ELECTRONIC SYSTEMS and TECHNOLOGIES

Master in Management Engineering

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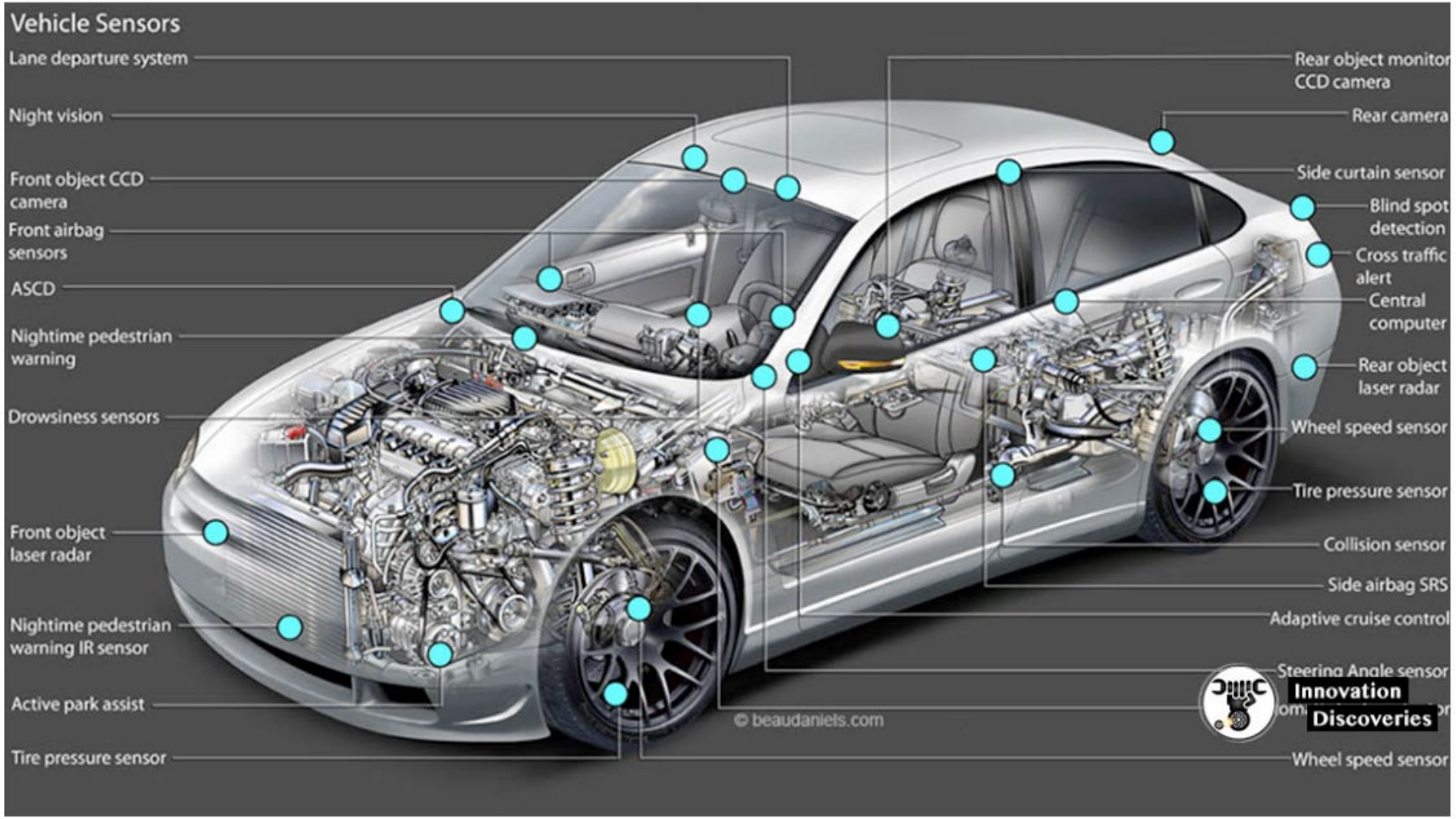
GROUND CONCEPTS ON ELECTRONICS

Analog and Digital Conversions

Sensing the real world (analog)

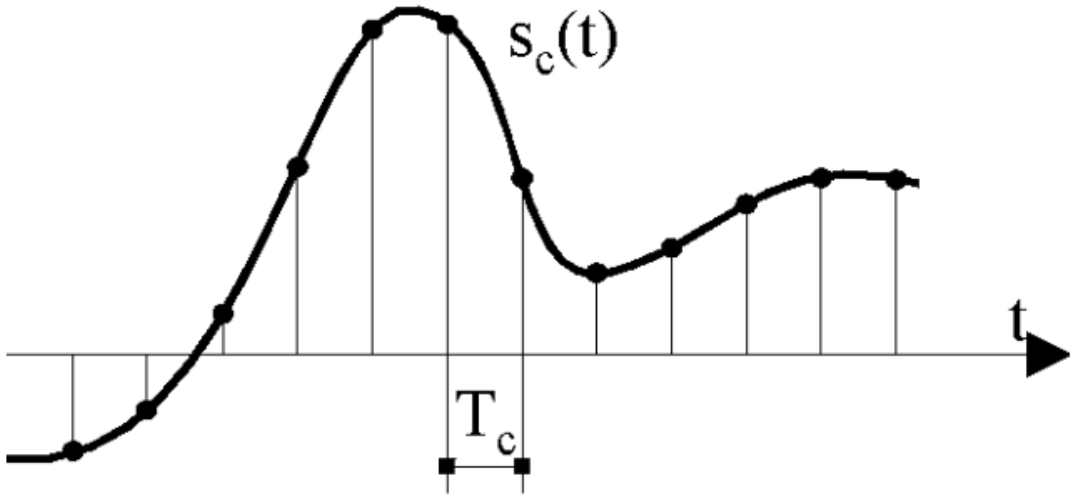
Signals from physical phenomena vary in time and amplitude in a continuous way

Processing is done by a microprocessor or a computer (in digital domain)

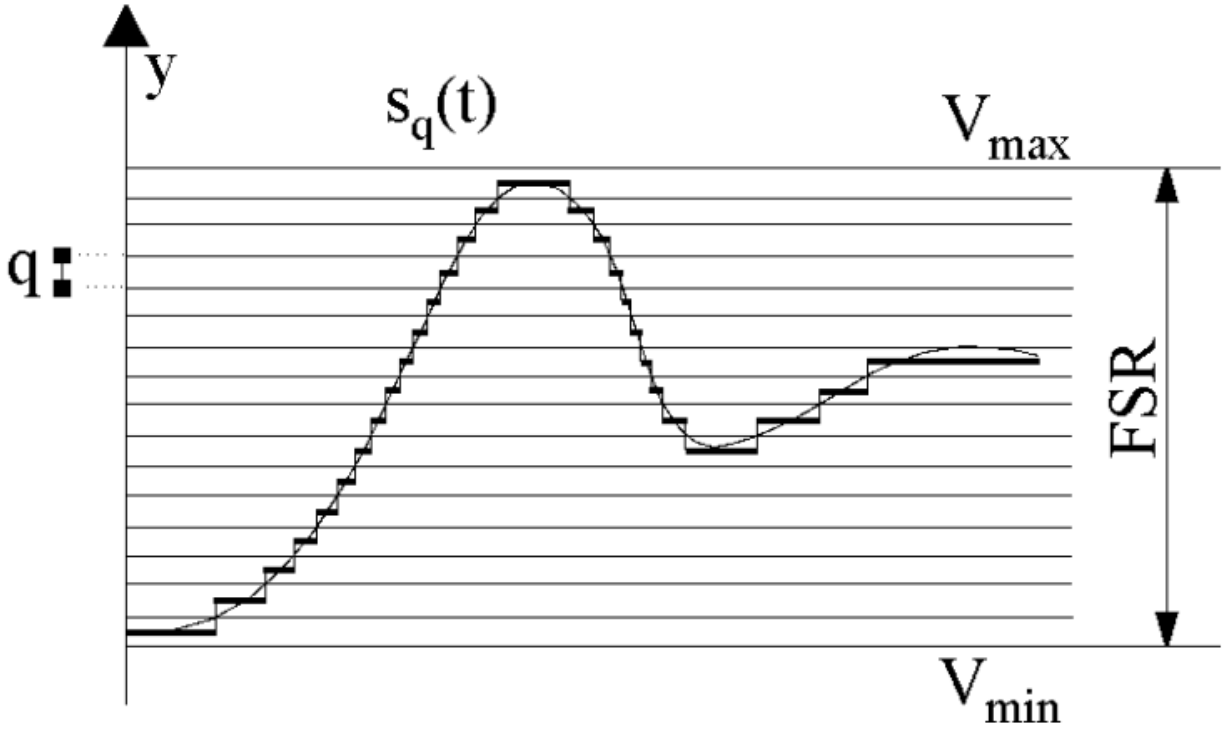


Analog to Digital Conversion

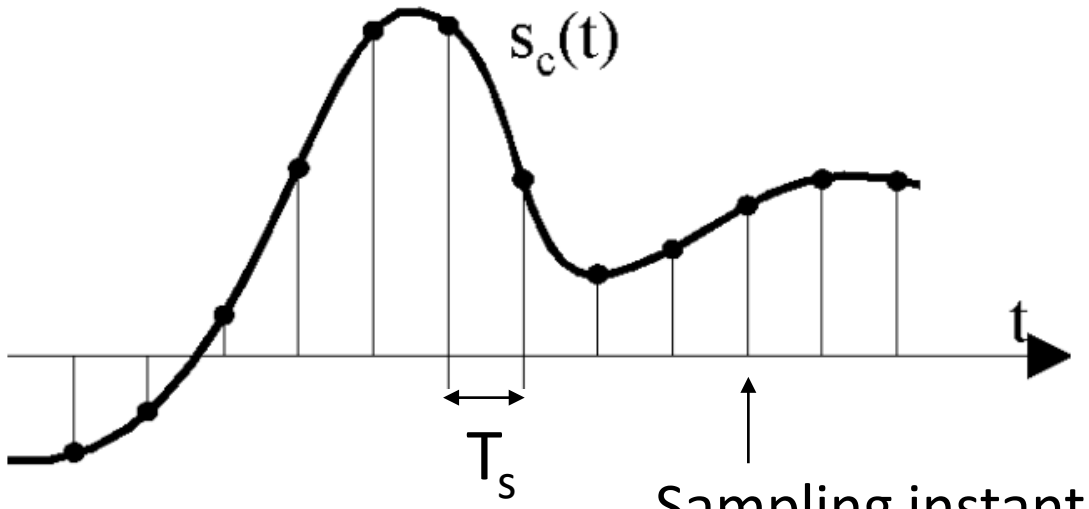
SAMPLING in time domain



QUANTIZATION in amplitude domain



SAMPLING in time domain



Sampling instant : sampling a continuous signal over time means considering its values only in correspondence to precise instants of time, called sampling instants.

Sampling causes part of the information contained in the analog signal to be lost (i.e. the signal between two successive sampling instants)

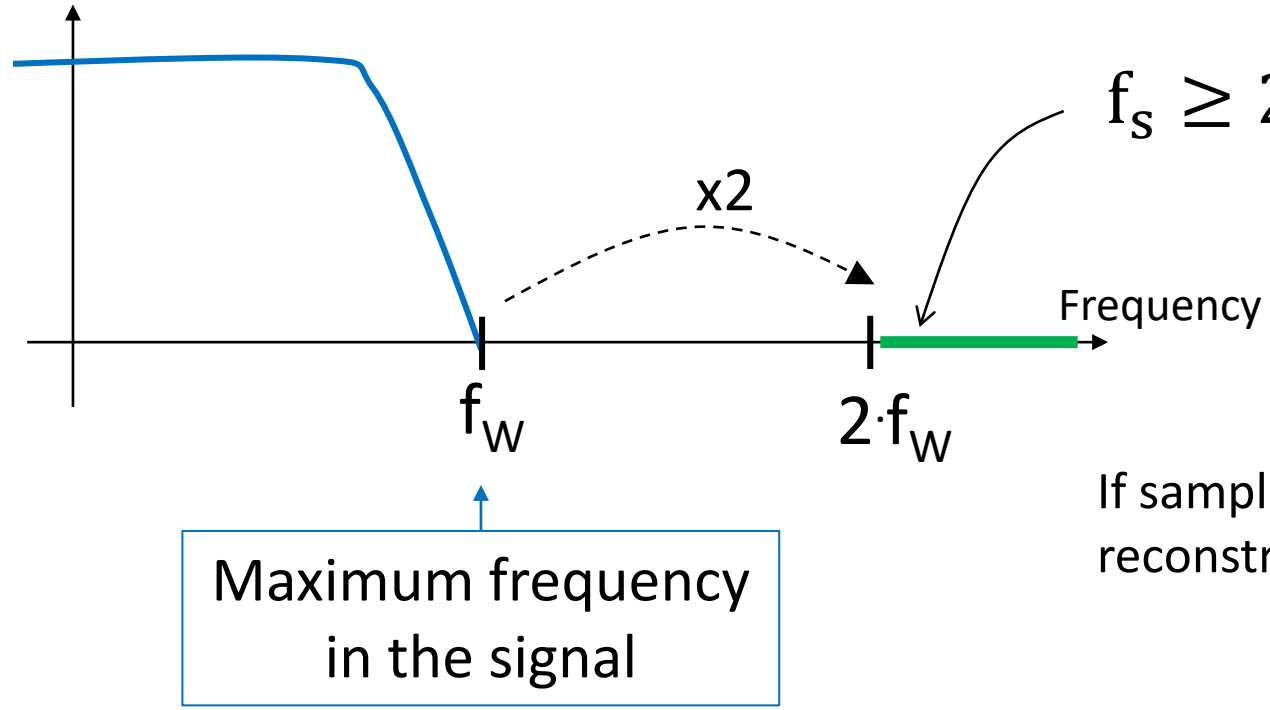
When sampling ?

T_s = Sampling time

$f_s = \frac{1}{T_s}$ = Sampling frequency

Sampling THEOREM

Frequency spectrum of an analog signal



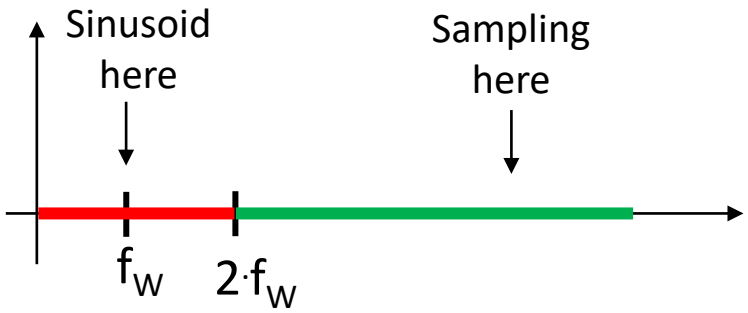
The sampling theorem states that :

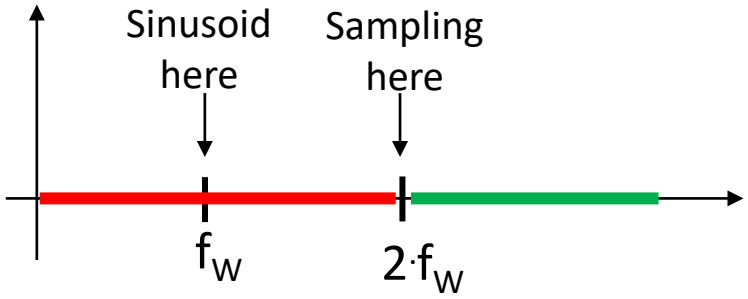
the minimum sampling frequency f_s at which a continuous-time signal needs to be uniformly sampled is greater than double the maximum frequency contained in the signal :

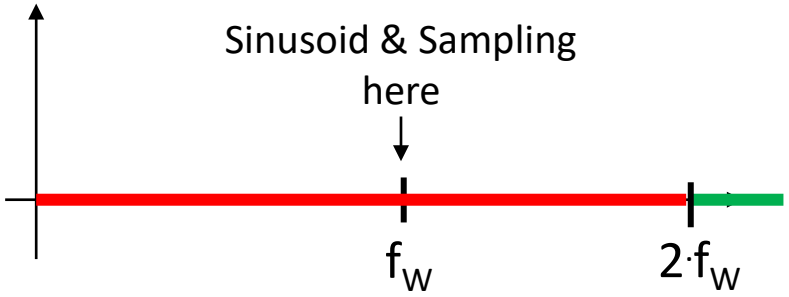
$$f_s \geq 2 \cdot f_w$$

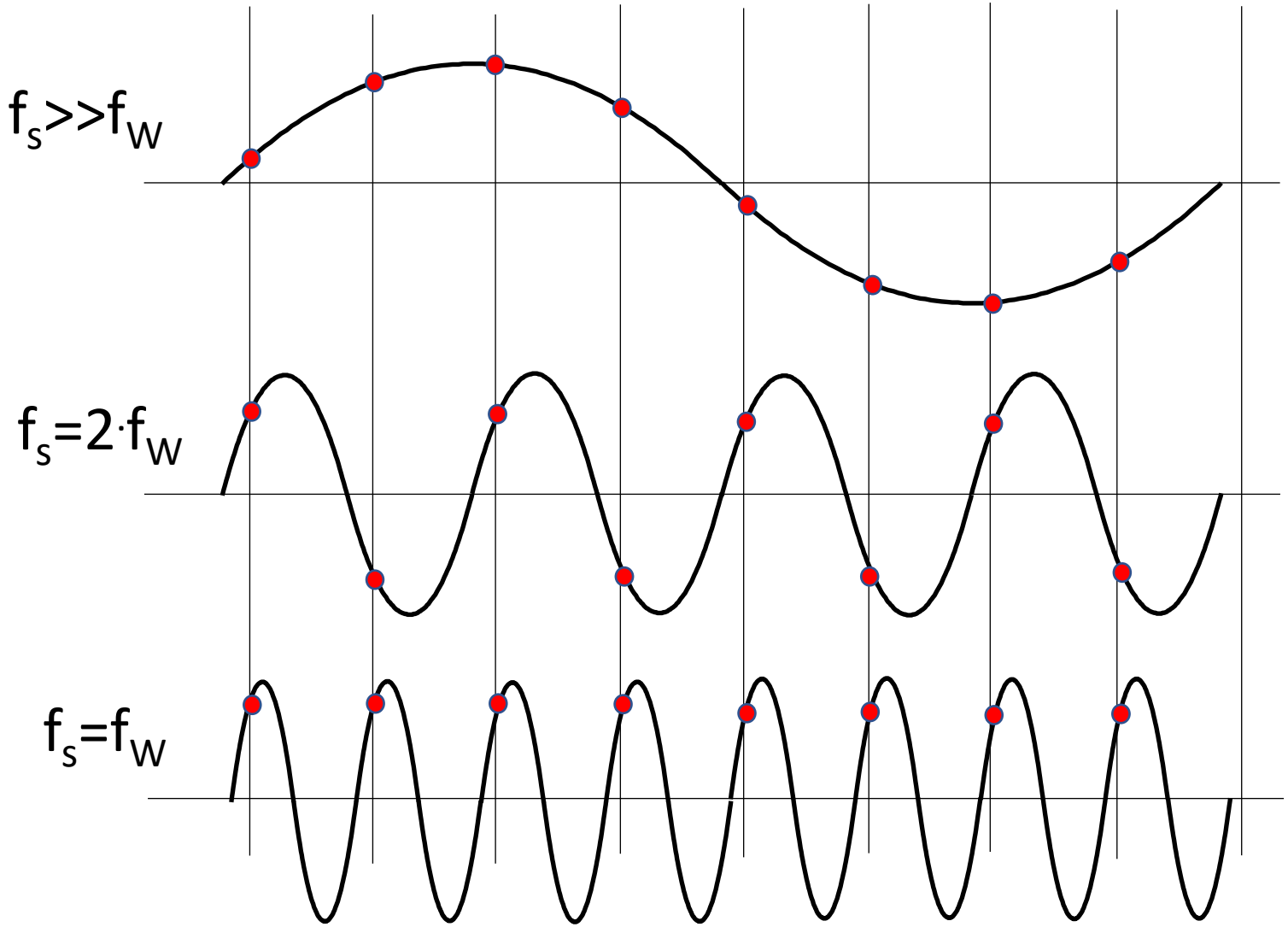
If sampled in that way, it is possible to reconstruct exactly the original signal

The Sampling Theorem is usually referred to as WKS sampling theorem after Whittaker, Kotel'nikov and Shannon.



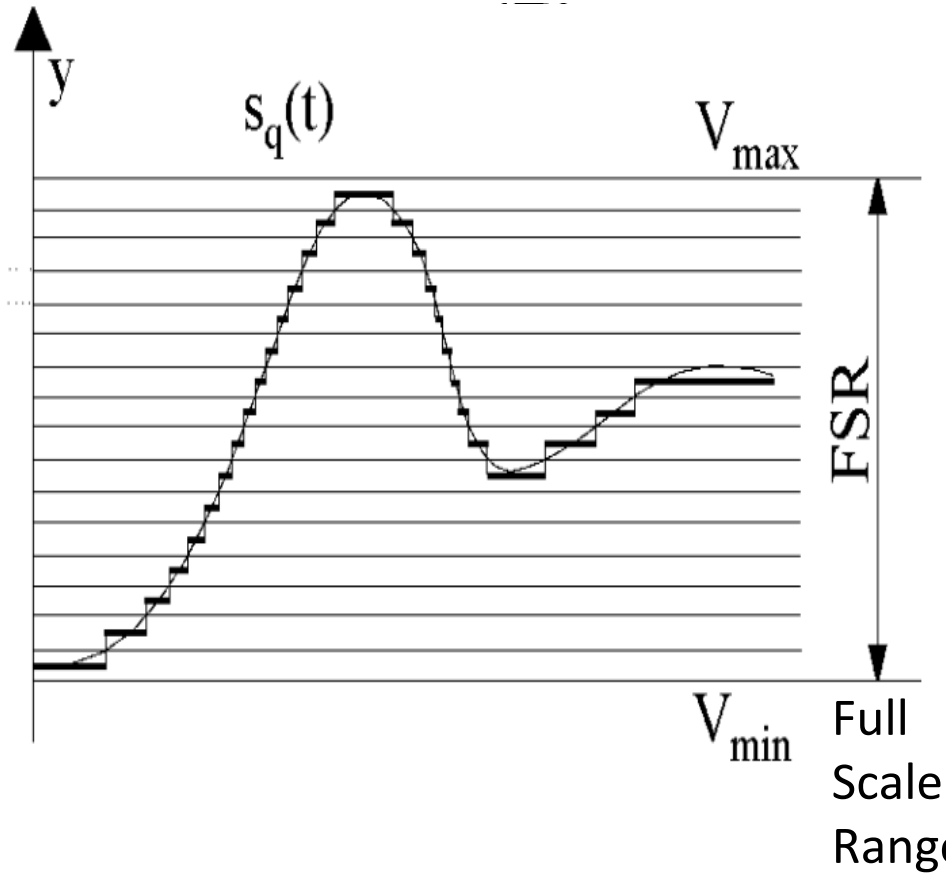


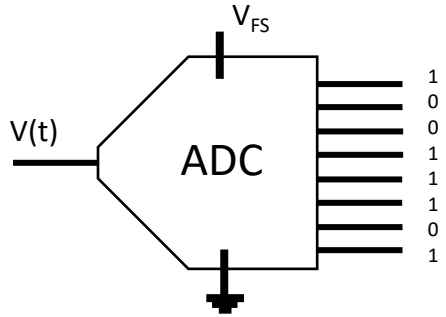


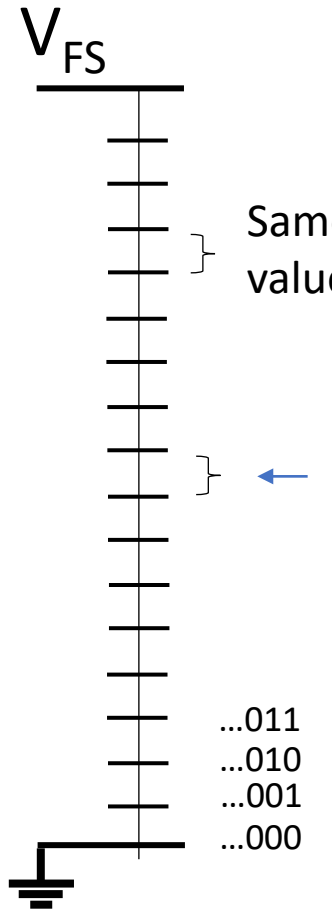


Aliasing (wrong reconstruction of signal) !

Quantization in amplitude domain







Same code for all values in this interval

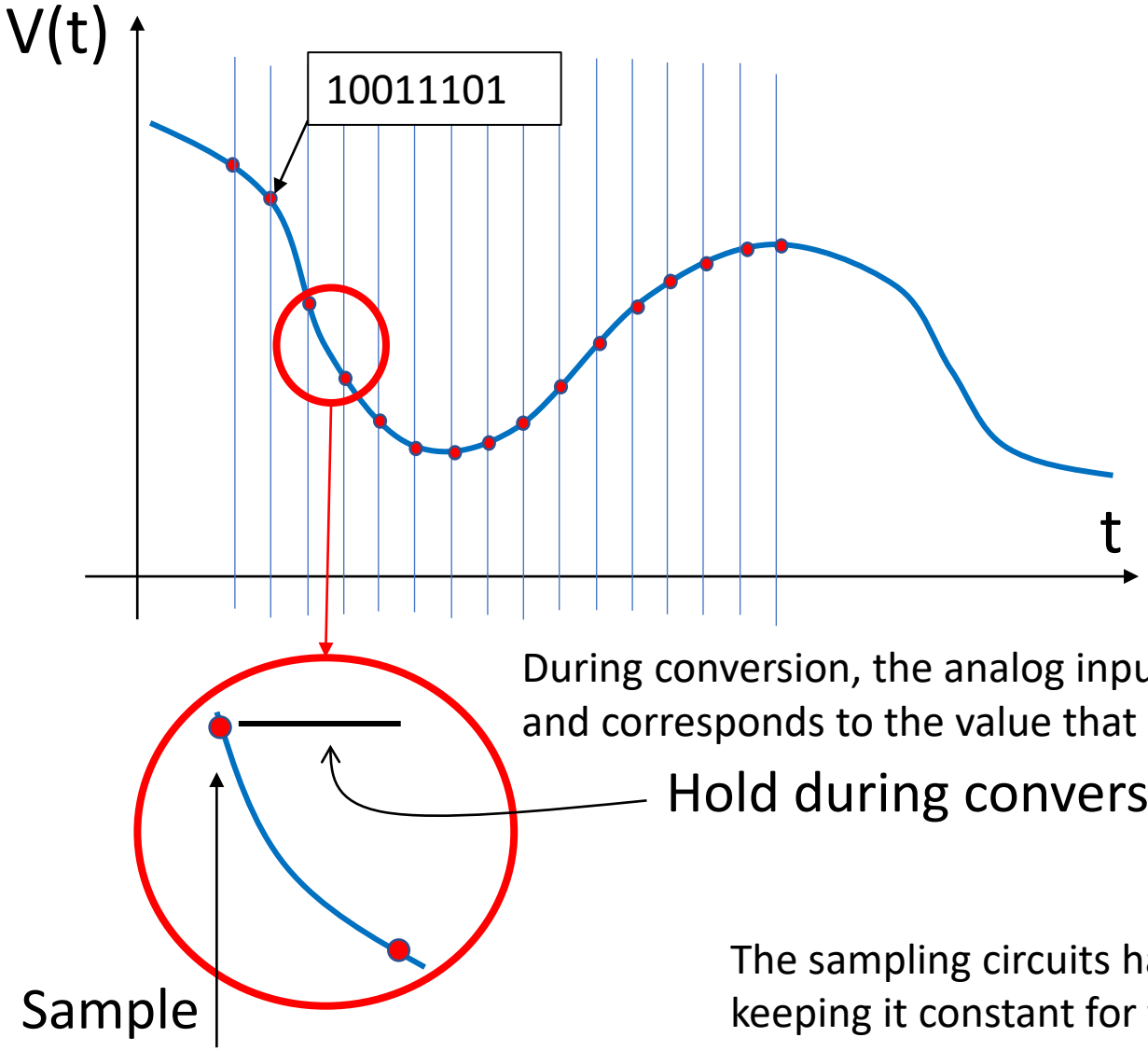
2^n intervals

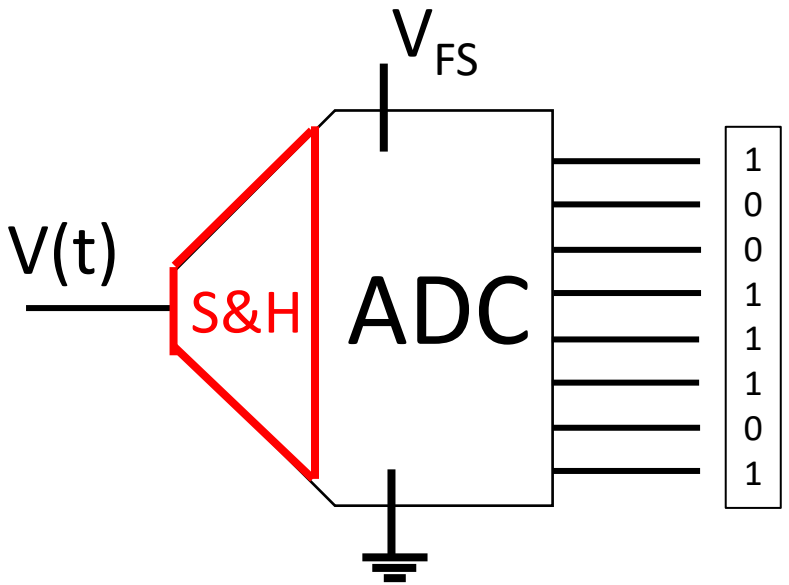
RESOLUTION = $\frac{V_{FS}}{2^n}$

All analog values of the signal that fall within one of these quantization intervals are considered indistinguishable from each other and a characteristic value is attributed to them (for example the central value)

n is the number of bits of the ADC

Sample&Hold in Analog to Digital conversion





During conversion, the analog input remains constant and corresponds to the value that has been sampled.

Hold during conversion

The sampling circuits have the task of extracting the sample from the signal and keeping it constant for the time necessary for the conversion (sample & hold).

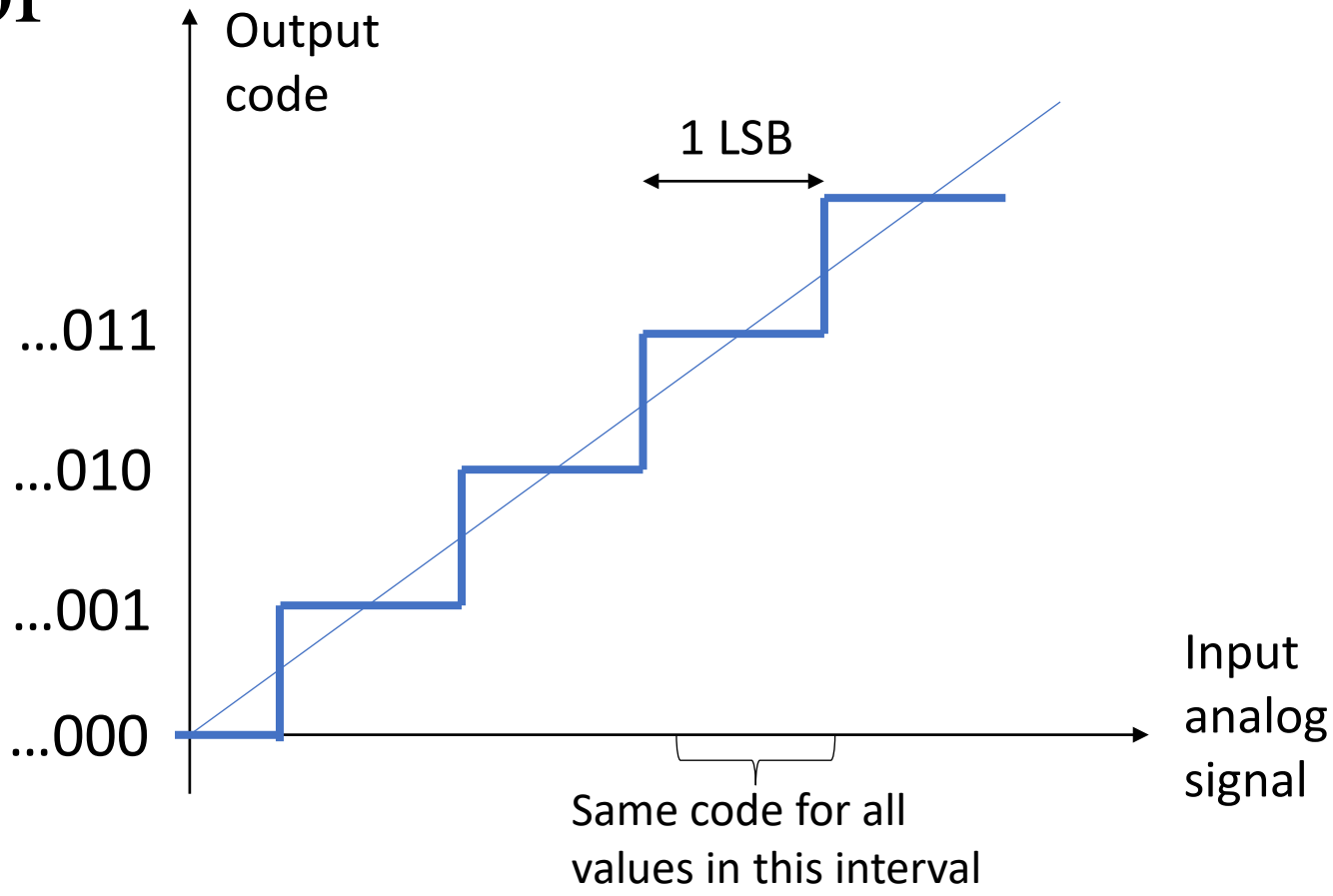
Questions & exercises

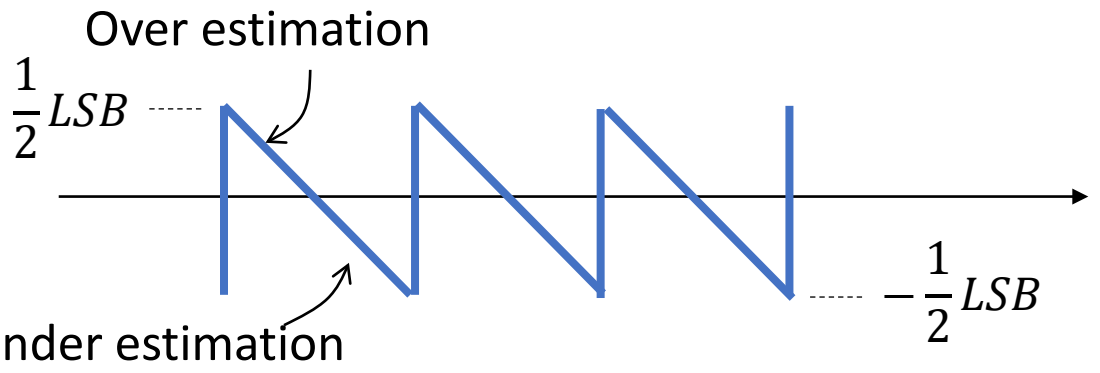
LSB

MSB

Quantization error

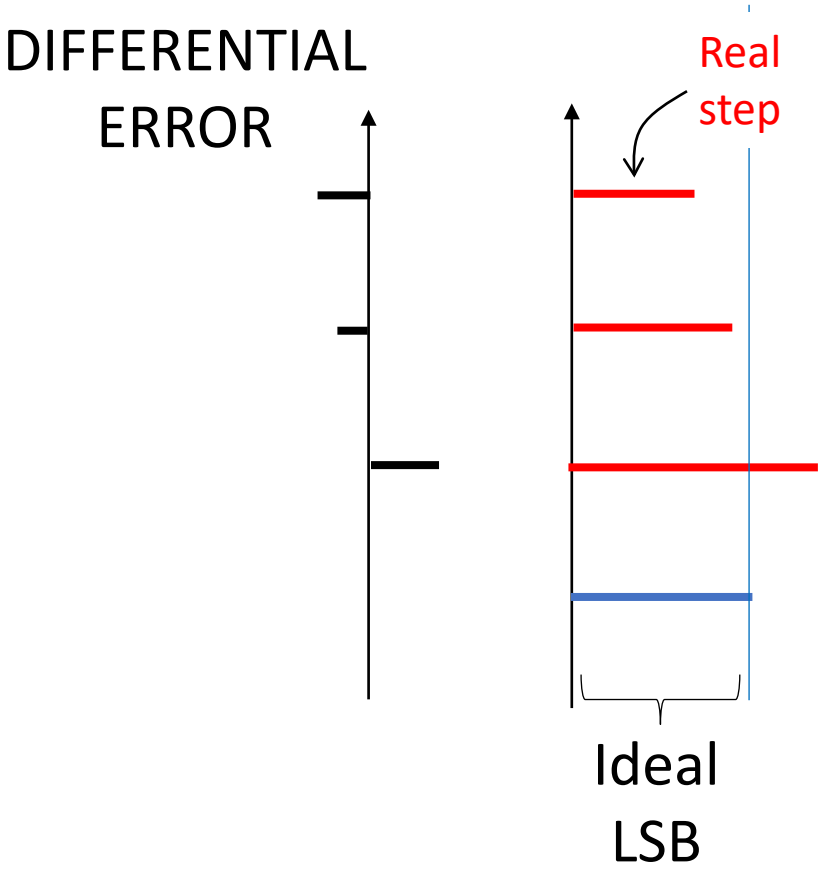
Non-avoidable error (present also in the **ideal ADC**)

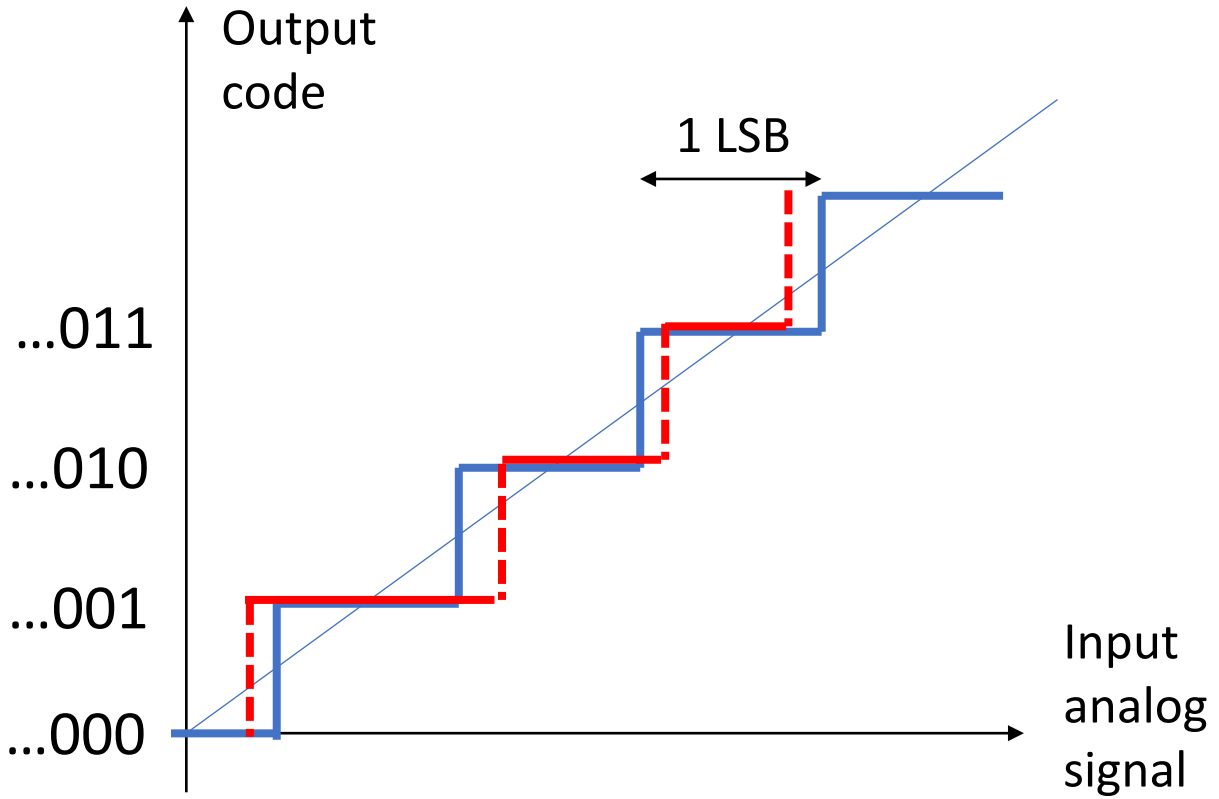




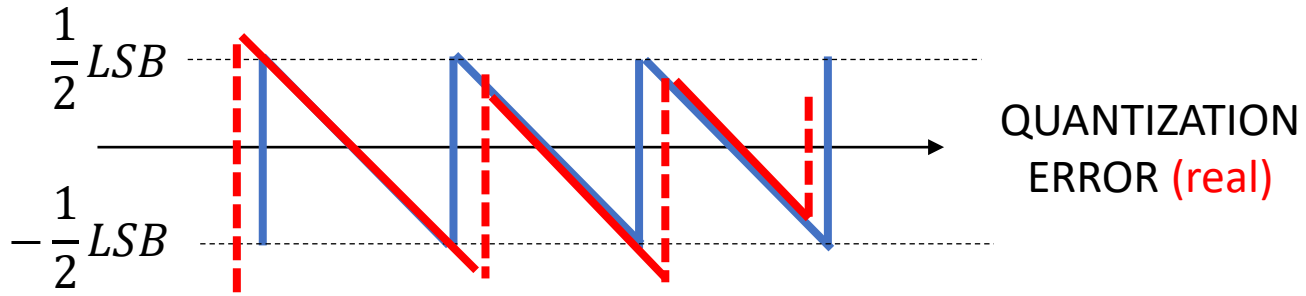
QUANTIZATION ERROR

Real ADC

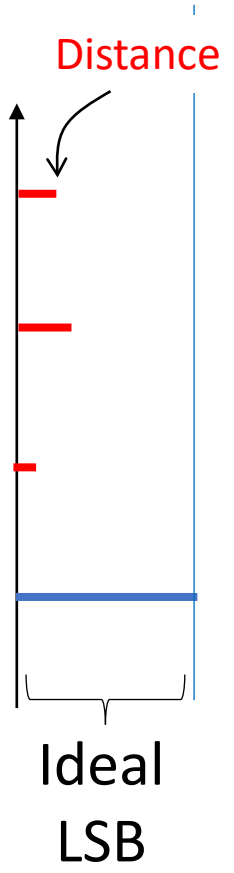


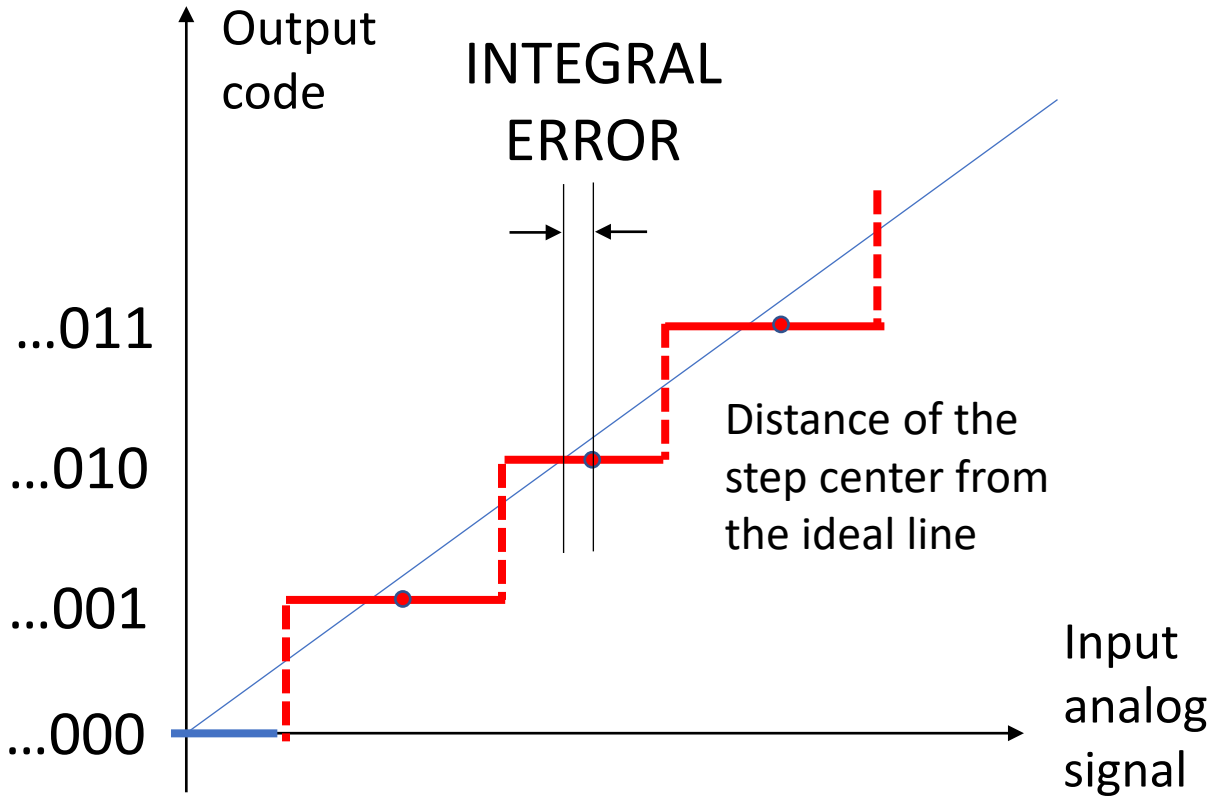


DIFFERENTIAL NON LINEARITY : $\dfrac{Real\ -LSB}{LSB} < X\ \%$



Real ADC



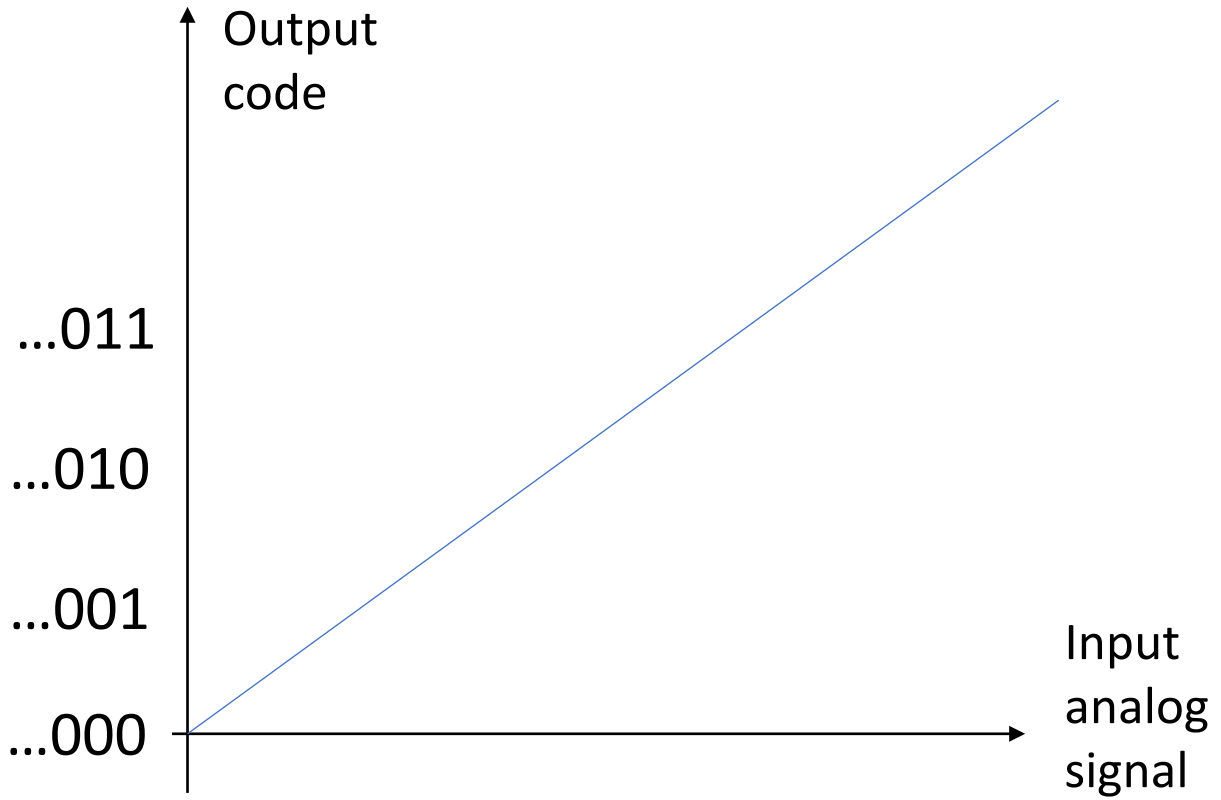


INTEGRAL
NON LINEARITY : $\frac{Distance}{LSB} < X\ \%$

Questions

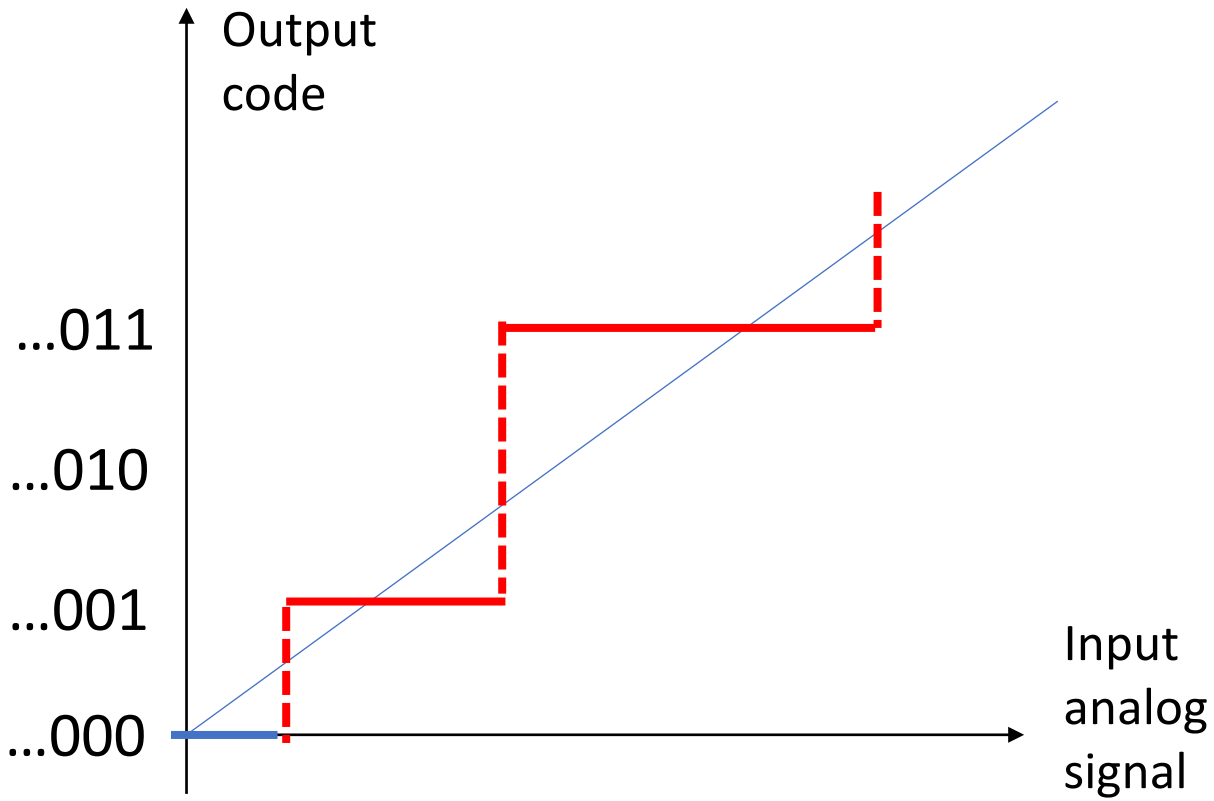
How is :
1) Big Differential nonlinearity & small Integral nonlinearity ?

How is :
2) small Differential nonlinearity & big Integral nonlinearity ?



Missing code

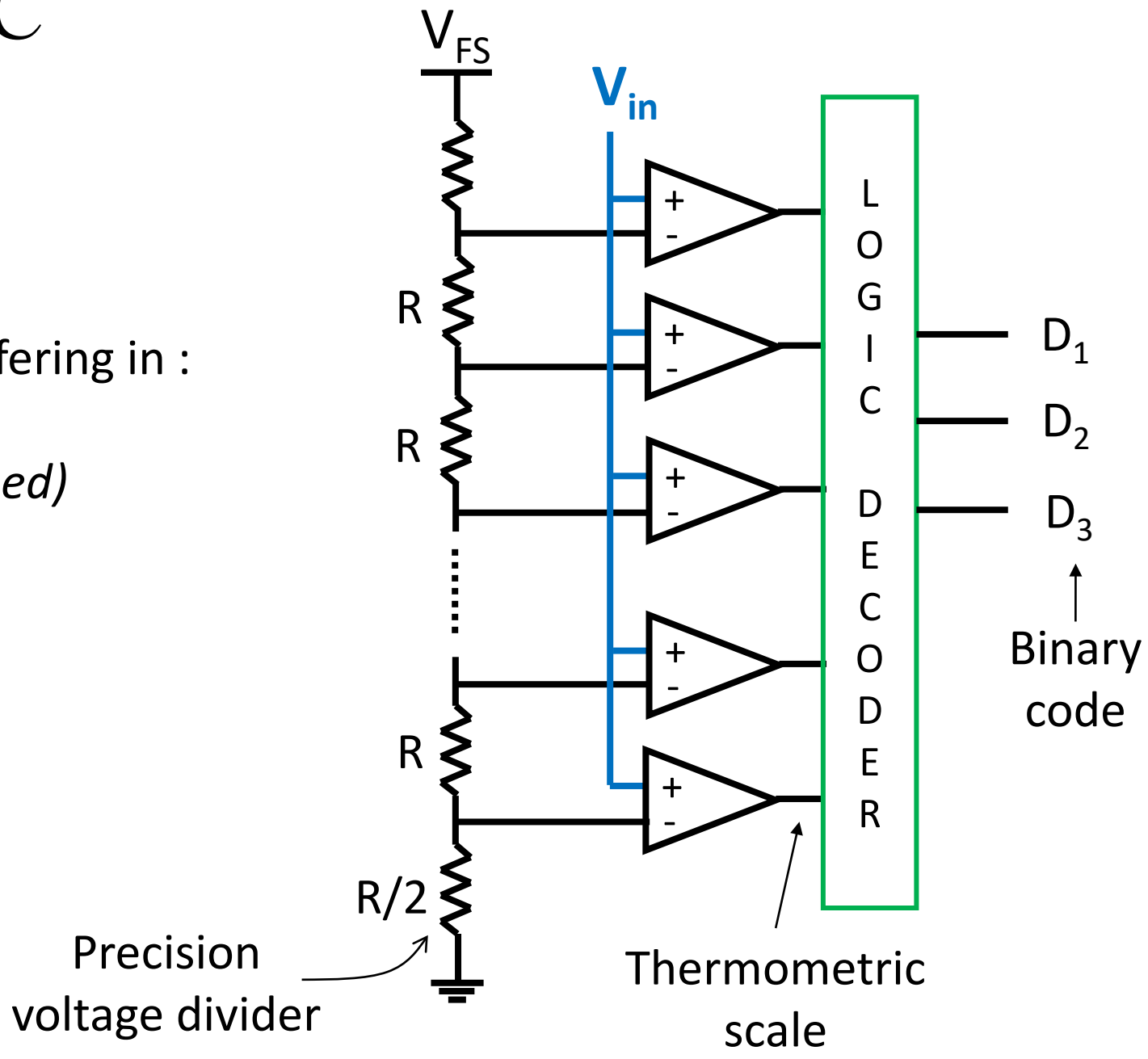
This code never comes out



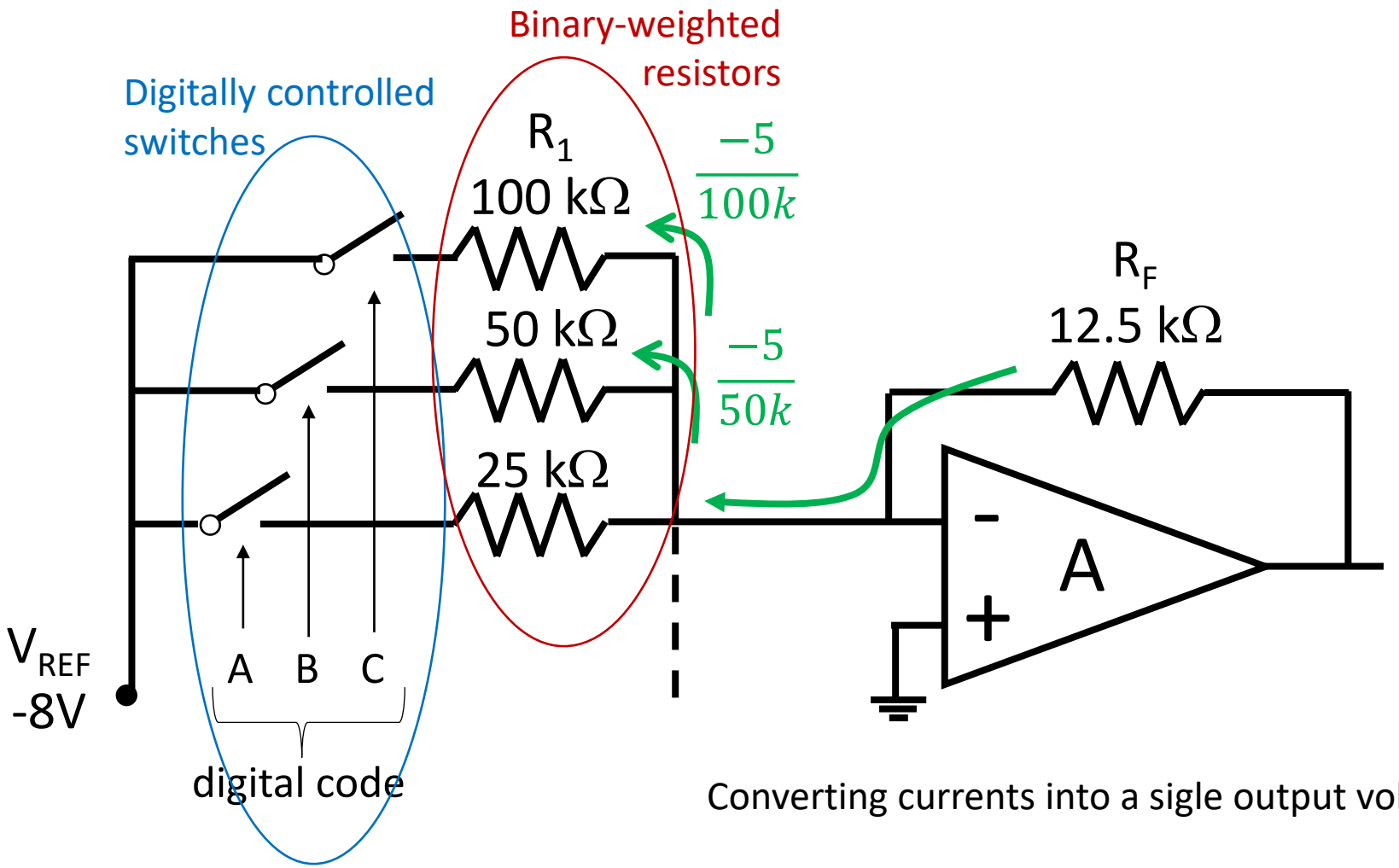
Example of ADC (Flash ADC)

Many other ADC exist, differing in :

- *Time of conversion (speed)*
- *Resolution*
- *Linearity*
- *Precision*
- *Power consumption*



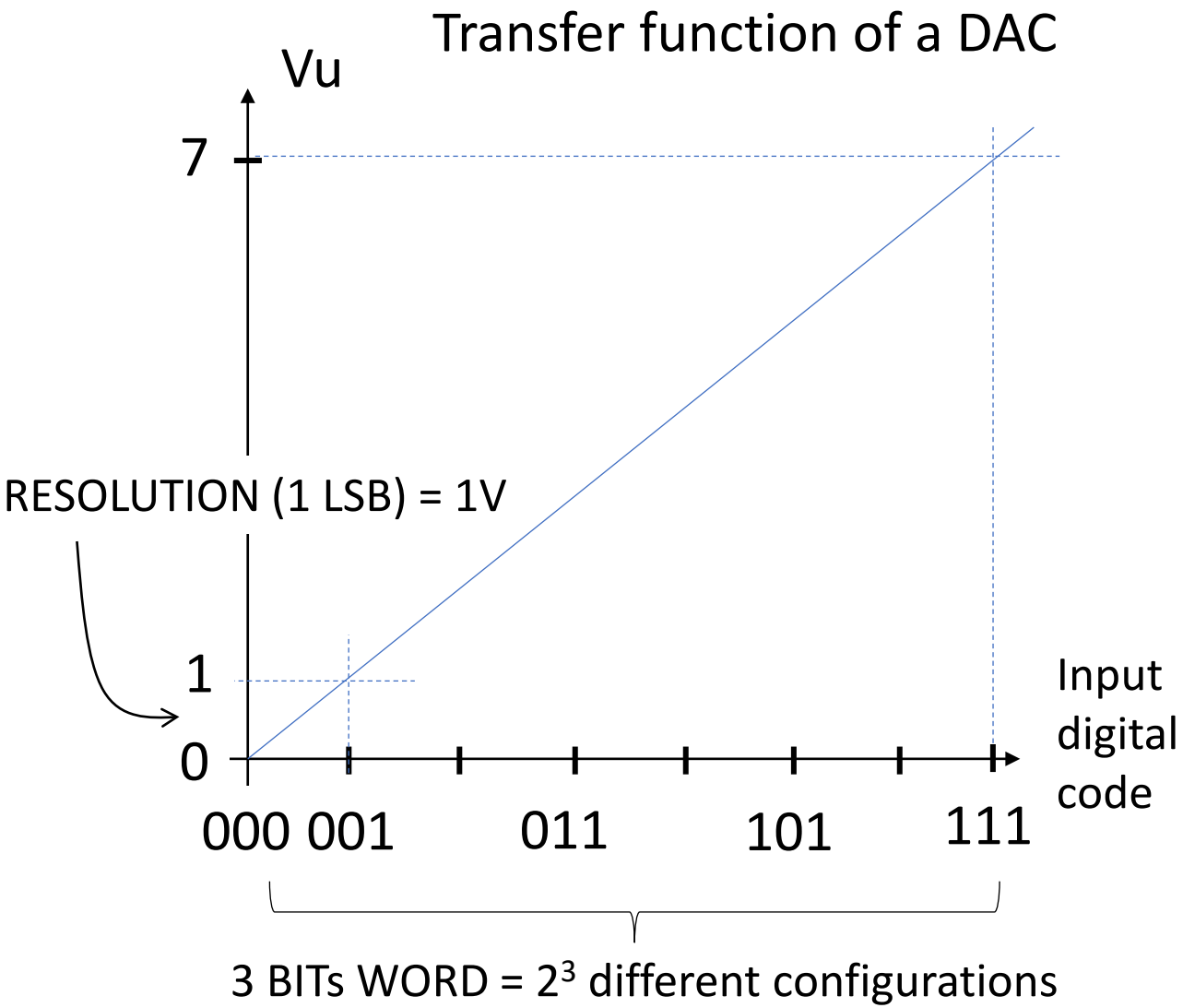
Example of a Digital-to-Analog Converter - DAC

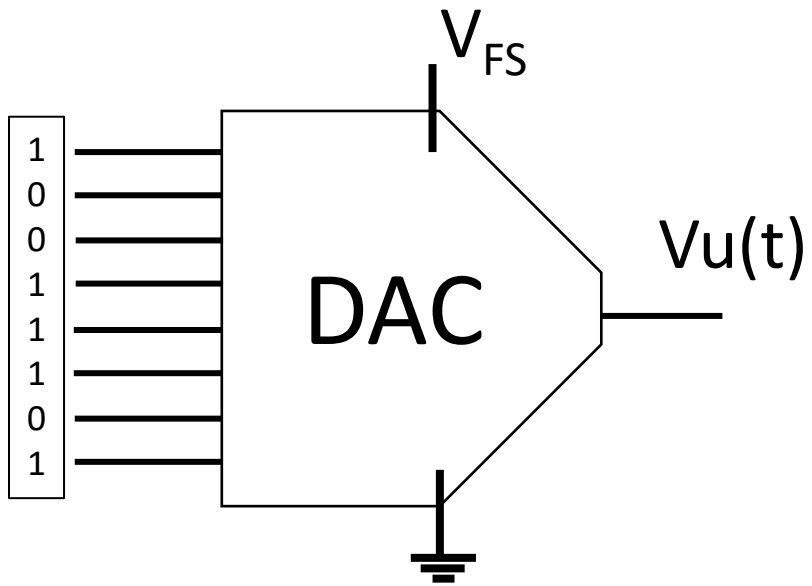


A	B	C	Vu
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

It is called Binary-Weighted DAC

DAC : Digital to Analog converters





DAC parameters :

- Number of bits in the input Word, ***n***
- Voltage span (V_{FS})
- Resolution ($V_{FS}/2^n$)

End of the lesson