Introduction to Programmable Logic Controllers Ex2_digital

DTU 31343

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Task 1

Converting decimal numbers to signed 8 bit binary representation:

$$12_{10} = 00001100_2\,, \tag{1}$$
$$-64_{10} = 11000000_2\,, \tag{2}$$
$$0_{10} = 00000000_2\,, \tag{3}$$
$$-127_{10} = 10000001_2\,. \tag{4}$$

The largest normal number that can be represented in the binary32 format is:

$$2^{127}\left(2 - 2^{-23}\right) \approx 3.4028234664 \cdot 10^{38}\,, \tag{5}$$

[1] where the bit pattern for the largest number is given by:

$$0 \quad 11111110 \quad 11111111111111111111111_2\,, \tag{6}$$

[1].

The first integer determines the sign (positive here), the second group of integers determine the value of the exponent, and the final group determines the fraction. For the largest normal number that can be represented, the last integer in the second group is kept as 0, because the exponent 11111111_2 remains reserved for an infinite number representation [1].

Task 2

The step size in volts of the analogue module is given by:

$$h = \frac{24 - 0}{2^{16}}\,, \tag{7}$$
$$\approx 0.366 \cdot 10^{-3}\,\mathrm{V}\,. \tag{8}$$

The smallest detectable change in °C that can be measured with the LM35DZ connected to the PLC, using the basic configuration, is:

$$h = \frac{150 - 2}{2^{16}}\,, \tag{9}$$
$$\approx 2.258 \cdot 10^{-3}\,^{\circ}\mathrm{C}\,, \tag{10}$$

which is sufficient given that the sensor will have accuracies between ±0.25 and ±0.75 °C [2].

If the range of the measurement would change to only being between 0 and 40 °C, the gain would be based on the voltage available (24 V) and the voltage given at the 40 °C (0.4 V):

$$K = \frac{24}{0.4}\,, \tag{11}$$
$$= 60\,. \tag{12}$$

Task 3

An SR-latch can be constructed using 2 NOR gates (see Figure 1).

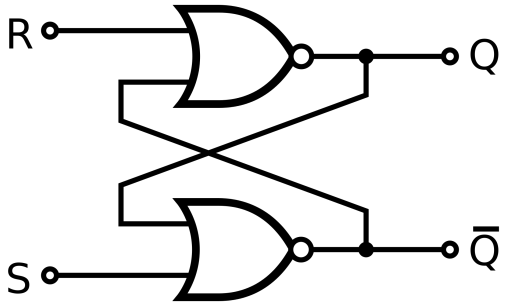

Figure 1: Diagram of an SR-latch constructed by 2 NOR gates (figure taken from [3]).

A traffic light operates by using sequential logic. This is because it requires past values in order to decide whether it will have to switch or if it remains the same. For example, generally, a traffic light will switch from green to red or vice versa based on a set timing. However, if for instance, a pedestrian wants to cross the street, an event will be triggered that will force the traffic light to switch after a given amount of time. In both cases, the traffic light must know its current state, the last time it had switched, and whether or not an event has occurred, which all rely on historic values.

References

[1] Single-precision floating-point format. https://en.wikipedia.org/wiki/Single-precision_floating-point_format, 2021. Accessed: 2021-05-28.

[2] LM35DZ Precision Centigrade Temperature Sensor. https://www.hotmcu.com/lm35dz-precision-centigrade-temperature-sensor-p-147.html, 2021. Accessed: 2021-05-28.

[3] An SR latch made from two NOR gates. https://en.wikibooks.org/wiki/Digital_Circuits/Latches#/media/File:RS_Flip-flop_(NOR).svg, 2009. Accessed: 2021-05-28.