MICROCONTROLLER PROJECT LABORATORY

EDUCATIONAL STUDIES PROGRAM – HIGH SCHOOL STUDIES PROGRAM – SUMMER 2001
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LABORATORY IV
ANALOG-DIGITAL FEEDBACK

VERSION 2

GOALS

In this lab, students will:

1. Measure an analog signal using the ADC0804 IC
2. Produce an analog signal through pulse width modulation
3. Construct a feedback loop to drive an LED at constant brightness

SUPPLIES

Hardware:

1) Completed Lab II project
2) ADC0804 A/D Converter IC
3) 1 K potentiometer
4) NPN 3904-style transistor
5) 220 pF capacitor
6) 10 µF capactor
7) 120 Ω resistor

Software:

8) adc.asm

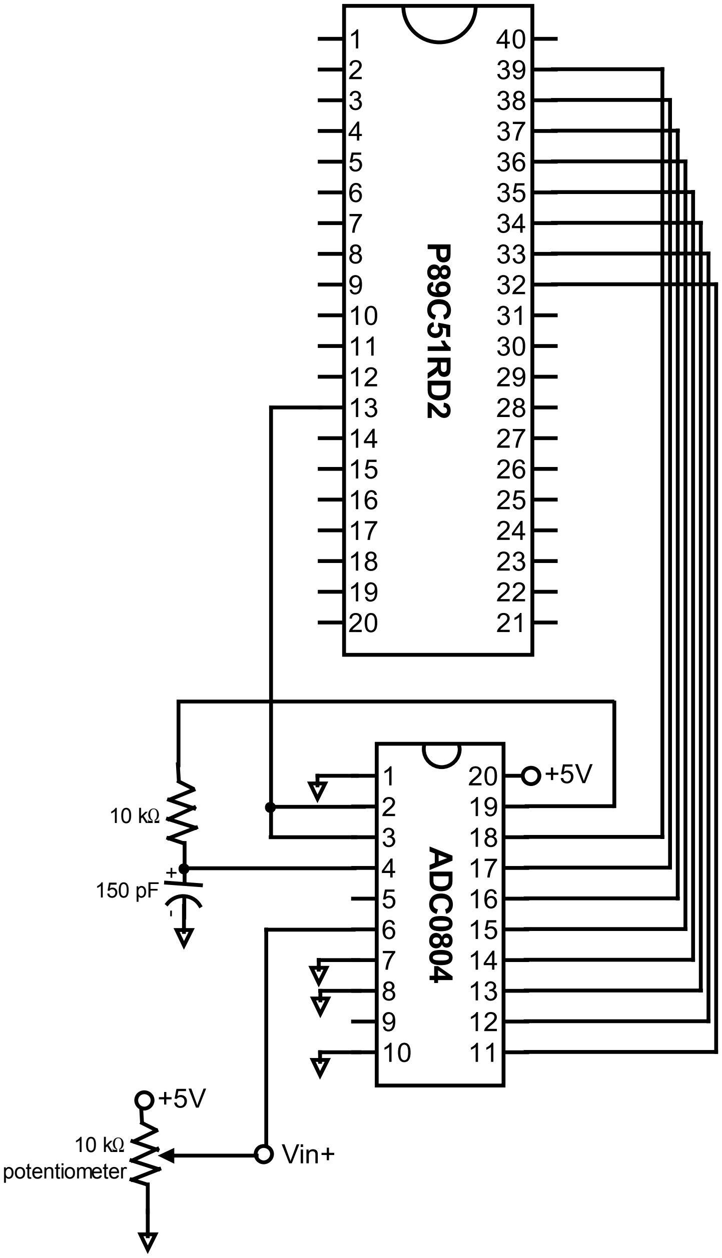
1.0 ANALOG-TO-DIGITAL: THE ADC0804

The ADC0804 is an integrated circuit that takes as input an analog value between 0 and 5 V and produces an 8-bit digital output.

Connect the ADC0804 analog-to-digital chip as shown in Figure 1 below:

1. Pins 11-18 of the ADC go to pins 32-39 on the 'RD2.
2. Pins 1, 7, 8, and 10 on the ADC all go to ground.
3. Pin 20 on the ADC connects to +5 V.
4. Pin 19 connects to pin 4 through a 10 kΩ resistor.
5. Pin 4 connects to ground through a 150 pF capacitor.
6. Pins 2 and 3 on the ADC connect to pin 13 on the microcontroller.

Now load adc.asm onto your chip and you will have a voltmeter!
(You can measure the variable voltage from a potentiometer by placing the two leads on the flat side into +5 and 0, and the 3rd lead connected to the input, pin 6.)



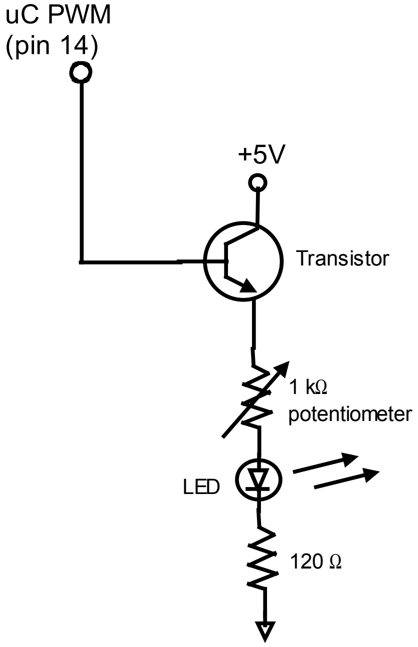
2.0 DIGITAL-TO-ANALOG: PULSE WIDTH MODULATION

Background
One way to convert a digital signal to analog is through pulse width modulation. In PWM, a signal is very quickly brought high (+5V) and low (0V) and a low pass-filter lets only the average voltage through. For example, +5 for 100 microseconds and 0 for 400 microseconds gives an average of 1 volt over that time period.

Hardware
Connect pin 14 to light up a yellow LED through a transistor. Pin 14 feeds into the control (middle) lead of the transistor, and power connects to the top (with the flat side facing right). The bottom of the transistor should go through a 1kΩ potentiometer set to about half way, then the LED, then a 120 Ω resistor to ground. (See the diagram.) The potentiometer adjusts the base brightness level; leave it in the middle for now.

Software
Now, running **adc.asm**, hold down * or # on the keypad. This should dim and brighten the LED. The LCD should tell you the duty cycle (% time on) of the current pulse width modulation. Find the percentages that correspond to maximum and minimum brightness on the LED. (For example, the LED may go completely dark at a duty cycle larger than 0%)

Note that in this case, there is no electrical low pass filter screening out the flicker; instead it is your eye that doesn't detect the fast changes.



3.0 FEEDBACK

This section uses the microcontroller to control the LED, maintaining a constant brightness despite changing resistance.

RC high pass filter

Although your eye could not detect the flickering of the light in part 2, the microcontroller and ADC chip are fast enough that they will notice it. To avoid confusing them, we will build a high pass filter to remove the flicker.A high pass filter made from a resistor and a capacitor has a cutoff frequency of:

$$f = \frac{1}{2\pi RC}$$

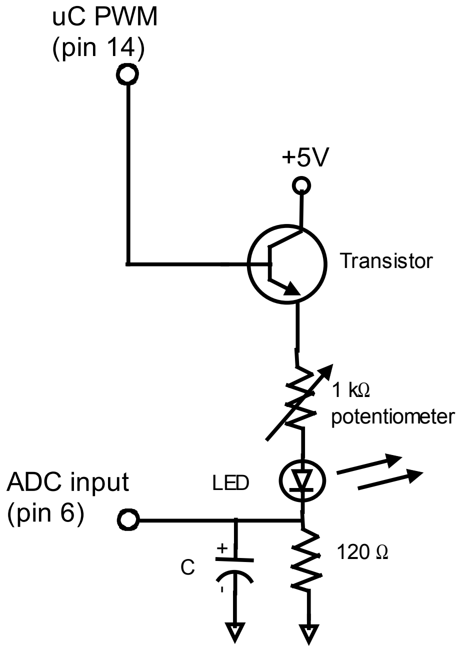
where R is the resistance and C is the capacitance. Frequencies lower than this cutoff will be significantly attenuated. Solve for C in order to have a cutoff frequency f of about 130 Hz, given a 120 Ω resistor. (Your answer will be in the μF range – μ is micro, one millionth.) Place a capacitor with this value of C in parallel with the resistor from the LED to ground.

Feedback

Now connect the ADC input (pin 6 on the ADC chip) to the anode (positive side) of the LED. Be sure to remove the potentiometer that was connected to the ADC input in part 1 of this lab.

Hold down the "D" key and the microcontroller will adjust its PWM output in an attempt to make the LED light up at a constant value. If it detects a voltage less than 0.3V from the ADC, it will increase the PWM duty cycle; if it detects a greater voltage, it will decrease it.

You can also click the "C" key to set the target brightness that "D" will try to produce. When you press C, the microcontroller will record its current reading from the ADC and make that the new target.


uC PWM
(pin 14)
+5V
Transistor
1 kΩ
potentiometer
LED
ADC input
(pin 6)
+
C
120 Ω