Wireless Temperature and Humidity Sensor Using TELRAN

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Abstract

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This application note describes the complete system design (hardware and software) of a wireless temperature and humidity monitoring system based on the TZ1053 ultra-low power wireless TELRAN chip. The wireless temperature and humidity system can measure temperatures from 0°C to +70°C where the sensor is co-located with TELRAN. The range for temperature can be extended to -40°C to +120°C and for relative humidity 0 to 100% where the sensor is remote from TELRAN.

1. Introduction

This application note describes the design of a wireless temperature and relative humidity system based on the TZ1053 TELRAN chip. The TELRAN chip is an ultra low power RF chip operating in the license free ISM bands (EU 862MHz – 870MHz, USA 902MHz – 928MHz; Japan: 950MHz – 956MHz and China: 779-787MHz). An example design of a wireless temperature and humidity system is shown (Fig 1) using the SHT21 temperature and humidity sensor from Sensirion™ (www.sensirion.com). Such systems can be used in homes and offices for temperature and humidity monitoring. They also find uses in automobiles, air conditioning systems and for remote temperature and humidity monitoring in industry. A schematic of the system is shown in Figure 4. This schematic shows the wireless temperature and humidity system made up of an SHT21 sensor interfaced to the TELRAN chip via I2C interface.

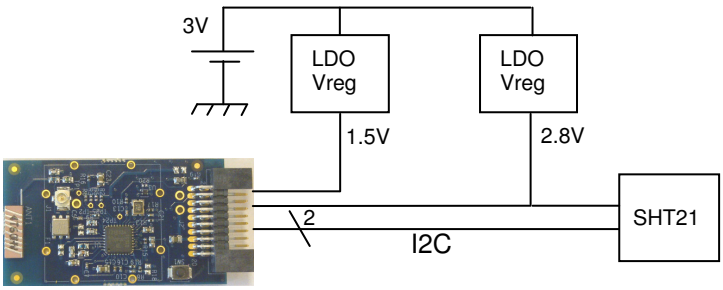

Fig 1: Block diagram of a TELRAN based wireless temperature and humidity sensor

2. Design Considerations

Designing the TELRAN-based wireless temperature and humidity system involves interfacing the TELRAN radio frequency module (RFM) to the SHT21 via I2C serial interface. As shown in the design of Figure 4 the I2C data line i.e. SDA is connected to pin 14 (GPIO 2/SDA) input of the TELRAN RFM. This connection requires a 10kohm pull-up resistor. Similarly the SHT21's clock input i.e. SCL is connected to pin 15 (GPIO 3/SCL) and this line also requires a 10kohm pull-up resistor. The power supply requirements are also important. The power supply requirements for the wireless temperature and humidity system are as follows:

SHT21: VDD (2.1V – 3.6V). For this application VDD is 2.8V

TELRAN Radio Frequency Module (RFM): Vchip (1.08-1.5V) and VDDIO (same digital I/O voltage of the circuit interfaced to TELRAN. For the wireless temperature and humidity application VDD is 2.8V hence the RFM's VDDIO is also 2.8V)

An example application is shown in Figure 4 using a single CR2032, 3V button cell and two voltage regulators to provide all the voltages required by the wireless temperature and humidity system. Alternatively a 1.5V button cell and a 3V boost circuit can also be used however the component count would be higher.

For enhanced noise immunity and to ensure satisfactory performance, all the power supplies should be decoupled using correct values of decoupling capacitors as specified in the schematics of Figure 4. Capacitors C1, C2, C3, C4 and C5 should be fitted and mounted close to the MCP1702 regulators while capacitor C6 should be mounted close to the TELRAN RFM.

Another important consideration is to ensure that the SHT21's signal lines notably the SDA and SCL lines are not routed close to regions of a circuit that are prone to noise as noise on the SDA and SCL lines can lead to unreliable and unpredictable results. The regions to avoid include power sections (especially those with switched-mode power supplies), or close to regions containing oscillators or clock signals. The SHT21 is a highly integrated multi-sensor module incorporating a capacitive-type humidity sensor and a band gap temperature sensor with a calibrated digital output hence adequate space (>2cm) should also be maintained between the TELRAN RFM and the SHT21 sensor to avoid interference between these devices.

3. Expected Performance

The wireless temperature and humidity sensor is designed using the factory calibrated Sensirion™ SHT21 temperature and humidity sensor. The SHT21 is a highly integrated multi-sensor module incorporating a capacitive-type humidity sensor and a band gap temperature sensor with a calibrated digital output. The TELRAN-based wireless temperature and humidity sensor is expected to measure temperature in the range of 0°C to +70°C with temperature accuracy of +/-0.5°C max where the sensor is co-located with TELRAN. It is also expected to measure relative humidity in the range of 0 to 100% with a typical relative humidity accuracy of +/-3% max within the range 20 to 80% RH, see SHT21 datasheet for details. Where the sensor is remote from the TELRAN the system can measure temperatures in the range -40°C to +120°C. For other temperature ranges please contact Toumaz.

4. Power Consumption and example battery life calculation

The wireless system shown in Fig 1 and

Figure **4** uses standard components such as the MCP1702 low dropout (LDO) voltage regulator. The peak total current consumption of the system is typically 4.3mA at 2.8V representing a peak power consumption of 12mW when the system is in continuous operation. Of the 4.3mA, 3.3mA is consumed by the TELRAN RFM when transmitting data to the TELRAN USB Dongle attached to the PC. Furthermore, the SHT21 sensor operates at 3V with typical current consumption of 300µA (during measurements) giving a total power consumption of 0.9mW. After a measurement the SHT21 automatically switches back to sleep mode with a typical current consumption of 0.15uA and waits for the next I2C command. The total power consumption of the system can therefore be significantly reduced by local buffering of data on the TELRAN RFM and duty cycling the transmission of data from the RFM to the TELRAN Dongle. The TELRAN RFM module is rated at 2.9mA in receive mode and 3.3mA in transmit mode. Its voltage supply ranges from 1.08 – 1.5V while its digital IO supply is set to the digital voltage level of the system that is interfaced to the TELRAN chip. For this application, this is set to 2.8V corresponding to the VDD voltage of SHT21 sensor as shown in Figure 4. Toumaz TELRAN RFMs (TZ1053RFM868 or TZ1053RFM915) can be purchased separately please see www.toumaz.com .

Example Battery Life Calculation assuming a 2 second update rate

Assuming 2x AAA batteries used with typical capacity of 1000mAhrs.

TELRAN programmed into alarm mode to send temperature updates once every 2 seconds.

Minimum payload size used for TELRAN (55bytes)

Total packet size = 15bytes (Preamble) + 12bytes (header) + 55bytes (payload) + 2 byte (check sum)= 84bytes @50kbps=13.44ms.

16MHz crystal takes 5ms max to turn on and stabilise.

Total time to turn TELRAN radio on and send a minimum size packet ~20ms

Sensirion SHT21 sensor

This can also be duty cycled.

Measurement time for 11bit temperature reading	11ms max (SHT21 datasheet)
Time to send I2C command and receive measurement	0.7ms

(I2C commands comprise 6bytes + 6 acks + 2 start bits. I2C can be clocked at 80KHz by TELRAN running with CPU clock 16MHz)

Total time for SHT21 sensor to be on	~12ms

Average power consumption

SHT21 measurement under the control, of TELRAN

[SHT21 sensor (300uA) + TELRAN@2MHz (0.3mA)] * 11ms/2s = 3.3uA

[SHT21 sensor (300uA) + TELRAN @16MHz (1.6mA)] * 0.7ms/2s = 0.66uA

TELRAN transmitting one measurement every 2seconds

3.3mA x 20ms/2s 33uA

Regulator standby current 2x2uA 4uA

TELRAN standby current 5uA

Total average current ~46uA (say 50uA)

Battery Life

1000mAhrs /50uA =20000 hours =833days

A further small amount of power may be saved by eliminating the voltage regulator which supplies the SHT21 and connect this directly to the battery supply.

5. Software Requirements

The SHT21 temperature and humidity sensor was interfaced to the TELRAN RFM via I2C serial link. It was therefore necessary to configure the TELRAN RFM for I2C communications. During I2C communications the host addresses the connected device using a specific I2C address (which for the SHT21 the I2C address is 40) and also issues the I2C clock signals. It was therefore necessary to configure the TELRAN RFM as the I2C host controller for issuing the device address, I2C clock signal, configuring the temperature and humidity control registers and reading data from the SHT21 sensor.

An in-house Toumaz script was used for configuring the TELRAN RFM for I2C operation. The compiled script produced by the Scripter was then programmed into a TELRAN USB Dongle and the Dongle in turn configures the target i.e. the TELRAN RFM by sending instructions to the RFM over a wireless link. *Further details about developing Scripter code can be found in the TZ1053 Scripter Userguide (TZ1053-SCU) and the TZ1053 Software Userguide.* A demo graphical user interface (GUI) was used to display the acquired temperature and relative humidity data and also log the data as shown in Figure 2.

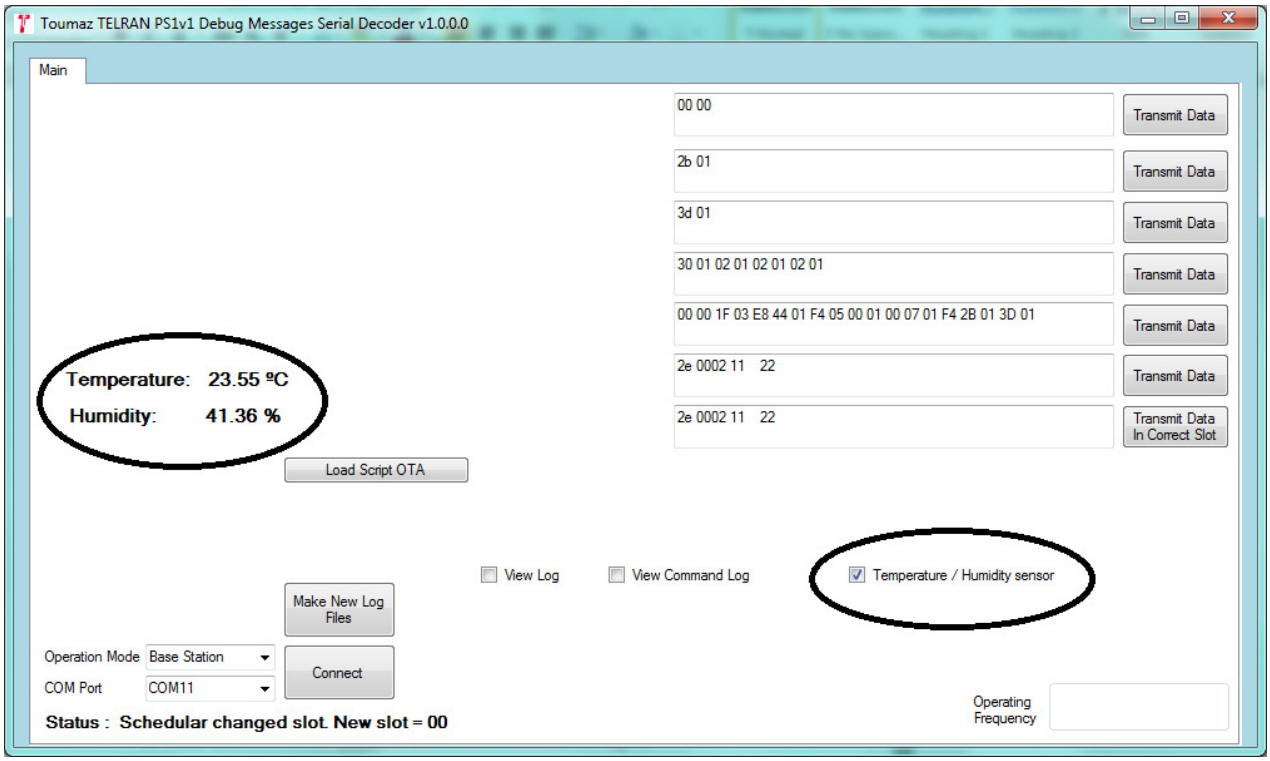

Figure 2 A demo GUI that was used to display the acquired temperature and relative humidity data

5.1 Firmware

The script source code (T-H.script), compiled script hex file (T-H.hex) and executable GUI (TELRAN Wireless Application Tools.exe) are available together with this application note. The following describes the key actions accomplished by the T-H.script code. The line numbers of the appropriate code in the T-H.script file are also given. The T-H.script file accomplishes the following:

1. Sets up the I2C in the TELRAN target (Lines 2 and 3)
2. Set the sample period (Line 6)
3. Enable the temperature control register and read temperature data (Lines 17)
4. Transmit wirelessly the temperature data to the TELRAN Dongle (Lines 21 and 22)
5. Enable the humidity control register and read humidity data (Lines 24 and 25)
6. Transmit wirelessly the humidity data to the TELRAN Dongle (Lines 29 and 30)

For actual operation, the script needs to be compiled into a hex file and loaded via the USB into the PIC on the USB Dongle using the bootloader (AN1310). The USB Dongle is then reset and the PIC will download over-the-air the script to run on the TELRAN wireless temperature and humidity sensor node. Figure 3 below gives an overview of the sequence of operations to compile the script into a hex file and then download the code from the computer into the PIC on the TELRAN Dongle. Note the script has to be separated into blocks of 256bytes which are compiled separately (see Section 6.2.2 of the Scripter Userguide). This is because the script can only be downloaded over the air to the TELRAN sensor node in blocks of 256bytes.

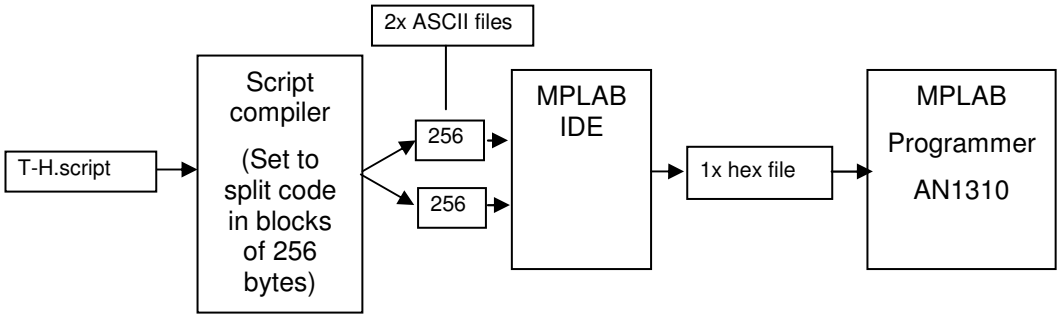

Figure 3 Sequence of actions to compile script and load hex file into the PIC on the USB TELRAN Dongle

6. Appendix

Wireless Temperature and Humidity System Schematic

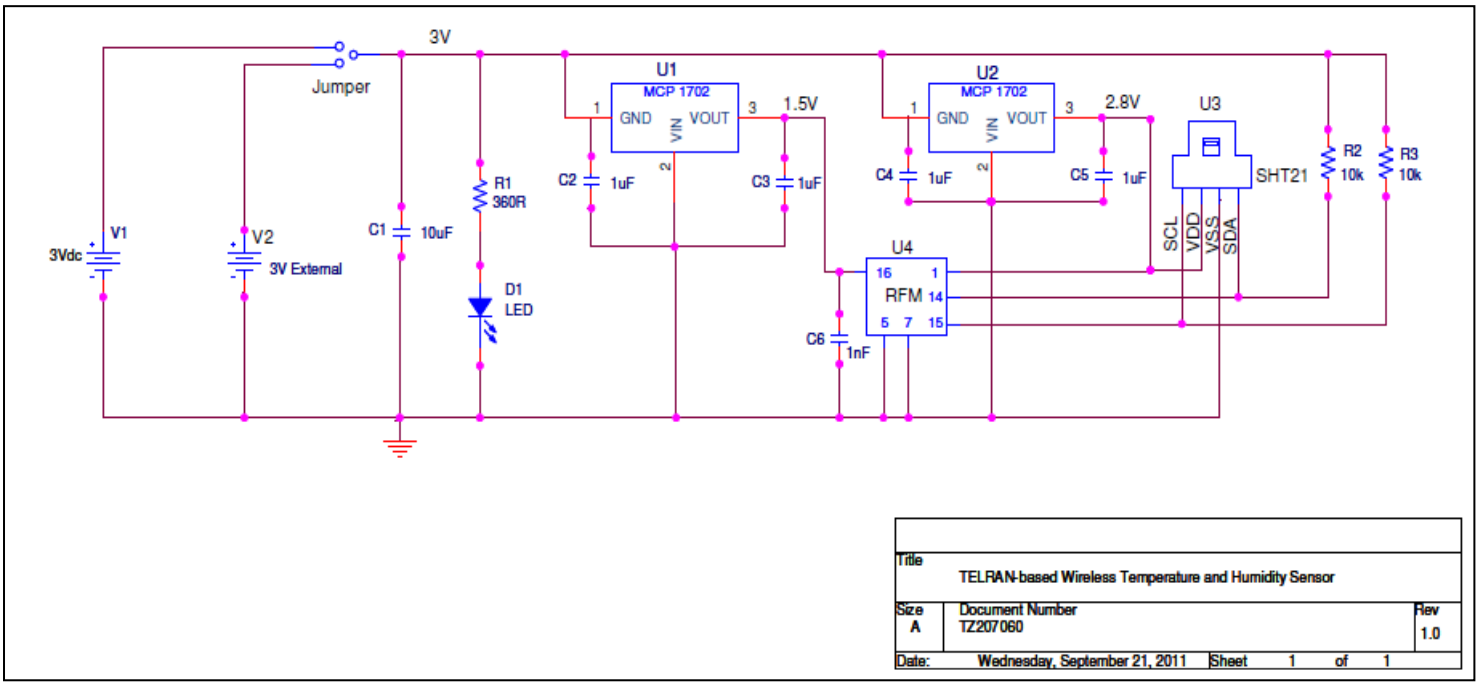

Figure 4 Schematic of a TELRAN-based wireless temperature and humidity sensor

Table 1: A Bill-of-Materials (BOM) for the wireless T/H system

Reference	Value	Description	Part No.	Manufacturer
R1	360R	Resistor	-	-
R2	10k Ω	Resistor	-	-
R3	10k Ω	Resistor	-	-
C1, C2, C3, C4, C5	1µ F	Capacitor	-	-
C6	1nF	Capacitor	-	-
D1	-	LED	-	-
U1	-	1.5V Low dropout (LDO) regulator	Manuf. No. MCP1702T1502E/CB Mouser No. 579-MCP1702T1502E/CB	Microchip
U2	-	2.8V Low dropout (LDO) regulator	Manuf. No. MCP1702T2802E/CB Mouser No. 579-MCP1702T2802E/CB	Microchip
U3	-	Temperature/humidity sensor	SHT-21	Sensirion
U4	-	TELRAN RFM	TZ1053RFM868 for EU (TZ1053RFM915 for US/Canada)	Toumaz Ltd
-	-	1.27mm socket for SHT21	Mouser No: 855-M52-5002545 RS part No. 702-3041	Harwin Preci-Dip

7. Further Information

To gain access to the wireless temperature and humidity script file, please register for the Toumaz extranet at www.toumaz.com For further information on the wireless temperature and humidity system design please contact:

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