**Background**

“The majority of clock sources for microcontrollers can be grouped into two types: those based on mechanical resonant devices, such as crystals and ceramic resonators, and those based on electrical phase-shift circuits such as RC (resistor, capacitor) oscillators” [2]. Crystal, ceramic resonator, and RC oscillators are all sensitive to electromagnetic interference; however, only the RC oscillator has the additional disadvantage of poor temperature performance. One of the few advantages of the low accuracy RC oscillator is that it is the lowest cost option available, and is also typically available onboard a microcontroller with no extra circuitry necessary. This makes RC oscillators the desired source for non-critical or “low-budget situations” [3].

Issues involving EMI effects on electrical systems have been known about for a long time. Documents addressing how to handle these issues often cite typical sources of where the EMI may be coming from. For example, in an application note on erratic behavior in power-driven wheelchair due to EMI, the document cites that “common sources of EMI [include] cellular phones, CB radios, TV and radio stations, amateur radios and fire and ambulance radios” [4]. This citation provides justification for the frequencies we will be testing including: 1 MHz (AM radio stations), 100 MHz (FM radio stations), 600 MHz (UHF TV), 850 MHz, (Cellular), and 1900 MHz (Cellular). The widespread presence of Wi-Fi signals at 2.4 GHz and 5 GHz in 2015 justifies its inclusion to the test frequencies.

Methods for establishing temperature sensitivity on frequency for RC oscillators and mechanical oscillators are well established, and may provide insight on how to properly present data and errors after measurements have been taken. Since temperature variation in a crystal oscillator is small, “the frequency error of a crystal oscillator (denoted ε) is expressed in ppm (parts per million)” [5]. If the drift due to RF emissions is too much, the ppm method will become ineffective, and the drift will be presented as percent error.

Solutions to measure to RC oscillator’s frequency include using a spectrum analyzer or a frequency counter. Using a spectrum analyzer involves connecting the analyzer’s 50 ohm input to an antenna port to measure the output frequency error on the RF carrier and hence, ε. For most chips with a clock-out function, using a frequency counter is the simplest solution. Frequency counters measure the frequency of a signal by counting how many times a signal passes past a threshold value. Selecting a longer time base interval allows for more samples to occur, which in turn results in a more accurate result. To ensure the accuracy of the instrument it must be brought up to operating temperature. This will require leaving the instrument on for sufficient time before measurements are taken. A frequency counter with a data port will be need for data collection, such as a RS232C port on the B&K Precision 1823A, 1856D frequency counter [6].

Despite the large amount of data available on temperature drift, there is no standard time to expose the devices to temperature that could be equated to the amount of time we should expose the devices to RF radiation. Therefore, it is reasonable that exposure should occur for an hour to account for the potential of long term effects. Frequency counter sweep time will be set at an interval of 1 second to capture short term drift effects. For an oscillator operating in MHz a sweep time of 1 second will ensure plenty of counter samples for accuracy of measurement, while still allowing for many data points (3600 for a hour of testing) to be collected over the testing period.

RF test chambers are anechoic chambers and “are used today for performing EMC measurements,” and provides shielding from unwanted environmental EMI as well as highly reducing [7]. These chambers are typically rated for emissions in the frequency range of 30 MHz up to 40 GHz [7]. We will be testing frequencies as low as 1 MHz. “While, there are standard that call for radiated measurements down to the low kHz or even to the low Hz range, these standards do not specify any need for absorption or anechoic behavior” [7]. “In most cases, at these low frequencies where current absorber technology cannot deliver any level of absorption, the chambers are going to be too small (electrically) for resonant modes to appear” [7].

The basic equipment needed to produce RF emissions in the frequency range we need is a signal generator, a power amplifier, a transmission line, and a radial antenna. Signal generators are limited on frequency range and output power, so an RF power amplifier is needed to reach the desired power densities.

[2] Maxim Integrated. "Application Note 2154: Microcontroller Clock—Crystal, Resonator, RC Oscillator, or Silicon Oscillator?" Maxim Integrated. Maxim Integrated Products, Inc., 10 Sept. 2003. Web. 20 Sept. 2015.

[3] Schweber, Bill. "MEMS Oscillators Challenge Quartz Crystals in RF Applications." MEMS Oscillators Challenge Quartz Crystals in RF Applications. Electronic Products, 30 Oct. 2014. Web. 23 Sept. 2015.

[4] Getz, Robin, and Bob Moeckel. "Understanding and Eliminating EMI in Microcontroller Applications." Texas Instruments. National Semiconductor, Aug. 1996. Web. 25 Sept. 2015. <http://www.ti.com/lit/an/snoa382/snoa382.pdf>. Literature Number: SNOA382

[5] Semtech Corporation. "Application Note AN1200.07: Improving the Accuracy of a Crystal Oscillator." Semtech.com. Semtech Corporation, Jan. 2009. Web. 17 Sept. 2015.

[6] "Frequency Counters: Models 1823A, 1856D." B&K Precision Corp., 2014. Web. 25 Sept. 2015. <http://www.mouser.com/ds/2/43/1823A\_datasheet-181239.pdf>.

[7] Wiles, Martin, and Vince Rodriguez. "Choosing the Right Chamber for Your Test Requirements." ETS-Lindgren. Interference Technology, May 2010. Web. 23 Sept. 2015. <http://www.ets-lindgren.com/pdf/item\_mwvr\_0510.pdf>.