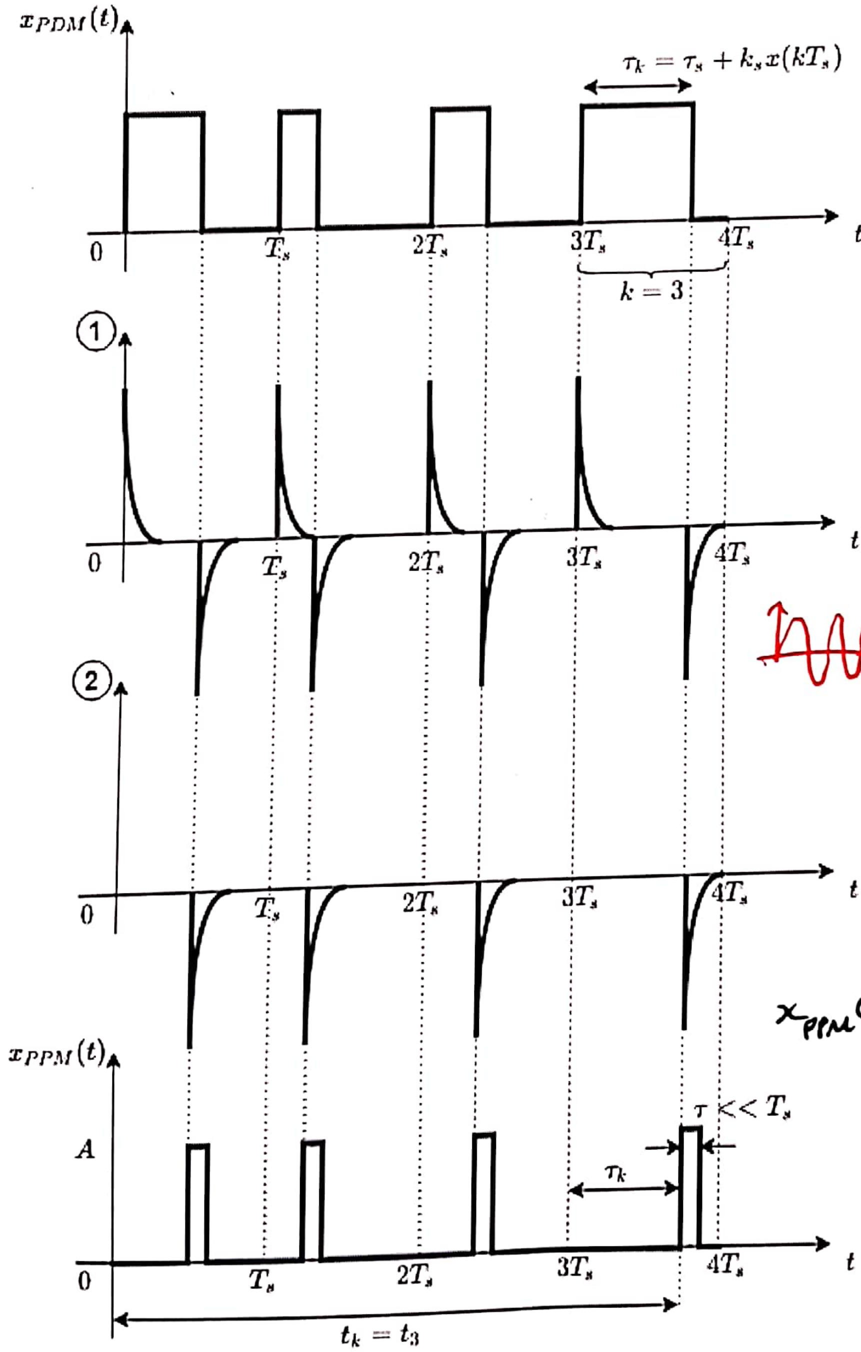
$$\tau_k = \tau_s + k_s x(kT_s)$$

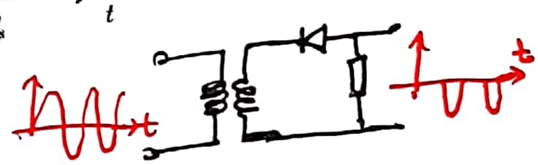
$$\langle\tau_k\rangle = \tau_s + k_s\langle x(kT_s)\rangle$$

2) Darbe Yeri Modülasyonu (Pulse Position Mod., PPM)



$$\frac{du(t)}{dt} = \delta(t)$$





$$x_{PPM}(t) = A\sum_{k=-\infty}^{\infty}\Pi\left(\frac{t - t_k - \tau/2}{\tau}\right)$$

Doğrusal değil.

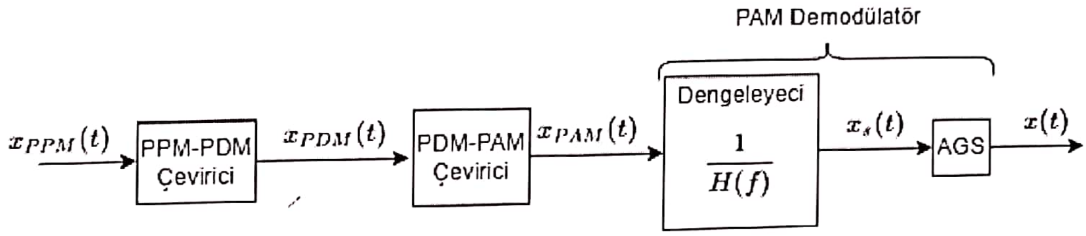
$t_k = kT_s + \tau_k$, $\tau_k = \tau_s + k_s \langle x(kT_s)\rangle$

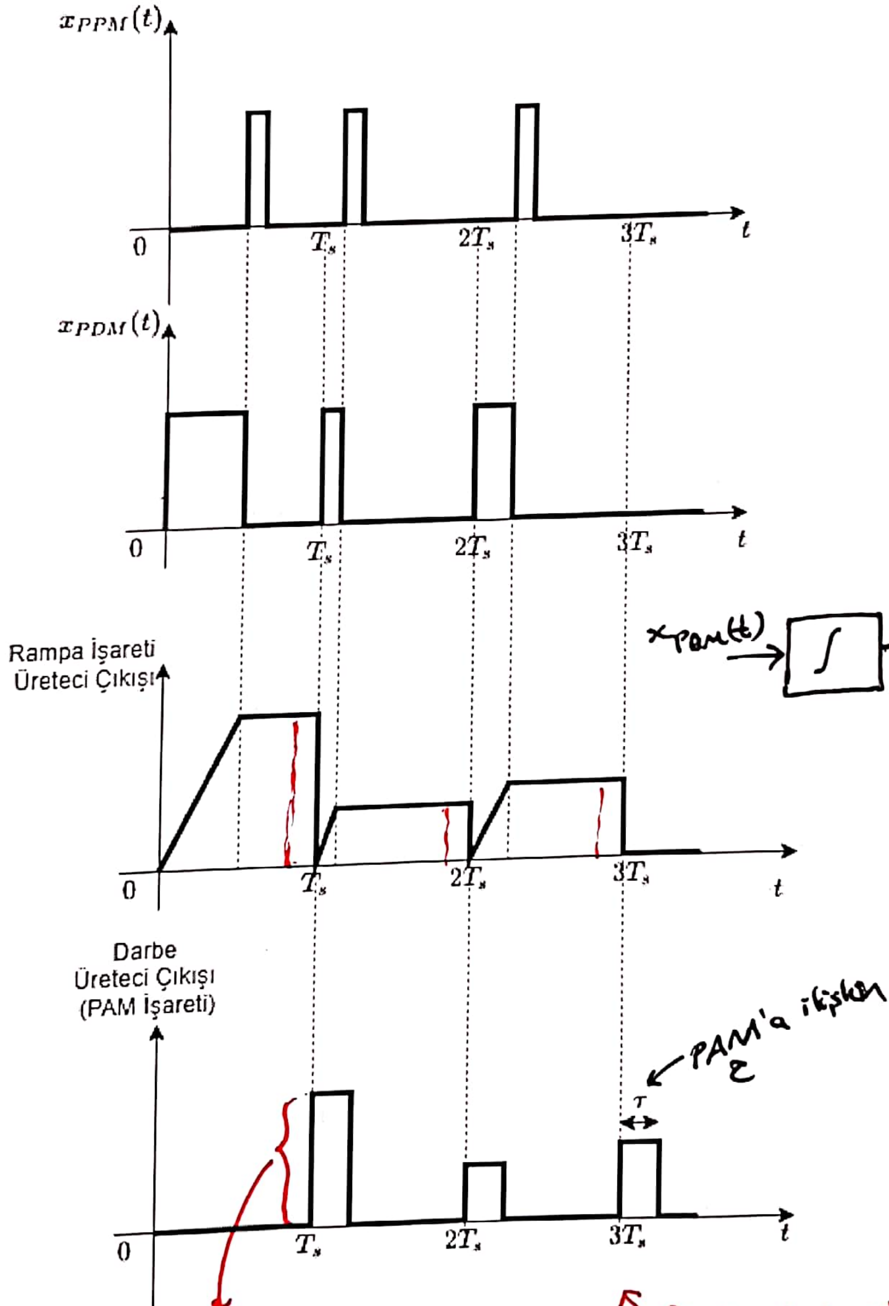
$P_\tau = \frac{A^2\tau}{T_s}$

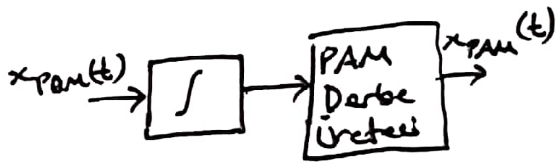
PDM'deki τ_k'nın aynı.

τ : PPM darbe genişliği

PPM ve PDM İşaretlerin Demodülasyonu:







Bu genlik değeri tüm darbelerden çıkartılmalı.

Orijinal işarete göre T_s sn. gecikmeli elde edilir.