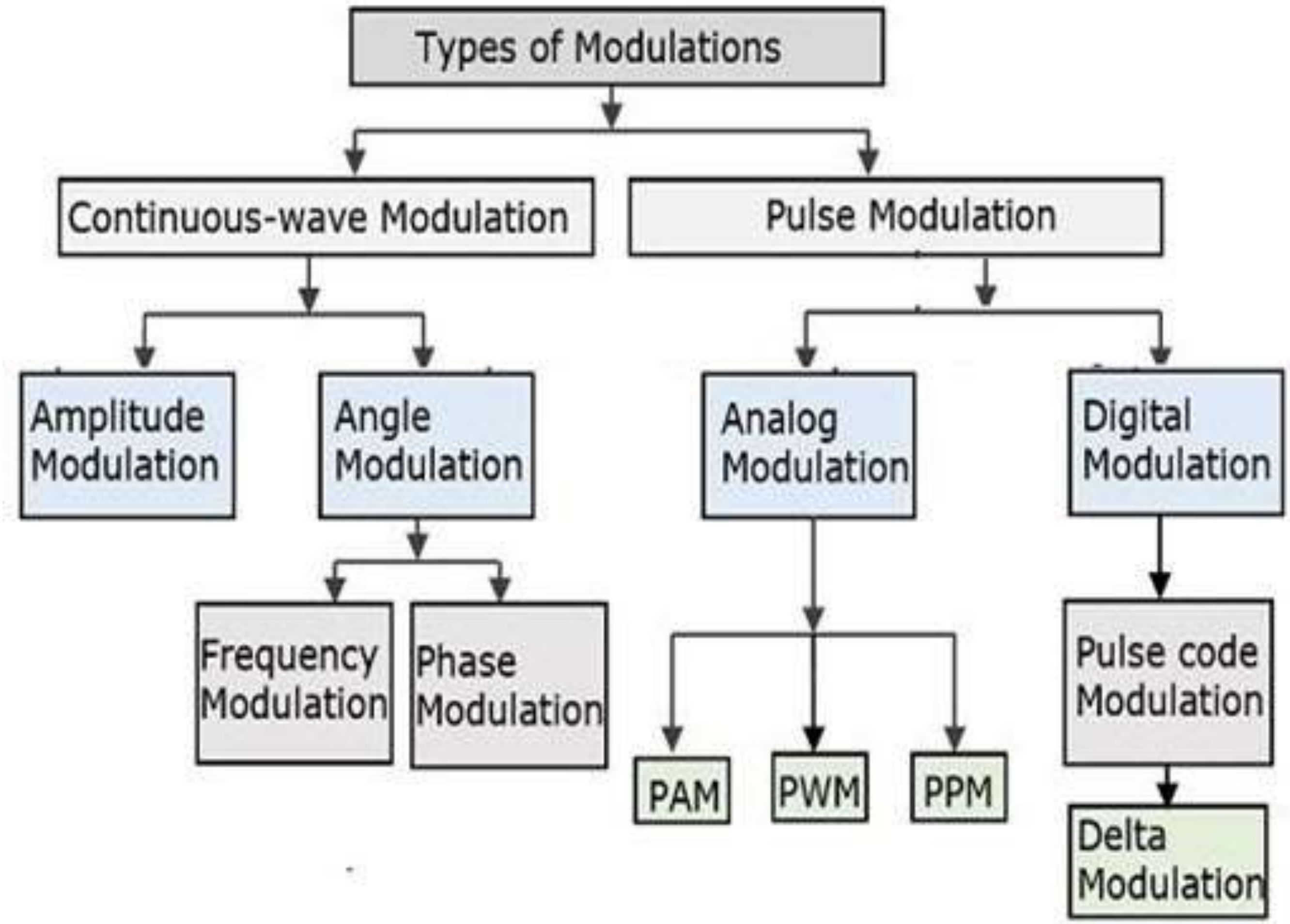
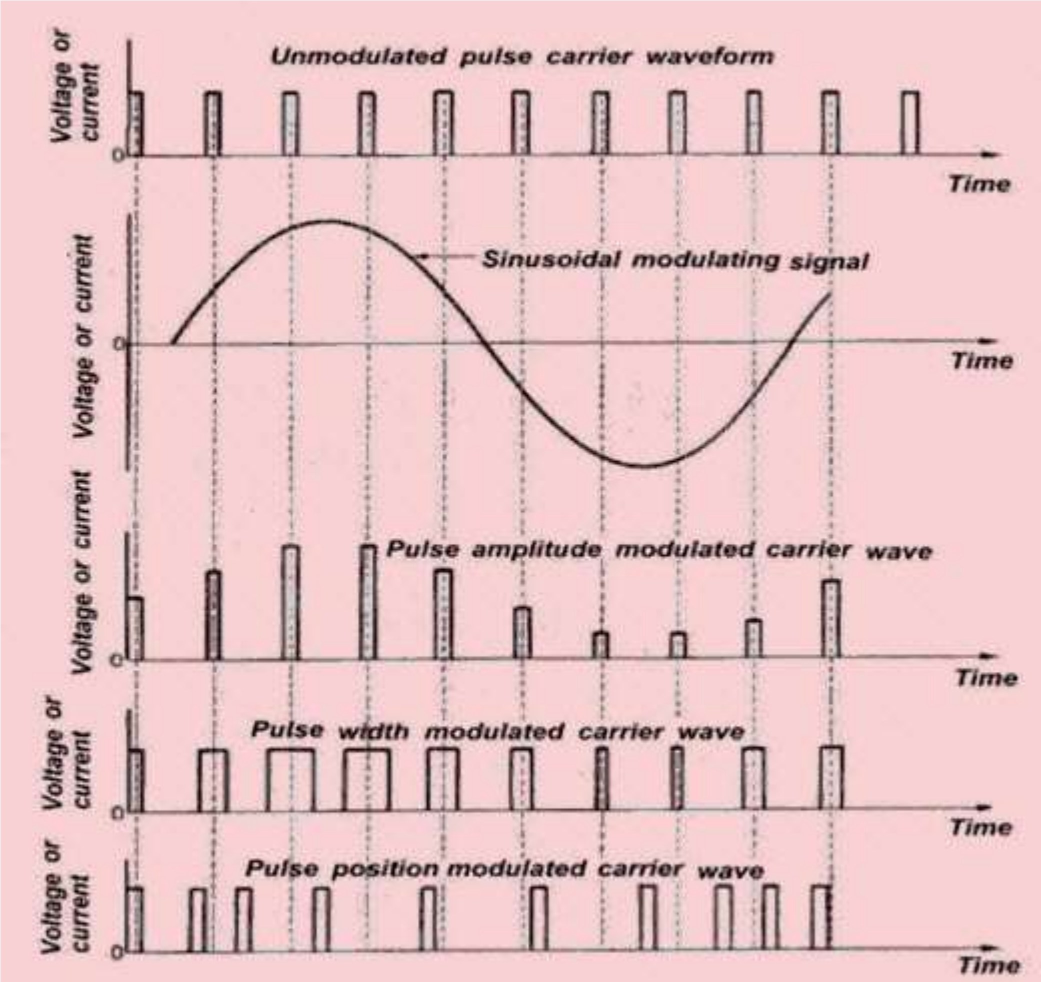
Modulation Techniques



Comparison of Pulse mofulation



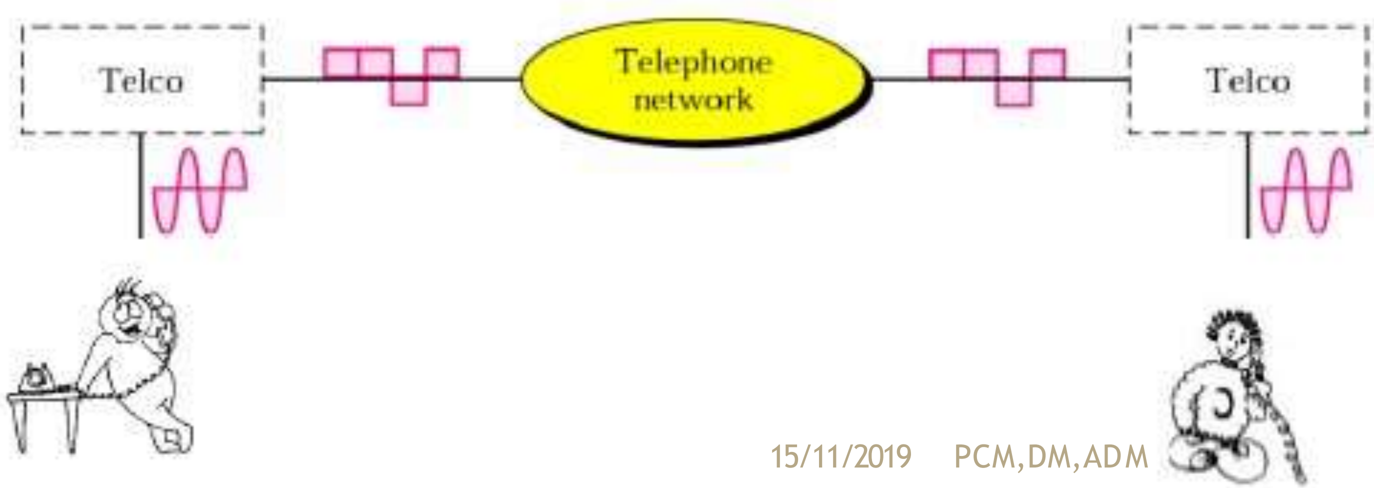
Comparison of Pulse mofulation

Sr. No.	Parameter	PAM	PWM	PPM
1	Type of Carrier	Train of Pulses	Train of Pulses	Train of Pulses
2	Variable Characteristic of the Pulsed Carrier	Amplitude	Width	Position
3	Bandwidth Requirement	Low	High	High
4	Noise Immunity	Low	High	High
5	Information Contained in	Amplitude Variations	Width Variations	Position Variations
6	Power efficiency (SNR)	Low	Moderate	High
7	Transmitted Power	Varies with an amplitude of pulses	Varies with variation in width	Remains Constant
8	Need to transmit synchronizing pulses	Not needed	Not needed	Necessary
9	Bandwidth depends on	Bandwidth depends on the width of the pulse	Bandwidth depends on the rise time of the pulse	Bandwidth depends on the rise time of the pulse
10	Transmitter power	Instantaneous transmitter power varies with the amplitude of the pulses	Instantaneous transmitter power varies with the amplitude and width of the pulses	Instantaneous transmitter power remains constant with the width of the pulses
11	The complexity of generation and detection	Complex	Easy	Complex
12	Similarity with other Modulation Systems	Similar to AM	Similar to FM	Similar to PM

Digital Transmission of Analog signal

Digitization – process of converting analog data into digital signal

- example: telephone system
  - human voice ↔ analog data ↔ analog signal ?!
  - analog signal is sensitive to noise, especially over long distance (cannot be perfectly reconstructed)
  - solution:
    (1) digitize the analog signal at the sender
    (2) transmit digital signal
    (3) convert digital signal back to analog data at the receiver



Application of pulse modulation

Application of Pulse Amplitude Modulation

- Ethernet Connectivity for Broadband interface communication
- To control signals in Micro-controllers
- Graphics card for high-speed networking and reduce the noise to signal ratio.
- In Photo Biology for the purpose of spectrofluorometric measurements during photosynthesis
- For energy-efficient lighting in LED drivers
- For better signal clarity and clearer picture in Digital Televisions

Application of PWM

- the PWM is commonly used to control the speed of electric motors, the brightness of lights, in ultrasonic cleaning applications, and many more.

- PWM (Pulse Width Modulation) is used to control electric power inside the motor coil. The output power is controlled by repeatedly turning the output ON and OFF. Constant voltage operates the motor with the constant period of the pulses. Used in IoT Drive buzzer with different loudness.
- Control speed of the motor.
- Control the direction of a servo.
- Provide an analog output.

Application of pulse modulation

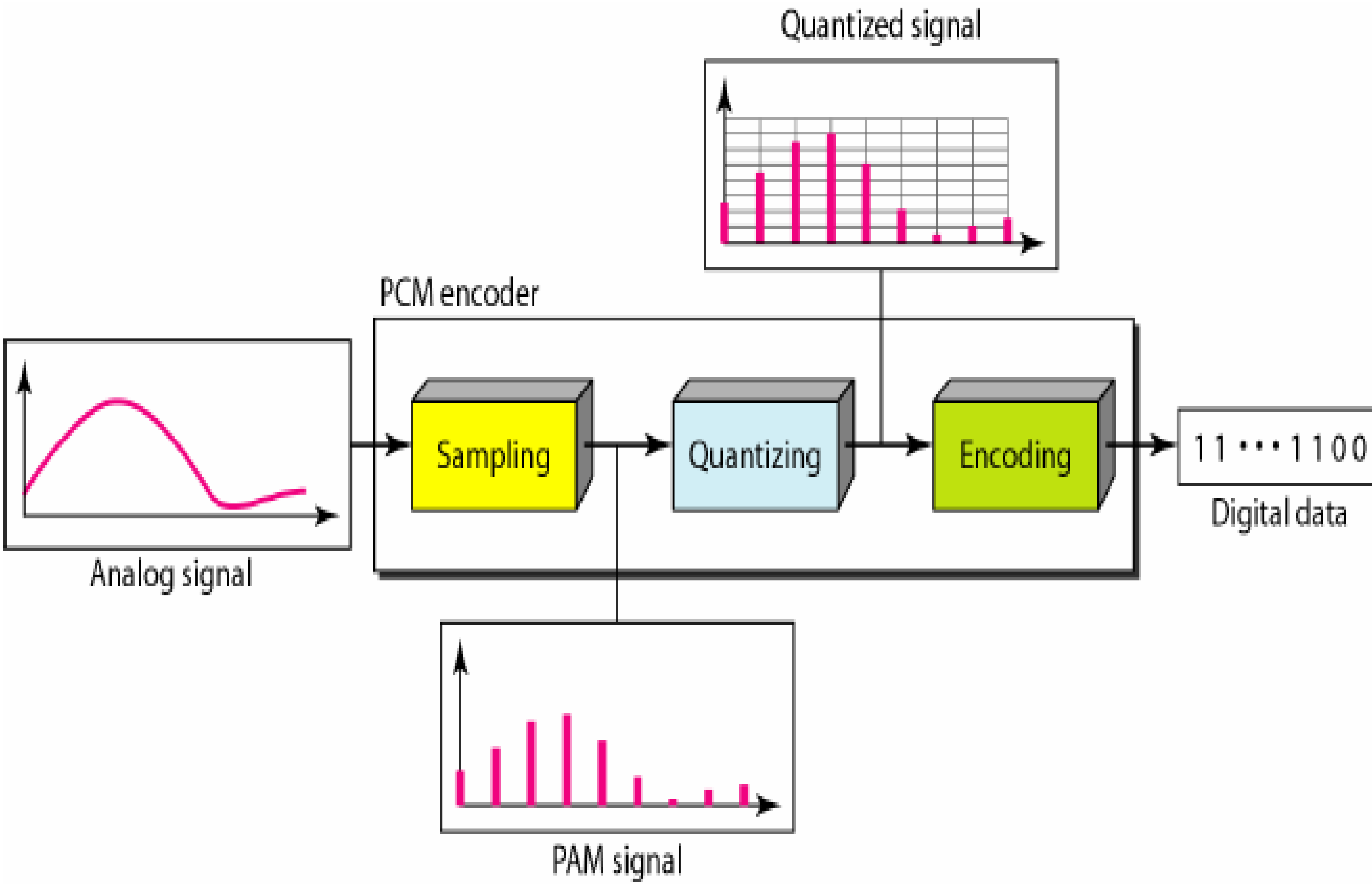
Applications of PPM:

•It is utilized in air traffic control and telecommunications networks.

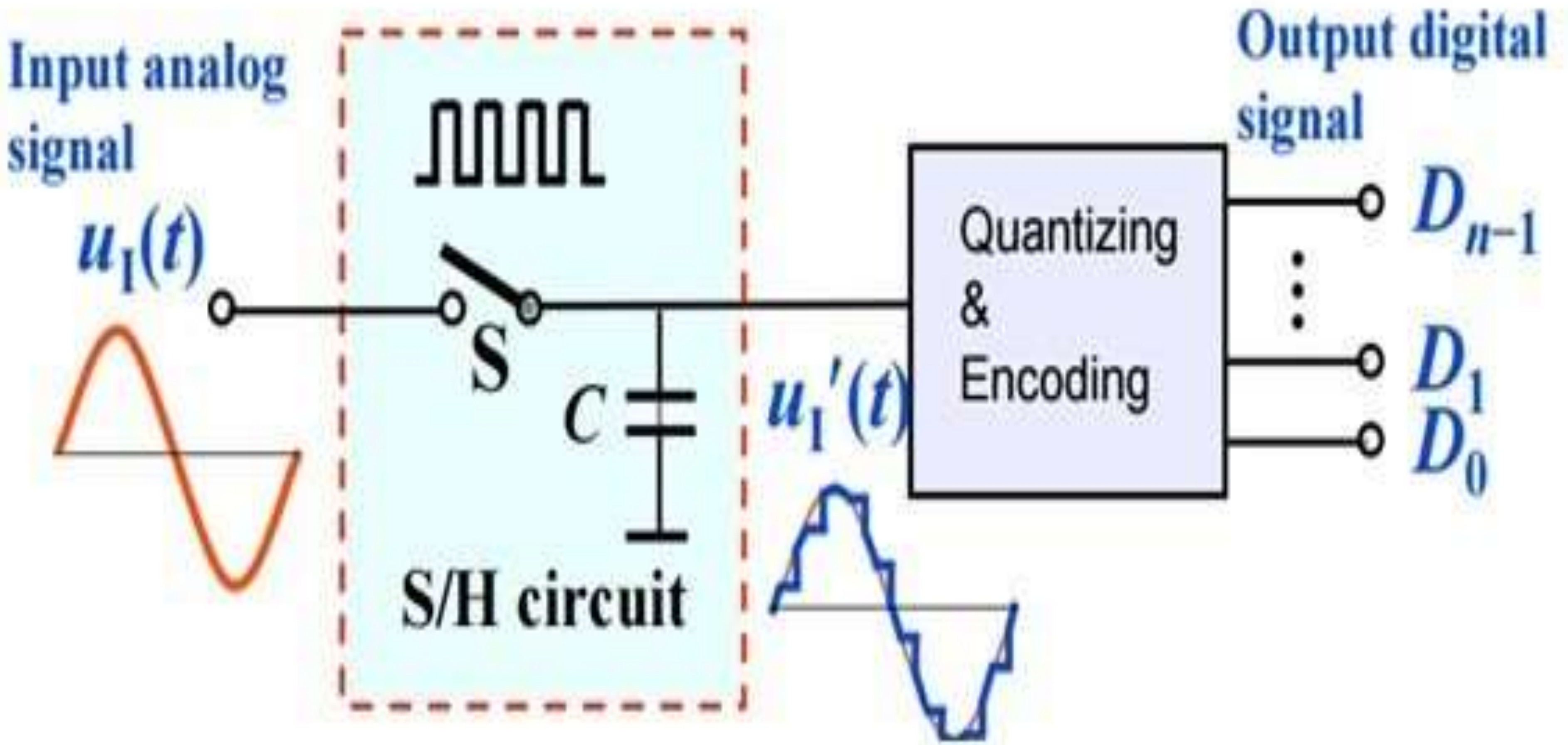
•Pulse code modulation is used in remote-operated autos, planes, and trains.

•It is used to compress data and, therefore, for storage.

Digital Transmission of Analog signal



Digital Transmission of Analog signal

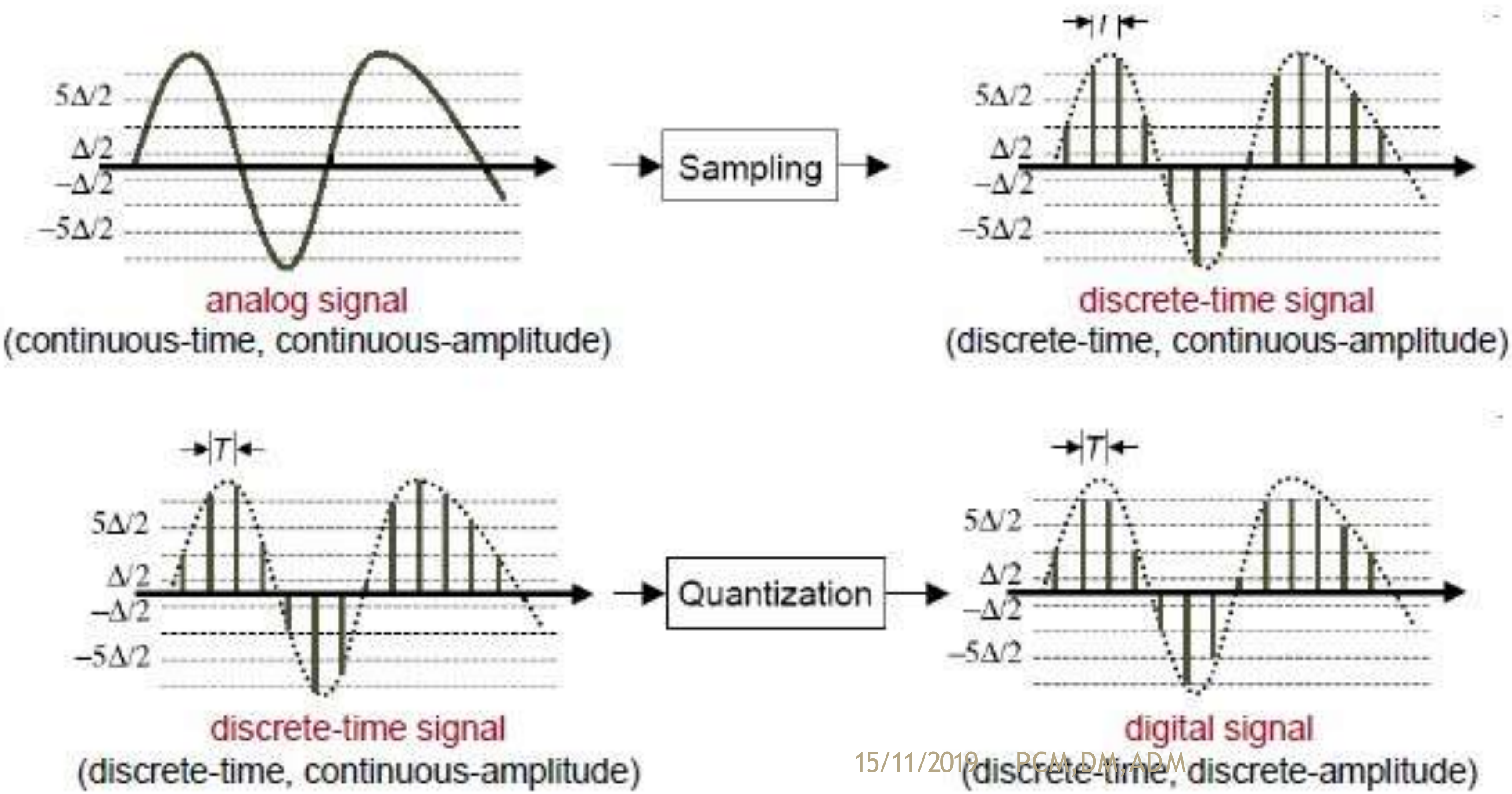


Digitization

Digitization Procedure – aka Pluse Code Modulation (PCM), consists of 2 steps

(1) **sampling** – obtain signal values at equal intervals (T)

(2) **quantization** – approximate samples to certain values



Pulse Code Modulation (PCM)

- Analog voice data must be translated into a series of binary digits before they can be transmitted.
- With <u>Pulse Code Modulation (PCM)</u>, the amplitude of the sound wave is sampled at regular intervals and translated into a binary number.
- The difference between the original analog signal and the translated digital signal is called <u>quantizing error</u>.

Pulse Code Modulation (PCM)

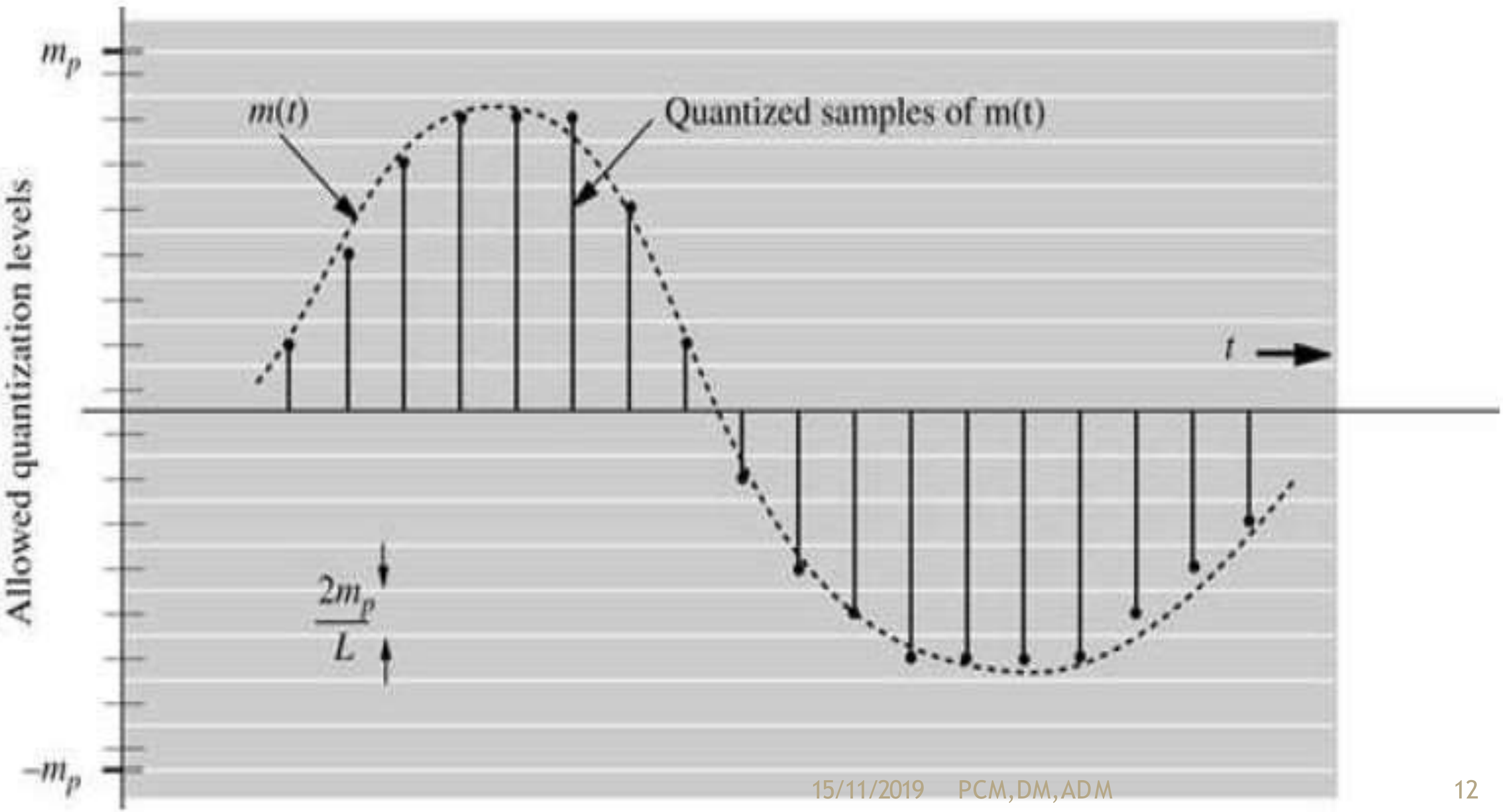
- PCM uses a sampling rate of 8000 samples per second.

- Each sample is an 8 bit sample resulting in a digital rate of 64,000 bps (8 x 8000).

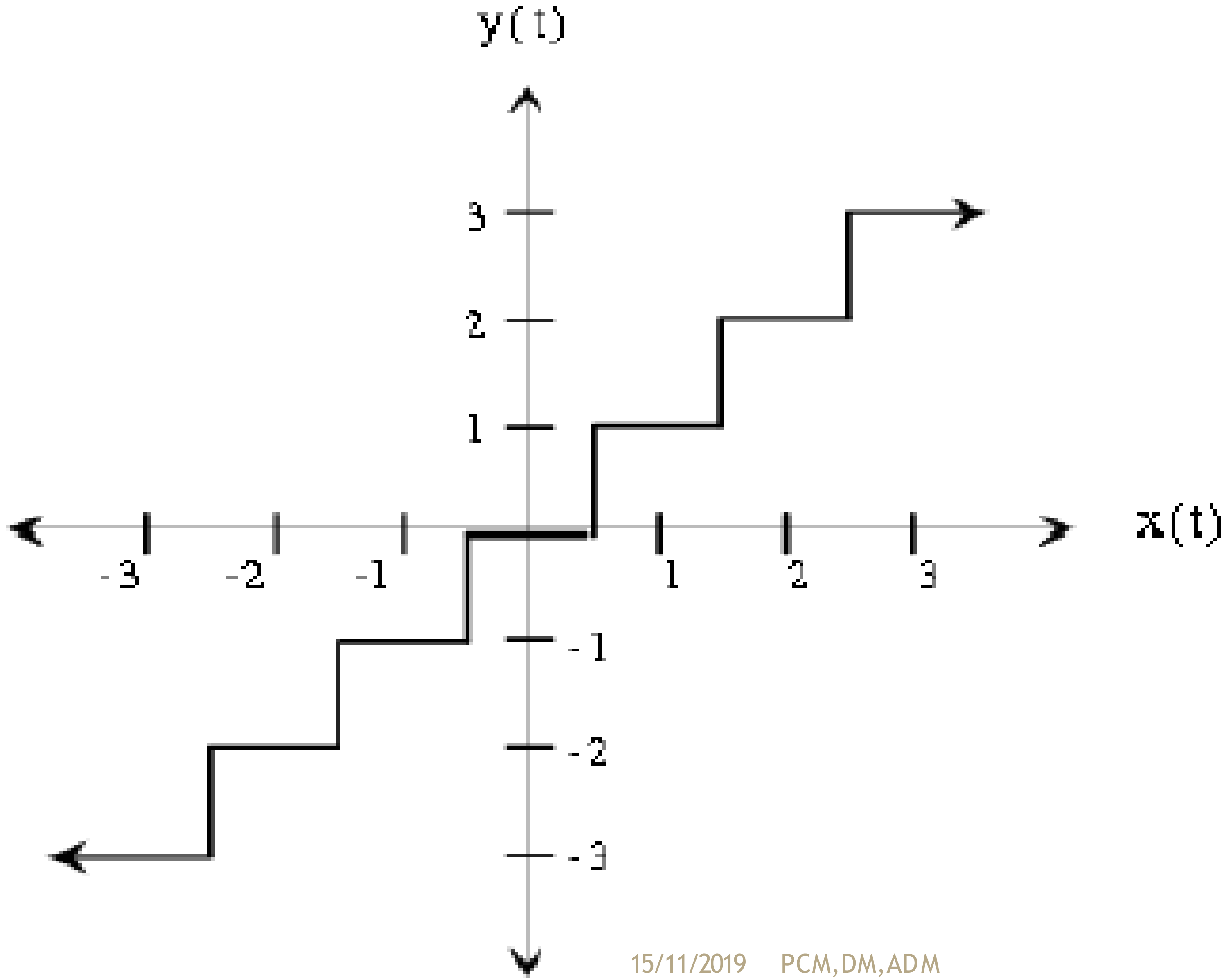
Quantization

Quantization of a signal produces the closest representable value.

For fixed number of values, spacing between values increases with range.



Uniform Quantization



Quantization

- The process of measuring the numerical values of the samples and giving them a table value in a suitable scale.

- The finite number of amplitude intervals is called the 'quantizing interval' like quantizing interval no.1 is 10-20mV; 2 is 20-30mV etc. in a case of 1V signal.

- Linear quantizing is where the quantizing intervals are of the same size

Quantization

- Quantization intervals are coded in binary form, and so the quantization intervals will be in powers of 2.

- In PCM, 8 bit code is used and so we have 256 intervals for quantizing (128 levels in the positive direction and 128 levels in negative direction)

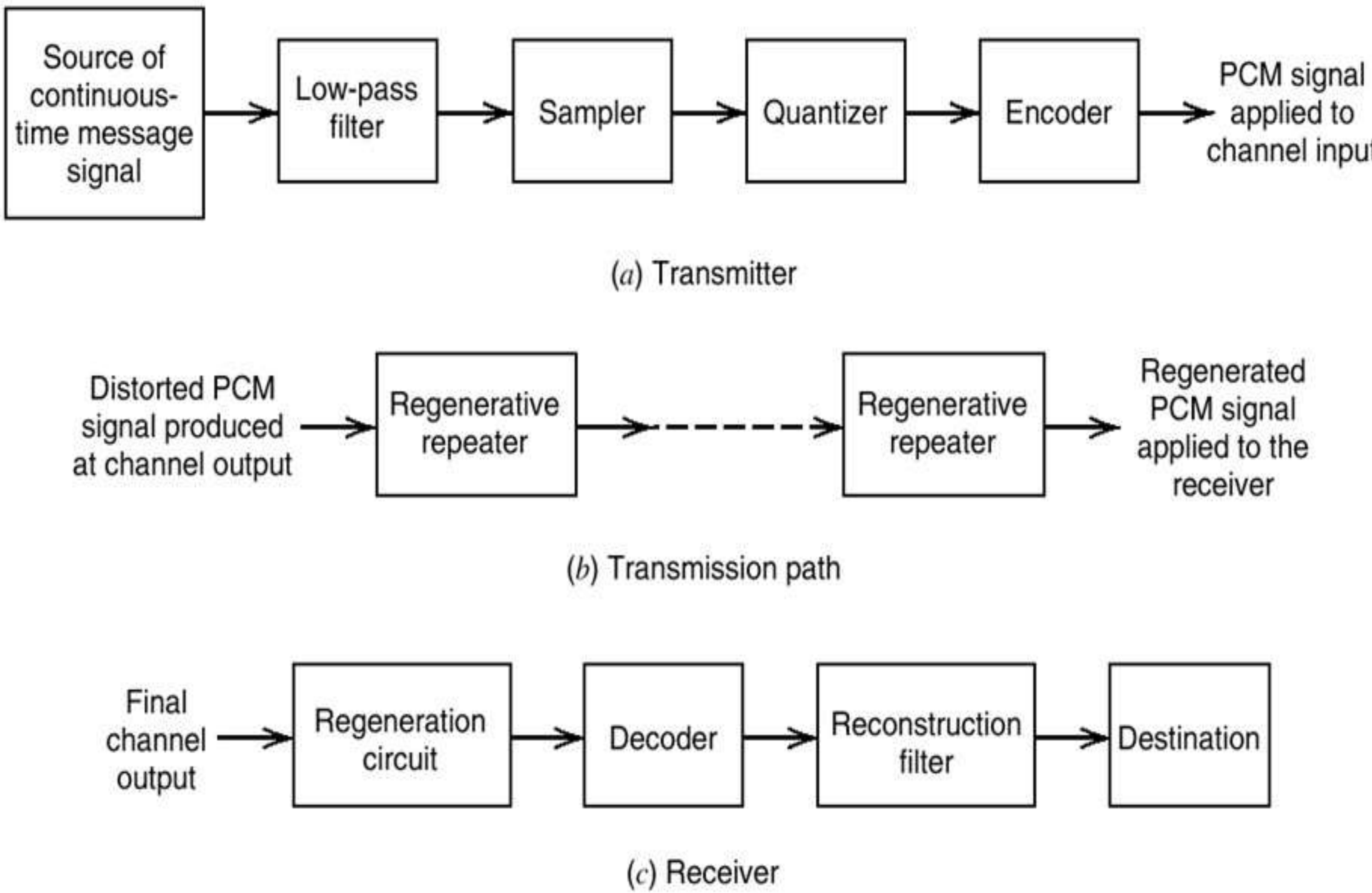
Quantization Error

- The deviation between the amplitude of samples at the transmitter and receiving ends.

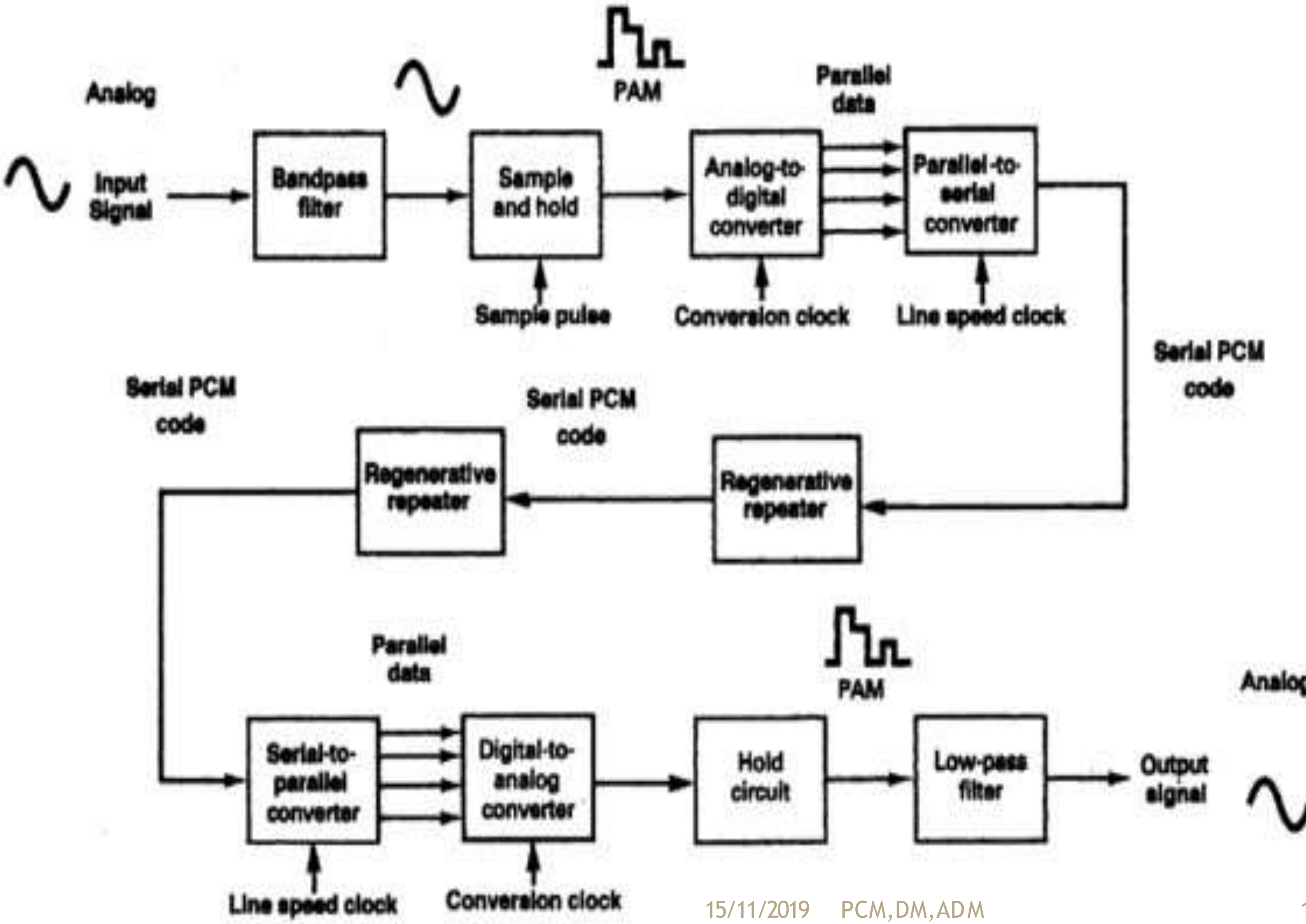
- In linear quantization, the distortion is more and to decrease the distortion, the no. of steps in the given amplitude range has to be increased.

- Due to BW limitations, more quantum levels in small amplitude region are planned results to, Non linear (uniform) quantization

PCM Transmission System



PCM Transmission System



Companding

- Is the process where non uniform quantization is achieved using segmented quantization.

- Companding is the process of compressing and them expanding.

- With companded systems, the higher-amplitude analog signals are compressed (amplified less than the lower-amplitude signals) prior to transmission.

Companding

- Non-uniform quantizers are difficult to make and expensive.
- An alternative is to first pass the speech signal through a nonlinearity before quantizing with a uniform quantizers.
- The nonlinearity causes the signal amplitude to be **Compressed.**
  - The input to the quantizers will have a more uniform distribution.

Companding

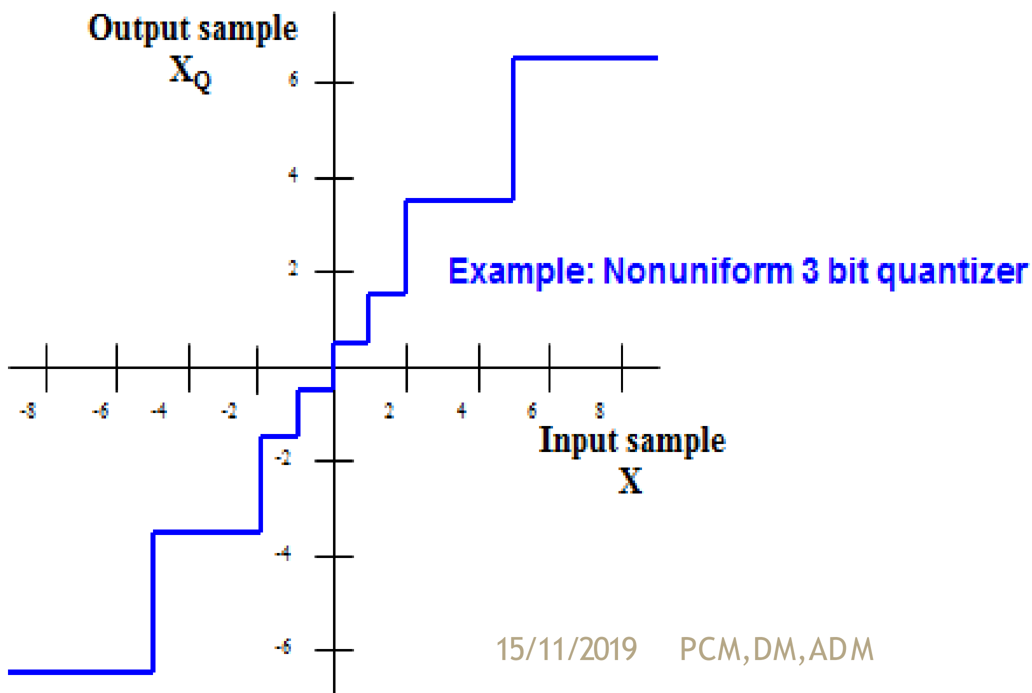
- At the receiver, the signal is **Expanded** by an inverse to the nonlinearity.

- The process of compressing and expanding is called **Companding.**

Companding

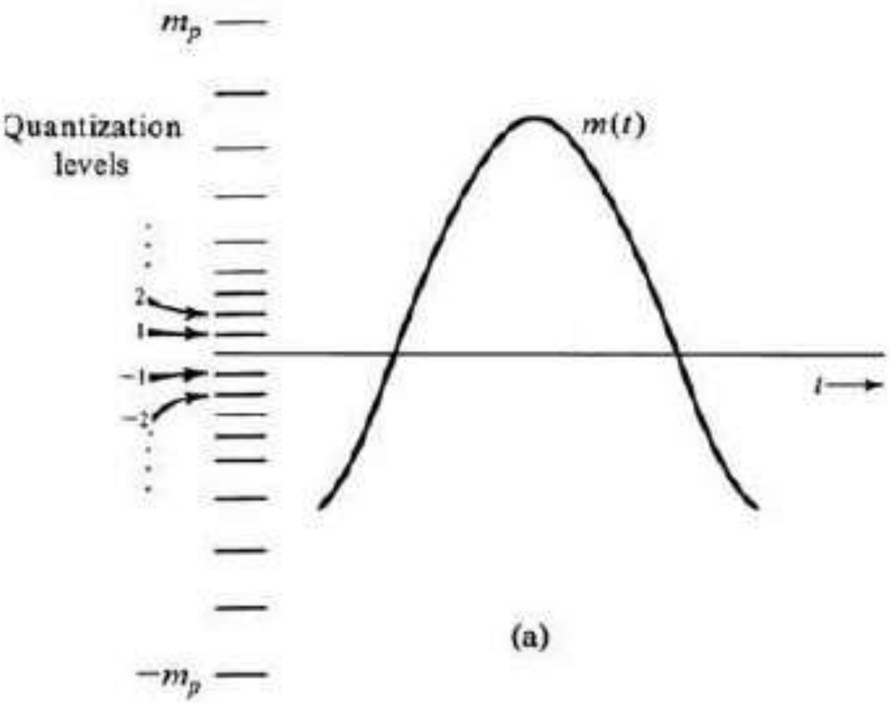
- It is then expanded (amplified more than the lower-amplitude signals) in the receiver.

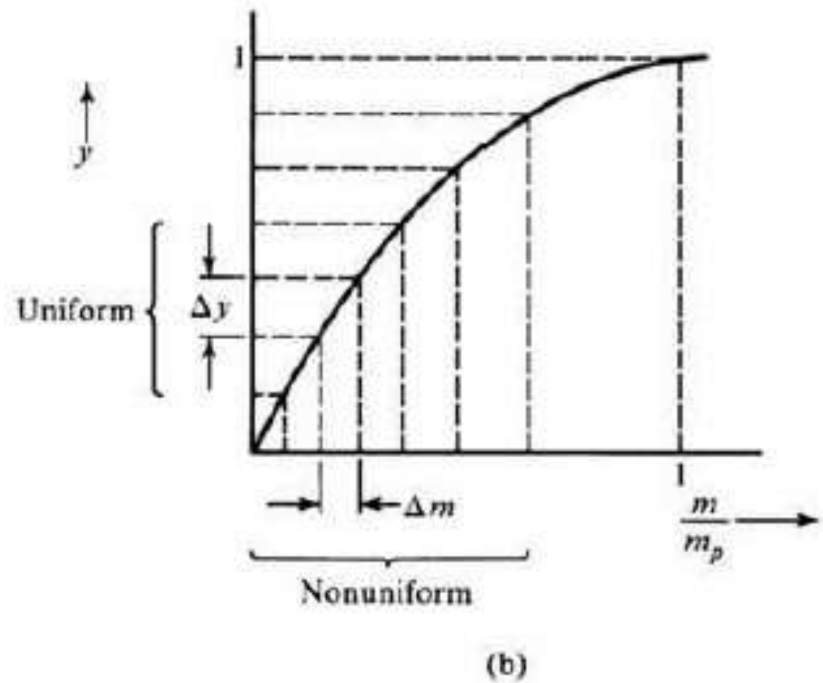
- Companding is the means of improving the dynamic range of communications system.



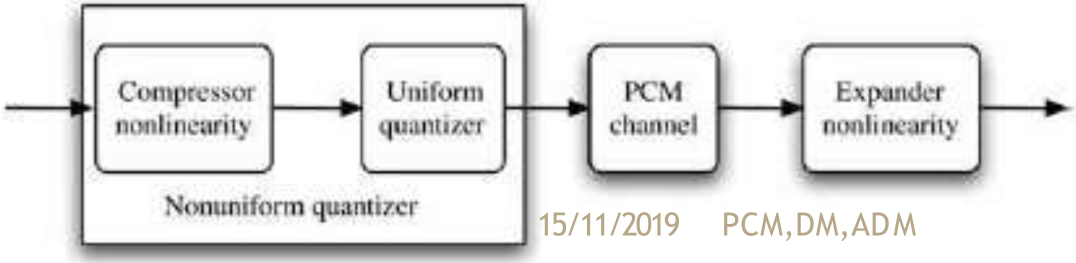
Non-Uniform Quantization

Nonuniform quantizers increase quantization intervals as magnitude of value. Interval proportional to value implies logarithmic curve.





An analog compressor (semiconductor diode) can be used.



Non-Uniform Quantization

Telephone systems use ITU standardized compression formula.

- μ-law: North America and Japan. For $\mu = 255$ (for 8-bit codes),

$$y = \mathrm{sgn}(x)\frac{1}{\ln(1+\mu)}\ln\left(1+|x|\right), \quad (0 < x < 1)$$

- A-law: Europe, rest of world.

$$y = \begin{cases} \mathrm{sgn}(x)\dfrac{A|x|}{1+\ln(A)} & |x| < \dfrac{1}{A} \\ \mathrm{sgn}(x)\dfrac{1+\ln(A|x|)}{1+\ln(A)} & \dfrac{1}{A} < |x| < 1 \end{cases}$$

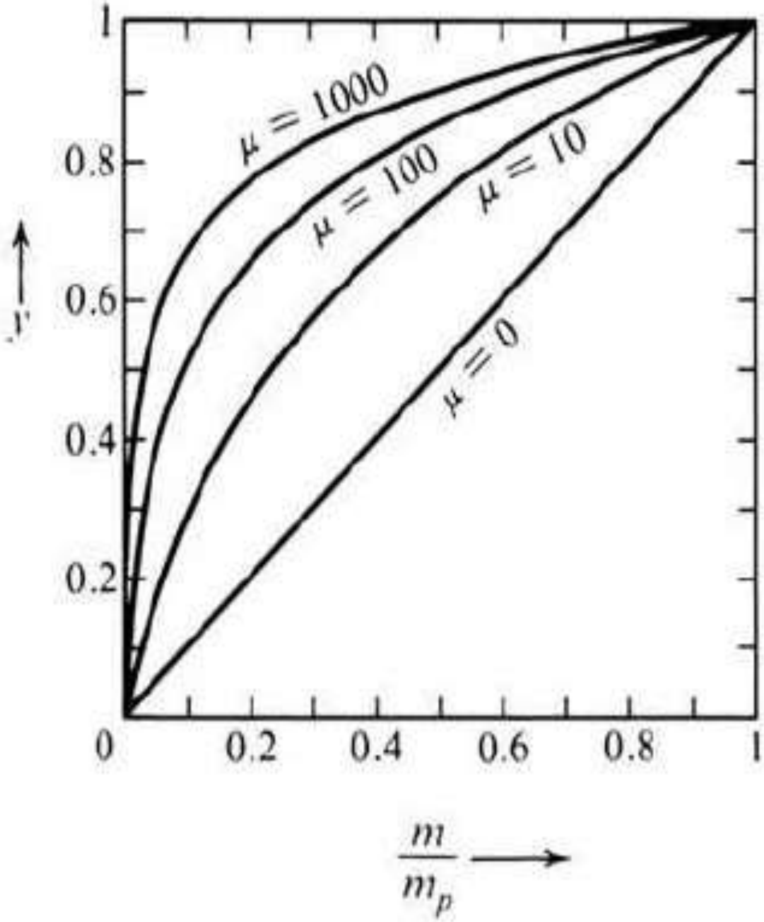
The standard value is $A = 87.7$.

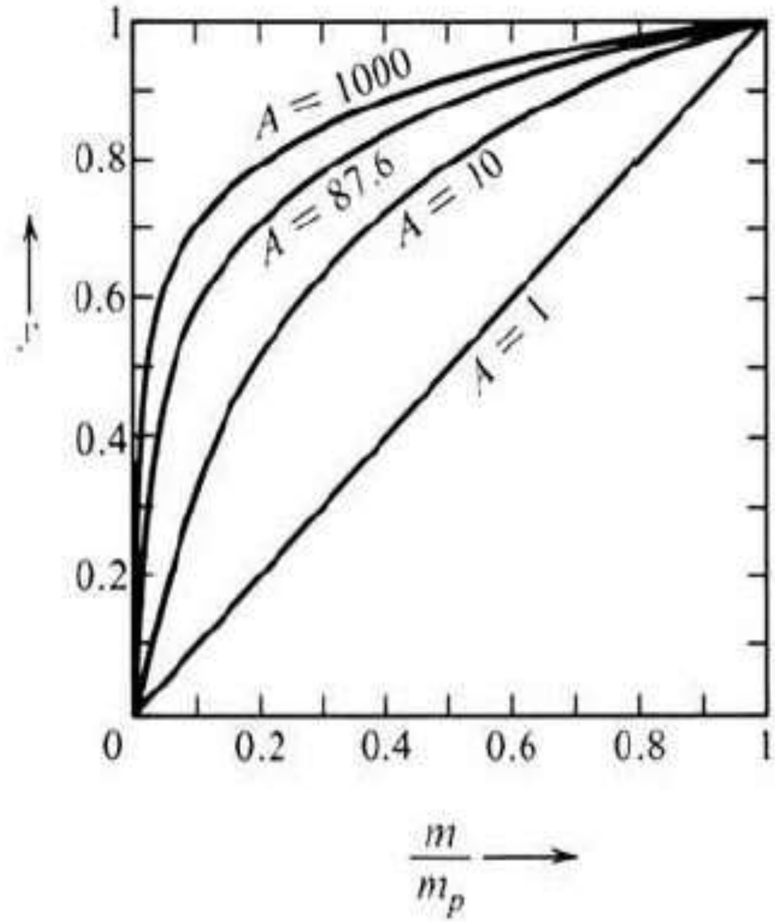
For both laws, the input to the compressor is

$$x = \frac{m(t)}{m_p}$$

where $-m_p \leq m(t) \leq m_p$.

μ-Law and A-Law Companding





- μ-law provides slightly larger dynamic range than A-law.
- A-law has smaller proportional distortion for small signals.
- A-law is used for international connections if at least one country uses it.

	Digital Modulation	Pulse Modulation
Modulating signal	Digital data (any number of bits)	Pulses provide modulation
Modulated signal	Continuously-varying analog signal	Continuous analog signal
Methods	PSK, FSK, ASK, OOK, QAM, CPM, OFDM, Trellis modulation	PCM, delta, delta-sigma, PDM
Applications	Wireless, fiber, high-speed networking, sensors	Telephone, audio, power electronics