

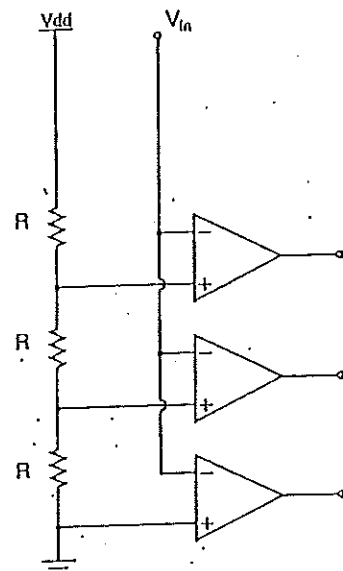
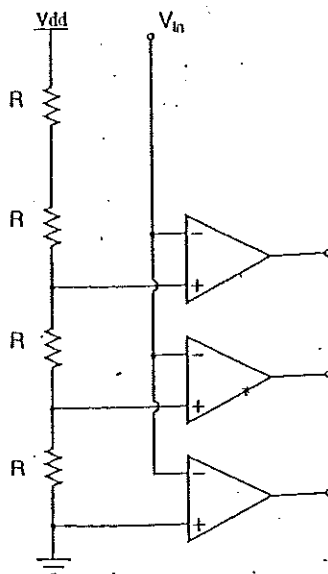
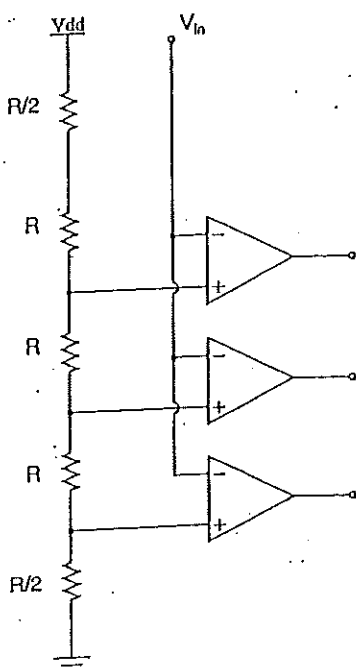
ECE 627

Midterm Examination

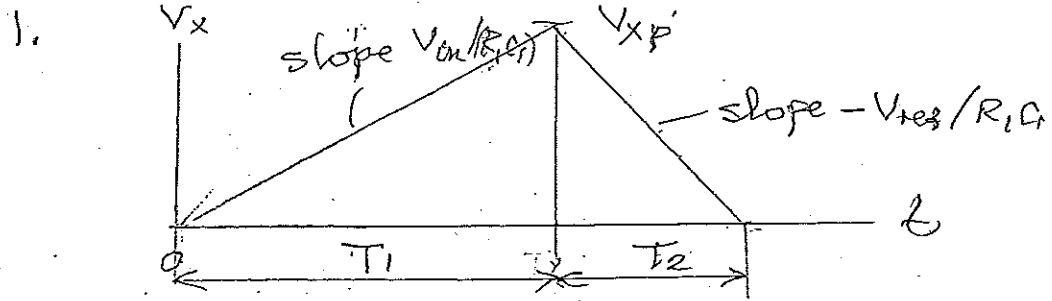
May 5, 2017

Open book

1. In a dual-slope ADC, $R_1 = 10 \text{ k}\Omega$ and $C_1 = 1 \mu\text{F}$. The reference voltage is 2 V, and the clock frequency is 5 MHz. What is the worst-case total time needed for an 18-bit conversion, if V_{in} is between 0 and 1 V?
2. An 8-bit DAC is constructed from binary-weighted capacitors. All capacitors may have a relative error r . What is the maximum value of $|r|$ if the DNL must be below $\frac{1}{2}$ LSB? What is the largest INL for this r ?
3. Analyze the flash ADCs shown below. $V_{dd} = 2.5 \text{ V}$.
 - a. Plot the input-output characteristics for all ADCs.
 - b. Draw the quantization error vs. V_{in} curves.
 - c. What are the non-overloaded input ranges for the ADCs?



2017. Midterm Solutions



Clock period $T_s = 0.2 \mu s$, $R_1 C_1 = 10^4 \mu s$

$$V_{xp} = (2^{18} T_s) V_{in} / (R_1 C_1) \approx 5.243 V_{in}$$

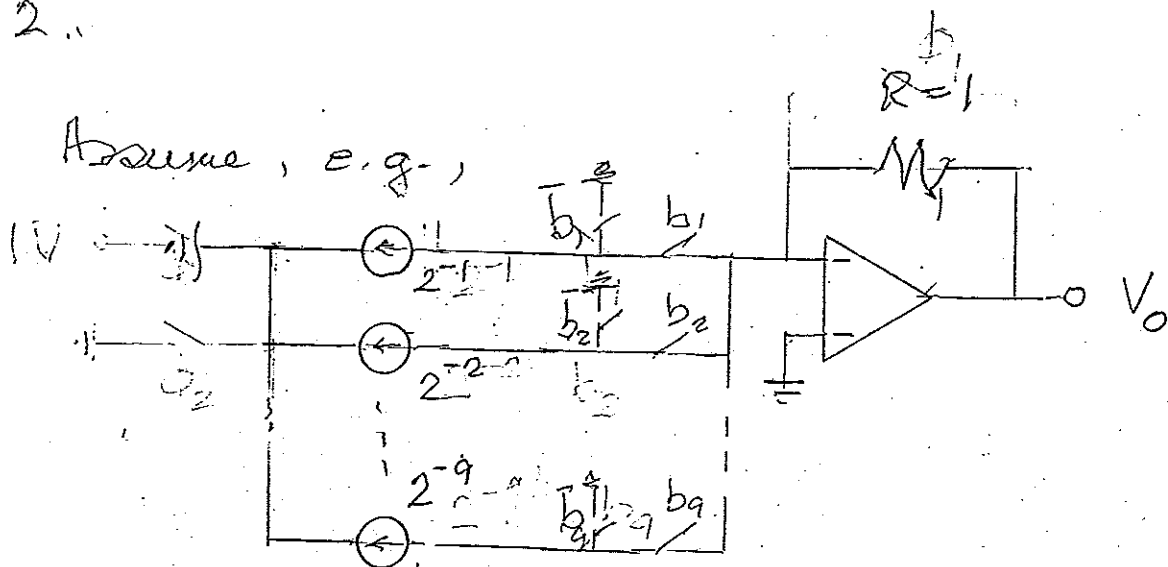
$$T_2 = V_{xp} R_1 C_1 / V_{ref} \approx 0.0262 \mu s = 0.0262 \mu s$$

$$T_1 + T_2 = 0.05243 + 0.026121 \approx 0.0786 \mu s$$

2.

Solutions

2.



$$V_0(n) = \sum_{i=1}^9 b_i(n) 2^{-i} \quad \text{for ideal sources.}$$

If the real sources have relative error r_i

$$V_0(n) = \sum_{i=1}^9 b_i(n) (1+r_i) 2^{-i}$$

DNL max. for 10000... \leftrightarrow 0111..., if $r_{MSB} \rightarrow (1+r_{max}) 2^{-1}$, and all others become $(1-r_{max}) 2^{-i}$; then

$$DNL_{max} = r_{max} \sum_{i=1}^9 2^{-i} = r_{max} (1-2^{-9}) \quad (V)$$

$$1 \text{ LSB} = 2^{-9} V, \text{ so}$$

$$DNL_{max} \approx 2^9 r_{max} (\text{LSB}) \stackrel{!}{=} 0.5 (\text{LSB})$$

$$\text{So } r_{max} \approx 2^{-10} \approx 0.9766 \times 10^{-3}$$

For absolute INL with $r_{max} = 111...1$

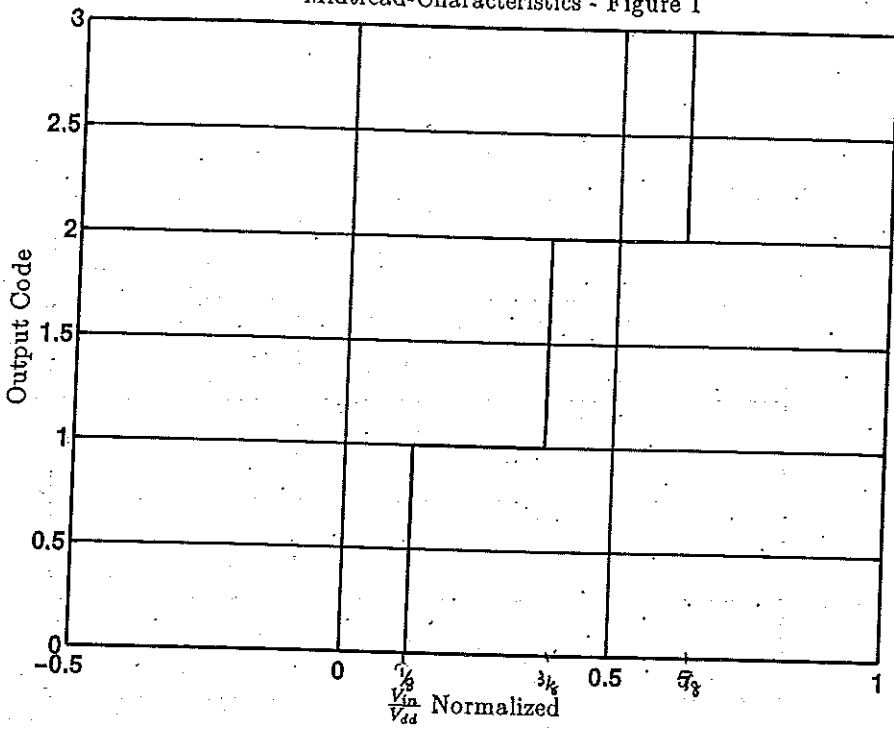
$$INL_{max}^a = DNL_{max} \approx 0.5 \text{ (LSB)} \approx 0.977 \text{ (mV)}$$

Endpoint DNL max occurs for $1000...0$

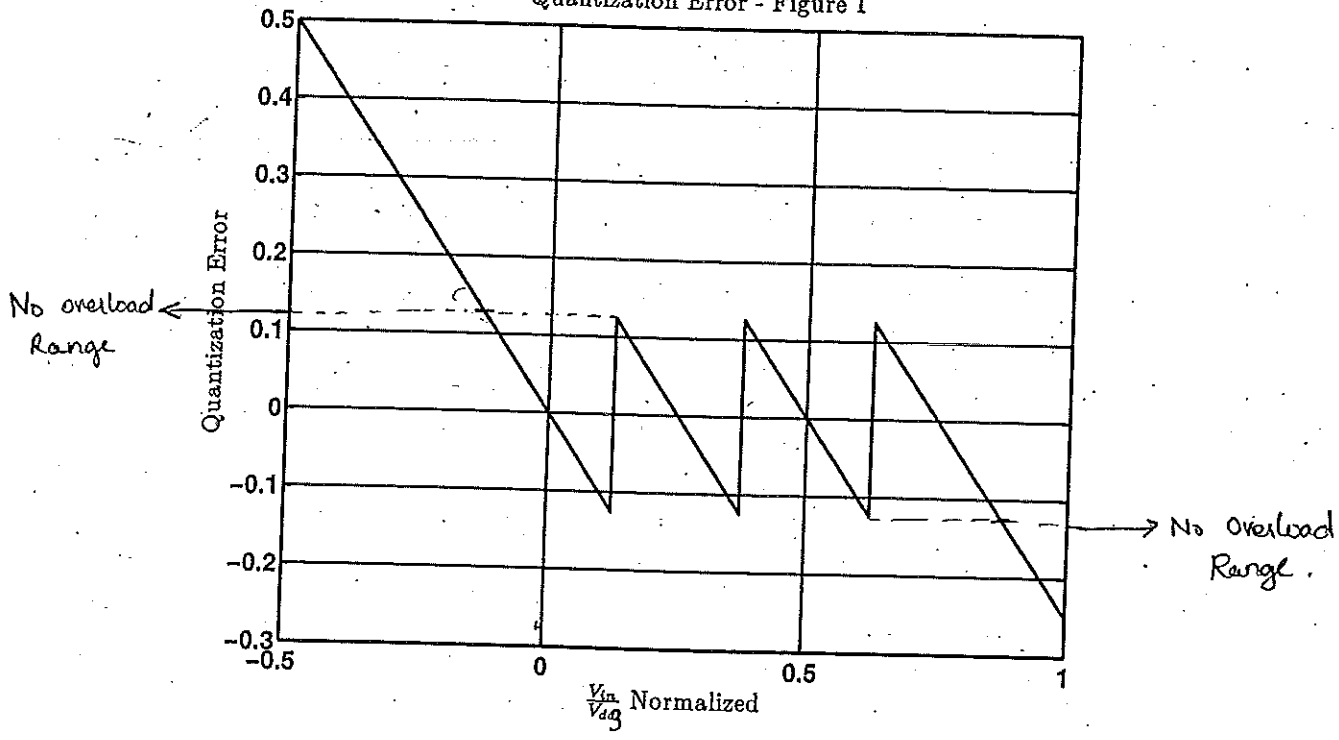
$$INL_{max}^e = 2^{-1} r_{max} \approx 0.488 \text{ mV} \approx 0.25 \text{ LSB}$$

DNLmax

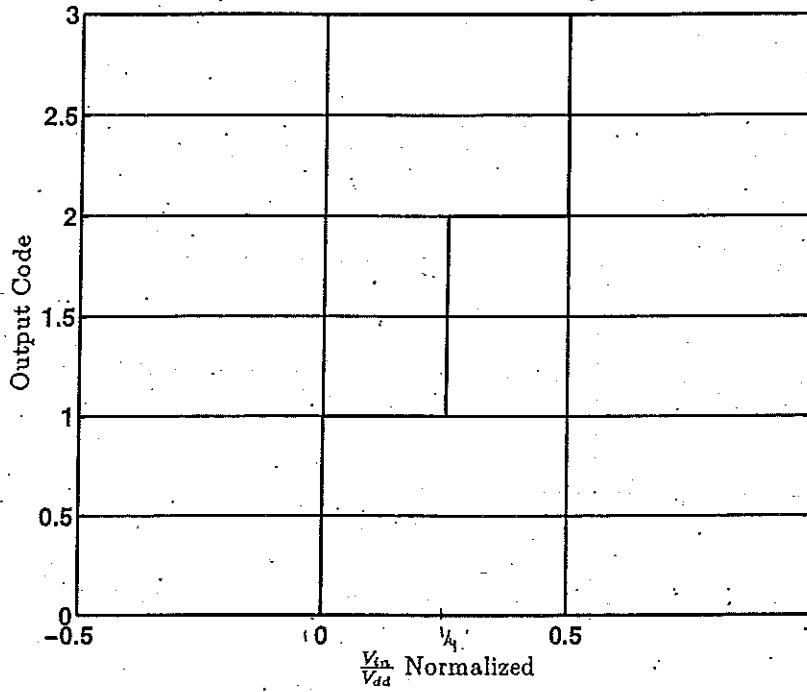
Midtread-Characteristics - Figure 1



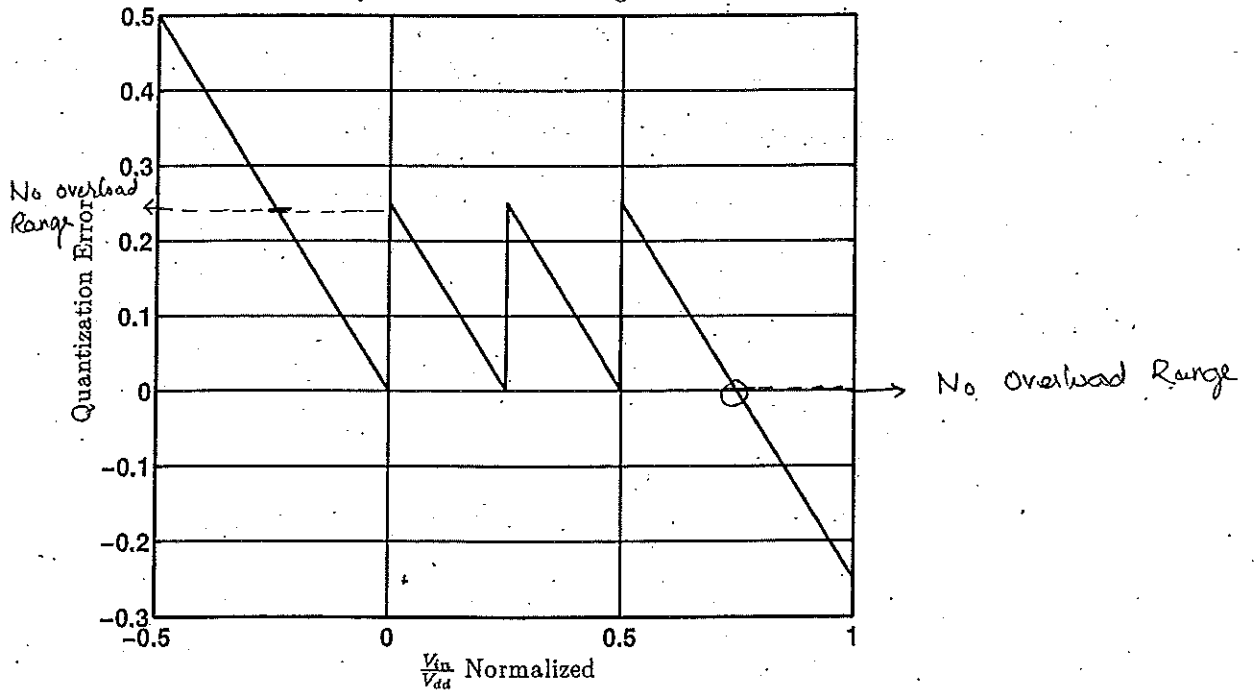
Quantization Error - Figure 1



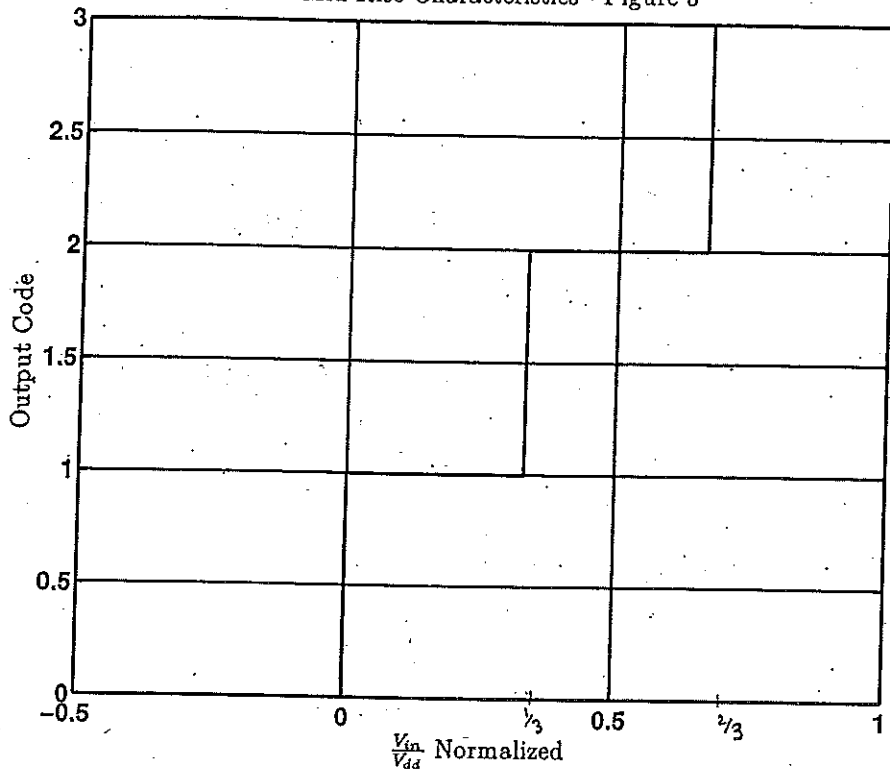
Mid-Rise-Characteristics - Figure 2



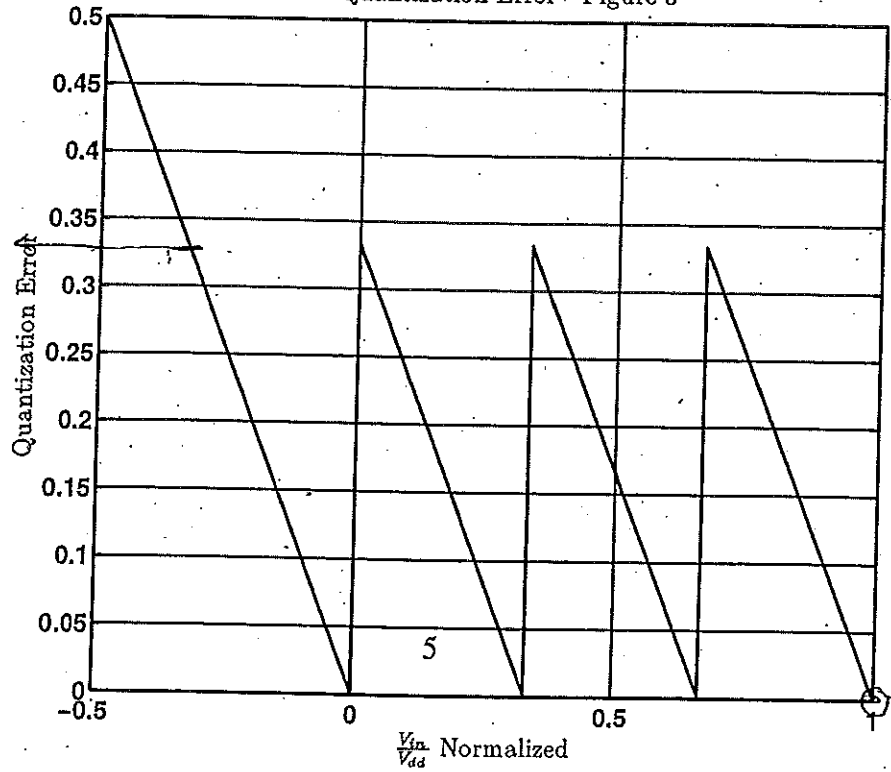
Quantization Error - Figure 2



Mid-Rise-Characteristics - Figure 3



Quantization Error - Figure 3



No Overload Range

No Overload Range

Figure 1

The no-overload input range is from $-5/8$ to $35/8$ V.

Figure 2

The no-overload input range is from $-5/4$ to $15/4$ V.

Figure 2

The no-overload input range is from $-5/3$ to 5 V.