Safety-Critical Systems 4:
Engineering of Embedded Software Systems
WiSe 2002/03

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Solution for Assignment 1

Bicycle Odometer – Environmental Quantities

The following specification makes several choices at points where the assignment is not precise. These choices are not marked in the text, since either they are consensus after the discussion of Oct. 24, or they are decisions of the omnipotent teacher.

For simplicity, we assume the diameter of the bicycle wheel to be fixed at 28 inches (= 71.1 cm). In a more realistic setting, we would add a button to the odometer which allows to enter the diameter of the wheel at power-up. In any case, the diameter will never change during operation of the odometer.

The odometer shall start to work immediately after a battery is inserted, and it shall continue to work until the battery is exhausted. When there is no battery power, the display is blank.

Variable	**mon.**	**ctrl.**	**Description**	**Value Set**	**Unit**	**Notes**
${}^{m}\mathrm{t}$	•		current time	$\mathbb{R}$	s	
${}^{m}\mathrm{sensor}$	•		rotation sensor pulse	$\mathbb{R}_0^+$	Ω	1
${}^{m}\mathrm{button}$	•		multi-function button position	$\{{}^{C}\mathrm{up}, {}^{C}\mathrm{down}\}$	—	2
${}^{c}\mathrm{number}$		•	number displayed	$\{0.0, \ldots, 9999.9, 0, \ldots, 100\}$	—	3
${}^{c}\mathrm{modeInd}$		•	mode indicator displayed	{“km/h”, “km total”, “km trip”}	—	4

Notes

1. The odometer has two electrical contacts, between which the electrical resistance is measured. The contacts are to be connected by the user to a magnetic reed sensor close to the wheel. Each time the wheel with the sensor is turned, a magnet will pass the sensor, and the sensor will give one short pulse per round. During the pulse, the resitance is $< 10\ \Omega$. Otherwise, it is (much) higher.

   Speed changes between pulses cannot be detected. The sensor cannot distinguish forward and backward motion of the wheel. It is assumed that the bicycle goes forward only.

   Due to the nature of the reed sensor, there may be “bouncing” at the beginning of a pulse. The resistance may change rapidly up and down during this period. The bouncing will be over after less than 10 ms.

   When the contact opens, there is no bouncing. But when the magnet passes, there may be a little mechanical delay before the contact actually opens or closes.

The contact is closed through about $\frac{1}{10}$ to $\frac{1}{50}$ of a wheel round (at low speed).

The bicycle cannot ride faster than 100 km/h. Therefore, the wheel rotation frequency is less than 39 Hz, and the rotation period is longer than about 25 ms.

2. There is a push button on the front side of the odometer. When it is pressed, ${}^{m}\text{button} = {}^{C}\text{down}$. Otherwise, ${}^{m}\text{button} = {}^{C}\text{up}$. The purpose of this multi-function button is to switch between display modes (current speed, total distance, and day trip distance), and to reset the day trip distance. Short presses cycle through the modes, and a long press resets.

3. The number displayed is either a distance, with a resolution of 0.1 km, or a speed with a resolution of 1 km/h.

4. The mode indicator determines the unit of the number displayed. Also, it distinguishes between total distance and day trip distance.

   For simplicity, we restrict the odometer to the metric system. For world-wide selling, it may be advantageous that the user can select the imperial measures miles per hour and miles. This could be done together with the selection of the wheel diameter, when the odometer is extended.