DELTA MODULATION

EEEN 464 -DIGITAL COMMUNICATION

Friday, 13 February 2026

RECAP: PCM BANDWITH

1. Consider a telephone channel with bandwidth of 4 KHz
2. If the channel is sampled at the Nyquist rate, i.e 2 x 4 = 8KHz and each sample coded with 8 bits, the resulting bitstream is 64 Kbits/second
3. In other words, we require 15 times the original bandwidth of the signal to be able to transmit it.
4. This is generally stated as

$$Bandwidth_{PCM} \geq 2f_m v$$

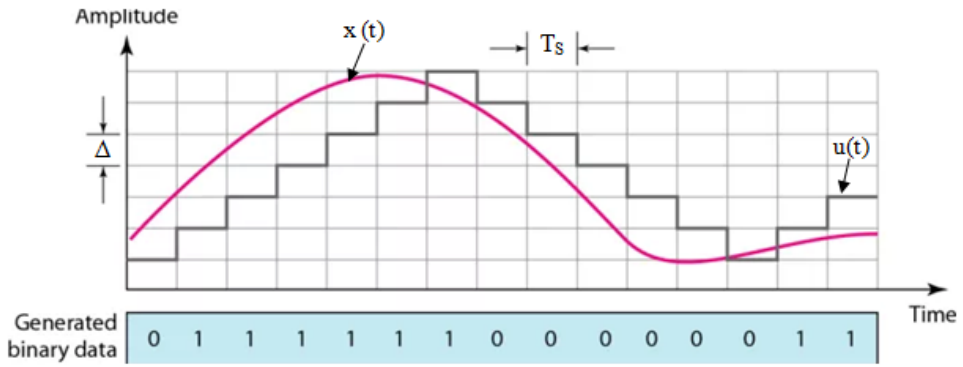
Where

f_m is the maximum frequency of the baseband analogue signal

2^v is the number of quantization levels

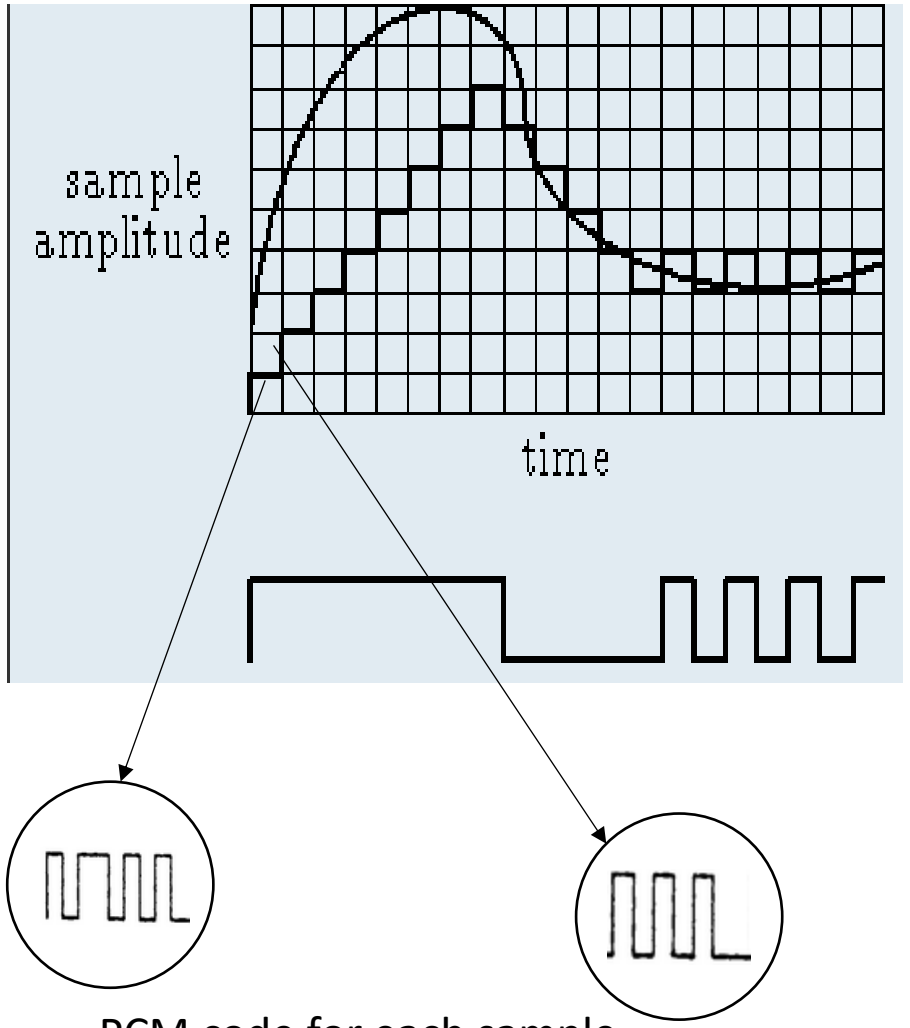
WHAT IS DELTA MODULATION?

1. **Delta modulation** is a technique for converting an analog signal to digital by only transmitting information about the change in signal amplitude between successive samples.
2. **Delta modulation** is useful when we require low bandwidth, and high quality isn't a priority.

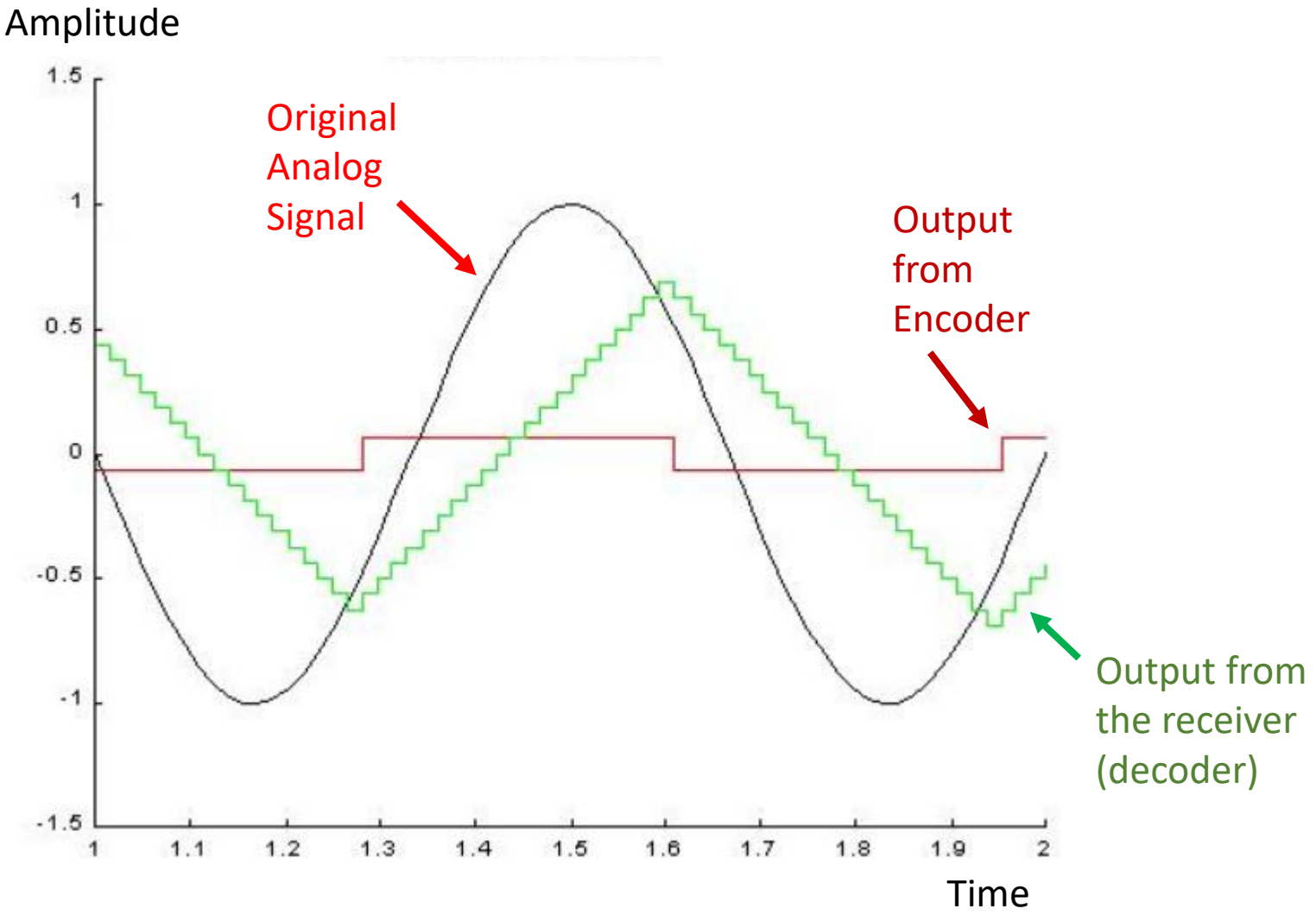


WHAT IS DELTA MODULATION?

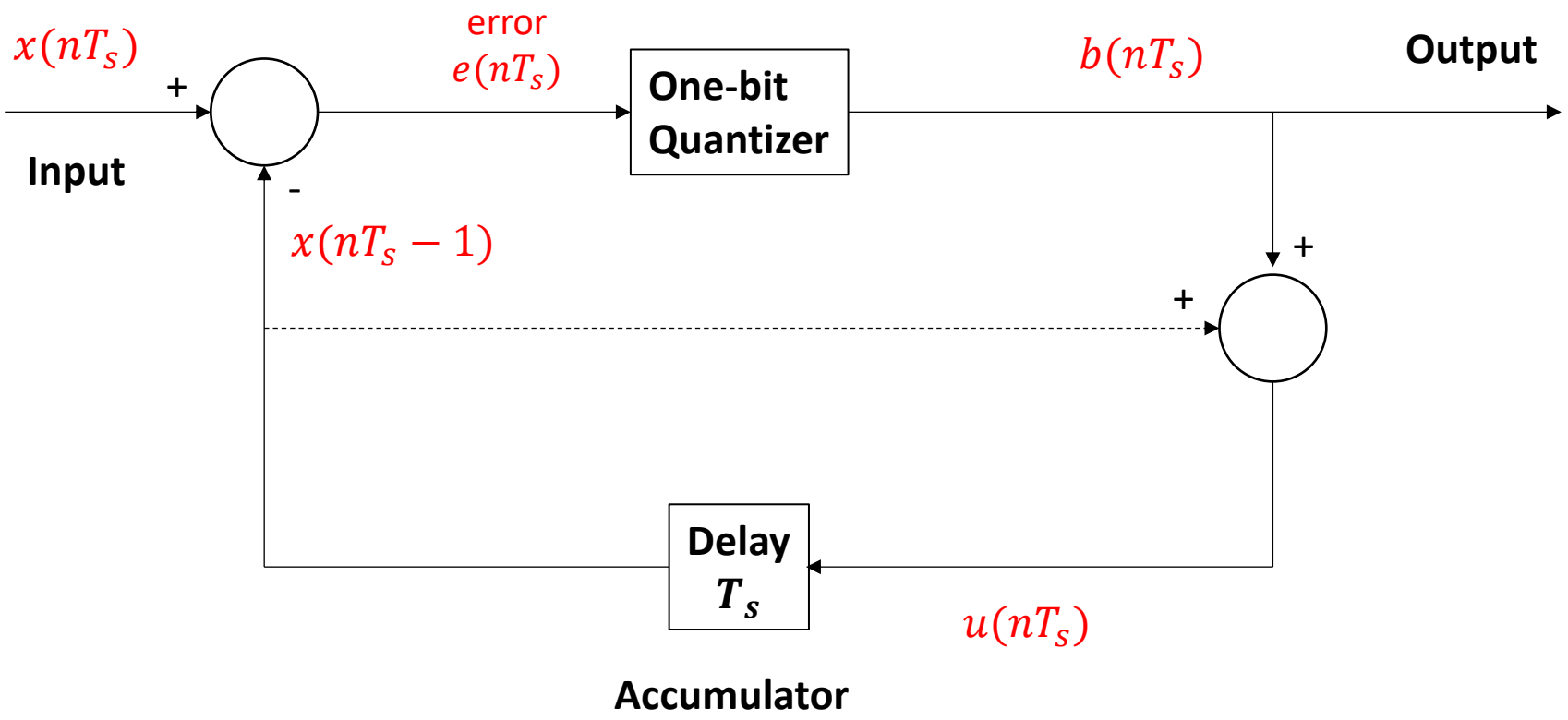
1. **Delta modulation** seeks to overcome the problem of high bandwidth requirement in conventional PCM.
2. Instead of generating and transmitting many bits per sample, only one bit is transmitted.
3. During coding, the present sample is compared with the previous and a 0 or 1 transmitted depending on whether the sample is higher or lower than the previous.



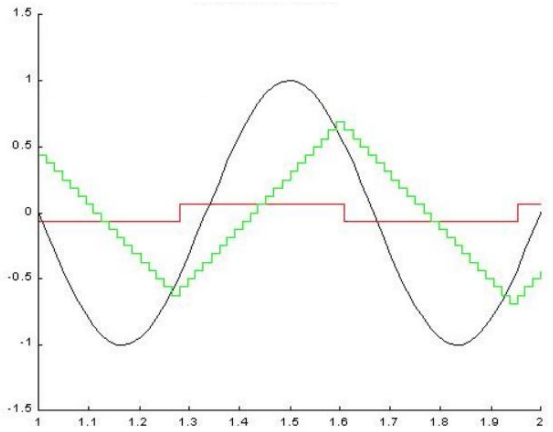
SIGNALS IN A DELTA MODULATION SYSTEM

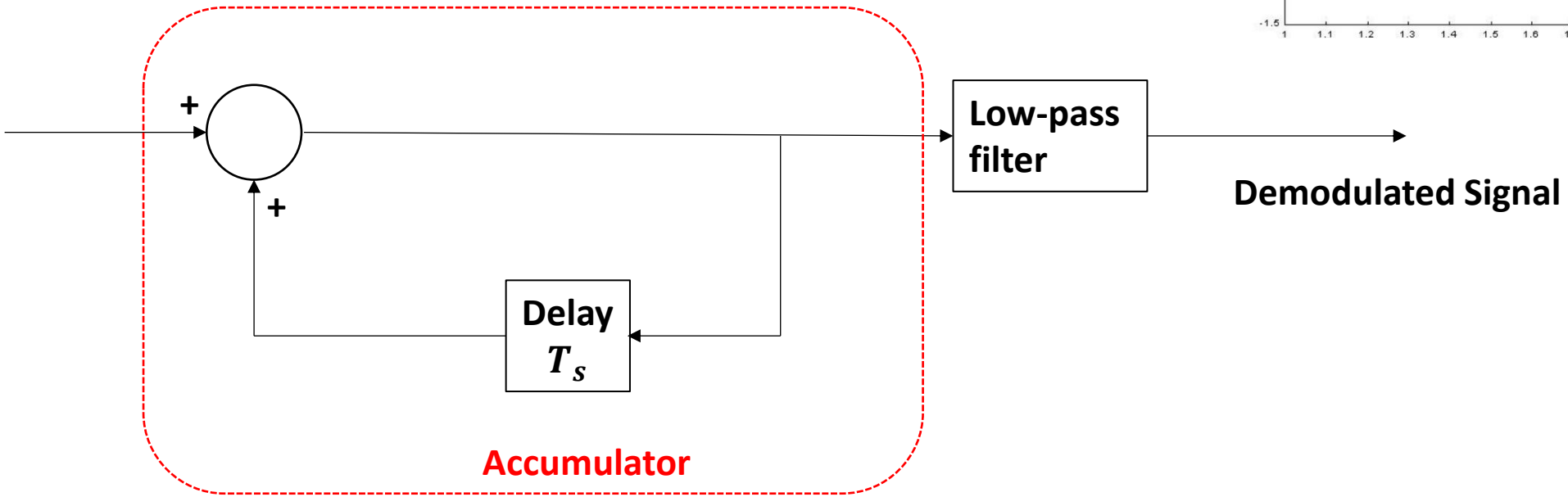


DELTA MODULATION TRANSMITTER



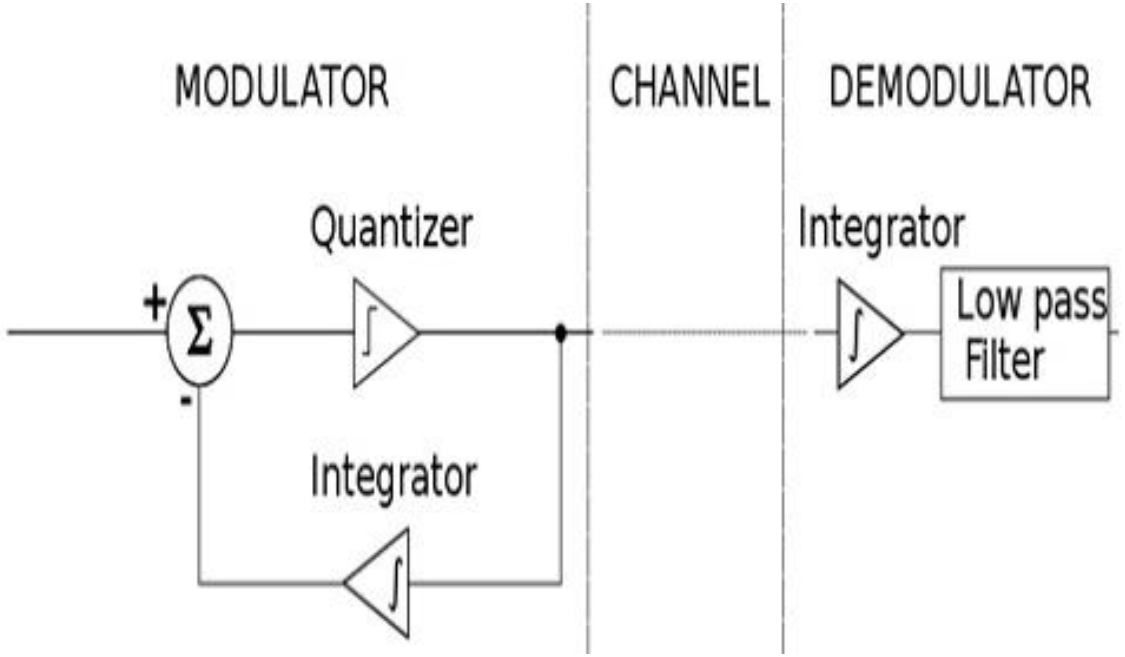
DELTA MODULATION RECEIVER





COMPLETE DELTA MODULATION COMMUNICATION SYSTEM

1. **Delta modulation** uses the over-sampling technique to achieve high signal-to-noise ratio.
2. **The transmitter** is composed of a Summer, Quantizer, Accumulator and an Encoder interconnected with each other.
3. **At the receiver,** demodulation is done using an integrator and a low pass filter.



ADVANTAGES OF DELTA MODULATION

Delta Modulation:

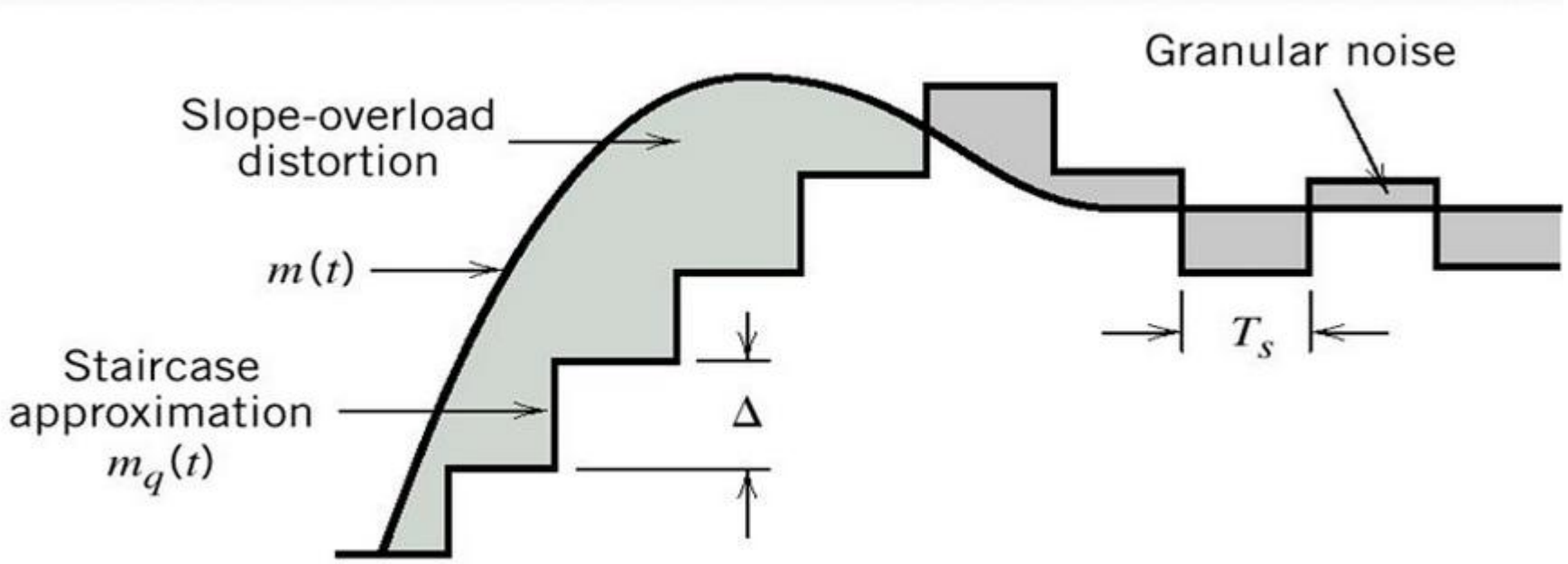
1. Requires very small bandwidth since it transmits only one bit per sample
2. Has very simple transmitter and receiver circuitry .

DISADVANTAGES OF DELTA MODULATION

Delta modulation has:

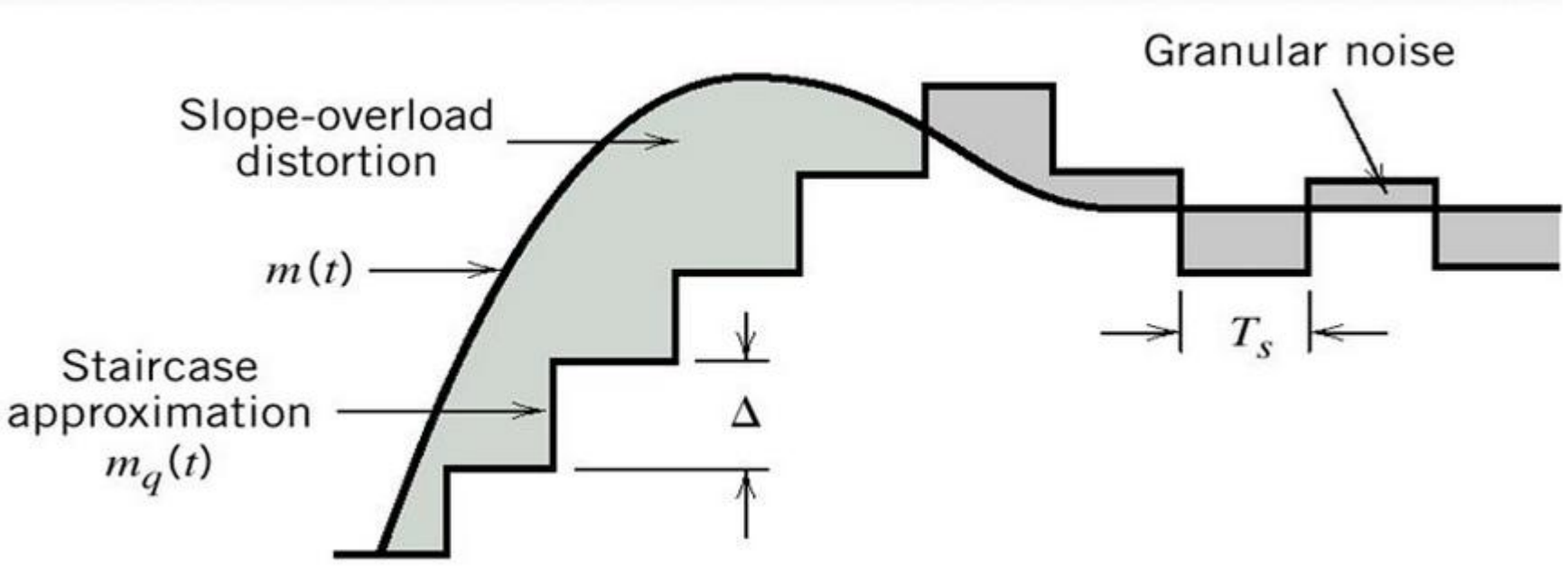
a) Slope and overload distortion

b) Granular and Idle noise



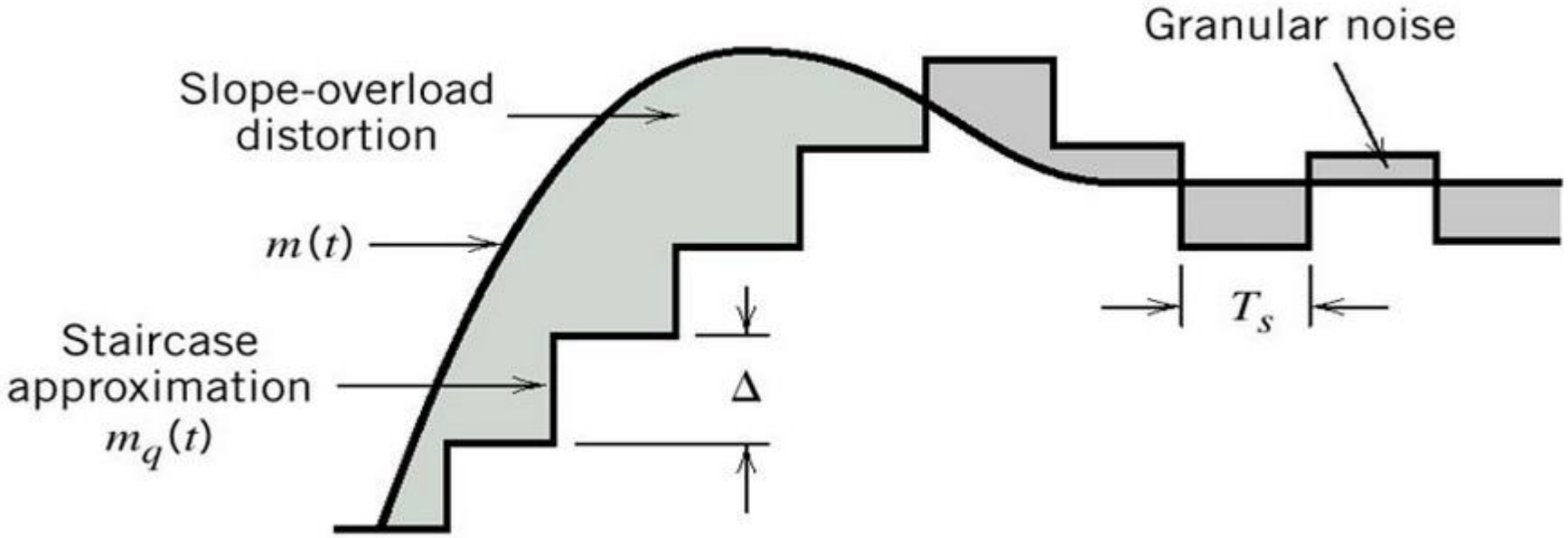
SLOPE OVERLOAD

- **Slope-overload** occurs when the step size is too small to follow a steep segment of the input waveform x(t).



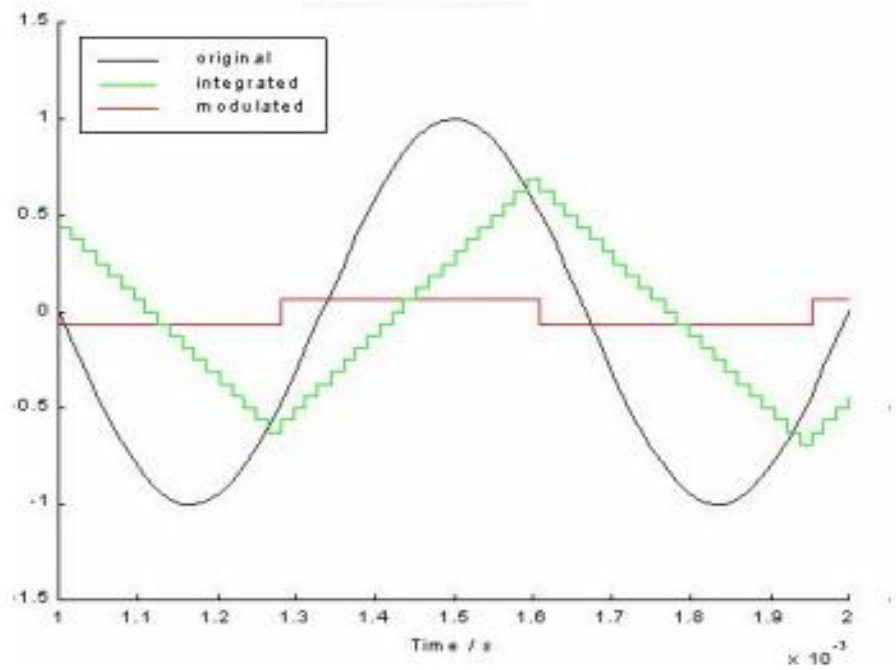
GRANULARITY

Granularity refers to a situation where the staircase function x(t) hunts around a relatively flat segment of the input function, with a step size that is too large relative to the local slope characteristic of the input.

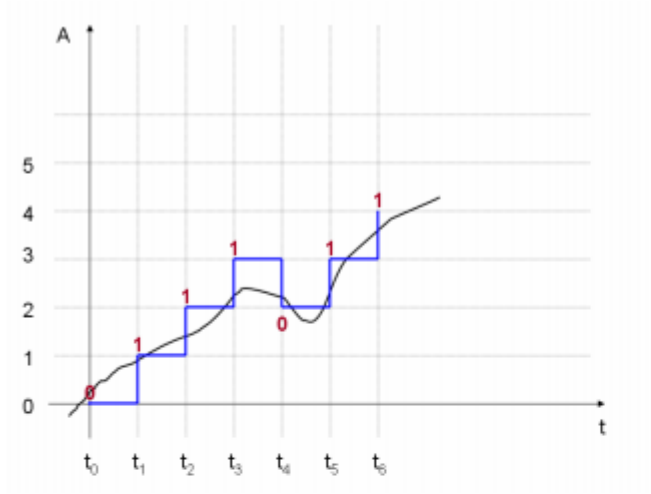


DELTA MODULATION PARAMETERS

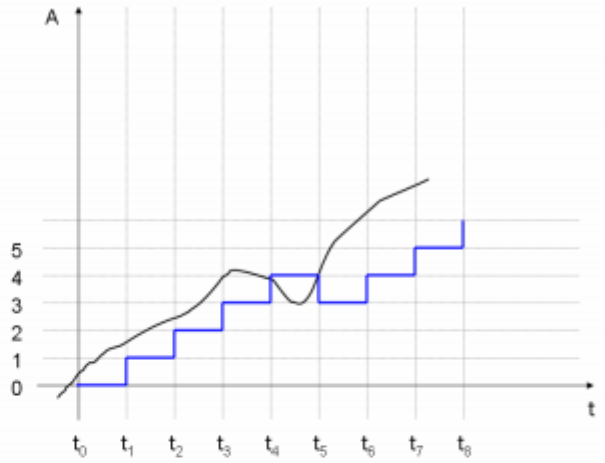
1. **Step Size (Δ):** (δ) – should not be too small, nor too large
   - small δ + signal changes rapidly ⇒ underestimation
   - large δ + signal changes slowly ⇒ overestimation
2. **Sampling Time (T):**
   - smaller T increase overall accuracy
   - but, small T increases output data rate, i.e. number of bps



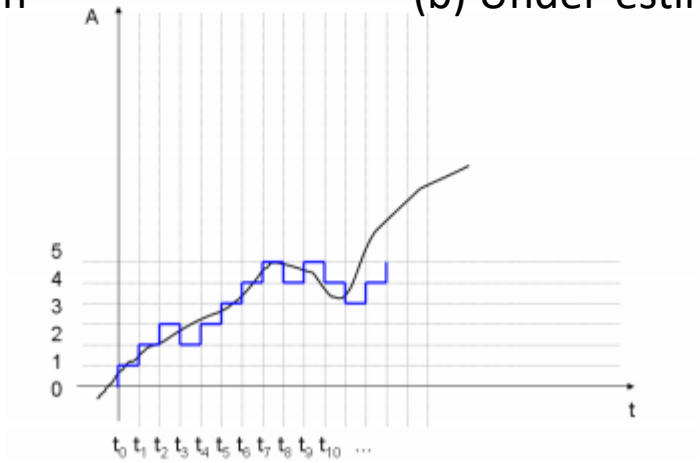
MINIMIZING STEP DISTORTION (VARYING Δ AND SAMPLING INTERVAL)



(a) Over-estimation

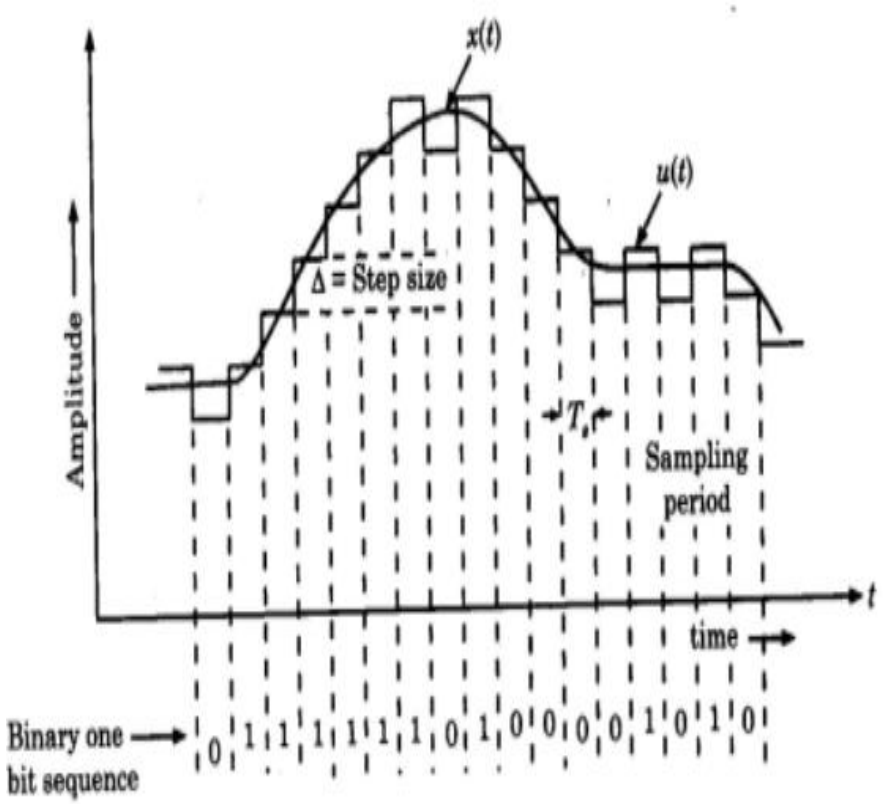


(b) Under-estimation



(c) Smaller sampling interval – more accurate

MINIMIZING STEP DISTORTION (THEORETICAL TREATMENT)



1. Consider a signal represented by a sinusoid:

$$x(t) = A_m \cos(2\pi f_m t)$$

2. The slope of the sinusoid is given by:

$$S(t) = \frac{d}{dt}\left(A_m cos(2\pi f_m t)\right) = -A_m 2\pi f_m sin(2\pi f_m t)$$

3. The maximum slope is therefore given by:

$$A_m 2\pi f_m$$

4. In order for there to be no slope distortion, we require that:

$$A_m 2\pi f_m \leq \frac{\Delta}{T_s} \qquad \text{or } A_m \leq \frac{\Delta}{2\pi f_m T_s}$$

EXAMPLE 1: DELTA MODULATION

A delta modulator is designed to operate at five times the Nyquist rate of a signal having 3 KHz bandwidth. Calculate the maximum amplitude of a 2 KHz input sinusoid for which there is no slope overload if the step size $\Delta = 250mV$

SOLUTION

Slope overload distortion occurs when

$$A_m \leq \frac{\Delta}{2\pi f_m T_s}$$

Substituting:

The maximum frequency f_m = 3KHz

Nyquist rate = $2f_m$ = 6 KHz

Sampling frequency is five times the Nyquist rate, i.e 5 x 6 = 30 KHz

$$T_s = \frac{1}{f_s} = \frac{1}{30 \times 10^3} = 3.333 \times 10^{-4}$$

Therefore

$$A_m \leq \frac{0.25}{2\pi \times 2 \times 10^3 \times 3.333 \times 10^{-4}} = 0.6V$$

ADAPTIVE DELTA MODULATION

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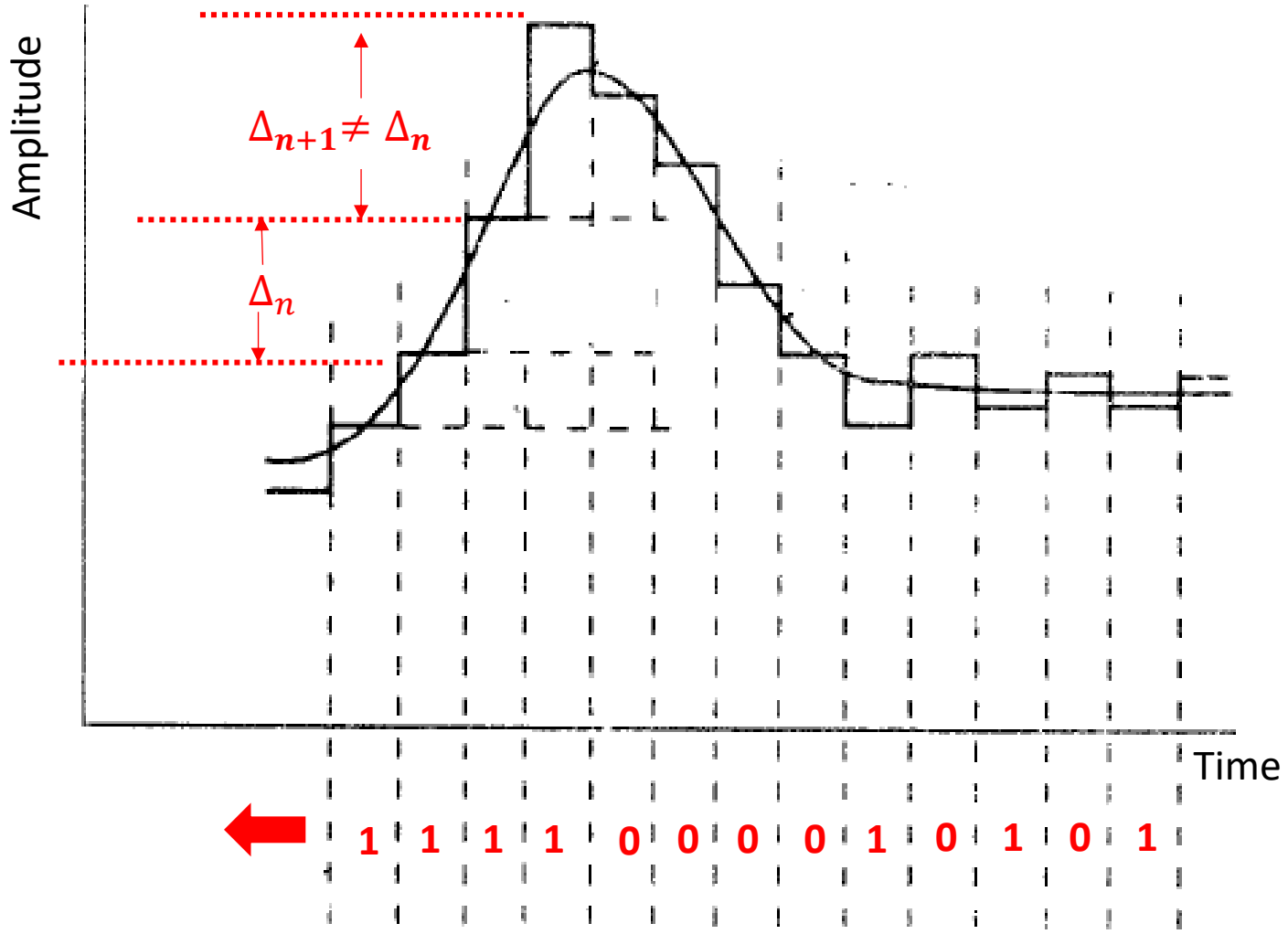
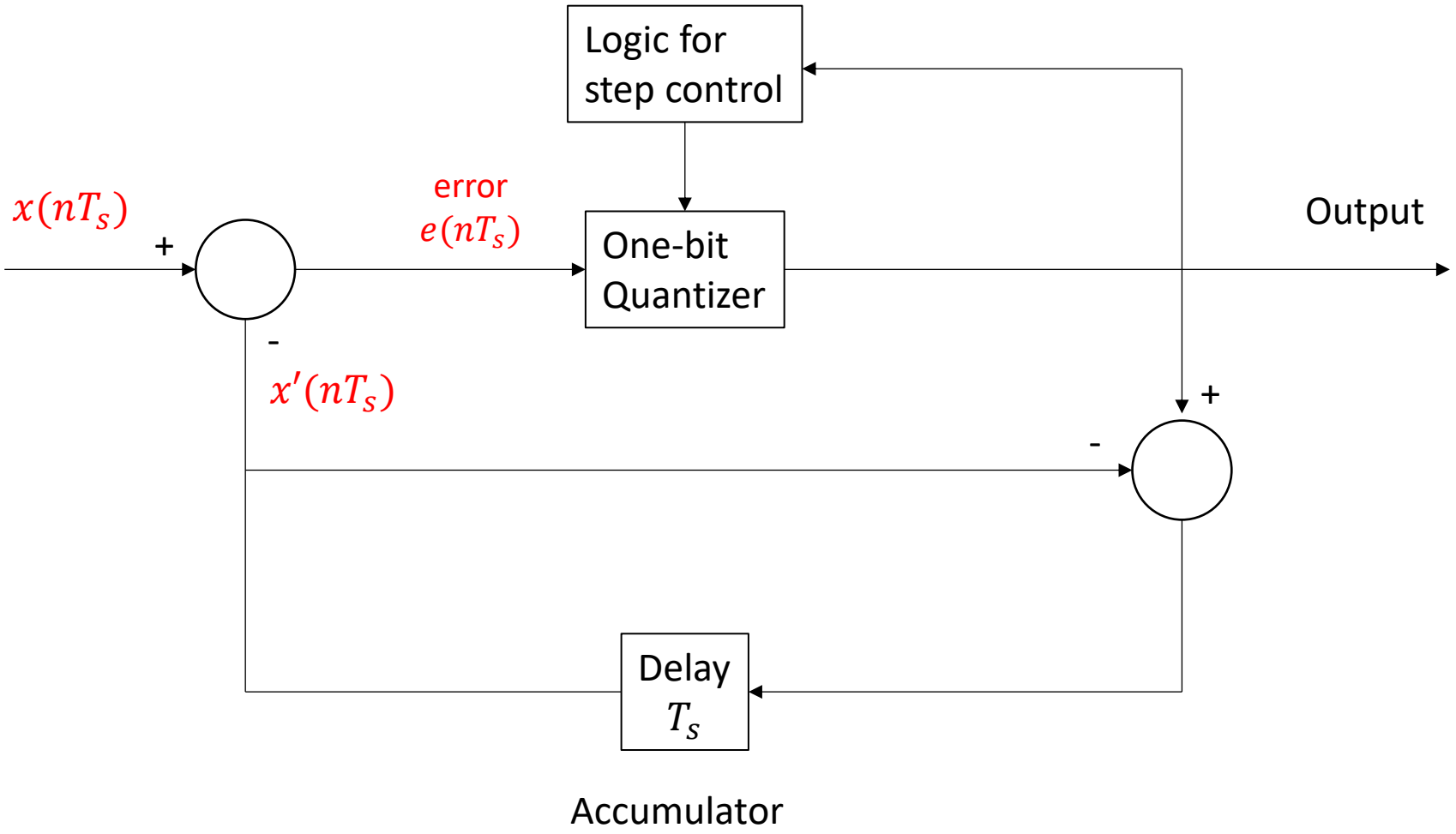
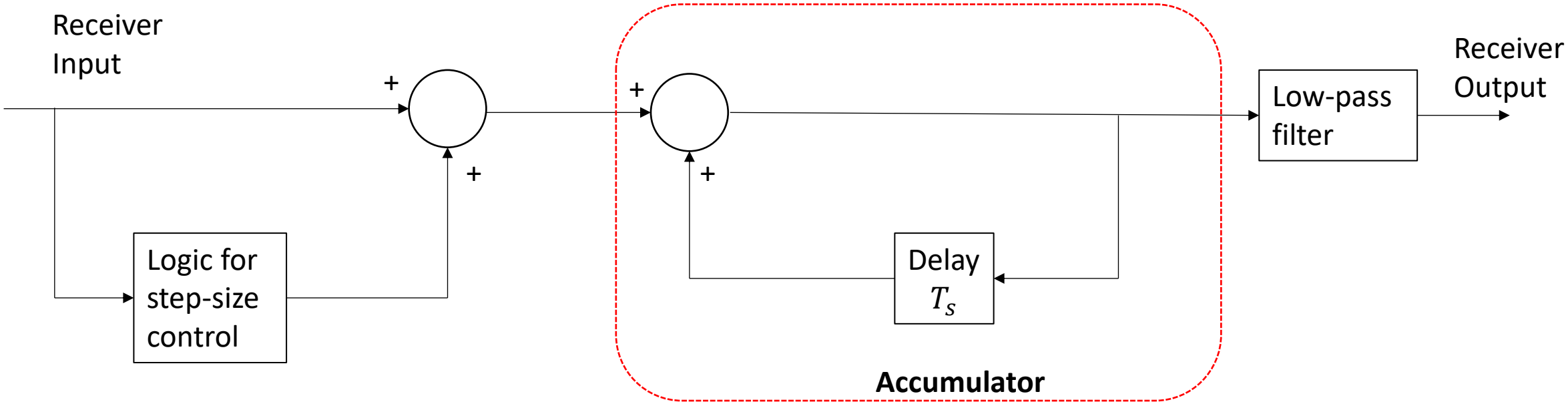
THE PRINCIPLE OF ADAPATIVE DELTA MODULATION

- **Adaptive Delta Modulation** seeks to overcome quantization errors arising from slope overload and granular noise by varying the step size in accordance to the signal amplitude.



ADAPTIVE DELTA MODULATION TRANSMITTER



ADAPTIVE DELTA MODULATION RECEIVER