

## Exercise 7: Digital Sensors

### Overview

In the last exercise, you have decoded the DCF77 time signal. For reasons of simplicity, we used sampling to decode the signal. In this lab course exercise, we will analyze a different type of signal with a different digital communication protocol. The protocol we are interested in is called ZACwire™ and our “communication partner” is a TSic™ 306 temperature sensor. Figure 1 shows an example oscilloscope plot of the ZACwire™ signal.

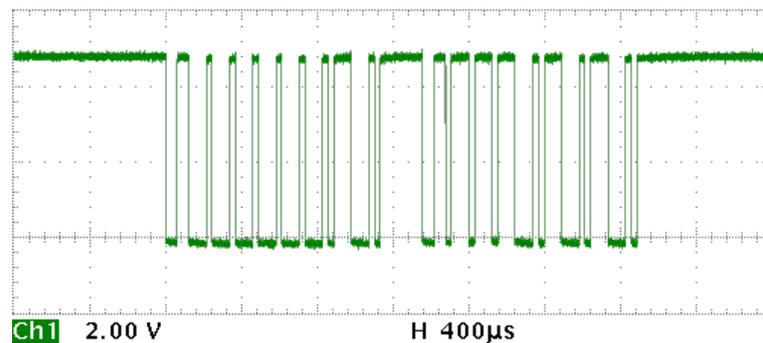


Figure 1: ZACwire™ signal plot

### ZACwire™ Signal Structure

The following files in the Subversion repository are needed for this lab course:

- ZACWire.pdf specifies the ZACwire™ protocol.
- TSic-Datasheet.pdf is the technical documentation of the TSic™ sensor family.

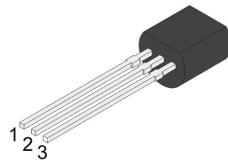
#### Exercise 7.1

Scan through the documents mentioned above and answer the following questions.

- What is the ZACwire™ signal used for?
- What is the advantage of sensors with digital communication in contrast to analog value acquisition? Think about the following aspects:
  - Sensor calibration.
  - Sensor networks with a large amount of sensors.
  - Long cables between sensor and microcontroller.

Can you imagine what the downside of this approach is?

- How often does the TSic 306 sensor transmit its temperature value? What is the resolution in °C of the sensor? What is the resolution of the value transferred in a ZACwire™ packet (in bits)? What is the possible range of values (in digital values) and their interpretation in °C?
- Derive a concrete formula to calculate the temperature value  $T$  in °C from the digital value  $d$  transmitted by TSic 306. Your formula should not include any variables besides  $T$  and  $d$ .
- Verify that you can manually decode the signal plot shown in figure 1 as 22.9 °C.



Pin	Name	Description
1	V+	Operating voltage (3 V... 5.5 V)
2	Signal	Temperature output signal
3	GND	Ground

Figure 2: TSic 306 pinout

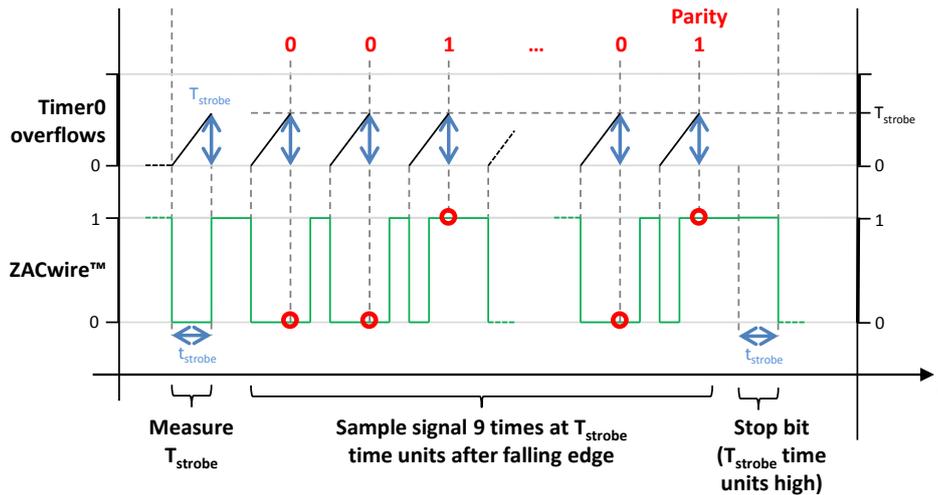


Figure 3: Sample logical timing diagram for a single ZACwire™ packet

- f) Which recommendations does the ZACwire™ specification give on attaching the sensor to a microcontroller? Explain the two possible scenarios and their advantages and disadvantages:
- “Always on” scenario as explained in section 1.4.
  - “Power up on request” scenario as presented in section 1.4.2.

### Microcontroller-based Analysis of the ZACwire™ Signal

#### Exercise 7.2

- Attach the TSic 306 sensor to STK500 in “power up on request” configuration as suggested in section 4.1.2 of the ZACwire™ specification. We neglect the RC filter circuit that is suggested in the specification. Attach the TSic signal pin to the INTO pin so that you will receive an interrupt when the signal changes its state. Document your pin assignment. The pinout of the sensor is given in figure 2. Please *ignore* figure 5-2 on page 9 of the TSic data sheet as it is quite misleading.
- Write a program that analyzes the ZACwire™ signal and displays the current temperature value in the debug console. Follow the guidelines given in the specification, namely first sampling  $T_{strobe}$  and then sampling the signal at the correct points in time (compare figure 3). Do not forget to verify that the parity is correct. You should use Timer0 for measuring  $T_{strobe}$  and sampling the signal, since we will use this code also in upcoming exercises where we still want to have Timer1 available for other purposes. To circumvent the low resolution of the timer, set OCR0A to a meaningful value and count the number of overflows.

**A Merry Christmas and a Happy New Year!**