Circuit Description and Operation

The module consists of a host microcontroller which serves as the central controller for the module and a radio transceiver subsystem. The host microcontroller communicates with external systems through a serial interface. Moreover, a pulse interface, through which dry contact closure pulses can be input to the host microcontroller for counting and storing is also provided. This pulse interface enables the module to be connected to, for example, energy measurement devices which output pulses in proportion to energy consumed.

The host microcontroller is also provided with RAM memory to store program and data. Address and data bus connections, operating at 15Mhz enable the host microcontroller to store in and retrieve data from the RAM. A real-time clock (RTC) that keeps the time of the day is also provided. The host microcontroller communicates with the RTC through an I^2C interface which operates at 100kHz.

Oscillators provided in the host microcontroller portion of the circuitry are: a) a 32.768Mhz clock that serves as the master clock for the host microcontroller and b) a 32.768kHz clock for the RTC.

The radio transceiver subsystem consists of a radio transceiver chip and front-end RF circuitry. In particular, the radio transceiver chip is an FCC Part 15 compliant off-the-shelf Bluetooth product (see the Bill of Material included in the submission).

The Bluetooth radio performs spectrum spreading by frequency hopping in 79 frequencies that are displaced by 1 MHz, between 2.402GHz and 2.480GHz. The eventual maximum transmit power at the antenna is 20 dBm, but the actual transmitted power on a link may be lower for optimization.

The modulation uses GFSK (Gaussian Frequency Shift Keying) where a binary one is represented by a positive frequency deviation and a binary zero by a negative frequency deviation. The Time-Bandwidth (BT) product is 0.5 and the modulation index is between 0.28 and 0.35.

The frequency synthesizer changes frequency between receive slot and transmit slot, but always returns to the same transmit frequency. The transmitted initial center frequency accuracy must be ±75 kHz from center. The frequency channel on which to transmit is chosen among the 79 frequencies according to a pseudo-random hopping sequence.

The channel is divided into time slots. Each slot is 625 μs in length and corresponds to a hop frequency. A time division duplexing (TDD) scheme is used where master and slave alternatively transmit. Specifically, the time slots are numbered according to the Bluetooth clock of the master, who starts its transmission in even-numbered time slots only, while the slave starts its transmission in odd-numbered time slots only. The packet start is aligned with the slot start.

The receiver has a sensitivity level of -70dBm or better to achieve a bit error rate (BER) of 0.1% or better. The interference performance on co-channel and adjacent 1 MHz and 2 MHz are

measured with the wanted signal 10 dB over the reference sensitivity level. On all other frequencies, the wanted signal is 3 dB over the reference sensitivity level. The out of band blocking is measured with the wanted signal 3 dB over the reference sensitivity level. The interfering signal is a continuous wave signal. The BER is less than or equal to 0.1%.

The reference sensitivity performance, BER = 0.1%, is met under the following conditions:

- The wanted signal at frequency f_0 with a power level 6 dB over the reference sensitivity level;
- A static sine wave signal at f_1 with a power level of -39 dBm;
- A Bluetooth modulated signal at f_2 with a power level of -39 dBm; and
- $f_0 = 2f_1 - f_2$ and $|f_2 - f_1| = n$ MHz, where n can be 3, 4, or 5.

The front-end RF circuitry consists of a power amplifier that boosts the output power, a low noise amplifier that serves as pre-amplifier in the receive path, a transmit/receive switch to multiplex transmit and receive paths, a front-end filter to improve rejection of out-of-band signals and an antenna. The antenna for the 2400B module is a quarter wave monopole wire antenna soldered directly on the 2400B module.