## 3. A Linux Kernel Module to Enable User-Space Device Interface for HC-SR04

**key words**: gpio pin multiplexing, TSC clock, software structures of kernel timer, gpio interrupt, Linux sysfs interface, platform device initiation.

- After sending a “ping” signal on its trigger pin, the HC-SR04 sensor sends 8 40khz square wave pulses and automatically detect whether receive any echo from a distance object.
- The distance to the object is computed as:

  *distance = (pulse width * ultrasonic spreading velocity in air) / 2*
- To connect each HC-SR04 sensor to Galileo Gen2 board, two digital IO pins of Arduino connector will be used for trigger and echo signals. They are configured as Linux GPIO pins.
- The edges on echo pin should trigger interrupts and the differences of TSC’s (time-stamp counter) of x86 processor at the positive and negative edges can give a precise measure of pulse width.
- Develop a loadable kernel module which initiates instances of HC-SR04 sensors (named as HCSR_n where n=0, 1, 2,…) and allows the sensors being accessed as device files in user space. Configurations are:

  1. Configuration of trigger and echo pins of HC-SR04 to the digital IO pins of Arduino connector.
  2. Configuration of HC-SR04 operation parameters (*m, delta*) , m: samples per measurement, delta: the sampling period.
- The module provides the following file operations:

  *read:* to retrieve a distance measure (an integer in centimeter) and a timestamp saved in the per-device FIFO buffer. The timestamp is a 64-bits integer of TSC clock indicating the time that the measurement is done. If the buffer is empty, the read call is blocked until a new measurement is collected from an on-going sampling operation, or from a new measure triggered by the call.

  *write:* The write call triggers a new measurement if there is no on-going measurement operation. The argument of the write call is an integer. The existing content of the per-device buffer should be cleared if the input integer has a non-zero value, and has no effect if the value is 0. EINVAL should be returned if there is an on-going measurement.

  *ioctl:* to include two commands “CONFIG_PINS” and “SET_PARAMETERS” for configuring the pins and setting up the operation parameters of sensor device. For “CONFIG_PINS”, the arguments include two integers to specify digital IO pins of Arduino connector for the sensor’s trigger and echo pins.
- The per-device FIFO buffer can keep the most-recent 5 measures.
- To enable periodic sampling, consider the Linux kernel hrtimer.