**INTRODUCTION:**
This document describes the Wireless Bicycle Power Meter and its hardware implementation. The Wireless Bicycle Power Meter is intended to measure a bicycle rider’s output power and display it on an LCD in front of the rider.

**Hardware Modules:**
My project has two main modules. The first module is the unit that will be mounted to the handlebars. This unit is comprised primarily of a Freescale MC13213 (U1-MCU1) microcontroller unit and an LCD screen. This microcontroller will simply receive data from another microcontroller unit and display it on the LCD screen. The second module is the unit that will be mounted on the cranks of the bicycle. This unit is also based around a Freescale MC13213 microcontroller (U1-MCU2), but it will be sampling data from a Freescale MMA7260Q accelerometer (U2-MCU2). This module also will have 2 fully active strain gauge bridge circuits (8 strain gauges) which outputs differential voltages to two AD627 instrumentation amplifiers (one per bridge circuit). The data that is sampled from the two bridge circuits and the accelerometer is sent wirelessly to the module mounted on the handlebars.

**LCD:**
The LCD used in this project is a 2x16 character display module. It is based around a SPLC780D chipset, which is compatible with the very common HD44780U chipset. This LCD requires a total of 16 connections. There are three control lines (RS, R/W, E), which are connected to the microcontroller PTA0, GND, and PTA6, respectively. The R/W control line is permanently grounded because the LCD is only used as an output. The eight LCD data lines are connected to PTB0-PTB7. This LCD requires power for the LCD itself and power for the backlight. The LCD power will come directly from the battery and the backlight power will come from an output pin from the microcontroller, which will enable me to turn the backlight off to save power.

**Antenna:**
Both modules will use an identical antenna setup. The antenna design I used is from a Freescale reference design. This design uses a 50/50 ohm 2.45 GHz balun and an antenna traced into the PCB board. The antenna circuitry connects to the microcontroller via three pins; RFIN_P (positive RF connection), RFIN_M (negative RF connection), and CT_Bias (bias control voltage for the modem).

**Accelerometer:**
The accelerometer (U2 on unit 2) in this project is used to measure the angular velocity of the bicycle cranks. The accelerometer is a 3-axis, low-power, selectable sensitivity accelerometer. The three axis’s are analog signals that are samples individually using three A/D ports on the microcontroller (ATD2, ATD3, ATD4). Each of these analog accelerometer signals must pass through a low-pass filter using a 1k resistor and a .1 uF capacitor, which minimizes noise on the line before being sample by the A/D port. The accelerometer sensitivity select is controlled via two select lines connected to PTB0 and PTB1. This allows the accelerometer to be set in 1.5g, 2g, 4g, or 6g sensitivity modes.
**Strain Gauges:**
The module mounted on the bicycle crank arms will have two fully active strain gauge bridges. As the crank arms of the bike strain, it changes the effective resistance within the strain gauges and produces a differential voltage on the output of the bridge circuit. Having a fully active bridge with four strain gauges maximizes the potential output of the strain output. A fully active bridge is also less susceptible to noise and temperature changes than a bridge with fewer gauges. There will be two gauges mounted on each side of each crank (two on the top, two on the bottom). The bridge circuit is powered by the battery voltage, which is the same voltage used for the A/D reference voltage. This produces a ratio-metric output, which allows the sample taken by the MCU to be unaffected by the battery voltage going down. The differential output of the bridge circuits will go directly into an instrumentation amplifier.

**Instrumentation Amplifiers:**
The outputs of the two strain gauge bridges will be fed directly into two AD627 instrumentation amplifiers (U3 & U4 on MCU2). The gain of U3 is set by R9 and the gain of U4 is set by R1. The gain of these amplifiers is equal to about 1000 (G = 5 + (200k/Rg)). This is the maximum suggested gain for these amplifiers. The positive supply is approximately 3.3 volts, which is bypassed by a .1 pF capacitor and the negative supply is grounded. The outputs of these amplifiers go directly into PTA0 & PTA1 to be sampled by the A/D converter.

**Power Supply:**
Each microcontroller is powered by two 1.6 volt AA batteries. The batteries are connected to a simple on/off power switch. When the switch is in the off position, no power is supplied to the microcontroller or any other project component. When the switch is in the on position, power is supplied to the MCU and all the other components that need power. On module one, the microcontroller (U1), and the LCD (LCD1) are the only two components that need this power. On module two, the microcontroller (U1), the accelerometer (U2), the two strain gauge bridges (R5-R8 & R10-R13), and the two instrumentation amplifiers (U3 & U4) all require power from the two batteries.

**Setup Switch:**
The setup switch (SW1) on module 1 is used to control the user-interface for the system calibration sequence. This is a simple pushbutton switch wired to ground. The switch is connected to PTA3 which has an internal pull-up resistor enabled.

**Miscellaneous Connections:**
Both modules have several miscellaneous connections. This includes the 2x3 debug port connected to the PTG0 and RESET pins. This allows the unit to be connected to a debug module for future debugging and programming. Both modules also include an external oscillating crystal operating at a frequency of 16 MHz. This crystal is connected to the XTAL1 and XTAL2 pins of both MCU’s with two 6.8 pF load capacitors each.
Each module also has a variety of connections to power and ground. VDD and VDDVCO are both decoupled to ground via 100 nF capacitors. VDDA, VDDLO1, and VDDLO2 are all connected to the battery source voltage with a 100 nF capacitor to help decouple noise. VDDINT and VDDBAT are also connected to the battery supply voltage with 1 uF decoupling capacitors. VDDLO1, VDDLO2, VDDBAT, and VDDINT are all power supplies for the internal modem unit of the MCU. Module 2 also has three additional power/ground connections to facilitate the use of the A/D module. VDDAD and VREFH are both connected to the battery supply voltage and VREFL are connected to ground. VDDAD is the pin to supply power to the A/D module and VREFH and VREFL are the upper and lower reference voltages used in the A/D conversions.