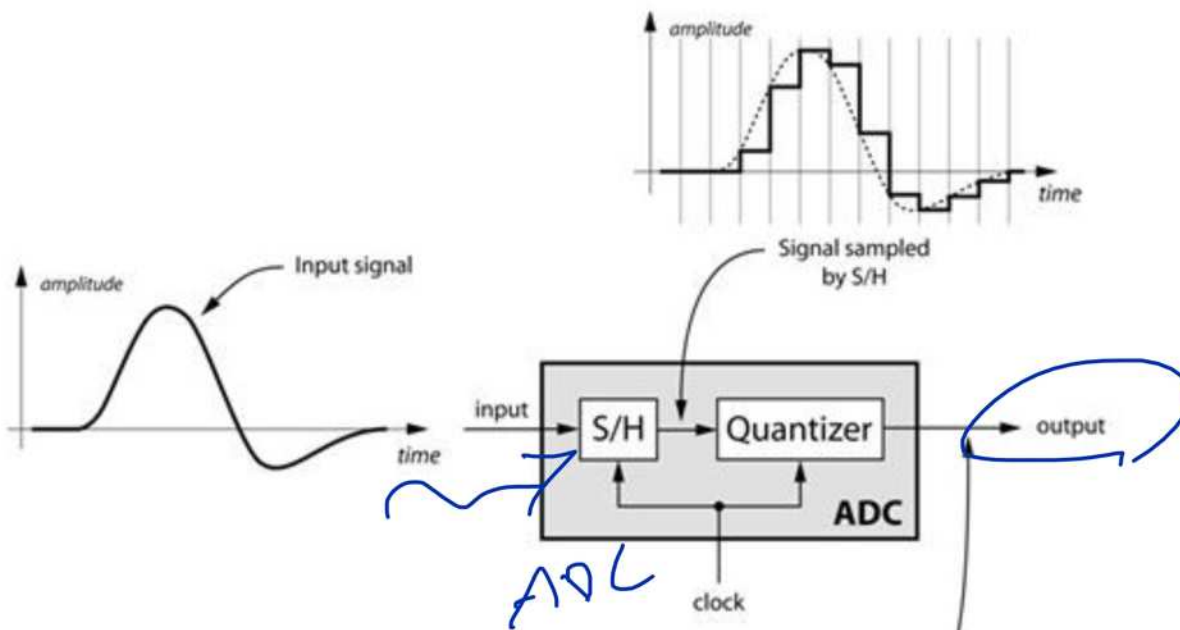
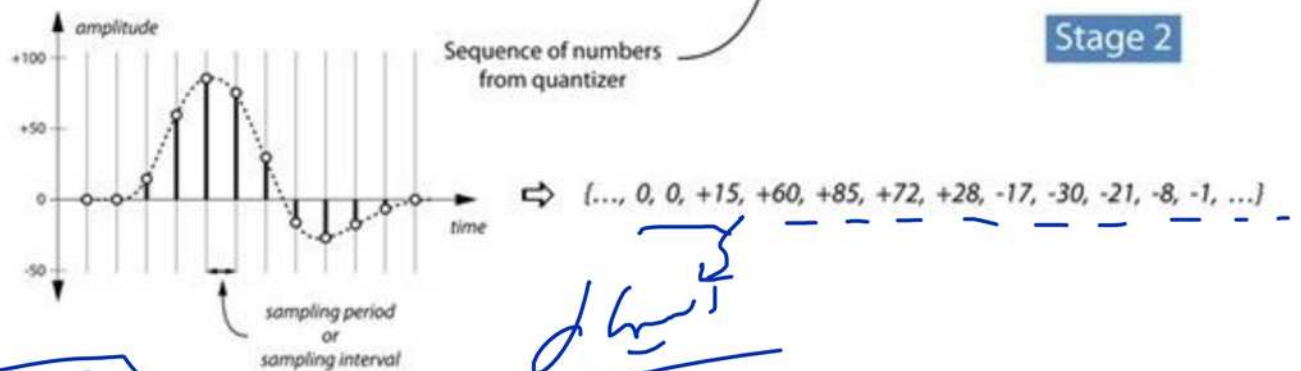


Stage 1

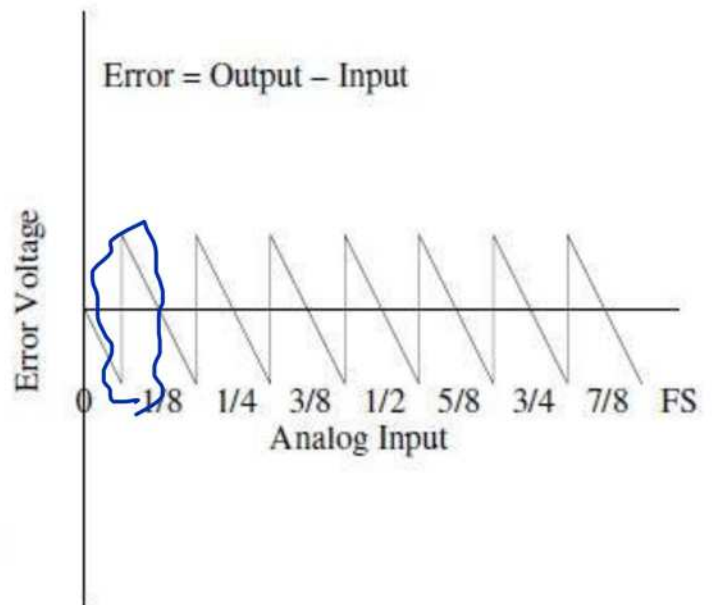
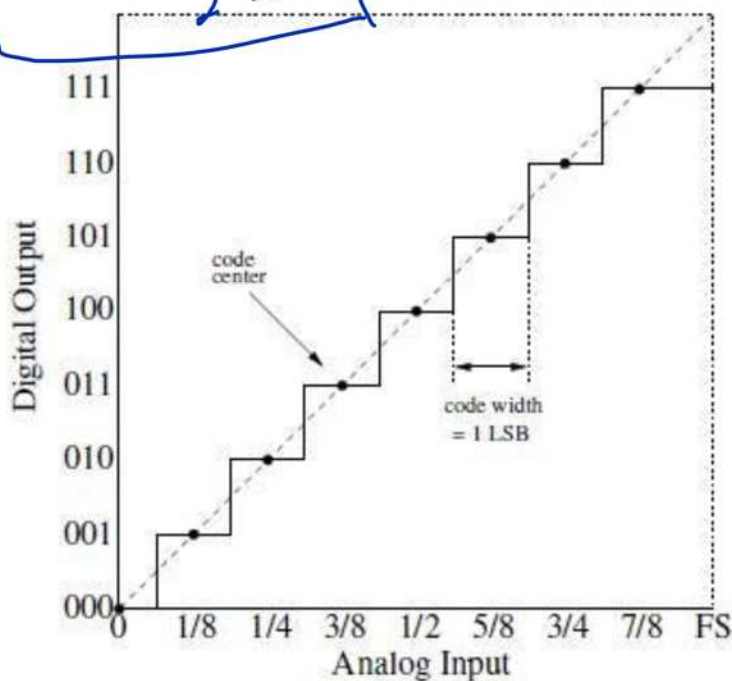


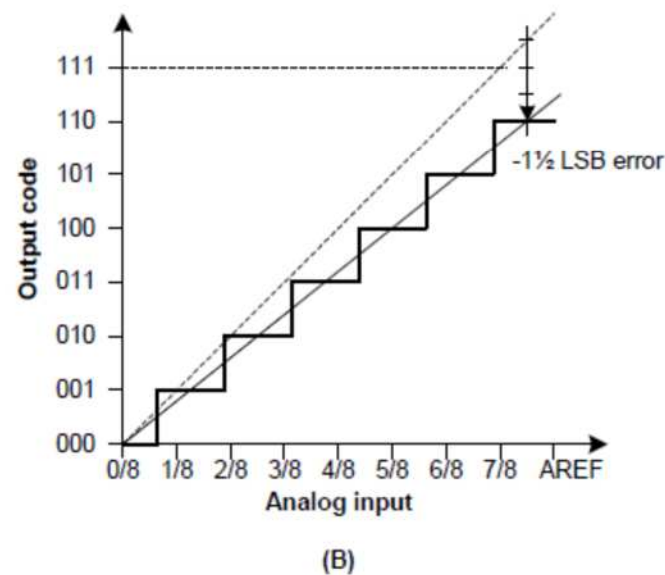
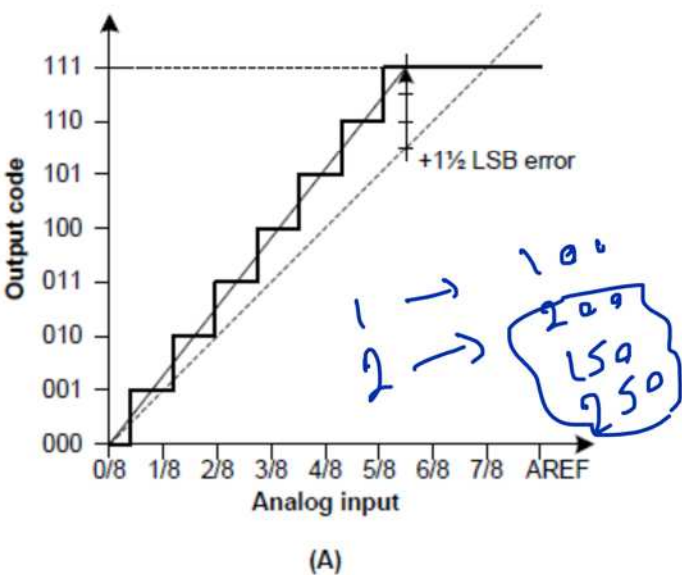
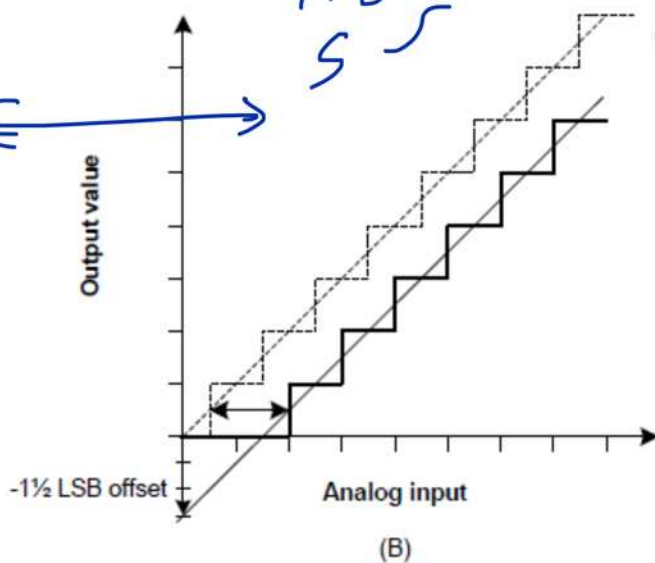
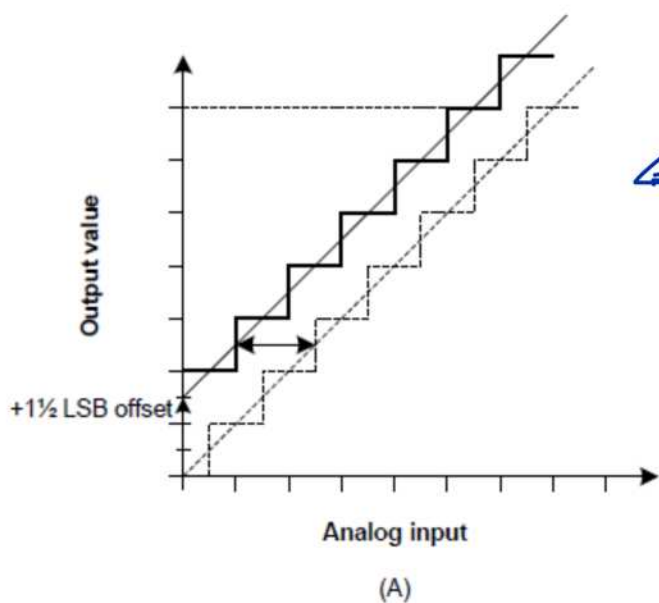
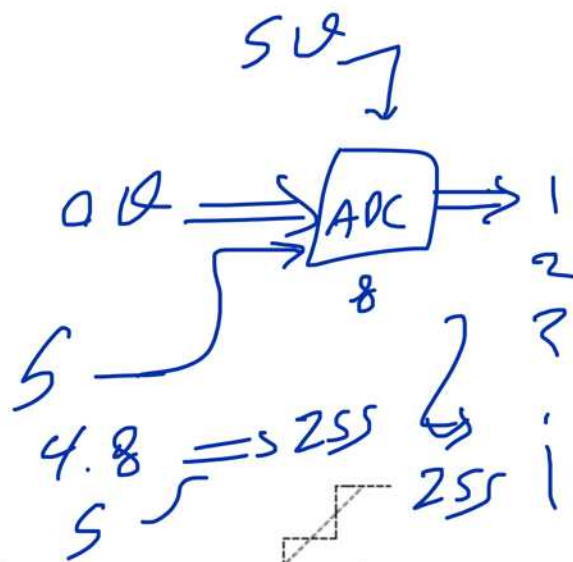
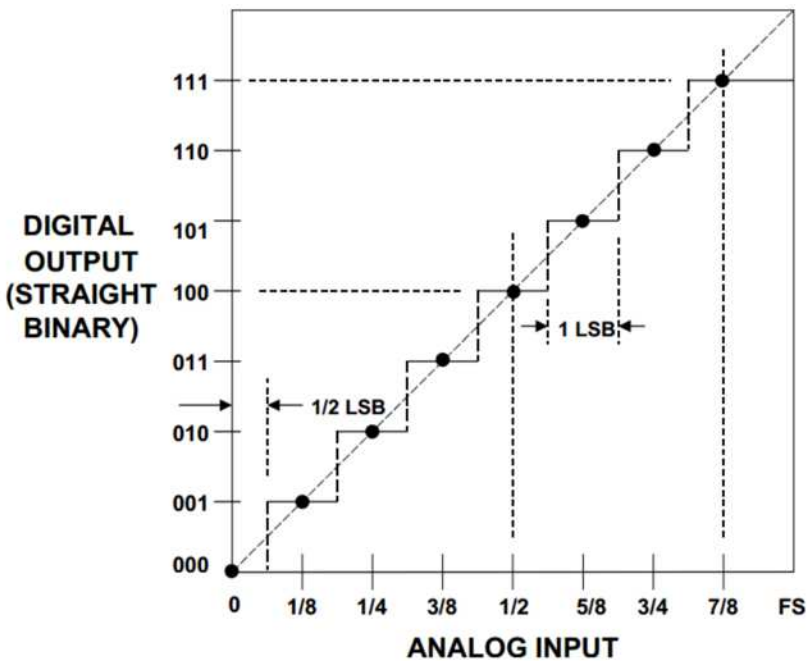
Stage 2



Sampling, Holding and Quantizing

$$2sb = \frac{v_{ref}}{2^{n-1}}$$

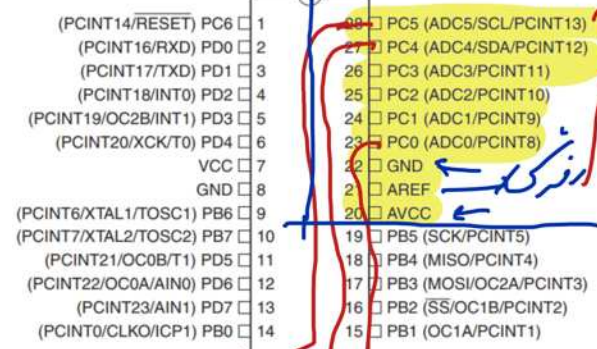
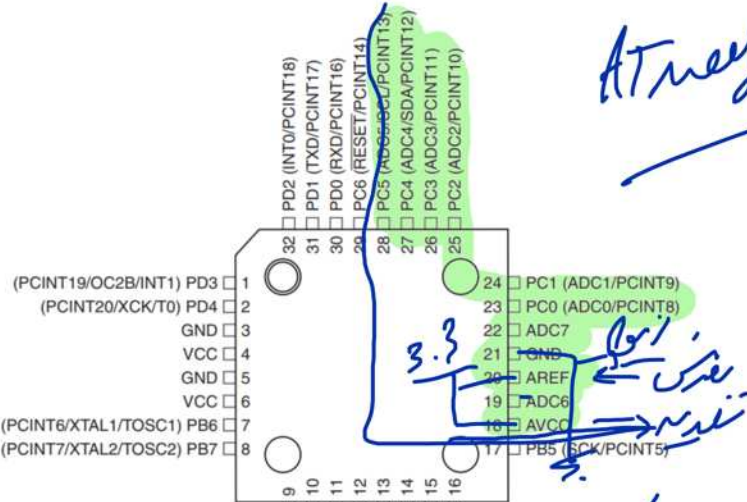




32 TQFP Top View

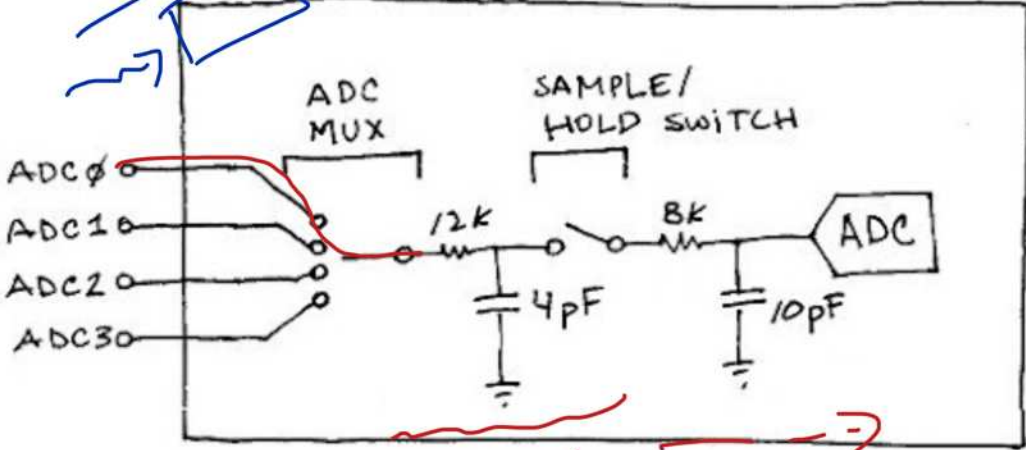
28 SPDIP

ATmega328

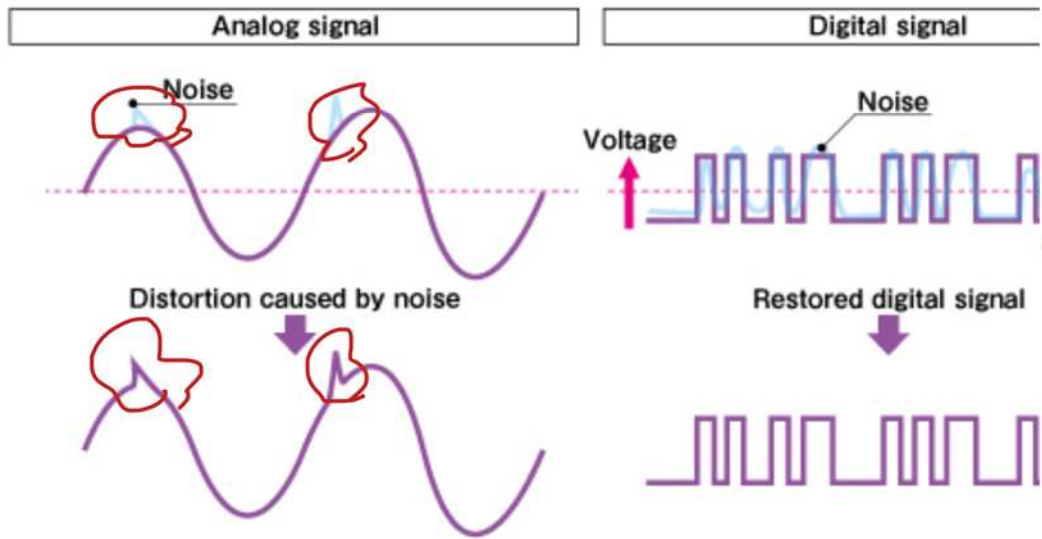


ref  
AVCC

ADL

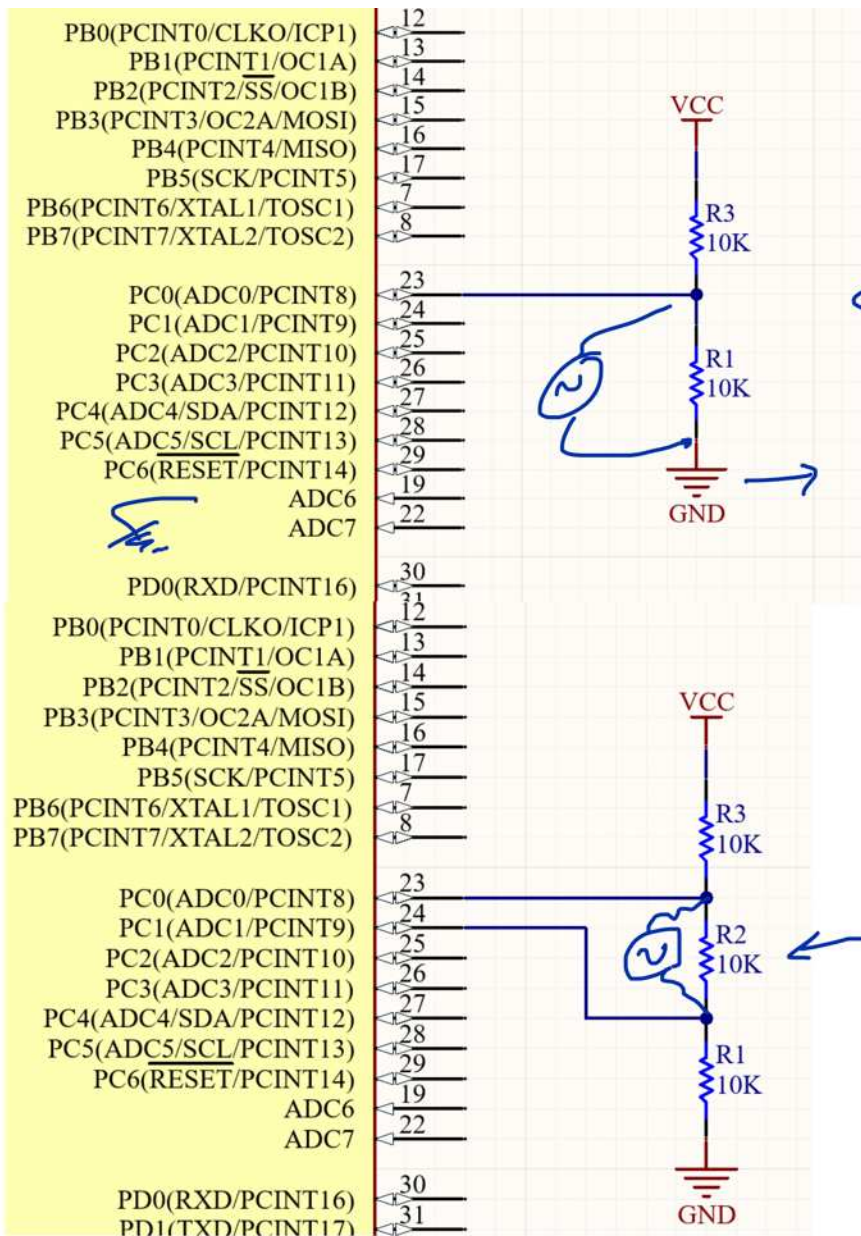


51K

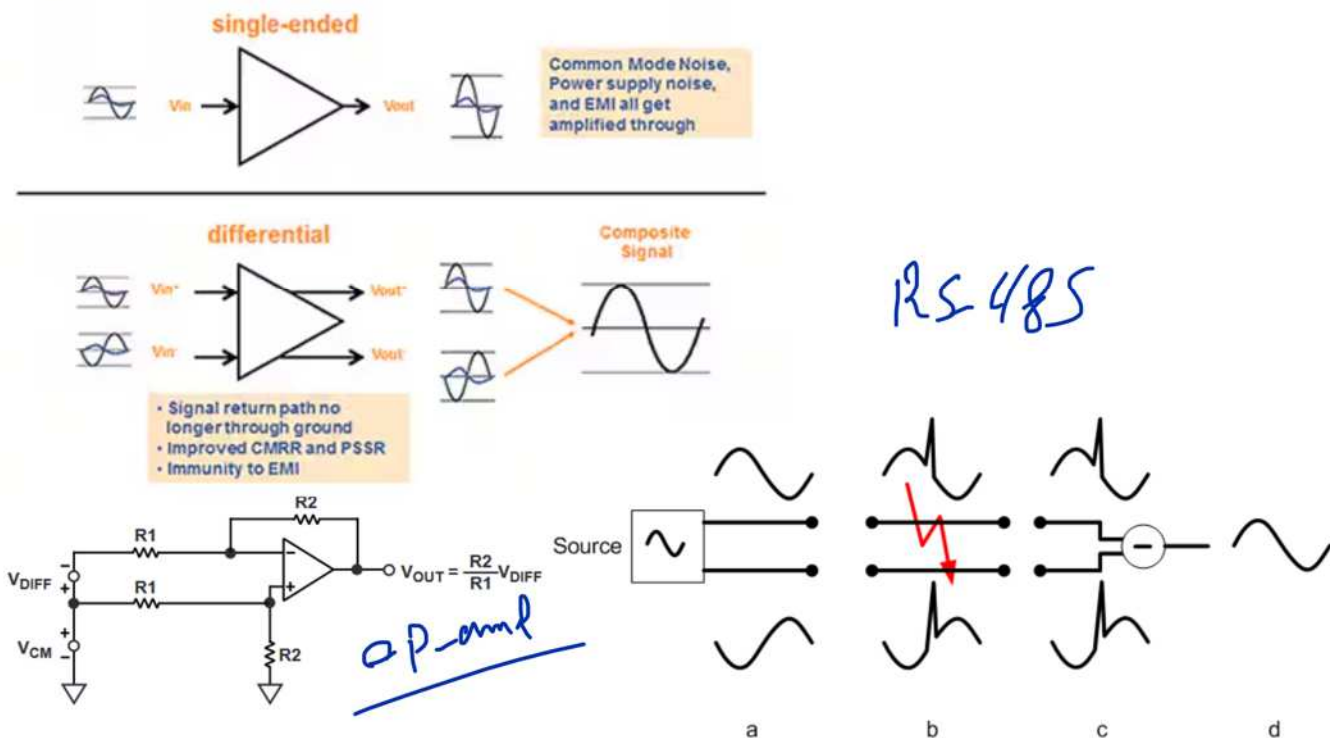


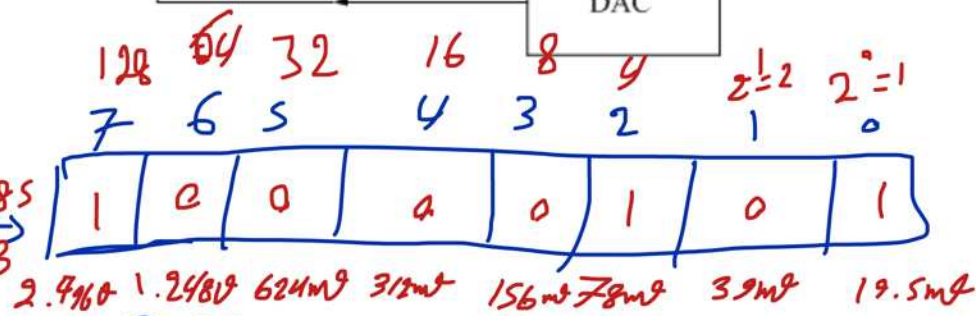
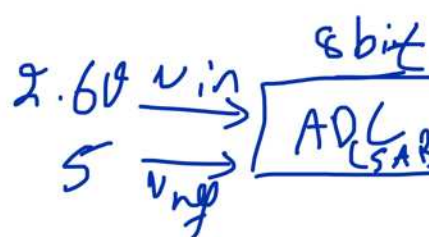
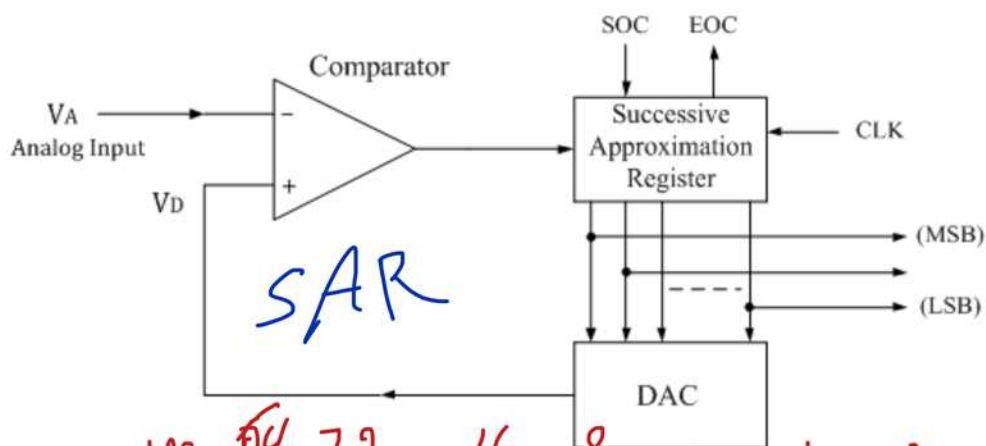
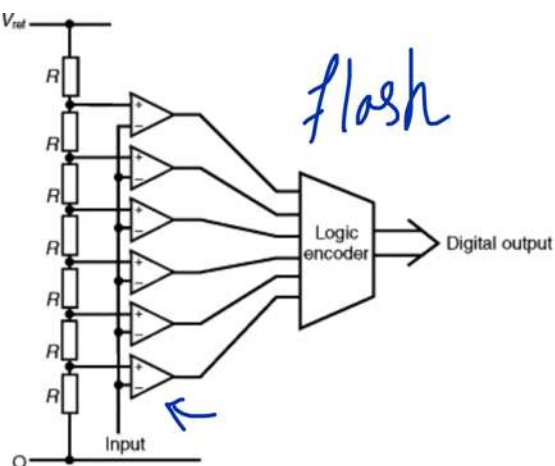
Analog  
digital





## Unbalanced Signal versus Balanced Signal





$$LSB = \frac{V_{ref}}{2^n - 1}$$

$$= \frac{5}{256 - 1}$$

$$LSB \approx 19.5mV$$

$$4 \times 85 = 133$$

$$7) 2.6 > 2.496V \quad \checkmark \quad (7) = 1$$

$$2.6 - 2.496V = 104mV$$

$$6) 104mV > 1.248V \quad \times \quad (6) = 0$$

$$5) 104mV > 624mV \quad \times \quad (5) = 0$$

$$4) 104mV > 312mV \quad \times \quad (4) = 0$$

$$3) 104mV > 156mV \quad \times \quad (3) = 0$$

$$2) 104mV > 78mV \quad \checkmark \quad (2) = 1$$

$$104mV - 78mV = 26mV$$

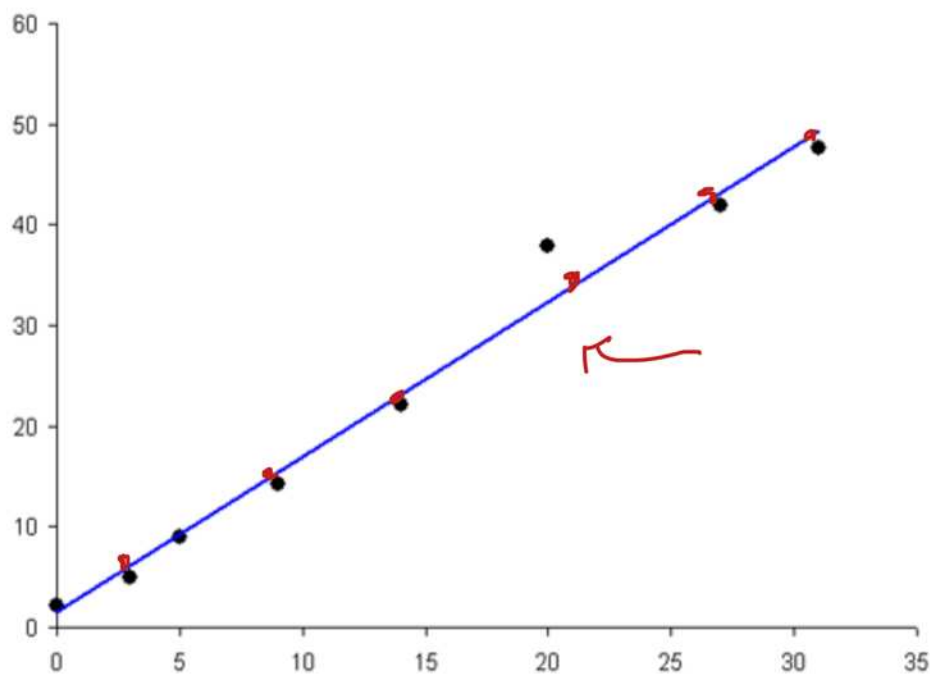
$$1) 26mV > 39mV \quad \times \quad (1) = 0$$

$$0) 26mV > 19.5mV \quad \checkmark \quad (0) = 1$$

$$adc\_raw = adc\_read(0); \quad 30mV - 19.5mV = 10.5mV$$

$$adc\_raw = 133;$$

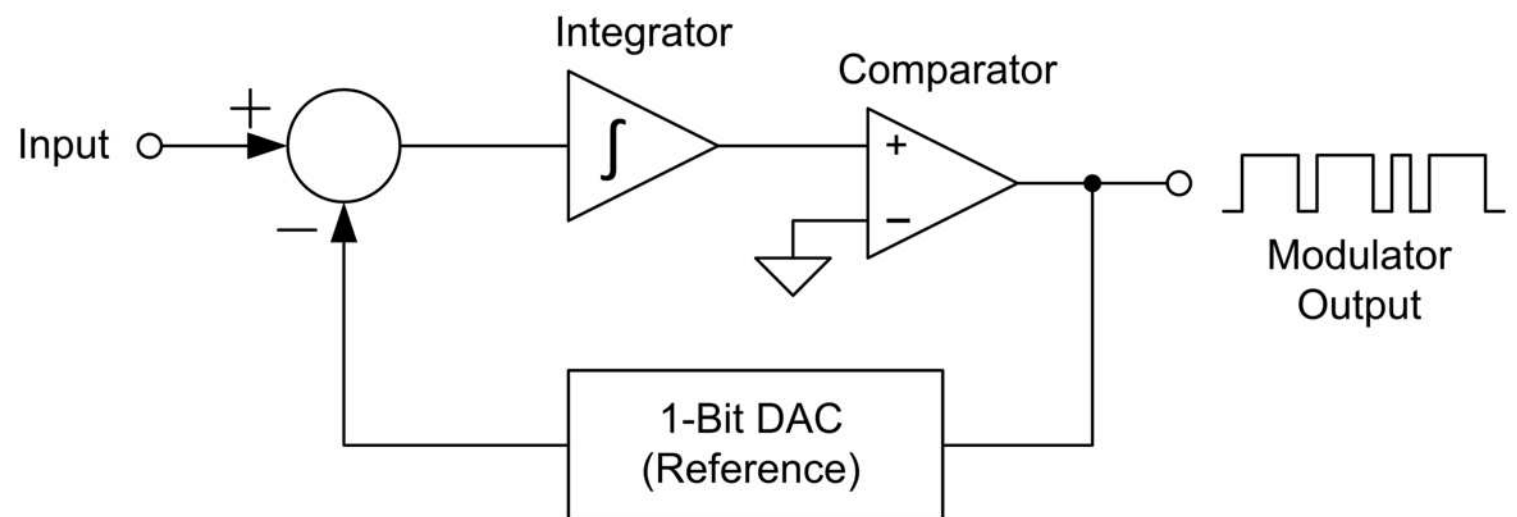
$$Volt = \frac{adc\_raw}{2^n - 1} \times V_{ref} = \frac{133}{256 - 1} \times 5 = 2.608mV$$



```

uint8_t adc_val[100];
for( ——— )
{
    adc_val[ ] = adc_read();
}
adc_value = mean(adc_val);

```



ADC Architecture	Resolution	Sample Rate	Power	Cost
Flash	8-Bit	Very High	High	High
SAR	8- to 16-Bit	Mid to High	Medium	Low to Mid
ΔΣ Delta-Sigma	up to 32-Bit	Low	Low	Low to Mid

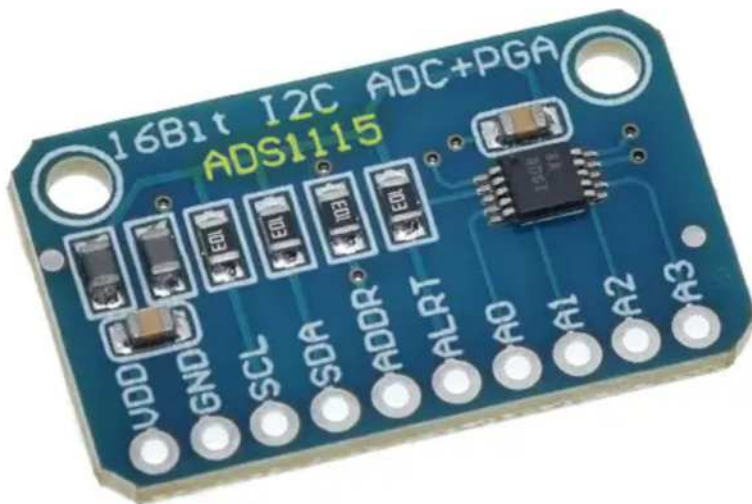
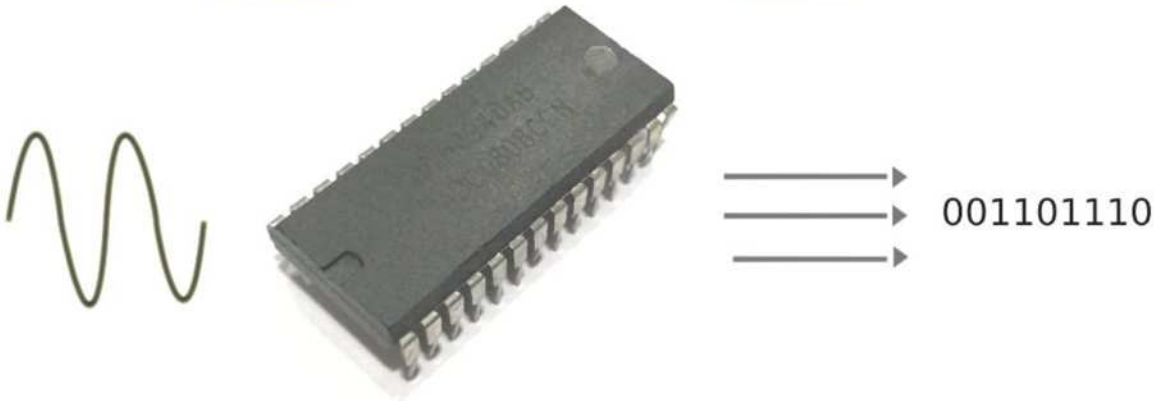


12 bit

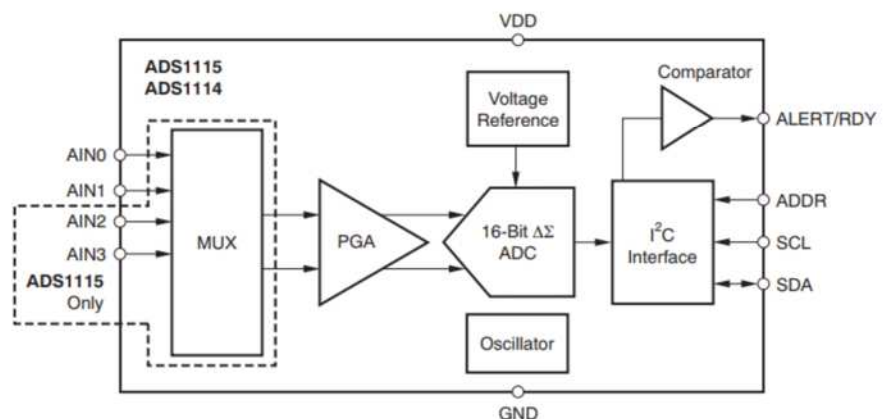
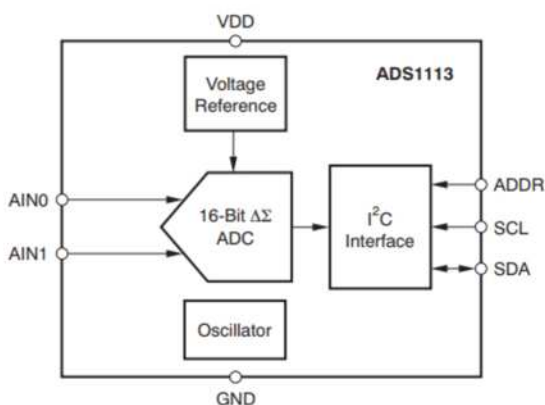
16 bit

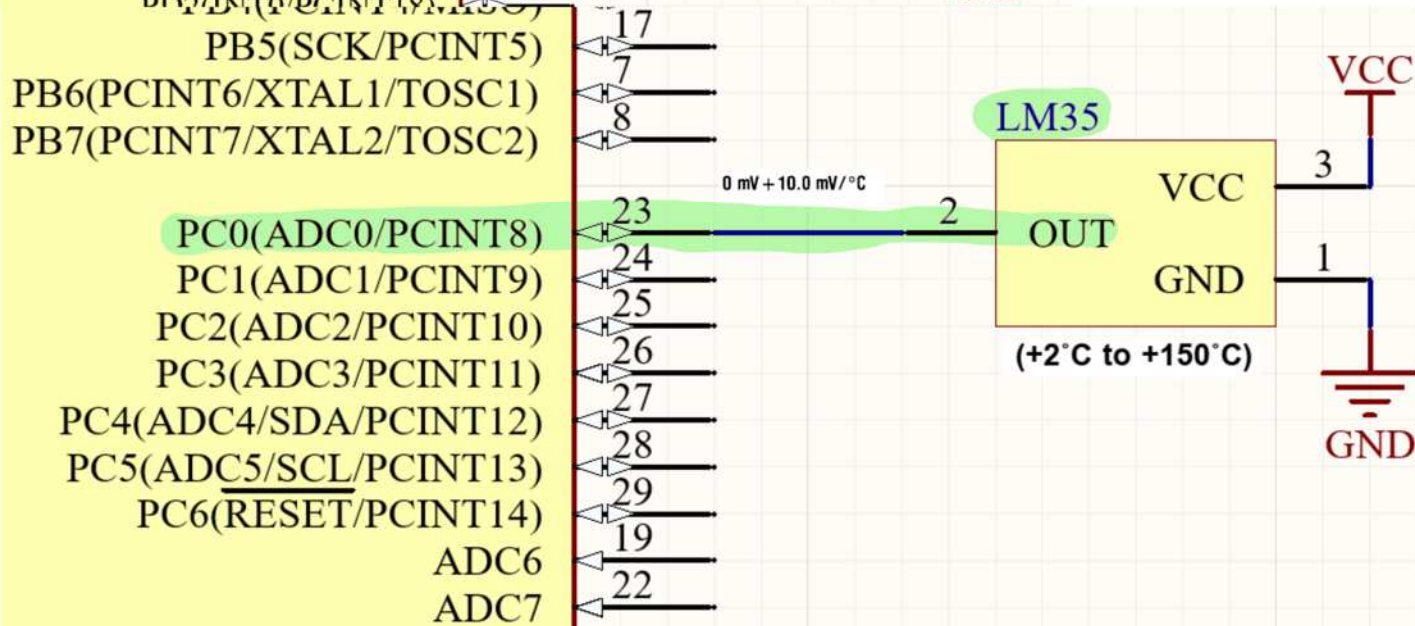
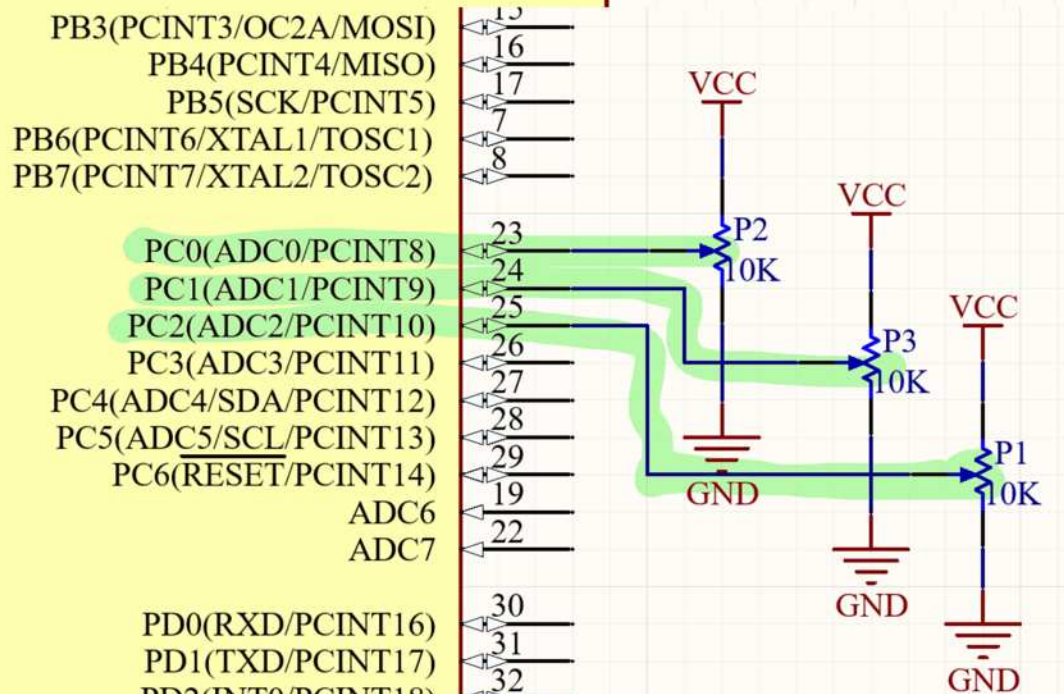
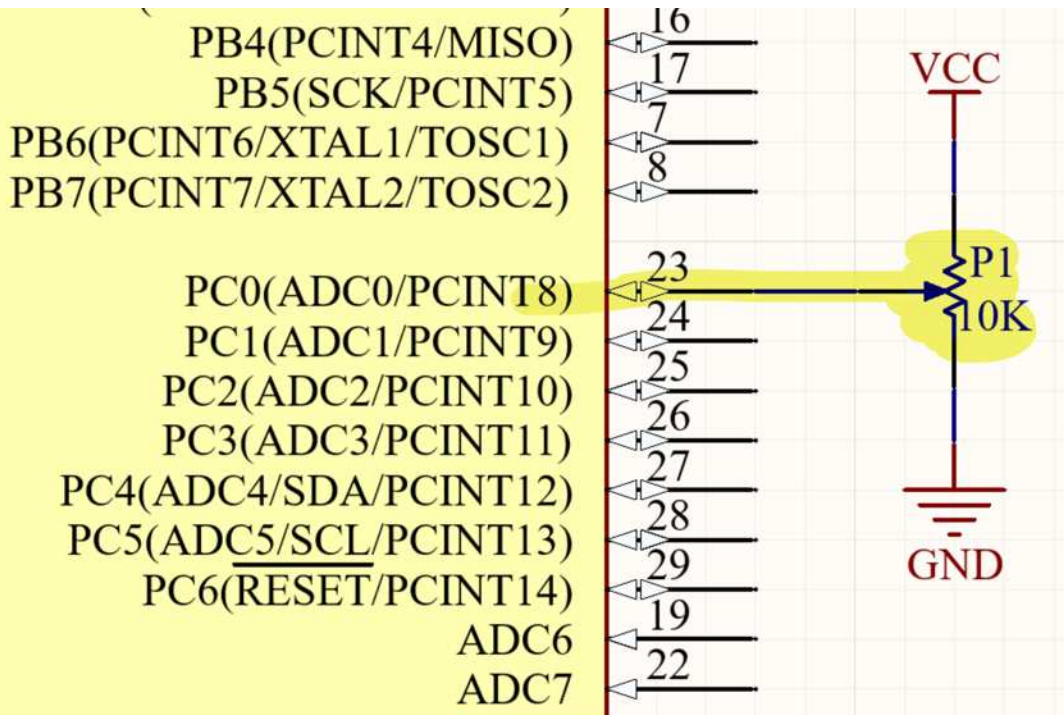
## Analog to Digital Converters

$\Delta \Sigma$



- **WIDE SUPPLY RANGE:** 2.0V to 5.5V
- **LOW CURRENT CONSUMPTION:**  
Continuous Mode: Only 150 $\mu$ A  
Single-Shot Mode: Auto Shut-Down
- **PROGRAMMABLE DATA RATE:**  
8SPS to 860SPS
- **INTERNAL LOW-DRIFT VOLTAGE REFERENCE**
- **INTERNAL OSCILLATOR**
- **INTERNAL PGA**
- **I<sup>2</sup>C™ INTERFACE:** Pin-Selectable Addresses
- **FOUR SINGLE-ENDED OR TWO DIFFERENTIAL INPUTS (ADS1115)**
- **PROGRAMMABLE COMPARATOR (ADS1114 and ADS1115)**





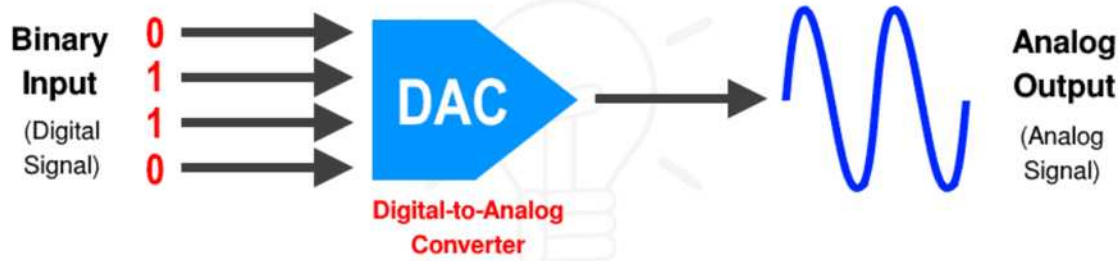




# DAC

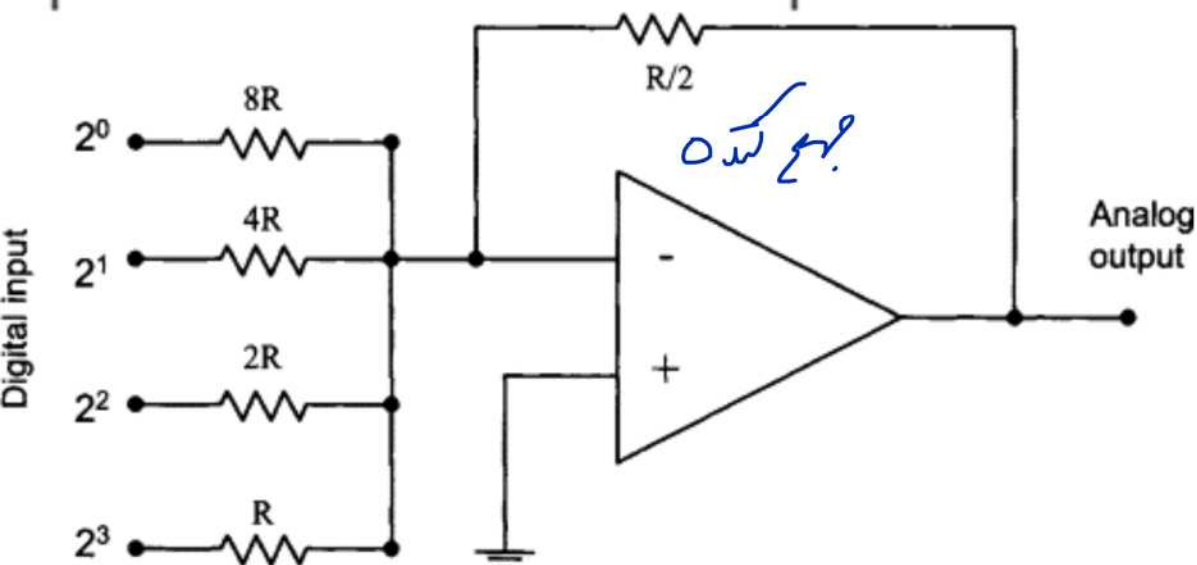
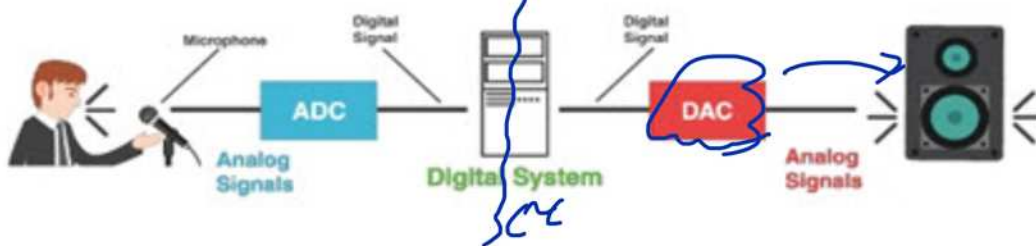


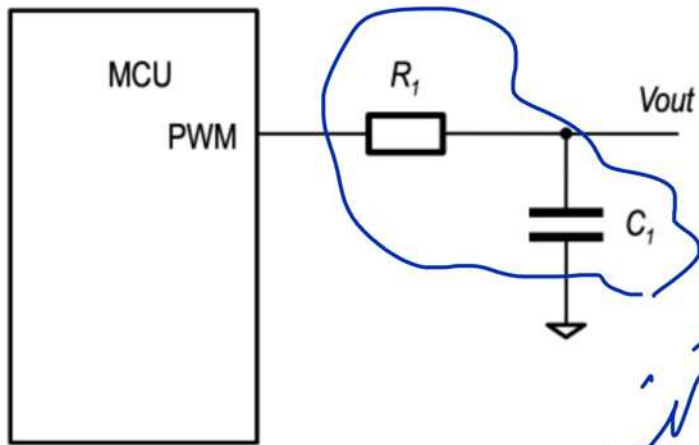
## DIGITAL TO ANALOG CONVERTER



## Digital to Analog Converter (DAC) and Its Applications

### Need of conversion

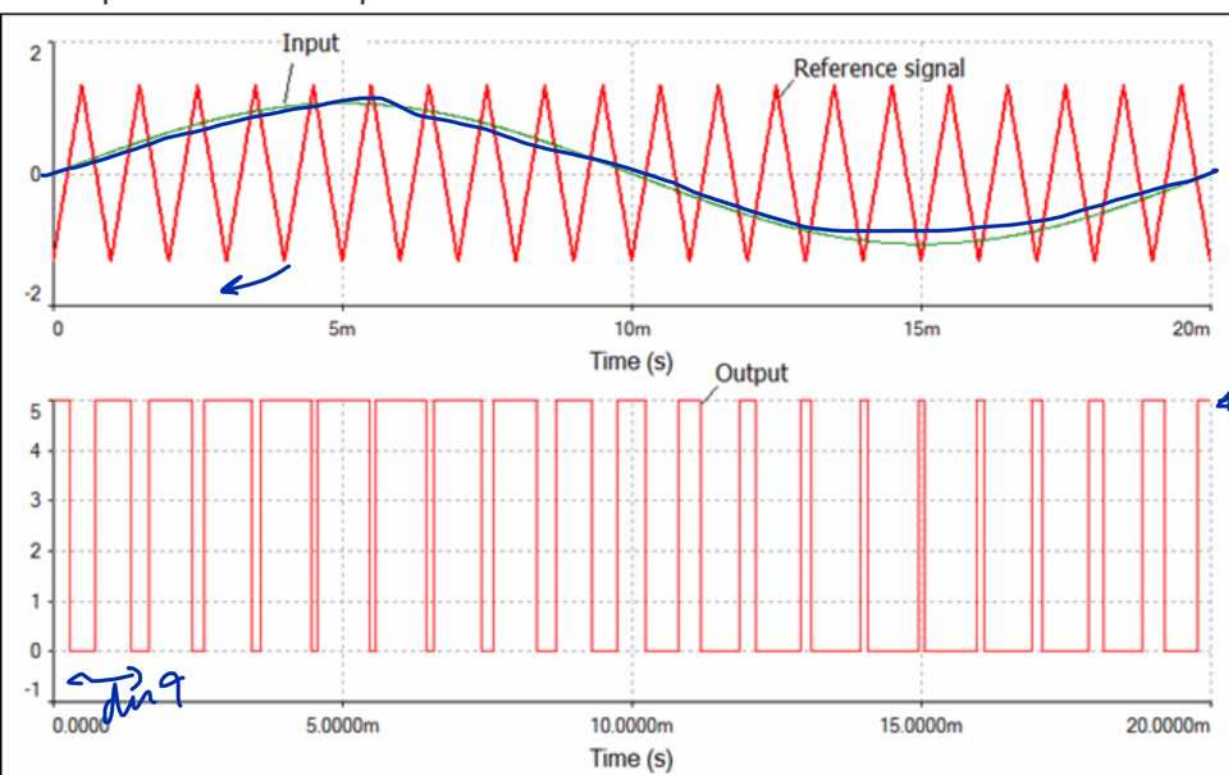
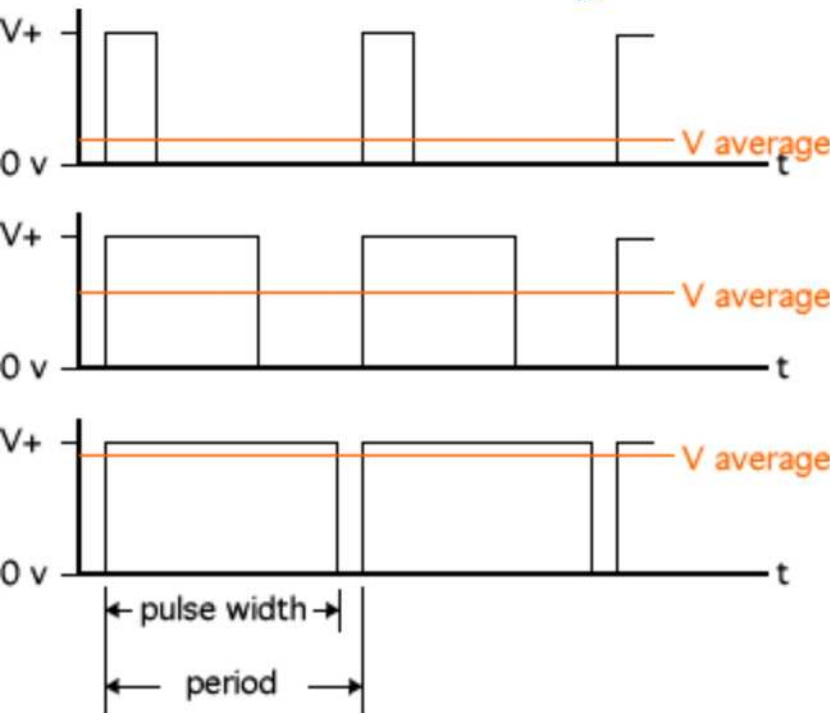




L.P.F  
 فیلتر پایین گذر

$$V_{out} = d \times V_{CC}$$

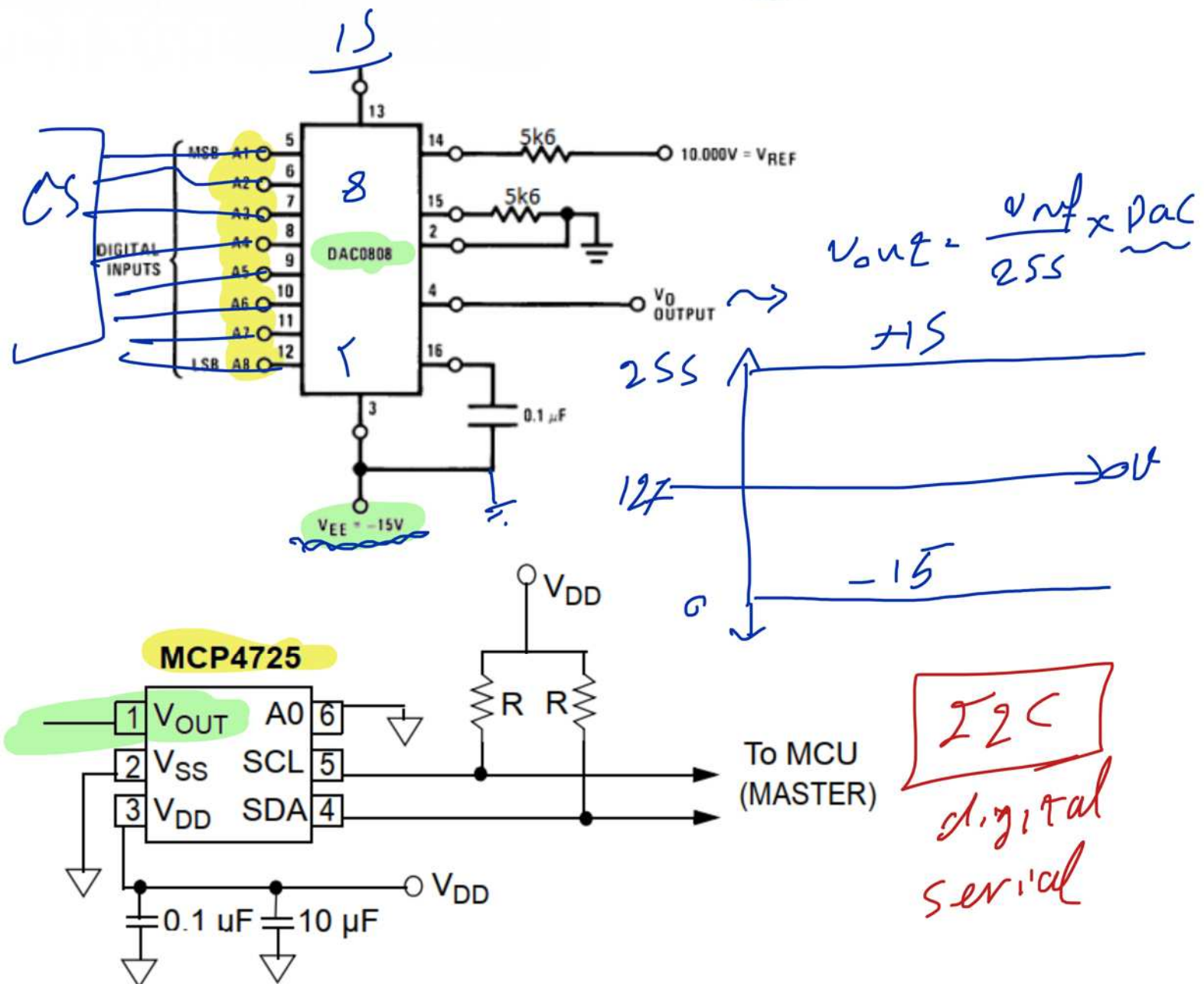
as  $V_{out} \leq V_{CC}$



فیلتر کاشی پاک کن  
 فیلتر کاشی پاک کن

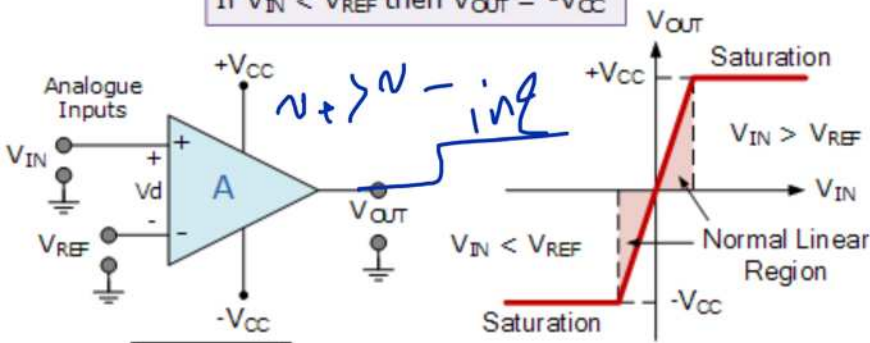
→  
 ←

دuty

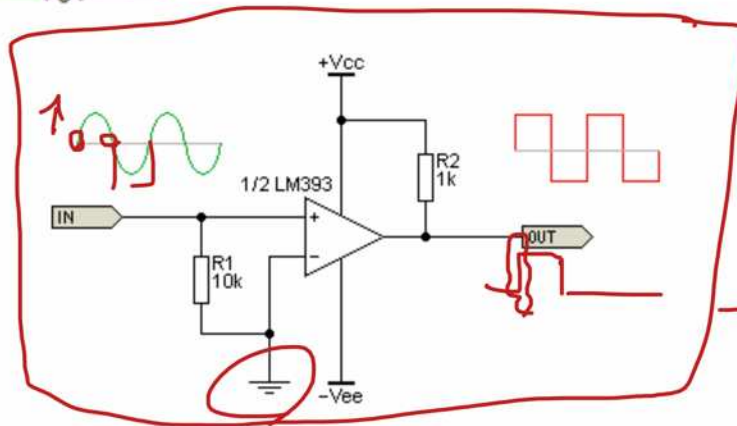
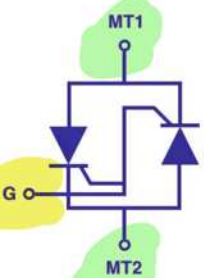
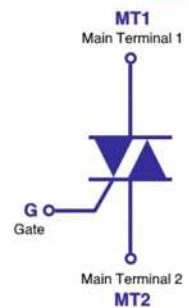
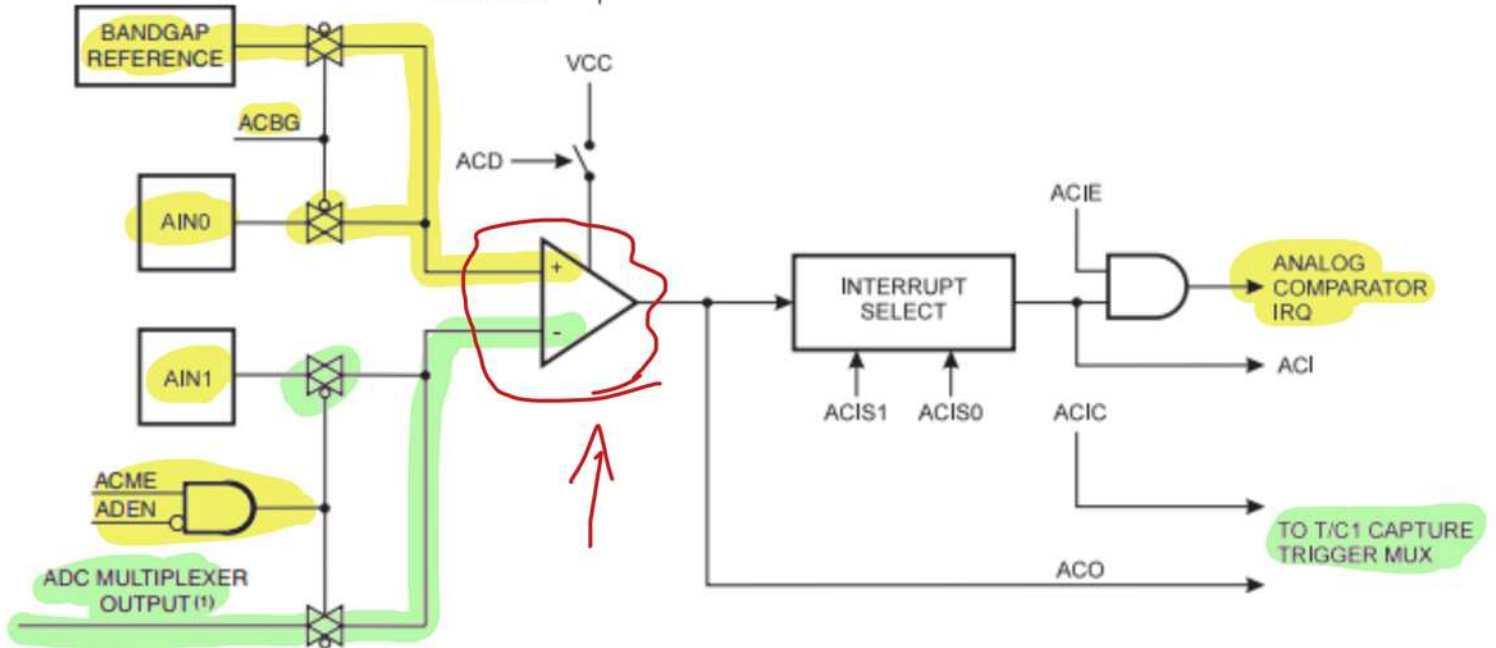




If  $V_{IN} > V_{REF}$  then  $V_{OUT} = +V_{CC}$   
 If  $V_{IN} < V_{REF}$  then  $V_{OUT} = -V_{CC}$



مکات یہ کہتے ہیں



تدائیک

توان AC  
 بیش و کمتر

