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29January 2008

Application note 007

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Really "low power" radio

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First published in Electronics World magazine. Aug 2007 issue

The term 'low power radio' is understood to refer to ISM band wireless links operating at 500mW or less. The purpose of this article is to examine their use in low power applications, where restrictions imposed by battery life (or other power availability issues) require extremely current-frugal design techniques.

To list a few such applications:

- battery powered remote monitoring (such as automated gas meter reading)
- fire and intruder alarm sensors
- long range tagging/RFID applications
- emergency lighting / alarms / signals
- pager applications

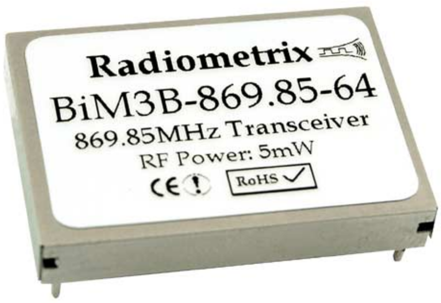

Fig 1: 868MHz ISM band transceiver

In the simplest case the application just requires a low power transmitter which is very infrequently activated (a temperature monitoring system might only need to take a reading every ten minutes, an agricultural soil condition monitor might only report once per day, while some wireless alarms only transmit when activated or when indicating low battery).

In more complicated applications the receiver power consumption is key, in tasks where it must constantly monitor for a command transmission which either initiates an operation (emergency lights, pagers) or triggers ('polls') a transmit-back burst of stored data (RFID tags, remotely read meters).

For all these types of applications the dominant design aim is to keep power consumption to an absolute minimum. While very low power design techniques constitutes a huge subject in itself, here are a few useful pointers:

Keep everything you aren't using turned completely off: Be prepared to switch the power supply to sensors, radio modules and other peripherals. (In 'standby' mode some of these devices can still draw tens of uA). If the main processor is too power hungry to operate constantly, then design a low current 'master timer' to periodically cycle it 'on'. (A single unijunction transistor operating as a relaxation oscillator can draw less than 1uA at a 1Hz rate.)

Design around the slowest digital clocks you can: CMOS logic power consumption is directly in proportion to the switching speed. Modern micro controllers intended for low power tasks frequently can be operated from 32KHz watch crystals, and often have lower power 'sleep' or 'wait' modes, from which timer interrupts can periodically wake them.

Activate the radio module as infrequently as possible: It will probably be the largest single power consumer in the design (a UHF receiver can consume 20mA at 3v, compared to below 100uA for a modern microprocessor). Keep transmit bursts short (within accepted data rate versus performance trade-offs), and where response time allows it, cycle the receiver on and off (see note 2).

Minimise standing (quiescent) currents:

- Use low quiescent current LDO regulators (78LCxx types draw only 1uA)
- Switch with mosfets (zero gate current), not bipolar devices
- Keep pull-up and bias resistors as large as possible
- If indicator lights are needed, use low current LEDs and flash them, slowly

Be aware of wasted charge in large capacitors:(A 100uF capacitor at 5v contains 500uC. Charging this up once per second is equivalent to an extra 0.5mA current drain). Where possible, switch 'down-stream' of such high value decouplers

Keep within maximum (peak) current drain, and temperature ratings, of the batteries used:. Outside these limits the performance of the cells can be significantly impaired (especially in the case of high energy density lithium cells)

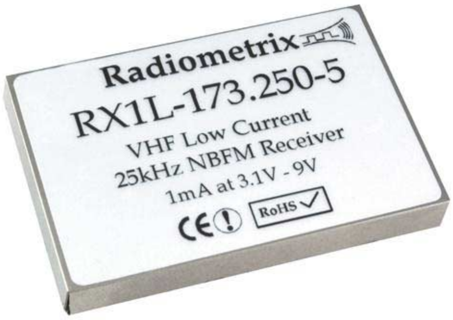

Fig 2: very low current receiver

Use moderate data rates, to reduce coding and decoding processing effort (and hence cpu clock speeds): There is no point in reducing the burst length to under 2mS by using an inconveniently high data rate, if the transmitter and receiver used require 20mS of preamble to key-up and settle

Most importantly of all: design for low power from the very begining. It is impossible to create a low power development of a design that is already based around bloated high level code running on power hungry processors, or which is committed to using current hungry radio devices. Do it right, from the start.

Note 1. *Power consumption of typical ISM band radios:*

very low current VHF single channel rx module	1mA @ 3v	(Radiometrix RX1L)
typical VHF single channel receiver module	7mA @ 3v	
typical UHF single channel receiver module	12mA @ 3v	
UHF multi channel receiver	20mA @ 3v	
1mW VHF transmitter	9mA @ 2.2v	
10mW UHF single channel transmitter	18mA @ 3v	
10mW UHF multichannel transmitter	34mA @ 3v	
Class 1 Bluetooth device	22-35mA @ 3v3	
Simple WiFi module	210-340mA @ 3v3	

Note 2. *Cyclic receiver operation (or "battery economy cycling"):*
A technique used to minimise receiver power consumption, originally applied to pagers. Simply, a transmit operation consists of the same sub-burst of data repeated over and over. The entire operation must be longer than the period between two receiver 'on' times, and the duration of the receiver 'on' time needs to be over twice the length of a sub-bursts (to ensure that, even if a receiver wakes in the middle of a sub-burst, it is then on for long enough to decode the next one).

The period between receiver 'on' can be as long as is desired (with commensurate power reductions), provided it is realised that the worst case response time of the system is equal to this period.

Example: A fire alarm system uses radio activated, battery powered emergency lights.
The system requires a response time of 5 seconds or less between alarm and 'lights on'
A 50 bit burst is used, at 1kbit/sec and the receiver needs 25mS to stabilise at power-on
(so a sub-burst needs 50mS for data, plus 25mS settling 'preamble' = 75mS)
(and receiver 'on time' must be 2 x sub-burst duration = 150mS)
For 5 second maximum response time, a receive cycle of (5-0.15) = 4.85 seconds is usable
So receiver off/on ratio is 4.7:0.15, or about 31:1

In this system, a 10mA receiver will have an effective current consumption of about 320uA

(if the lights run from 18 amp-hour D cells, and this radio current is the dominant power drain, then we can expect a 'lights off' battery life of about six years)

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The Intrastat commodity code for all our modules is: 8542 6000