

4 Project 3: Distance Measurement

4.1 Objectives

This work's objective is to develop a system able to measure the distance to an object placed at its front. It can be used either as a standalone measurement instrument, or embedded on a more complex equipment (e.g. a car, a mobile robot), to detect nearby objects.

For standalone operation, the user interface is carried out via a PC. Using the PC, the user should be able to view the distance to an object in range (measured in mm). Embedded use is supported by means of an analog 4-20mA loop output signal. In both cases the system should signal when no object is in range.

The system shall comprise a signal conditioning module, in order to adapt the distance sensor output to the micro-controller characteristics, guaranteeing that the resolution is the best possible. The system also comprises the 4-20mA module, to implement the analog output interface.

4.2 Block Diagram

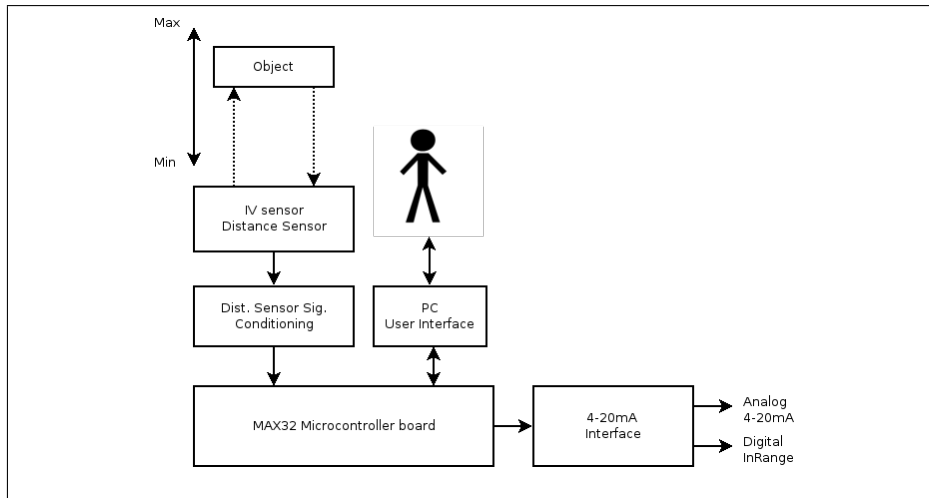


Figure 3: Distance measurement: HW architecture

4.3 Operation principle

The distance sensor conditioning circuit converts the output of the distance sensor (a voltage) to the full range of the micro-controller ADC, in order to maximize the resolution. The signal produced by the distance sensor is highly non-linear, therefore the micro-controller shall have to implement a suitable linearization algorithm, in order to obtain accurate results. Hardware-based filtering should be considered. The output of the sensor should be analyzed in order to decide about the kind of filter that should be adopted. Once the voltage is converted to distance, the corresponding value is sent to the User Interface

(PC) and to the analog output interface (4-20mA loop).

The 4-20mA loop is a standard sensor/actuator interface in industrial process control, where an analog 4mA output current corresponds to 0% of the signal (minimum distance, in this case) and 20 mA corresponds to 100% of the output signal (maximum distance, in this case). The system should also have one digital output that signals if there is an object in range or not.

The user interface is implemented in an external PC. The communication between the PC and the micro-controller is carried out by an USB cable. The micro-controller features an USB/UART interface that emulates an UART connection at both ends.

4.4 Functionality and specifications

- Communication between the micro-controller and PC using the USB cable (seen as UART at both ends);
- Distance range between $100mm$ and $600mm$;
- Signal conditioning should maximize the resolution;
- The system should detect and signal scenarios in which there are no objects within the measurement range;
- The UI should show the instantaneous distance ($1mm$ resolution);
 - “E” means that no object is in range;
- The system should provide a $4 - 20mA$ analog output loop:
 - $4mA$ corresponds to the minimum distance;
 - $20mA$ corresponds to the maximum distance;
 - Variation of current within the range should be directly proportional to the distance;
 - An additional digital output signals whether an object is in range (“1”) or not (“0”);
 - This digital output should drive a Led.