

EXPERIMENT 7 ANALOG TO DIGITAL CONVERTER: PULSE WIDTH MODULATION

1. PURPOSE:

We will implement an analog (signal from a physical sensor) to digital (input port signal for a microcontroller) interface, based on the measurement of the duty-cycle (pulse-width) of a signal generated by a comparator.

2. ANALOG-TO-DIGITAL INTERFACE : PULSE-WIDTH MODULATOR

2.1 Temperature to voltage converter

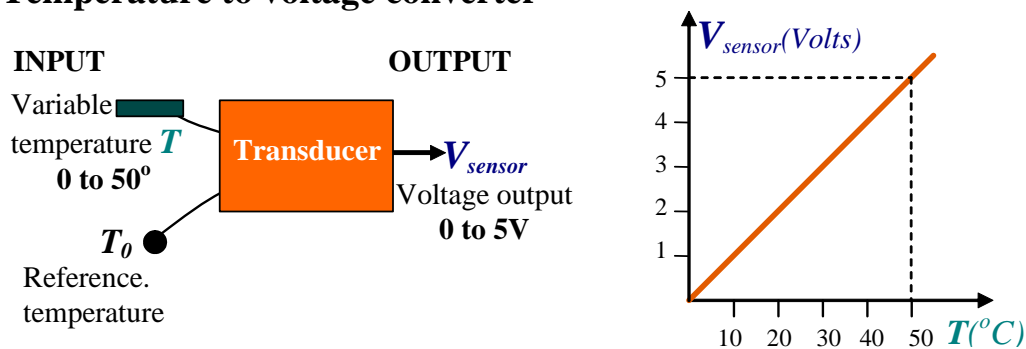


Fig.1 Left: Transducer (thermocouple) signal is converted to a voltage. **Right:** The relationship between the temperature variation and the output voltage is assumed to be linear.

2.2 Pulse-width Modulator

Use the op amp LM358AP to compare two input volages: the sensor voltage, and a sawtooth voltage of constant frequency (try 100 Hz). We will mimic the sensor voltage by providing a manually variable voltage (0 to 5 V range.)

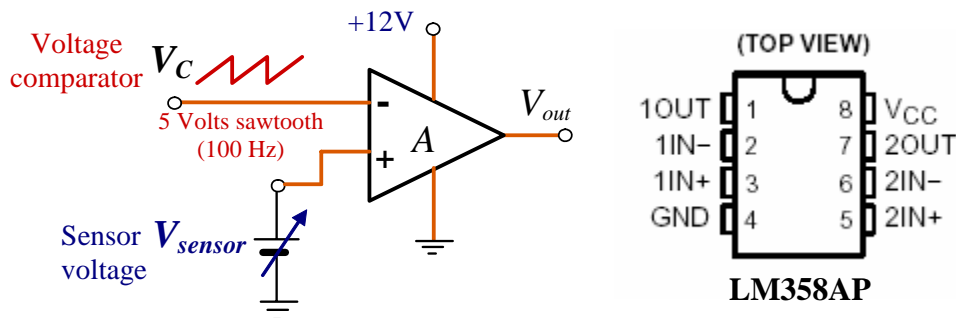


Fig.2 Left: Comparator circuit. **Right:** Pin connections of the LM358AP. Notice that a ground terminal replaces $-V_{CC}$.

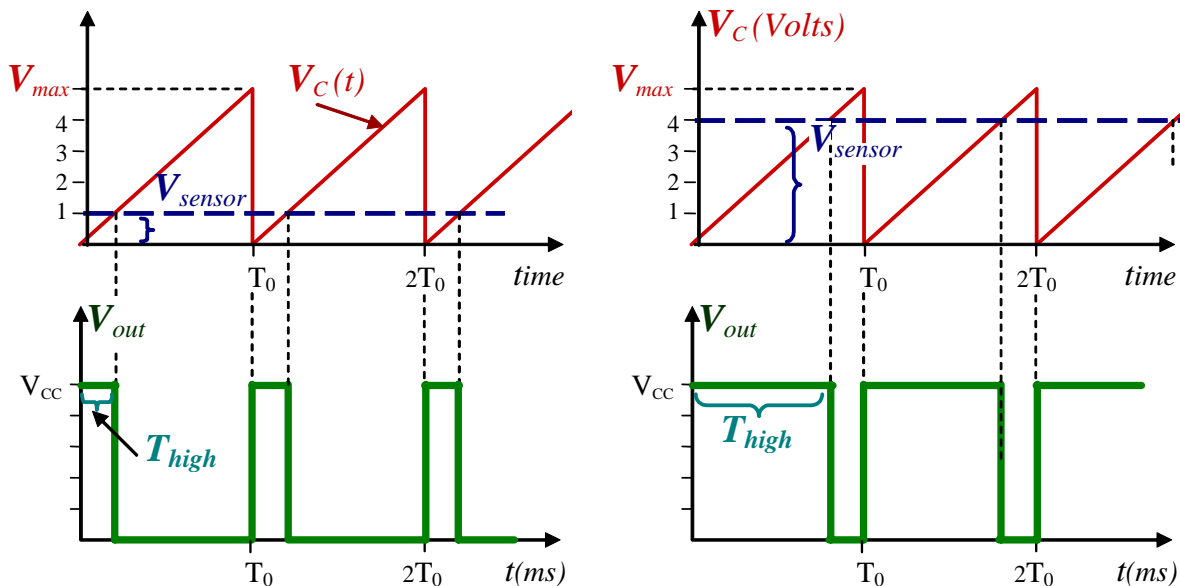


Fig. 3 Notice the higher the sensor voltage V_{temp} , the longer the time T_{high} the output voltage stays in the high level. T_0 is the period of the sawtooth signal V_c .

Notice in Fig.3 that $\frac{V_{max}}{T_0} = \frac{V_{sensor}}{T_{high}}$. That is,

$$T_{high} = \frac{T_0}{V_{max}} V_{sensor}$$

where T_{high} is the time the output voltage remain the high level.

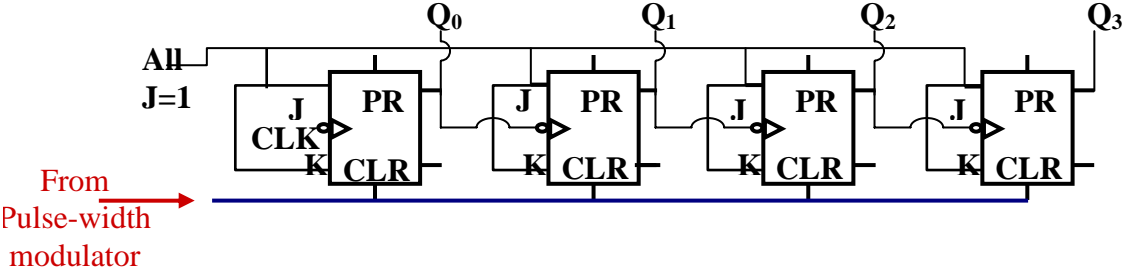
T_0 is the period of the sawtooth input signal

The pulse-width modulator then convert the analog voltage sensor to an output that is digital in nature (high or low); the time during which the output is high is proportional to the voltage sensor.

Implementation:

- Use the op amp LM358AP to implement the comparator circuit shown in Fig.2. Initially, use a sawtooth voltage of 100 Hz
- Verify that the circuit works as advertised in Fig.3
- Increase gradually the frequency of the sawtooth signal, and estimate the bandwidth of the device.

2.3 Counting pulses during an interval T_{high}



During the time in which the output from the pulse-width is high the counter will count the pulses. Thus, the voltage from the sensor will be proportional to the counts.