POLITECNICO
MILANO 1863

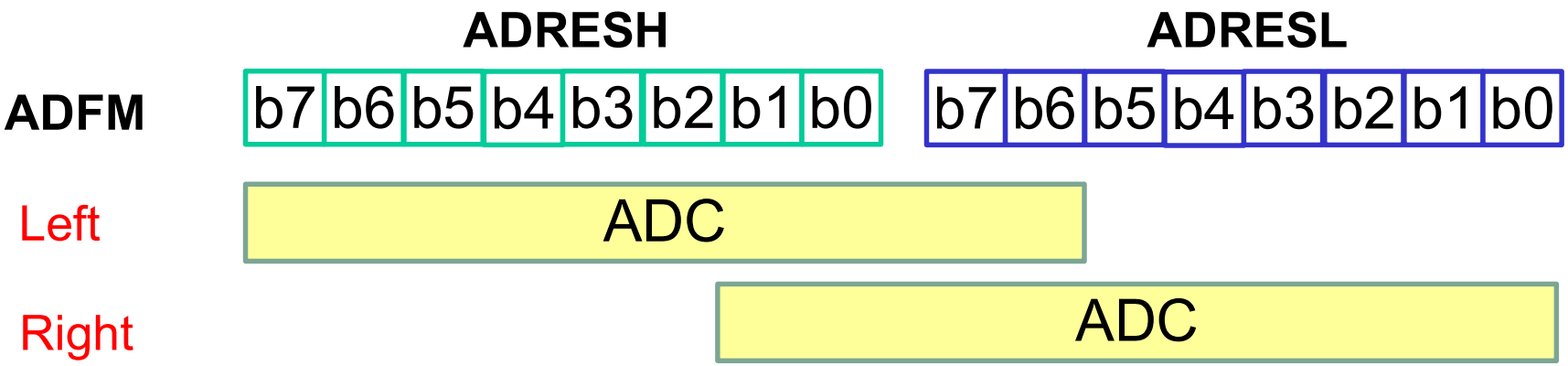




MICROCONTROLLERS

LAB – FIXED POINT

Left: ADRESH/ADRESL



Left: ADRESH/ADRESL

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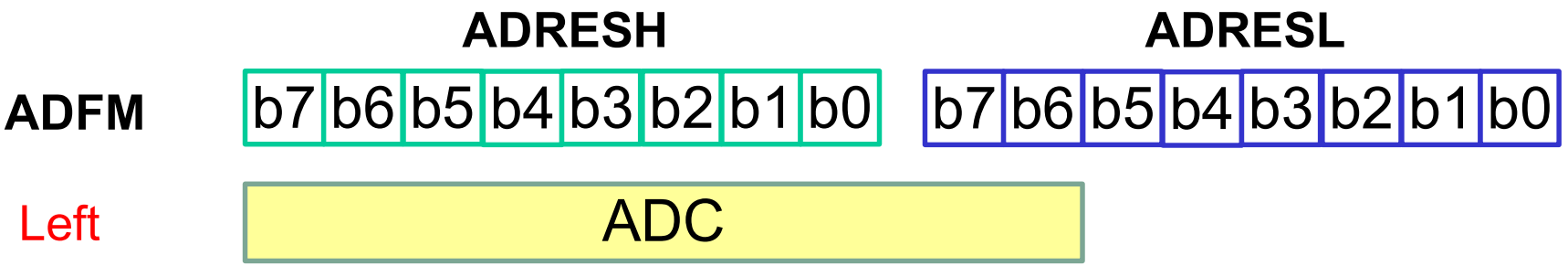
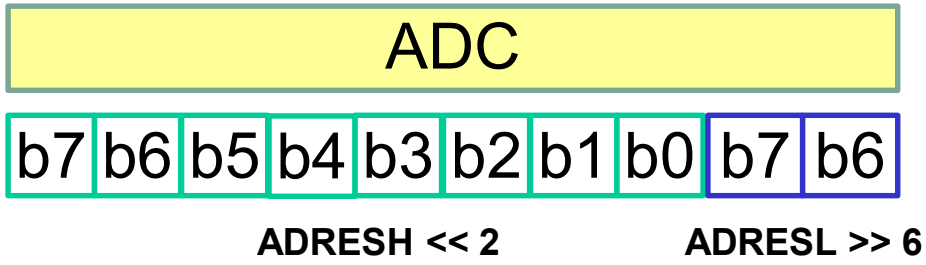
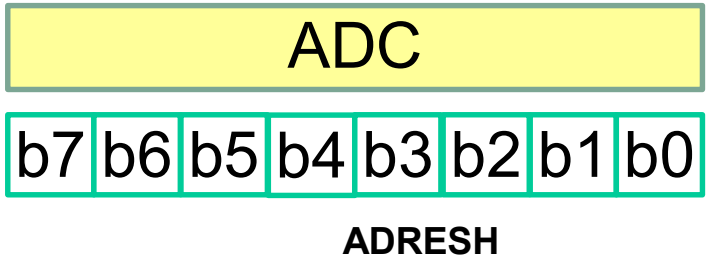


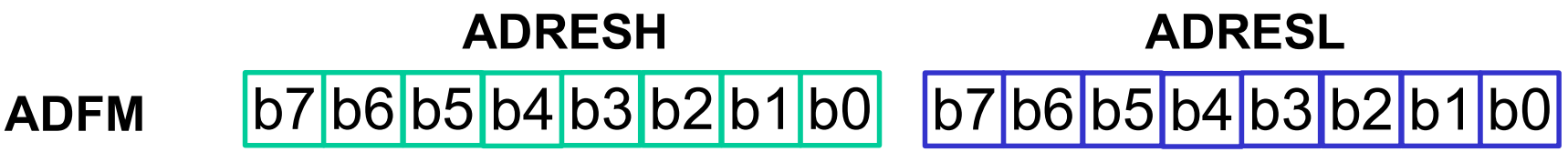
$$N_{10} = ADRESH \cdot 4 + ADRSEL/64$$



$$N_8 = ADRESH$$

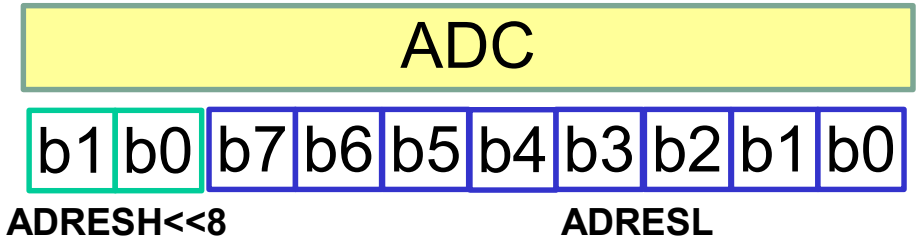


Right: ADRESH/ADRESL

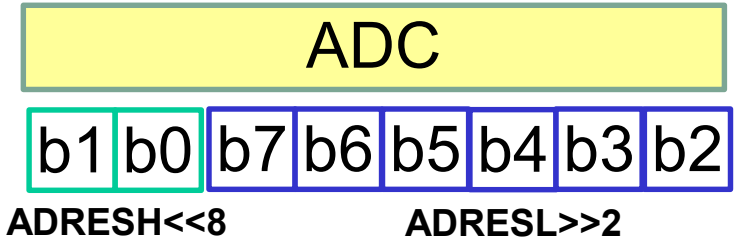


Right

$N_{10} = ADRESH \cdot 256 + ADRESL$



$N_8 = ADRESH \cdot 256 + ADRESL/4$



Error LSB

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$$V_{ADC,10} = N_{10} \cdot LSB_{10}$$

$$V_{ADC,8} = N_8 \cdot LSB_8$$

$$LSB_{10} = \frac{FSR}{2^{10}}$$

$$LSB_8 = \frac{FSR}{2^8}$$

$$LSB_{10} = \frac{5000\ mV}{1024} \cong \frac{5000\ mV}{1000} = 5\ mV$$

$$LSB_8 = \frac{5000\ mV}{256} \cong \frac{5000\ mV}{200} = 20\ mV$$

$$\frac{5000\ mV}{1024} = 4{,}8828125\ mV$$

$$\frac{5000\ mV}{256} = 19{,}53125\ mV$$

$$err_{10} = \frac{5\ mV - 4{,}8828125\ mV}{5\ mV} = 2{,}34\%$$

$$err_8 = \frac{20\ mV - 19{,}53125 mV}{20\ mV} = 2{,}34\%$$

Advaced Computation: LSB 10

$$V_{ADC,10} = N_{10} \cdot \frac{5000}{1024}$$

NB: unsigned int $\in [0; 65.535]$

$N_{10} \in [0; 1023]$

$$N_{10}^{MAX} \cdot 5000 = 5.115.000! > 65.535$$

$$N_{10}/1024 = 0!$$

$$\frac{5000}{1024} = \frac{5^4 \cdot 2^3}{2^{10}} = \frac{5^4}{2^7}$$

$$V_{ADC,10} = N_{10} \cdot \frac{5^4}{2^7} = \frac{N_{10} \cdot 5 \cdot 5 \cdot 5 \cdot 5}{2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2}$$

Advaced Computation: LSB 10

NB: unsigned int $\in [0; 65.535]$

$N_{10} \in [0; 1023]$

$$\frac{65535}{N_{10}^{MAX}} = 63 \qquad \frac{65535}{\left(\frac{N_{10}^{MAX} \cdot 5^2}{2}\right)} = 5$$

$$\frac{65535}{\frac{\left[\left(\frac{N_{10}^{MAX} \cdot 5^2}{2}\right) \cdot 5\right]}{2^3}} = 8$$

$$\boldsymbol{V_{ADC,10} = N_{10} \cdot \frac{5^4}{2^7} = \left\{\frac{\left[\left(\frac{N_{10} \cdot 5^2}{2}\right) \cdot 5\right]}{2^3}\right\} \cdot 5 \cdot \left(\frac{1}{2^3}\right)}$$

$\boldsymbol{err = 0,02\%}$

Advaced Computation: LSB 8

$$V_{ADC,10} = N_8 \cdot \frac{5000}{256}$$

NB: unsigned int $\in [0; 65.535]$

$N_8 \in [0; 255]$

$$N_8^{MAX} \cdot 5000 = 1280000! > 65.535$$

$$N_8/256 = 0!$$

$$\frac{5000}{256} = \frac{5^4 \cdot 2^3}{2^8} = \frac{5^4}{2^5}$$

$$V_{ADC,10} = N_{10} \cdot \frac{5^4}{2^5} = \frac{N_{10} \cdot 5 \cdot 5 \cdot 5 \cdot 5}{2 \cdot 2 \cdot 2 \cdot 2 \cdot 2}$$

Advaced Computation: LSB 8

NB: unsigned int $\in [0; 65.535]$

$N_8 \in [0; 256]$

$$\frac{65535}{N_8^{MAX}} = 255 \qquad \frac{65535}{\left(\frac{N_8^{MAX} \cdot 5^3}{2^2}\right)} = 8$$

$$\boldsymbol{V_{ADC,8} = N_8 \cdot \frac{5^4}{2^5} = \left\{\frac{\left[\left(\frac{N_8 \cdot 5^3}{2^2}\right) \cdot 5\right]}{2^3}\right\}}$$

$\boldsymbol{err = 0,02\%}$

Advaced Computation: Code

$$V_{ADC,10} = N_{10} \cdot 5$$

ADC10bit * 5

$$\boldsymbol{err = 2,34\%}$$

$$V_{ADC,10} = N_{10} \cdot \frac{5^4}{2^7} = \left\{\frac{\left[\left(\frac{N_{10} \cdot 5^2}{2}\right) \cdot 5\right]}{2^3}\right\} \cdot 5 \cdot \left(\frac{1}{2^3}\right)$$

(((((ADC10bit * 25) >> 1)*5)>>3)*5)>>3

$$\boldsymbol{err = 0,02\%}$$

$$V_{ADC,8} = N_{10} \cdot 20$$

ADC10bit * 20

$$\boldsymbol{err = 2,34\%}$$

$$V_{ADC,8} = N_8 \cdot \frac{5^4}{2^5} = \left\{\frac{\left[\left(\frac{N_8 \cdot 5^3}{2^2}\right) \cdot 5\right]}{2^3}\right\}$$

(((ADC10bit * 125) >> 2)*5)>>3

$$\boldsymbol{err = 0,02\%}$$