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5.1 Sampling Process

- Instantaneously (ideal) sampled signal : $g_\delta(t) = \sum g(nT_s)\delta(t-nT_s)$ $\quad \sum g(nT_s)\delta(t-nT_s) \Updownarrow$

$\sum g(nT_s)\delta(t-nT_s) \Leftrightarrow f_s \sum G(f-mf_s) = \sum g(nT_s)\exp(-j2\pi nT_s f) = G_\delta(f)$ $\quad \sum g(nT_s)e^{-j2\pi nT_s f} = f_s \sum G(f-mf_s)$

- Sampling Theorem
  - A discrete-time Fourier transform of the sequence : $G_\delta(f) = \sum g(\frac{n}{2W})\exp(-\frac{j\pi nf}{W})$
  - For a strictly band-limited signal $\quad G_\delta(f) = f_s G(f) + f_s \sum G(f-mf_s)$

  under the two conditions : $G(f) = 0 \quad |f| \geq W$, $f_s = 2W$

  : $G(f) = \frac{1}{2W} G_\delta(f) \ (-W<f<W)$: $G(f) = \frac{1}{2W}\sum g(\frac{n}{2W})\exp(-\frac{j\pi nf}{W}) \ (-W<f<W)$

5.2 Pulse-Amplitude Modulation (PAM)

$s(t) = \sum m(nT_s)h(t-nT_s)$, $h(t) = \mathrm{rect}\left(\frac{t-\frac{T}{2}}{T}\right)$, $m_\delta(t) = \sum m(nT_s)\delta(t-nT_s)$

$m_\delta(t) * h(t) = \int m_\delta(\tau)h(t-\tau)d\tau = \sum m(nT_s)\int_{-\infty}^{\infty}\delta(\tau-nT_s)h(t-\tau)d\tau$, $\int \delta(\tau-nT_s)h(t-\tau)d\tau = h(t-nT_s)$

- Aperture Effect and its Equalization
  - Aperture effect : the distortion caused by the use of pulse-amplitude modulation to transmit an analog information-bearing signal
  - Equalizer : decreasing the in-band loss of the reconstruction filter as the frequency increases, The amplitude response of the equalizer $\frac{1}{|H(f)|} = \frac{1}{T\,\mathrm{sinc}(fT)} = \frac{\pi f}{\sin(\pi f T)}$

5.3 Pulse-Position Modulation

- PDM (Pulse-duration modulation) → this method is wasteful of power.
- PPM : The position of a pulse relative to its unmodulated time of occurence is varied in accordance with the message signal.

  $s(t) = \sum g(t-nT_s-k_p m(nT_s))$, $g(t)=0$, $|t| > (T_s/2) - k_p|m(t)|_{max}$, $k_p|m(t)|_{max} < (T_s/2)$

5.5 Quantization Process

- Amplitude quantization : The process of transforming the sample $m(nT_s)$ of $m(t)$ at time $t = nT_s$ into a discrete amplitude $v(nT_s)$ taken from a finite set of possible levels.
- Partition cell $I_k : \{m_k < m \leq m_{k+1}\}$, $k = 1, 2, \cdots, L$, m_k : decision level or decision threshold.

  v_k : representation level or reconstruction level. v_k is allocated to each partition cell.

5.6 Pulse-Code Modulation (PCM) : Message signal is represented by a sequene of coded pulses, which is accomplished by representing the signal in discrete from in time and amplitude.