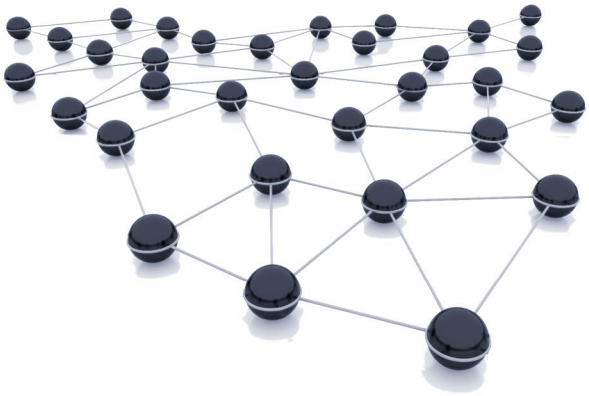
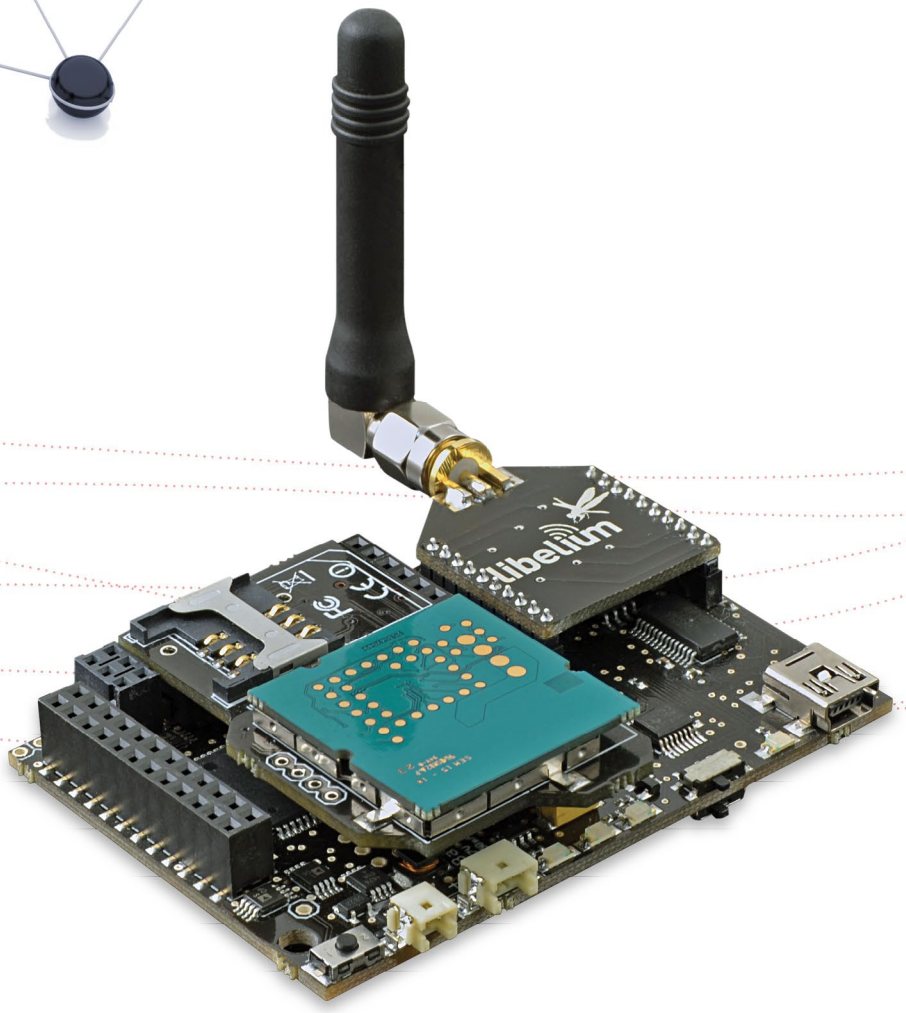
Waspmote RTC

Programming Guide





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1. General Considerations

1.1. Waspmote Libraries

1.1.1. Waspmote RTC Files

WaspRTC.h; WaspRTC.cpp

1.1.2. Constructor

To start using the Waspmote RTC library, an object from class 'WaspRTC' must be created. This object, called 'RTC', is created inside the Waspmote RTC library and it is public to all libraries. It is used through the guide to show how Waspmote RTC library works.

When creating this constructor, no variables are initialized by default.

1.1.3. Pre-Defined Constants

There are some constants defined in 'WaspRTC.h' to help with the comprehension of the code when reading the first times. These constants are related with RTC register addresses, some functions, inputs and alarm modes.

1.1.4. Variables

Some variables have been defined for storing time, date and alarm data. These variables have been named after the data they store (i.e. `RTC.year` stores the year, and `RTC.month` stores the month).

The Waspmote RTC allows setting the day of the week, which is a number between 1-7. This part of the date can be modified by the user providing they are sequential, it meaning that if Sunday is equal to 1, Monday must be equal to 2.

An array called '`registersRTC`' has been created for storing the data to send to the RTC. This array is used in each writing or reading operation.

1.1.5. Flags

There are various flags used for handling interruptions while using Waspmote RTC.

1.1.5.1. Global Interruption Flag

It is used to check the port in which the interruption has got activated. It is used in this library and other libraries which generate interrupts too.

1.1.5.2. Global Interruption Flag Array

It is used to store the number of times each interruption has been detected. It is used in this library and other libraries which generate interrupts too.

1.1.5.3. Global Interruption Counter

It is used to store the number of interruptions detected. It is used in this library and other libraries which generate interrupts too.

2. Initialization

Before getting information from the RTC, I2C bus has to be initialized.

2.1. Initializing the RTC

It powers the RTC up and initializes I2C bus for communicating with the RTC. It reads from the RTC time, date and alarms, setting the corresponding variables.

It returns nothing and modifies no flag.

Example of use:

```
{
	RTC.ON();	// Executes the init process
}
```

2.2. Saving Battery

The RTC is powered by the main battery through a microcontroller pin. When the RTC main power is down, the RTC guarantees its non-stop running powered by the Waspmote main battery.

When the RTC is OFF, only the internal oscillator is enabled, using just 0,7uA. When RTC is powered by microcontroller, the power consumption is around 150-200uA. Because of that, when the RTC is only counting time or waiting to launch an alarm, it is recommended to power it down.

It is recommended to set the RTC off when it is not going to be used. This operation can be made using a function developed for that purpose.

Example of use:

```
{
	RTC.setMode(RTC_ON);		// Powers RTC UP
	RTC.setMode(RTC_OFF);		// Powers RTC Down
}
```

2.3. Switching RTC Off

It turns it off and closes the I2C bus.

It returns nothing and modifies no flag.

Example of use:

```
{
	RTC.OFF();	// Turns it off and closes the I2C bus
}
```

3. Setting Time and Date

First step to be able to use the RTC is setting time and date. Some functions have been created for managing these operations.

3.1. Setting Time and Date

It sets time and date on the RTC.

Time and Date are specified by the inputs, which corresponds to the different variables: year, month, date, day, hour, minute and second.

'day' is the day of the week, having a value between 1-7. By default, Sunday is equal to 1 and Saturday is equal to 7.

This function extracts each part of date and time, storing each part in the corresponding variable. After this, '`registersRTC`' array is loaded with these variables and data is sent to the RTC.

It returns nothing and modifies no flag.

Example of use:

```
{
        // Setting date and time [yy:mm:dd:dow:hh:mm:ss]
        RTC.setTime("09:06:29:02:10:00:00");
}
```

Related variables:

`year`, `month`, `hour`, `minute`, `second` → stores the time and date set
`day` → stores the day of the week
`date` → stores the day of the month

An example of the functions:

http://www.libelium.com/development/waspmote/examples/rtc-01-setting-and-reading-time/

An example of how to set RTC via USB port:

http://www.libelium.com/development/waspmote/examples/rtc-07-set-waspmote-date/

3.2. Getting Time and Date

It gets time and date, storing them in the '`registersRTC`' array and the corresponding variables.
It returns a string containing time and date in the following format: "YY:MM:DD:dow:hh:mm:ss".

Example of use:

```
{
  char* time_date;
  time_date = RTC.getTime();
}
```

Related Variables:

`year`, `month`, `hour`, `minute`, `second` → stores the time and date set
`day` → stores the day of the week
`date` → stores the day of the month

An example of the functions:

http://www.libelium.com/development/waspmote/examples/rtc-01-setting-and-reading-time/

3.3. Getting day of week

This function calculates the day of the week based on the year, month and day. Sakamoto's algorithm is used in this function. Valid for any date in the range [September 14, 1.752] – [December 31, 9.999].

The inputs for `dow()` function are: year, month and day of month.
Example of use:

```
{
        uint8_t day_of_week = 0;
        day_of_week = RTC.dow(2012,12,4);
}
```

The function returns:

1 → Sunday
2 → Monday
3 → Tuesday
4 → Wednesday
5 → Thursday
6 → Friday
7 → Saturday

4. Setting Alarms

Waspmote RTC provides two alarms to enable interruptions and wake up the device from a low-power state.

There are two different RTC alarms:

- **Alarm1**: is set by day/date, hour, minutes and seconds
- **Alarm2**: is set by day/date, hour and minutes.

When setting alarms there are three inputs: time, offset and mode.

- Time: represents the time/date for the alarm.
- Offset: represents the two modes for setting the alarm time: offset or absolute. When offset is selected, the input time is added to the actual time in the RTC and the result is set as the alarm time. When absolute is selected, the input time is set as the alarm time.
- Mode: represents the different alarm modes. Alarm1 has 6 modes and Alarm2 has 5 modes.

When the time set in Alarm1 or Alarm2 matches the time on RTC, a pin is enabled to indicate the match. This pin is connected to an interrupt pin on the microcontroller, so as the alarm can wake up the microcontroller from a sleep power mode.

An example of the functions:

http://www.libelium.com/development/waspmote/examples/rtc-02-setting-reading-alarms/

4.1. Setting the Alarm1 (using a string as input)

It sets the Alarm1 to the specified time, offset and mode.

The input 'time' has the following format: "dd:hh:mm:ss".

The input 'offset' has some possible values:

`RTC_OFFSET`: 'time' is added to the current time read from RTC
`RTC_ABSOLUTE`: 'time' is set as the time for Alarm1

The input 'mode' specifies the mode for Alarm1. Possible values are:

`RTC_ALM1_MODE1`: Day, hours, minutes and seconds match
`RTC_ALM1_MODE2`: Date, hours, minutes and seconds match
`RTC_ALM1_MODE3`: Hours, minutes and seconds match
`RTC_ALM1_MODE4`: Minutes and seconds match
`RTC_ALM1_MODE5`: Seconds match
`RTC_ALM1_MODE6`: Once per second

When this function is called, the Alarm1 is set and no more functions need to be executed.

It returns nothing, but when the Alarm1 matches the time, interruption flags will be modified to indicate it.

Example of use:

```
{
        // Example: Sets Alarm1 for 29th of the month at 11:00:00
        RTC.setAlarm1("29:11:00:00", RTC_ABSOLUTE, RTC_ALM1_MODE2 );

        // Example: Sets Alarm1 for 5 minutes from now
        RTC.setAlarm1("00:00:05:00", RTC_OFFSET, RTC_ALM1_MODE4 );
}
```

Related Variables:

day_alarm1→ stores the day or date of the Alarm1

hour_alarm1, minute_alarm1, second_alarm1 → store the time of the Alarm1

4.2. Setting the Alarm1

It sets the Alarm1 to the specified time, offset and mode.

The inputs 'day_date', '_hour', '_minute' and '_second' specify the time for the Alarm1.

The input 'offset' has some possible values:

RTC_OFFSET: 'time' is added to the current time read from the RTC
RTC_ABSOLUTE: 'time' is set as the time for the Alarm1

The input 'mode' specifies the mode for the Alarm1. Possible values are:

RTC_ALM1_MODE1: Day, hours, minutes and seconds match
RTC_ALM1_MODE2: Date, hours, minutes and seconds match
RTC_ALM1_MODE3: Hours, minutes and seconds match
RTC_ALM1_MODE4: Minutes and seconds match
RTC_ALM1_MODE5: Seconds match
RTC_ALM1_MODE6: Once per second

When this function is called, the Alarm1 is set and no more functions need to be executed.

It returns nothing, but when the Alarm1 matches the time, interruption flags will be modified to indicate it.

Example of use:

```
{
      // Example: Sets Alarm1 for 29th of the month at 11:00:00
      RTC.setAlarm1( 29,11,0,0, RTC_ABSOLUTE, RTC_ALM1_MODE2 );

      // Example: Sets Alarm1    for 5 minutes from now
      RTC.setAlarm1( 0,0,5,0, RTC_OFFSET, RTC_ALM1_MODE4 );
}
```

Related Variables:

day_alarm1 → stores the day or date of Alarm1

hour_alarm1, minute_alarm1, second_alarm1 → store the time of Alarm1

4.3. Getting the Alarm1

It gets the Alarm1 time from RTC.

It returns a string containing this time and date for the Alarm1.

Example of use:

```
{
      // Gets time for Alarm1
      USB.println(RTC.getAlarm1());
}
```

Related Variables:

`day_alarm1` → stores the day or date of the Alarm1

`hour_alarm1`, `minute_alarm1`, `second_alarm1` → store the time of the Alarm1

4.4. Setting the Alarm2 (using a string as input)

It sets the Alarm2 to the specified time, offset and mode.

The input 'time' has the following format: "dd:hh:mm".

The input 'offset' has some possible values:

`RTC_OFFSET`: 'time' is added to the current time read from the RTC
`RTC_ABSOLUTE`: 'time' is set as the time for the Alarm2

The input 'mode' specifies the mode for the Alarm2. Possible values are:

`RTC_ALM2_MODE1`: Day, hours and minutes match
`RTC_ALM2_MODE2`: Date, hours and minutes match
`RTC_ALM2_MODE3`: Hours and minutes match
`RTC_ALM2_MODE4`: Minutes match
`RTC_ALM2_MODE5`: Once per minute

An example of the alarm modes:

http://www.libelium.com/development/waspmote/examples/rtc-04-alarm-modes/

When this function is called, the Alarm2 is set and no more functions need to be executed.

It returns nothing, but when the Alarm2 matches the time, interruption flags will be modified to indicate it.

Example of use:

```
{
      // Example: Sets Alarm2 for 29th of the month at 11:00
      RTC.setAlarm2("29:11:00", RTC_ABSOLUTE, RTC_ALM2_MODE2 );

      // Example: Sets Alarm2 for 5 minutes from now
      RTC.setAlarm2("00:00:05", RTC_OFFSET, RTC_ALM2_MODE4 );
}
```

Related variables:

`day_alarm2` → stores the day or date of Alarm2
`hour_alarm2`, `minute_alarm2` → store the time of Alarm2

4.5. Setting the Alarm2

It sets the Alarm2 to the specified time, offset and mode.

The inputs 'day_date', '_hour' and '_minute' specify the time for the Alarm2.

The input 'offset' has some possible values:

`RTC_OFFSET`: 'time' is added to the current time read from RTC
`RTC_ABSOLUTE`: 'time' is set as the time for Alarm2

The input 'mode' specifies the mode for the Alarm2. Possible values are:

`RTC_ALM2_MODE1`: Day, hours and minutes match
`RTC_ALM2_MODE2`: Date, hours and minutes match
`RTC_ALM2_MODE3`: Hours and minutes match
`RTC_ALM2_MODE4`: Minutes match
`RTC_ALM2_MODE5`: Once per minute

When this function is called, Alarm2 is set and no more functions need to be executed.
It returns nothing, but when Alarm2 matches the time, interruption flags will be modified to indicate it.

Example of use:

```
{
      // Example: Sets Alarm2 for 29th of the month at 11:00
      RTC.setAlarm2( 29,11,0, RTC_ABSOLUTE, RTC_ALM2_MODE2 );

      // Example: Sets Alarm2 for 5 minutes from now
      RTC.setAlarm2( 0,0,5, RTC_OFFSET, RTC_ALM2_MODE4 );
}
```

Related Variables:

`day_alarm2` → stores the day or date of the Alarm2
`hour_alarm2`, `minute_alarm2` → store the time of the Alarm2

4.6. Getting Alarm2

It gets the Alarm2 time from RTC.

It returns a string containing this time and date for the Alarm2.

Example of use:

```
{
      // Gets time for Alarm2
      USB.println(RTC.getAlarm2());
}
```

Related variables:

`day_alarm2` → stores the day or date of the Alarm2
`hour_alarm2`, `minute_alarm2` → store the time of the Alarm2

4.7. Clear Alarm Flags

It clears alarm flags (`A1F` and `A2F`) in the RTC.

If these flags are not cleared after an interrupt is captured, no more interrupts could be captured.

Example of use:

```
{
      RTC.clearAlarmFlag();
}
```

4.8. Disable Alarms

There are specific functions to disable preset RTC alarms. These functions avoid the interruption to be executed.

The `disableAlarm1()` function disables the RTC Alarm1.

The `disableAlarm2()` function disables the RTC Alarm2.

Example of use:

```
{
   RTC.disableAlarm1();
   RTC.disableAlarm2();
}
```

4.9. Capture alarms

If an RTC alarm has been set, when the time event happens, some library flags are updated in order to know the alarm has been captured.

The general interruption register `intFlag` stores the captured events. In the case of the RTC alarms, it is necessary to check the value of this register so as to identify the RTC alarm generation. For further information refer to the **Interruptions Programming Guide.**

Example of use:

```
{
   if (intFlag & RTC_INT)
   {
      // RTC captured
   }
}
```

RTC alarm example:

http://www.libelium.com/development/waspmote/examples/rtc-06-complete-example/

4.9.1. Identify triggered alarm

When an RTC alarm is captured it is possible to distinguish which one generated the event: Alarm1 or Alarm2. To that purpose, the `clearAlarmFlag()` function, which is internally called when exiting, a low-power-consumption state, updates the `alarmTriggered` attribute indicating the value to identify the alarm generation. Possible values are:

'1': Alarm1 triggered

'2': Alarm2 triggered

'3': Both alarms triggered

Example of use:

```
{
   if (intFlag & RTC_INT)
   {
      if (RTC.alarmTriggered == 1) { // Alarm1 }
      if (RTC.alarmTriggered == 2) { // Alarm2 }
      if (RTC.alarmTriggered == 3) { // Both Alarm1 & Alarm2 }
   }
}
```

How to know the RTC triggered alarm example:

http://www.libelium.com/development/waspmote/examples/rtc-09-triggered-alarm/

5. Getting Temperature

The Waspmote RTC is provided with an internal temperature sensor which can be used to know the temperature in the same board to calibrate its internal oscillator.

5.1. Getting Temperature

It gets temperature from the RTC. It reads associated registers to temperature and stores the temperature in a variable called '`temp`'.

It returns the temperature value.

Example of use:

```
{
	float temperature = 0.0;
	temperature = RTC.getTemperature();
}
```

Related variables:

`temp` → stores the temperature read from the RTC

An example of the functions:

http://www.libelium.com/development/waspmote/examples/rtc-03-rtc-temperature/

6. Using RTC with hibernate

If the hibernate mode is used in a script, RTC alarms must only be used to set the wake up from the hibernate mode. When the hibernate switch is open, any RTC alarm arriving while the code is running could cause internal collisions. The RTC alarm is supposed to happen when Waspmote is hibernating.

There are several way to set alternative alarms:

- use the Watchdog
- compare current time and date with previous conditions
- use the function `millis()`

7. Unix / Epoch time

Unix time (also known as **POSIX** time or **Epoch** time) is a system for describing instants in time, defined as the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970, not counting leap seconds. It is used widely in Unix-like and many other operating systems and file formats.

Example: 1419086327 (2014-12-20T14:38:47Z)

Waspmote API defines some functions to use this time format which can be useful in order to translate Dates into seconds and perform addition or subtraction of time.

An example of the functions that are shown below:

http://www.libelium.com/development/waspmote/examples/rtc-08-unixepoch-time

7.1. Getting Epoch time

The function `getEpochTime()` permits to calculate the Unix time associated to a specific year, month, day, hour, minute and second values. It is possible to indicate these values as input or use the current values of the RTC.

Example of use:

```
{
  // Define variable to store Epoch time
  unsigned long epoch;

  // Example: Get Epoch time from RTC values
  epoch = RTC.getEpochTime();

  // Example: Get Epoch time from input values(i.e: 2014-12-20 at 14:38:47)
  epoch = RTC.getEpochTime( 14, 12, 20, 14, 38, 47 );
}
```

Note: *The function* `getEpochTime()` *updates the RTC attributes because it calls* `getTime()` *function.*

7.2. Breaking Epoch time into 'Time and Date'

The function `breakTimeAbsolute()` permits to convert the input epoch time to time and date values (as UTC components). Thus, it can be useful to add/subtract times. For example: get Epoch time from RTC and add several seconds to calculate a new time instant.

The structure called `timestamp_t` is defined in WaspRTC class for converting epoch time into UTC timestamps.

Example of use:

```
{
  // Define variable for UTC timestamps
  timestamp_t   time;

  // Break Epoch time into UTC time
  RTC.breakTimeAbsolute( epoch, &time );

   // Available info: UTC Date
   USB.print( time.year,   DEC );
   USB.print( time.month,  DEC );
   USB.print( time.date,   DEC );
   USB.print( time.hour,   DEC );
   USB.print( time.minute, DEC );
   USB.print( time.second, DEC );
}
```

The function `breakTimeOffset()` permits to convert the input (great period of seconds) into offset time values (as the number of days, hours, minutes and seconds that the input argument defines). Thus, it can be useful to add/subtract times. For example: get Epoch time from RTC in different instants and then calculate the difference as number of days, hours, minutes and seconds.

The structure called `timestamp_t` is defined in WaspRTC class for converting great periods of seconds into number of days, hours, minutes and seconds.

Example of use:

```
{
  // Define variable for timestamps
  timestamp_t   time;

  // Get offset time from ‘411361’ seconds
  RTC.breakTimeOffset( 411361, &time );

  // Available info: ‘4’ days, ‘18’ hours, ‘16’ minutes and ‘1’seconds
  USB.print( time.date,   DEC );
  USB.print( time.hour,   DEC );
  USB.print( time.minute, DEC );
  USB.print( time.second, DEC );
}
```

8. Code examples and extended information

In the Waspmote Development section you can find complete examples:

http://www.libelium.com/development/waspmote/examples

Next lines show a complete example of use of the RTC functions.

```
/*
 *  ------Waspmote RTC Complete Example--------
 *
 *  Explanation: This example shows how to read the temperature using
 *  the sensor integrated in Waspmote
 *
 *  Copyright (C) 2012 Libelium Comunicaciones Distribuidas S.L.
 *  http://www.libelium.com
 *
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 *  GNU General Public License for more details.
 *
 *  You should have received a copy of the GNU General Public License
 *  along with this program.  If not, see <http://www.gnu.org/licenses/>.
 *
 *  Version:           0.1
 *  Design:            David Gascón
 *  Implementation:    Marcos Yarza
 */

void setup(){

  // Setup for Serial port over USB
  USB.ON();
  USB.println(F("USB port started..."));

  // Powers RTC up, init I2C bus and read initial values
  USB.println(F("Init RTC"));
  RTC.ON();

}

void loop(){

  USB.println(F("+++++++++++++++++++++++++++++++++++++++++++++++++++++"));

  // Setting time
  RTC.setTime("09:10:20:03:17:35:00");
  USB.print(F("Time: "));
  USB.println(RTC.getTime());

  // Setting and getting Alarms
  RTC.setAlarm1("20:17:35:30", RTC_ABSOLUTE, RTC_ALM1_MODE2);
  USB.print(F("Alarm1: "));
  USB.println(RTC.getAlarm1());

  // Setting Waspmote to Low-Power Consumption Mode
  PWR.sleep(ALL_OFF);
```

```
  // After setting Waspmote to power-down, UART is closed, so it
  // is necessary to open it again
  USB.ON();

  // Waspmote wakes up at ‘17:35:30’
  if( intFlag & RTC_INT )
  {
    intFlag &= ~(RTC_INT); // Clear flag
    Utils.blinkLEDs(1000); // Blinking LEDs
    Utils.blinkLEDs(1000); // Blinking LEDs
  }

  RTC.ON();
  RTC.setAlarm2(“20:17:36”, RTC_ABSOLUTE, RTC_ALM2_MODE2);
  USB.print(F(“Alarm2: “));
  USB.println(RTC.getAlarm2());

  // Setting Waspmote to Low-Power Consumption Mode
  PWR.sleep(ALL_OFF);

  // After setting Waspmote to power-down, UART is closed, so it
  // is necessary to open it again
  USB.ON();

  // Waspmote wakes up at ‘17:36’
  if( intFlag & RTC_INT )
  {
    intFlag &= ~(RTC_INT); // Clear flag
    Utils.blinkLEDs(1000); // Blinking LEDs
    Utils.blinkLEDs(1000); // Blinking LEDs
  }

  // Getting Temperature
  RTC.ON();
  USB.print(F(“Temperature: “));
  USB.println(RTC.getTemperature(),DEC);

  delay(5000);
}
```

9. API Changelog

Keep track of the software changes on this link:

www.libelium.com/development/waspmote/documentation/changelog/#RTC

10. Documentation changelog

From v4.7 to v4.8

- Add chapter related to RTC alarms

From v4.6 to v4.7

- New chapter for Unix/Epoch time functions
- Links to the web examples
- Minor corrections

From v4.5 to v4.6

- Link to the new online API changelog

From v4.4 to v4.5:

- API changelog updated to API v011

From v4.3 to v4.4:

- API changelog updated to API v010

From v4.2 to v4.3:

- API changelog updated to API v007

From v4.1 to v4.2:

- API changelog updated to API v005

From v4.0 to v4.1:

- API changelog updated to API v004
- New chapter for alarm disabling