COMPANDING

EEEN 464 – DIGITAL COMMUNICATION

Friday, 06 February 2026

COMPANDING DIGITAL AUDIO SIGNALS

- The data rate is important in telecommunication because it is directly proportional to the cost of transmitting the signal.

- Companding is a common technique for reducing the data rate of audio signals by making the quantization levels unequal.

BASIS FOR COMPANDING

- The loudest sound that can be tolerated (120 dB SPL) is about one-million times the amplitude of the weakest sound that can be detected (0 dB SPL).
- The ear cannot distinguish between sounds that are closer than about 1 dB apart.
- If the quantization levels are equally spaced, 12 bits must be used to obtain telephone quality speech.
- However, only 8 bits are required if the quantization levels are made unequal, matching the characteristics of human hearing.

THREE METHODS OF COMPANDING

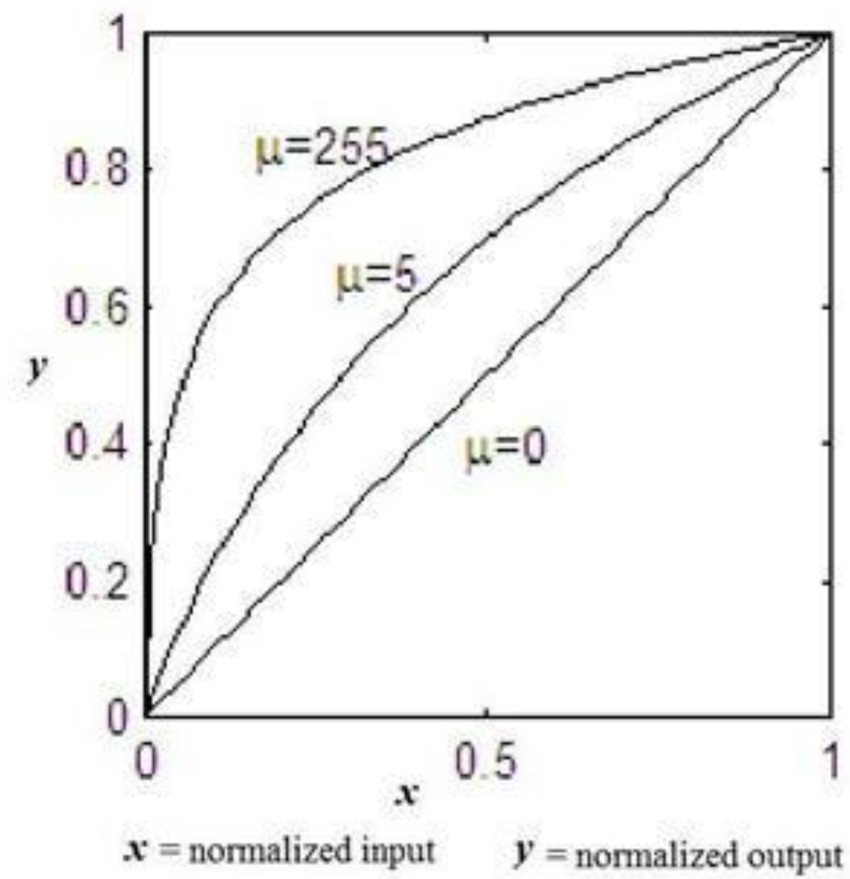
1. Run the analog signal through a nonlinear circuit before reaching a linear 8 bit ADC,
2. Use an 8 bit ADC that internally has unequally spaced steps, or
3. Use a linear 12 bit ADC followed by a digital look-up table (12 bits in, 8 bits out).

- Each of these three options requires the same nonlinearity, just in a different place: an analog circuit, an ADC, or a digital circuit.

COMPANDING STANDARDS

(1) μ255 law (also called mu law), used in North America

(2) "A" law, used in Europe.



"A" LAW

$$F(x) = \operatorname{sgn}(x) \begin{cases} \dfrac{A|x|}{1+\ln(A)}, & |x| < \dfrac{1}{A} \\ \dfrac{1+\ln(A|x|)}{1+\ln(A)}, & \dfrac{1}{A} \leq |x| \leq 1, \end{cases}$$

Where A is the compression parameter 87.7.

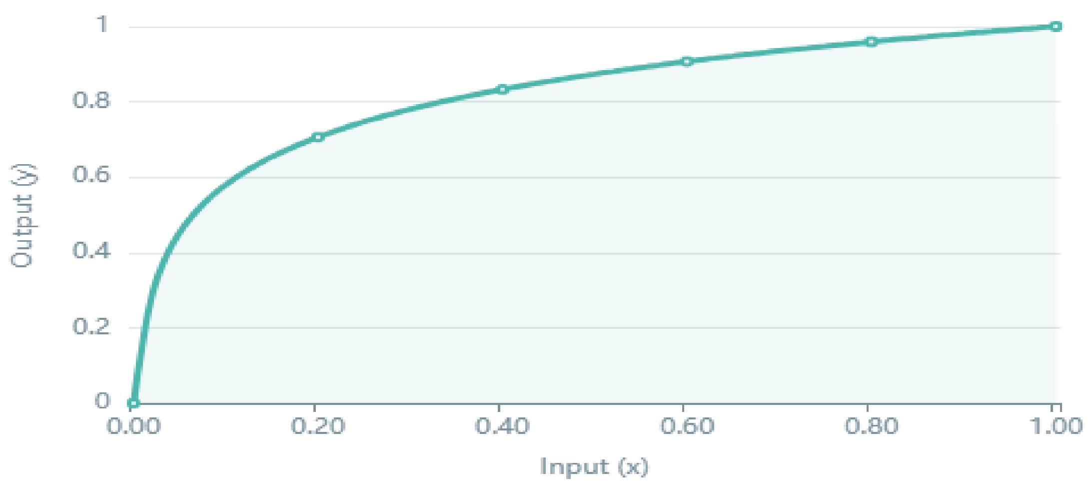
$$F^{-1}(y) = \operatorname{sgn}(y) \begin{cases} \dfrac{|y|(1+\ln(A))}{A}, & |y| < \dfrac{1}{1+\ln(A)} \\ \dfrac{\exp(|y|(1+\ln(A))-1)}{A}, & \dfrac{1}{1+\ln(A)} \leq |y| < 1. \end{cases}$$

μ-LAW

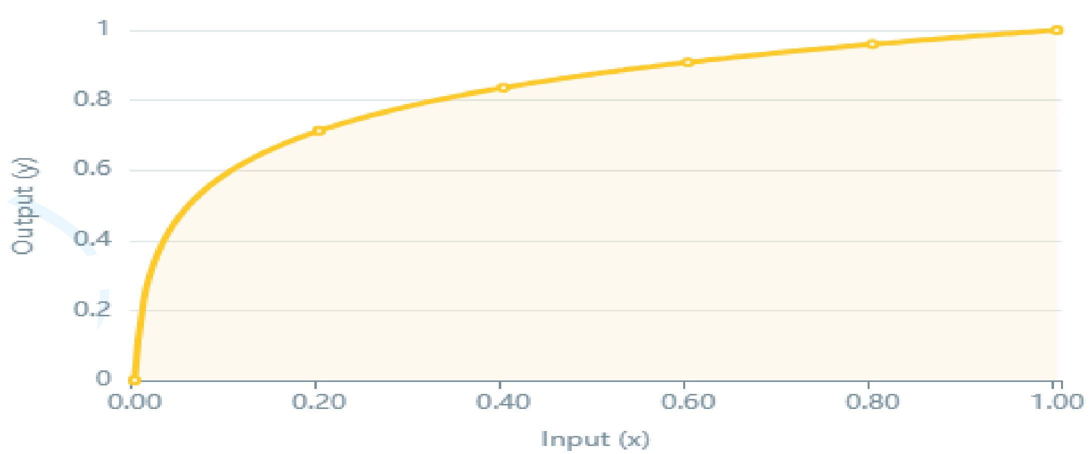
$$F(x) = \text{sgn}(x)\frac{\ln(1+\mu|x|)}{\ln(1+\mu)} \qquad -1 \le x \le 1,$$

where μ is 255 for 8 bits.

$$F^{-1}(y) = \text{sgn}(y)(1/\mu)((1+\mu)^{|y|} - 1) \qquad -1 \le y \le 1$$


1
0.8
0.6
0.4
0.2
0
Output (y)
0.00
0.20
0.40
0.60
0.80
1.00
Input (x)

"A" LAW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