DTU Electrical Engineering

ASSIGNEMENT 2

31342 - Introduction to Programmable Logic Controllers

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TASK 1

To represent a number in binary, every bit corresponding to the fraction of two that we want must be active, in the case that we want to represent the negative of a number using two's complement, all the bits must be complemented and then 1 should be added to that.

Compute signed 8 bit binary representation using two's complement of:
Change all bits and add 1

- 12:
  $12 = 0 \times 2^0 + 0 \times 2^1 + 1 \times 2^2 + 1 \times 2^3$ therefore:
  $(12)_2 = 00001100$
- -64:
  $64 = 2^6 \; (64)_2 = 01000000$ $\quad (-64)_2 = NOT(001000000) + 1 = 110111111 + 1 =$
  $(-64)_2 = 11000000$

- $(0)_2 = \; 00000000$
- $(-127)_2 = \; 10000001$

What is the largest number it is possible to represent in this format ?
In format binary32 the biggest possible format to be represented is
$(2 - 2^{-23}) \times 2^{127} \approx 3.402823 \times 10^{38}$

Where the bit representation would be:

Bit signal	Exponent (Biased by 127)	
0	11111110	11111111111111111111111

This number is reached by doing $(-1)^{bitsignal} \times 2^{Exponent} \times mantissa$ where the exponent and mantissa are calculated in the following way:

Exponent : $(11111110)_{10} = 254$ 254-127= 127
Mantissa: $(11111111111111111111111)_{10} = 1 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3} + \cdots + 1 \times 2^{-22} = 2 - 2^{-23}$

Alternatively, an even bigger number is positive Infinity(+∞) which is represented in the following way:

Bit signal	Exponent (Biased by 127)	
0	11111111	00000000000000000000000

Task 2

Calculate the step size in volts of the analog module:

The step size is calculated using the following formula

$$Q = \frac{V_{max} - V_{min}}{2^{ADCbits}}$$

Which results in

$$Q = \frac{24 - 0}{2^{16}} \approx 3.6621\ 10^{-4} = 0.3662\ \mathrm{mV}$$

Calculate the smallest change in °C it is possible to measure with the LM35DZ directly connected to the PL:

According to the datasheet: http://www.ti.com/lit/ds/symlink/lm35.pdf, This sensor's transfer function is given by:

$$V = 10\frac{mV}{\text{°C}} \times T$$

Replacing V by the step size we get, $T = 0.0366\text{℃}$.

This means that each step on the voltage corresponds to a temperature that is 0.0366ºC higher than the one before.

Its is important to note that since the actual sensor accuracy is not that high (can only have an accuracy of about ¾ ºC over the −55°C to 150°C temperature range, the least significant bits on the ADC will correspond to noise.

If temperatures in the range of 0-40°C should be measured, what amplification would you use ?

Again using

$$V = 10\frac{mV}{\text{°C}} \times T$$

By making $T = 40\ \text{℃}$ we get $V = 0.4\,V$

And by setting $T = 0\text{℃}$ we get $V = 0\ V$

So, to use the full range of the 16bit ADC, we should amplify the signal by:

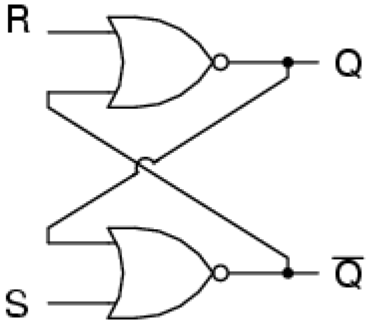
$$Gain = \frac{FullRangeADC}{FullRangeMeasurement} = \frac{40}{0.4} = 100$$

So by having an amplifying circuit with a gain of 100, we can see with better resolution the measurements of the LM34DZ.

Task 3

How can a SR-latch be build using standard logic gates?

The SR-latch can be built just by using 2 NOR gates with the configuration seen below



S	R	Q	$\overline{Q}$
0	0	latch	latch
0	1	0	1
1	0	1	0
1	1	0	0

S is used to set the value stored in the latch to 1, and R (Reset) is used to set the value on the latch to 0. If both R and S are zero, the latch keeps in memory the last value that was set, this happens due to the SR latch's circuit configuration namely, the fact that each NOR gates has its output connectect to the input of the other one.

Is the logic system driving a typical traffic light combinational logic or sequential logic?

It is a sequential logic system since its current state depends on the previous values. For example if its green, its next state will be orange and then red going back to orange and finally green again. Having therefore a sequence that loops overtime.