Analog to Digital Converter

CSCI 332 IoT

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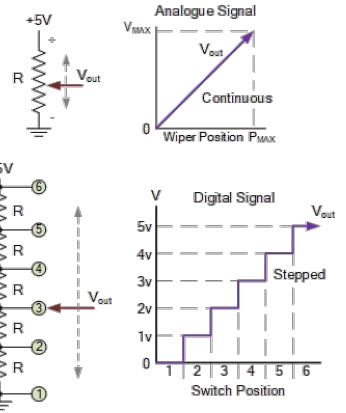
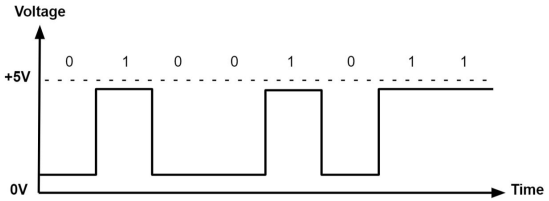
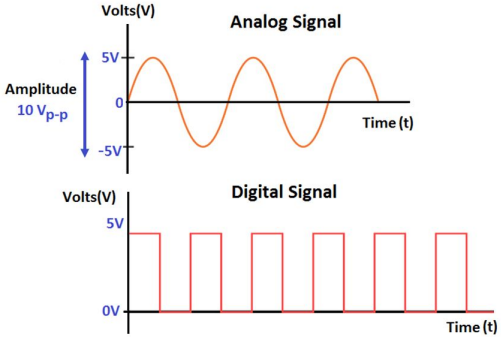
What is Analog to Digital Converter

- Measures a Analog Signal to Digital Signal
  - Analog Signal
    - Is continuous (can measure voltage from 0 to V_max)
    - Some analog signals are temperature, pressure, etc
  - Digital Signal
    - Has discrete values

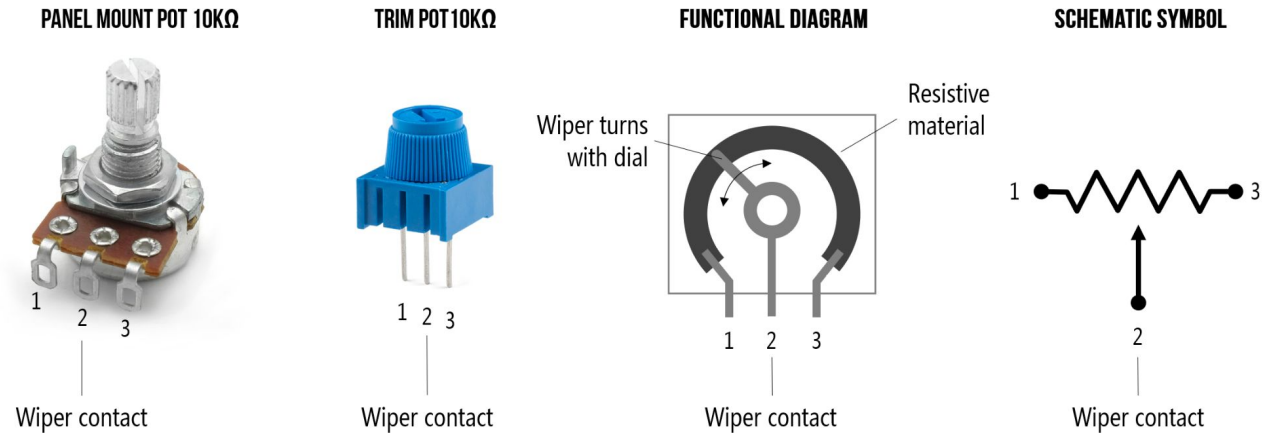






Potentiometer

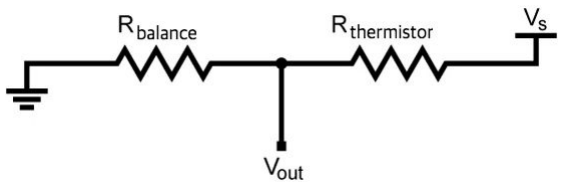
- A position sensor
- Resistance can be changed by adjusting the position on the potentiometer (the wiper position)



Thermistor

- A thermistor has a large change in resistance with a small change in temperature
- Higher temperature, lower resistance
- Steinhart-Hart Equation:
  - T_o = reference temperature, usually room temperature
  - R_o = resistance at T_o
  - Beta = contant, usually given from the datasheet
- $R_{balance}$ is used to balance out the voltage
  - $R_{balance}$ = thermistor resistance at midpoint of temperature range

$$\frac{1}{T} = \frac{1}{T_o} + (\frac{1}{\beta}) \cdot \ln\left(\frac{R}{R_o}\right)$$



Example (find temperature with a thermistor)

Voltage reading: V_{th} = 2454 mV

Balance resistor: V_b = 3300mV - 2454mV = 846mV

Current: **I** = V_b / R_b = 846mV/10 kΩ = 84.6 μA

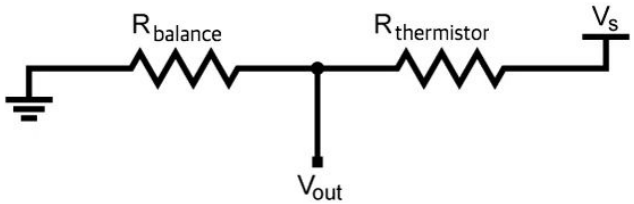
Thermistor resistance: R_{th} = (**V_{th}** * 1000) / **I** = 29007 Ω

$$T = \frac{1}{\frac{1}{T_o} + \frac{1}{\beta} \cdot \ln\left(\frac{R_{th}}{R_o}\right)} = 275.977K - 273 = 2.977^\circ C$$

β = 3977 K

R_o = 10 kΩ

T_o = 25 ℃



Example (find temperature with a thermistor)

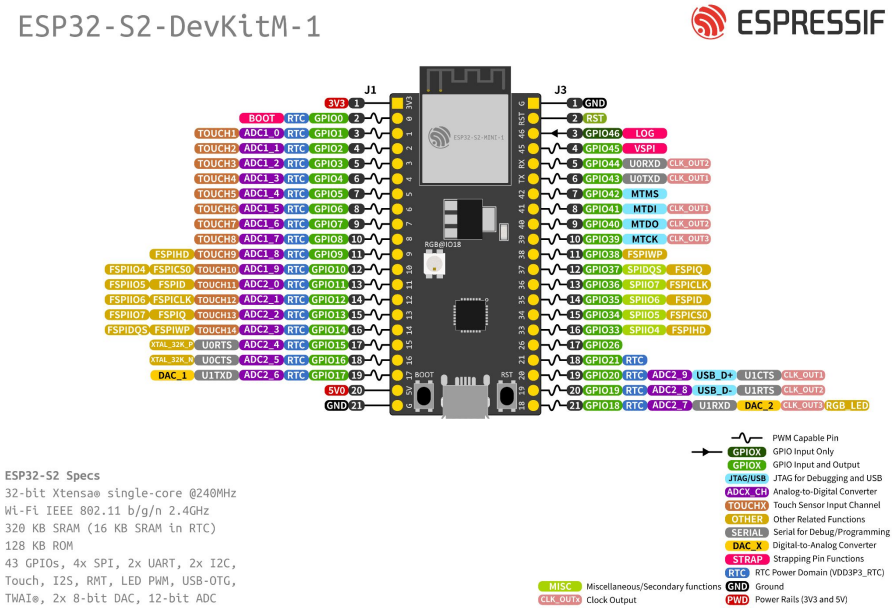
```
106
107         //Get temperature value
108
109         // Find current V = I*R
110         // V = 3.3V - the voltage reading
111         long voltage_b = 3300-voltage;
112         // current is in micro amp
113         // current is found by dividing the v_b by 10 (10K ohm resistor)
114         long current = voltage_b/10;
115         printf("current: %ld\n", current);
116         // resistance for the thermister (using V = I*R)
117         // resistance is milli volts / micro amps = kilo ohms
118         long resistance_t = (voltage*1000)/current;
119         printf("resistance %ld\n", resistance_t);
120         //temperature in Kelvin
121         float temperature_k = 1/((1/298.15) + (1.0/3977.0)*(log(resistance_t/10000.0)));
122         printf("Raw: %d\tVoltage: %dmV\n", adc_reading, voltage);
123         //temperature in Celsius
124         float temperature_c = temperature_k - 273.15;
125         printf("temperature: %f C\n", temperature_c);
126         vTaskDelay(pdMS_TO_TICKS(1000));
```

$$\frac{1}{T} = \frac{1}{T_o} + \left(\frac{1}{\beta}\right) \cdot \ln\left(\frac{R}{R_o}\right)$$

```
current: 84
resistance 29214
Raw: 7731       Voltage: 2454mV
temperature: 2.820001 C
current: 83
resistance 29662
Raw: 7755       Voltage: 2462mV
temperature: 2.528863 C
current: 83
resistance 29686
Raw: 7763       Voltage: 2464mV
temperature: 2.513422 C
current: 83
resistance 29710
Raw: 7769       Voltage: 2466mV
temperature: 2.497980 C
current: 82
resistance 30134
Raw: 7785       Voltage: 2471mV
temperature: 2.227502 C
```

Notes

- The channels supported are
  - ADC1 → 10 channels: GPIO1 - GPIO10
  - ADC2 → 10 channels: GPIO11 - GPIO 20
- Four Attenuation options
  - ADC_ATTEN_DB_0 → 0 mV ~ 750 mV
  - ADC_ATTEN_DB_2_5 → 0 mV ~ 1050 mV
  - ADC_ATTEN_DB_6 → 0 mV ~ 1300 mV
  - ADC_ATTEN_DB_11 → 0 mV ~ 2500 mV



Reference

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