

Wireless Temperature Sensor

Application Note
AN80201

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Introduction

As part of the effort to improve energy management, there is a growing need to be able to monitor temperatures in areas that were not originally designed with thermostats. Going back and wiring thermostats is both messy and costly. As a result, wireless temperature sensors are growing in popularity in industrial, commercial, and even residential settings.

There are three challenges in designing a wireless temperature sensor: 1) the sensor must be affordable; 2) the sensor must last for at least 2 years on user-replaceable batteries; and 3) the sensor must be reliable. Previously, these three challenges often required decisions that were at cross purposes to each other. For example, to be affordable, low cost wireless technologies were employed but they were not always reliable and they shortened battery life. To run on batteries for 2 years, low power wireless technologies were employed that were not reliable. And to achieve good reliability, higher power wireless technologies were used that substantially reduced battery life.

More recently, improvements have been made in wireless technology allowing low power wireless technologies to be employed at low cost with reliability enhanced by mesh technology. Oftentimes, however, mesh technologies require that some or all of the wireless devices be on all the time making battery operation impossible. Either some temperature sensors need to be plugged into a power source or additional routing devices that don't sense temperature must be added to allow the mesh to operate. In addition, there needs to be some device to collect the sensor information and make it available to applications or appliances. Both of these requirements add to the cost of the temperature sensing network effectively increasing the cost of each sensor.

The WSN802G Solution

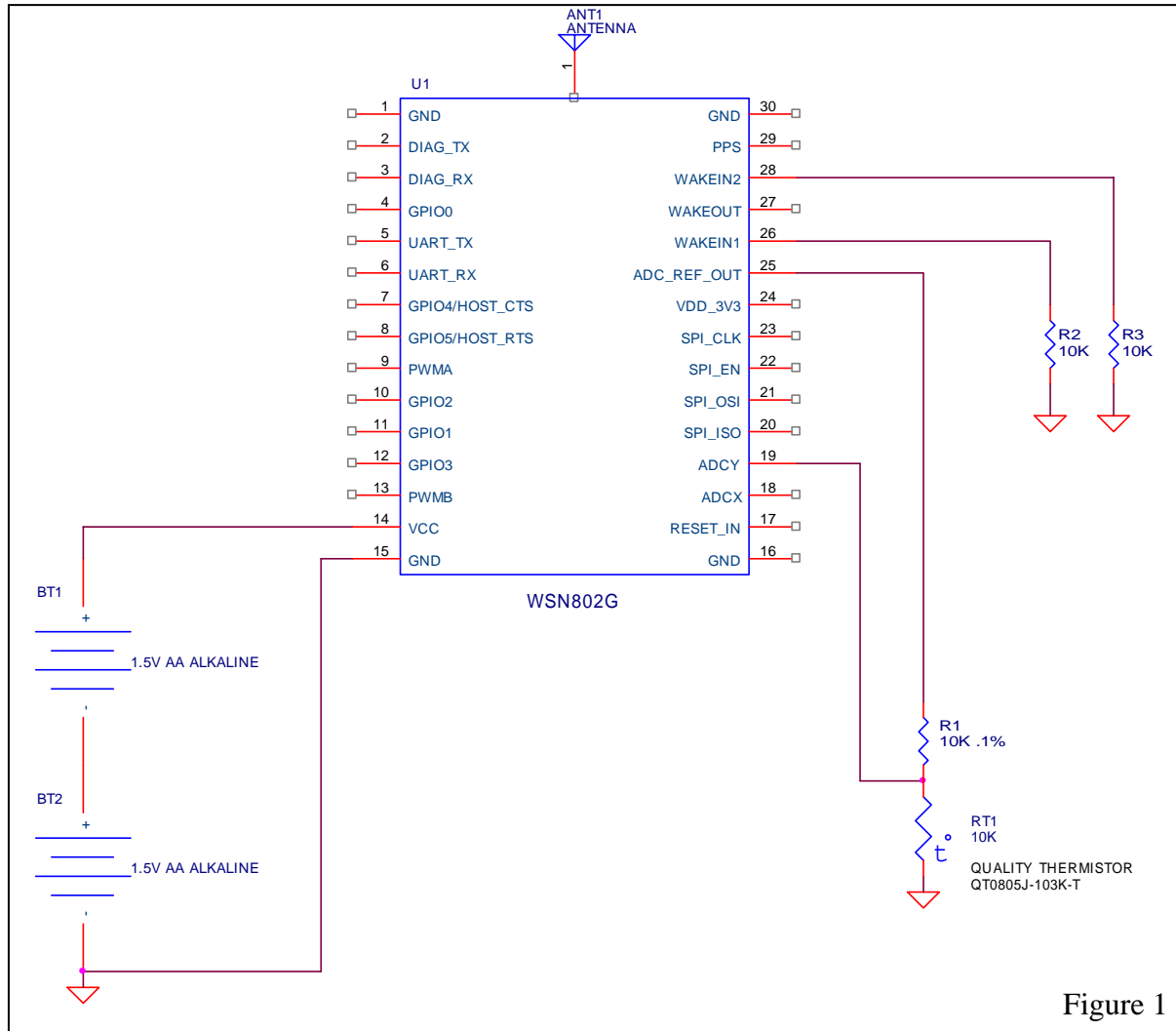
The WSN802G module is an 802.11b/g module with analog and digital I/O as well as UART and SPI serial interfaces. The WSN802G has the unique ability to enter a very low power sleep mode while still associated with an 802.11b/g access point. This means when the module wakes up, it does not need to go through the association process with the access point which takes several seconds and consumes power. The WSN802G has built-in functions that allow the designer to configure the module to enter sleep mode and wake up on an adjustable timer. When the module wakes up, it reads the analog and digital I/O lines and automatically sends the data to a configurable IP address. This eliminates the need for a co-processor to read the temperature, format it into a serial data stream and send it to a wireless transmitter.

The WSN802G module also solves the problem of how to collect the sensor data. By utilizing existing 802.11b/g access points, the WSN802G-based temperature sensor does not require a special device be designed to collect the data.

The Design

Figure 1 shows the schematic of the wireless temperature sensor. As you can see, all it takes is the WSN802G module, two standard resistors, one 0.1% resistor, a thermistor, and a two cell AA Alkaline battery pack.

The ADC_REF_OUT pin of the WSN802G provides a 1.8V reference voltage for the resistor divider created by the 0.1% 10K ohm resistor R1, and the 10K thermistor RT1. Resistors R2 and R3 are 10K pull-down resistors on the two wake-in pins of the WSN802G to prevent the lines from floating high causing unintended wake-ups of the module. The WSN802G module is powered by the two cell battery pack. The on-board regulator of the WSN802G allows the battery voltage to be fed directly into the module.



At 25° C, the 10k thermistor has a resistance of 10Kohm, resulting in a ADCY input voltage of $1.8V/2 = 0.9V$. However, the ADC reference voltage has a 36mV offset due to saturation which will affect the ADCY reading. Since ADCY is a 10-bit ADC, and the reference voltage from the WSN module is 1.8 volts, the 36mV represents 20 counts out of the 1024 possible in the 10-bit ADC. Thus the resistance of the thermistor is determined by the formula:

$$RT_1 = \frac{R_1}{\left[\frac{1044}{\text{Count}} - 1 \right]}$$

The temperature application performs this simple calculation from the ADC value auto-reported by the wireless module. The temperature versus resistance values are derived from tables provided by the thermistor manufacturer. The application performs a simple lookup function to convert the resistance to a temperature.

For the antenna, a simple wire was used. The length of the wire was set to one-half the wavelength of the signal. Since the WSN802G has several channels that cover the entire 2.4GHz band, 2.443GHz was picked. The speed of light is about 300,000,000 meters per second. The wavelength of 2.443GHz is 300,000,000 meters divided by 2,443,000,000 or 0.1228 meters or about 4.9 inches. The 2.25" wire was simply soldered to the WSN802G module. The wire was routed around the edge of the enclosure.

Since the WSN802G module has an on-module voltage regulator, batteries can be directly connected to the module. Two Alkaline AA batteries connected in series will provide 3.1 volts, more than enough to run the 1.8 volt regulator that runs the core of the module. An off-the-shelf battery holder was used as the power pack. Alternatively, complete, inexpensive enclosures are available with built-in battery compartments.

Module Configuration

The WSN802G module comes from the factory with WPA2-PSK enabled as the default. The default SSID is WSN-COMMISSION and the default passphrase is RFM-Wireless. Once the module has been powered on and associated with an access point matching the SSID and passphrase, the WSNConfig utility program can be used to change those to the desired entries. These configuration changes are made over the air eliminating the need for the sensor to have a serial port, another cost savings. The WSN802G uses standard SNMP commands and traps, allowing standard network management programs to configure the module too.

For this application, the module was also configured to wake up on the internal wake up timer every 30 seconds and send its auto-report which includes the current values of the analog and digital inputs. Although not needed in this application, the WSN802G allows a "pre-delay" to be set which allows the WAKEOUT signal, indicating the module is awake, to be asserted before the module is awake, giving sensors that require some settling time to settle before being read by the module. This allows the rest of the WSN802G to remain asleep, conserving energy, while the sensor settles out. The amount of pre-delay is a configurable parameter.

As an added benefit, the WSN802G includes the battery voltage as part of the auto-report. The unregulated battery voltage is used to run the real time clock of the WSN802G to reduce sleep current and thus the battery voltage is available to be reported. Thus the application can detect when the battery voltage begins to drop and can alert the user that it is time to change the battery.

The WSN802G module sends UDP packets when it auto-reports. The IP address of the PC or server where the application resides is configured into the WSN802G. All of the auto-reports are sent to this IP address. This simplifies application development as the application only has to receive data and does not need to keep track of sensors and periodically poll them to collect data.

To keep the association with the access point active while the WSN802G sleeps, the module periodically wakes up and sends a brief message to the access point. The frequency of these link-up traps depends on the access point with once a minute and once every two minutes being the most popular intervals.

The other consideration is how to modify the configuration settings of a module that is sleeping and only wakes up occasionally. This is handled by having the WSN802G wake up every so often and asking if there are any configuration changes for it. This interval is also configurable and is typically set to a short interval for deploying the sensor but is then changed to a much longer interval. One hour or longer is a typical configuration wake interval once a device has been deployed as the need to change configurations is very infrequent. The WSNConfig Utility has the ability to listen for and respond as needed to these configuration inquiries. Again, these use standard SNMP traps and commands and thus can be handled by standard network management programs if desired.

Conclusion

Since the firmware on the WSN802G module can be configured to wake up on a configurable interval and send its I/O data, no co-processor is required. Since the temperature sensor uses existing WiFi access points, no gateway or other collection hardware is required. This meets the first criterion, affordability.

By utilizing the sleeping function of the WSN802G module as well as the built-in firmware functions, a wireless temperature sensor can be built using just batteries, a thermistor, wire antenna, and the WSN802G module. Because the WSN802G module maintains its association with the access point while it sleeps, waking up and sending the thermistor data takes less than 50 milliseconds. This provides more than 2 years operation on 2 AA alkaline batteries. This meets the second criterion, battery life.

The ability of the module to sleep and wake very briefly allows a true 802.11g radio to be used. No compromise was made in terms of a less reliable radio in order to save cost or to lengthen battery life. This meets the third criterion, reliability.

Previously, creating wireless temperature sensors involved making a tradeoff on cost, battery life, and/or reliability. The WSN802G module enables the construction of wireless temperature (or any other sensor type) sensor that is low cost, reliable, and with long battery life.