Digital Multi-Functional Thermometer

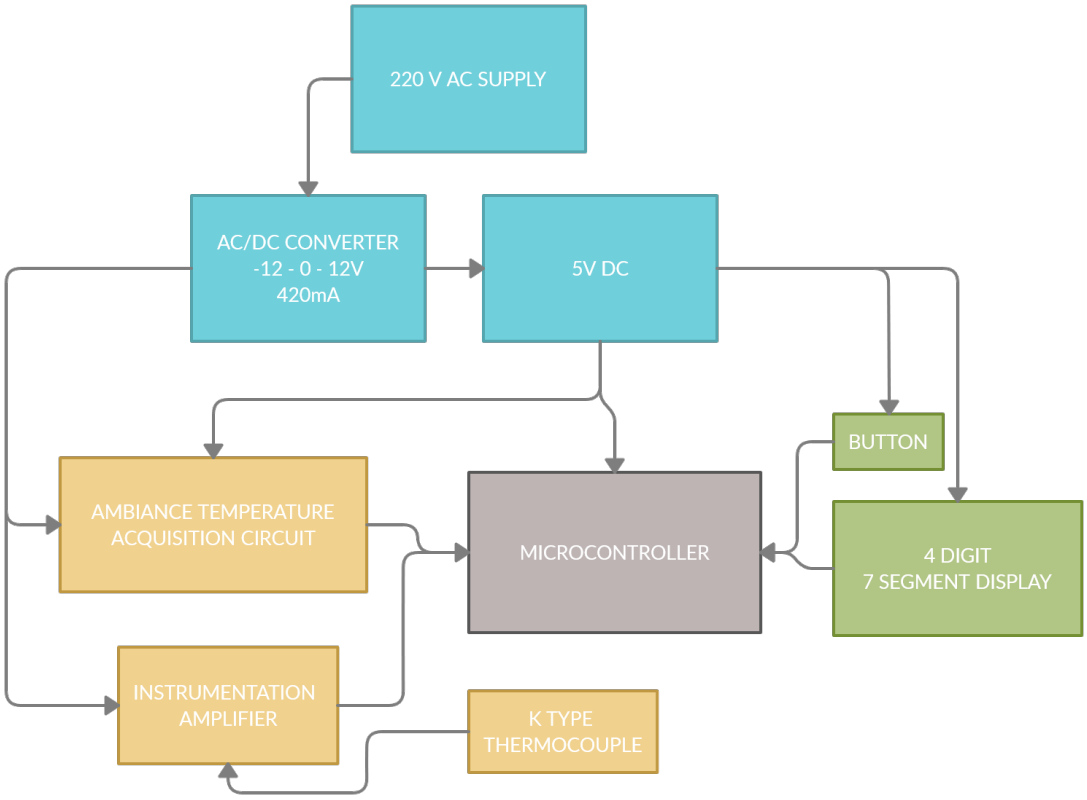
This thermometer provides instant digital readout of the temperature sensed by a K type thermocouple. It can measure temperatures precisely between 20 and 250 ºC (68 ºF and 482 ºF). This appliance is useful for both beginners and professional cookers to monitor the internal temperature of foods like steaks, chicken, fish and liquids like water or cooking oil.

It can also measure the ambience temperature through a diode, which is also used to make a temperature compensation in the thermocouple.

Specifications:

- Power supply: 220V AC
- Temperature display units: ºC
- Resolution: 0.5 ºC
- Temperature range: 0ºC ~ 250ºC
- Temperature accuracy: ± 2 ºC

System block diagram:



The voltage that provides the k thermocouple is amplified with a gain of 243 to provide a signal of 10mv per degree to an adc channel in the microcontroller.

The ambience temperature it's acquired with an 1N4148 diode and his temperature dependency, which is about -2mV/ºC the circuit uses an op-amp in differential mode to amplify this signal with a gain of five and then is sended to an adc channel in the microcontroller.

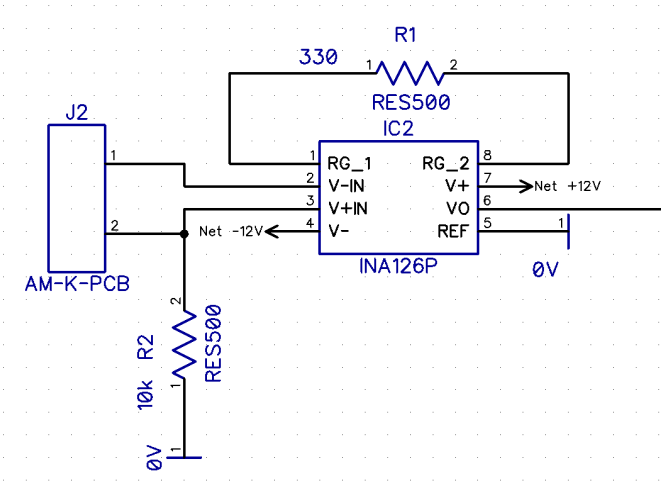
The four-digit seven segment display utilises a circuit to multiplex the displays, 12 digital pins of the microcontroller are used.

The voltage comes from and ac to dc converter which provides 12, -12 and 0 volts along with an LM7805 which provides 5 volts.

The microcontroller is an Atmega328P with an arduino IDE.

Selection of components.

Thermocouple.



The type k thermocouple provides a linear seebeck coefficient in the range between our range of application (0 – 250ºC) of about 41 µV/ºC, therefore.

$$Vin = 41 \cdot 10^{-6}(T - Tamb)$$

Our microcontroller has a resolution of 4.9 mV, so we need to amplify our signal to about 10mV/ºC

$$Vout = 10 \cdot 10^{-3}(T - Tamb)$$

To do that an ina126p instrumentation amplifier is used, it has low quiescent current, low offset voltage, low offset drift, low noise which is ideal for the application.

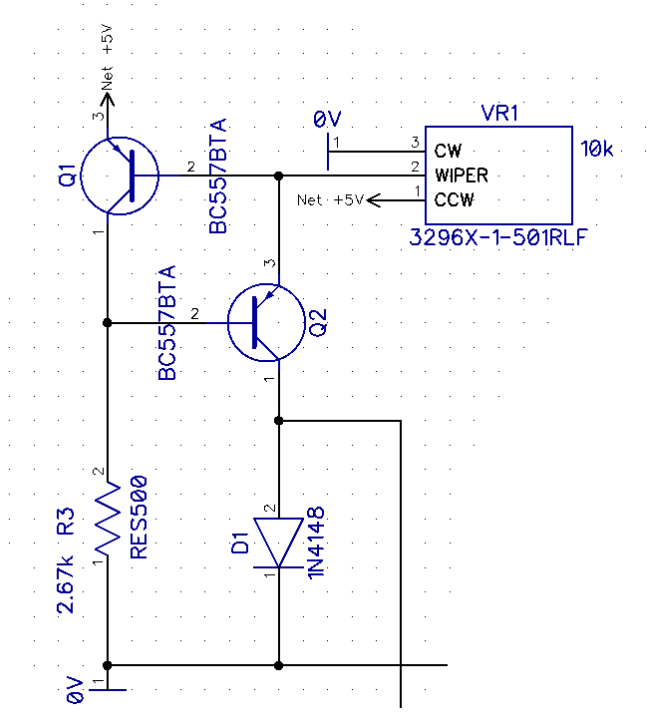
$$G = \frac{10^{-3}}{41 \cdot 10^{-6}} = 243$$

With the gain equation of the ina126p:

$$G = 5 + \frac{80K}{Rg} \rightarrow \boldsymbol{Rg = R1 = \frac{80k}{G - 5} = 330\Omega}$$

R2 = 10K -> To provide a path for the input bias current of both inputs.

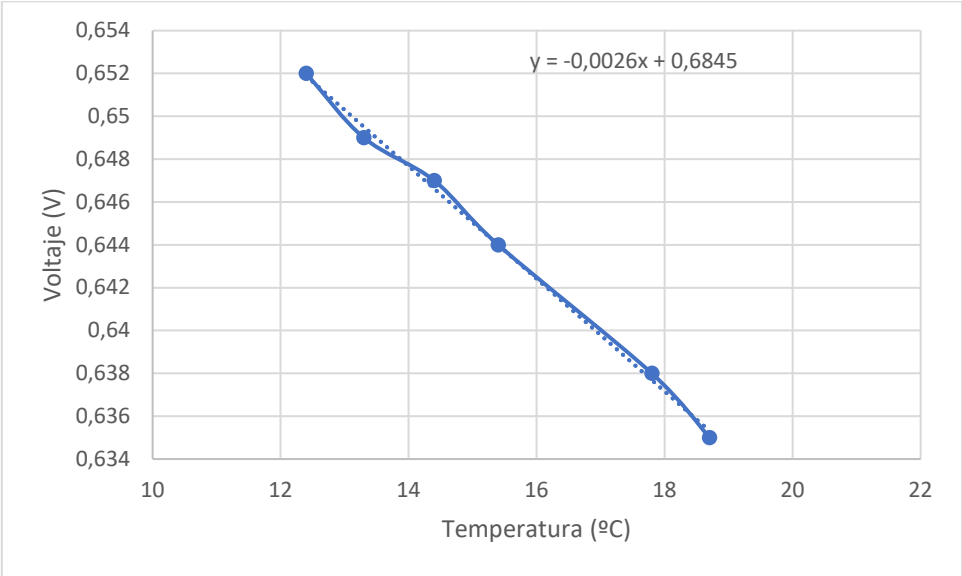
Temperature acquisition circuit.



First, we provide a constant current thru the diode to delete this dependency and obtain the following output. (For the tested diode)

$$Vout = 0.6849 - 0.0026 \cdot T$$

Which was obtained with a linear trendline.



$$Ie,q2 = 2mA \rightarrow R2 = VR1 = \frac{Vbe,q1}{Ie,q2} \cong 350\Omega \rightarrow \boldsymbol{VR1\ potentiometer\ of\ 1K}$$

$$R3 = \frac{Vcc - Vbe,q1 - Vbe,q2}{Ie,q1} \rightarrow R3\,\min = 1800\Omega, R3\,\max = 1950\Omega$$

$\boldsymbol{R3 = 2.67K\Omega}$ to provide enough current to saturate transistors.