12R007 FIRST STEPS IN MICRO-CONTROLLERS 31-JAN-12

AIM - A SERIES OF TASKS TO LEARN HOW MICRO-CONTROLLERS CAN BE USED IN POWER ELECTRONIC APPLICATIONS

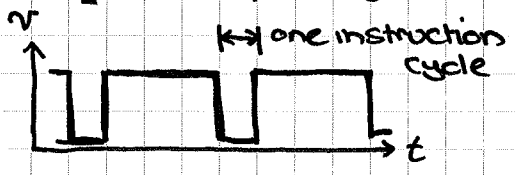
As it is not possible to monitor the internal operation of micro-controllers it is necessary to use a step-by-step development process.

1) DIGITAL OUTPUT

Write code to toggle a digital output and watch the effect on a CRO

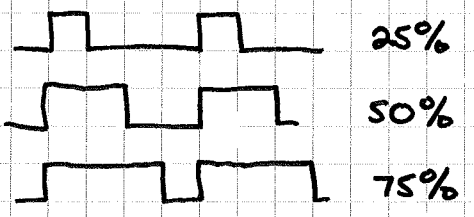
pseudo code

```
repeat forever
    set output high
    set output low
    set output high
```



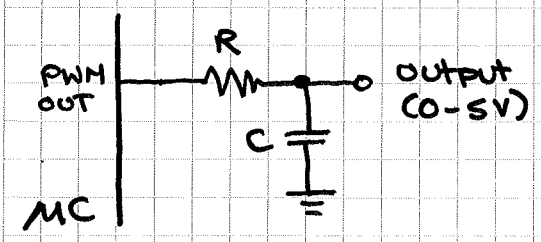
2) PWM OUTPUT

set PWM switching frequency in the range 5-20kHz, collect CRO waveforms for different values of duty-cycle.



3) ANALOG OUTPUT

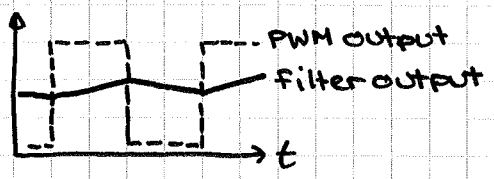
most micro-controllers do not have analogue outputs but this can be created using a PWM output with a low-pass filter.



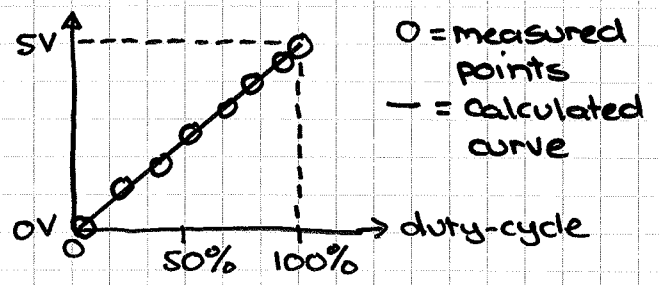
for a 20kHz PWM frequency we can set the low-pass filter cut-off frequency to say 1kHz

$$f_c = 1/(2\pi RC) \Rightarrow RC \doteq 160\mu s$$

e.g. $R = 15k\Omega$, $C = 10nF$



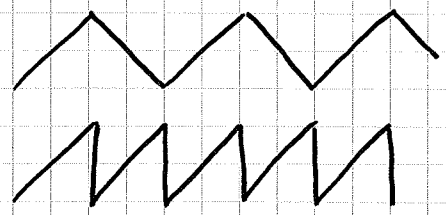
plot dc output voltage versus duty-cycle (steady-state)



thus show a linear relationship between the two

now by varying the duty-cycle appropriately, can create arbitrary shaped waveforms

hint - keep fundamental frequency to say 50 or 100Hz, well below low pass filter cut-off



4) ANALOG INPUT

analog inputs are typically 0-5V range with 10 bit resolution, to test this, write a program to read the analog input and then produce the same voltage on the analog output

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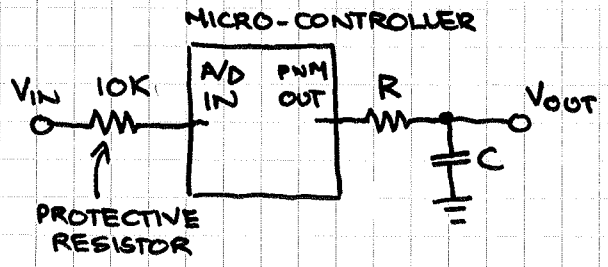
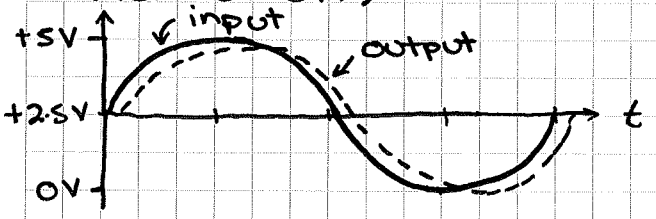
1-FEB-12



use a signal generator for the input with the DC offset set on its output to +2.5V so that V_{IN} stays between 0 and 5V, a protective resistor is worth-while to protect micro-controller if $V_{IN} < 0V$ or $V_{IN} > 5V$

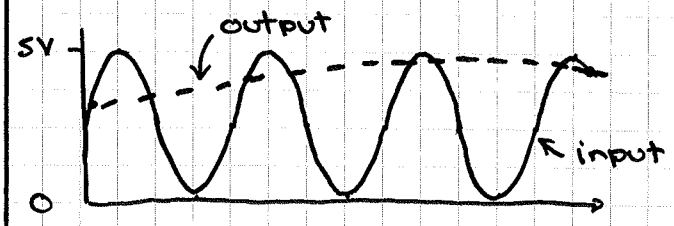
if input voltage of 0-5V produces a 10 bit output (0-1023), and if for instance the PWM output needs a duty-cycle register range of 0-255 (8 bits) to get an output variation of 0-5V, then to make the output voltage equals the input, we use only the most significant 8 bits of the input - another words you need to scale the A/D reading to match the maximum duty-cycle value

set the sampling rate of the analog input to say 2 kHz (comparable with low-pass filter cut-off)

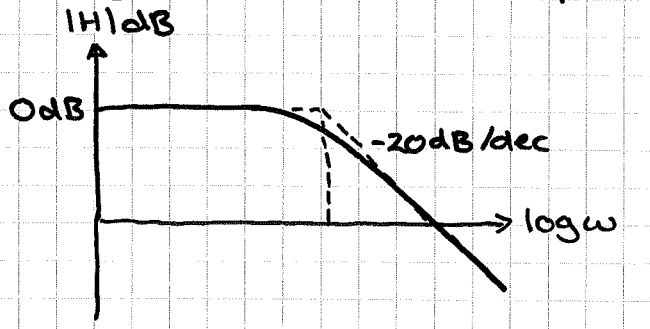


experiment with different frequencies, amplitudes and wave form shapes

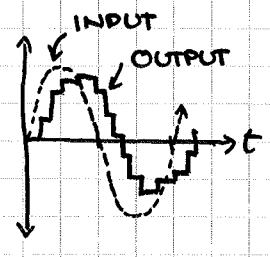
demonstrate aliasing where input frequency is greater than half the sampling frequency



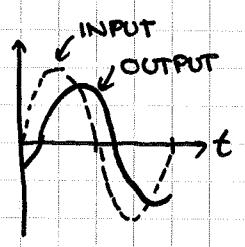
measure frequency response of system for sinewave input



when measuring the output voltage amplitude, this is most easily done on a digital CRO by triggering on the smooth input sinusoidal signal and using averaging when measuring the output signal



actual signal



with triggering on input signal and output signal averaging

"For God so loved the world that He gave his one and only Son, that whoever believes in Him shall not perish but have eternal life."