# OUTLINE

**\*NOTE: this outline will be primarily used to expand ideas and topics in an organized manner. Any grey text, for reasons sometimes not specified, is obsolete or not applicable, but remains for documentation purposes.**

1. Frequencies in question (Where the RF radiation is coming from)
   1. Wifi
      1. 2.4 GHz
      2. 5 GHz
   2. Space
      1. Frequencies?
   3. Radio towers
      1. AM radio
         1. 535-1605 kHz [8]
         2. Carrier frequencies of 540 to 1600 kHz are assigned at 10 kHz intervals. [8]
      2. FM radio
         1. 88 to 108 MHz [8]
   4. Cellular towers
      1. 824-896 MHz commonly termed 800 MegaHertz (may also be known as 850MHz). [9]
      2. 1850MHz-1990MHz commonly termed 1900 MegaHertz or 1.9 GigaHertz. [9]
2. Power densities for each frequency
3. Clock sources and radiation
   1. Often in space applications, electronic equipment must be designed to withstand conditions not typically encountered on earth. For example, missions to Venus must face extreme “high temperature up to 460~470 degrees celsium, high pressure to 90 bar, shock and vibration, [as well as] total dosage exposure.” [7]
4. Clock sources
   1. Overview of operation
      1. Oscillator types
         1. Crystal oscillator
         2. Ceramic resonator
         3. Internal Fast RC oscillator
      2. Chip modes
         1. XT Mode, medium gain, medium frequency mode to work with crystal frequencies of 3.5MHz to 10MHz [1] pg21
         2. HS Mode, High Gain, High-Frequency mode used to work with crystal frequencies of 10 MHz to 40 MHz [1] pg21
         3. EC Mode, if the on-chip oscillator is not used, the EC mode allows the internal oscillator to be bypassed. [1] pg21
      3. Oscillator Start-up Time [1] pg22
         1. Primary oscillator
         2. In reference to the experiment, the oscillator should be stable when taking measurements, and the oscillator startup time should be avoided.
      4. RC oscillator
         1. 7.37 MHz
         2. -12% to +11.625% tunable
         3. Phase shift oscillator [2]
         4. Wein bridge oscillator [2]
         5. Op-amp oscillators are restricted to the lower end of the frequency spectrum because they do not have the required bandwidth to achieve low phase shift at high frequencies. [3]
         6. “RC oscillators, in contrast, provide fast startup and low cost, but generally suffer from poor accuracy over temperature and supply voltage, and show variations from 5% to 50% of nominal output frequency.”
         7. “internal RC oscillator (RCO) is useful in applications where an external quartz crystal or resonant element cannot be used for cost reasons.” [5]
   2. Purpose for each type of oscillator
      1. Crystal oscillators
         1. “Crystal and ceramic resonator-based oscillators (mechanical) typically provide very high initial accuracy and a moderately low temperature coefficient.” [4] If a system requires a very stable and accurate clock source, a crystal or ceramic oscillator is preferred. However, these clock sources incur an additional cost and take up board real estate
   3. Known data for internal oscillator

# Definitions

1. **Radiation** is the emission or transmission of energy in the form of waves or particles through space or through a material medium.
2. An **electronic oscillator** is an electronic circuit that produces a periodic, oscillating electronic signal, often a sine wave or a square wave.
3. **Total Effective Dose Equivalent (TEDE)** is the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). <http://www.nrc.gov/reading-rm/basic-ref/glossary/total-effective-dose-equivalent-tede.html>
   1. This definition may be equivalent to “Total dose exposure” in [7]

# References

* [1] <http://ww1.microchip.com/downloads/en/DeviceDoc/70005131a.pdf>
  + dsPIC33/PIC24 Family Reference Manual – Oscillator module
* [2] <http://www.daenotes.com/electronics/digital-electronics/rc-feedback-oscillators>
  + Types of oscillators
* [3] <http://www.ti.com/lit/an/sloa060/sloa060.pdf>
  + Op amp oscillator
* [4] <https://www.maximintegrated.com/en/app-notes/index.mvp/id/2154>
  + Microcontroller clock sources
* [5] <http://www.atmel.com/Images/article_ac9_atmegaxx8pa-15-rc-oscillator.pdf>
  + Shorthand section on temperature drift by Atmel
* [6] <http://www.semtech.com/images/datasheet/xo_precision_std.pdf>
  + Temperature drift of crystal oscillators
* [7] <http://solarsystem.nasa.gov/docs/7_7SARIRIVI.pdf>
  + NASA presentation slides on *Extreme Temperature/Radiation Tolerant Crystal Oscillator for High Reliability & Space Applications.*
* [8] <http://hyperphysics.phy-astr.gsu.edu/hbase/audio/radio.html>
  + Frequency bands for radio signals
* [9] <http://www.criterioncellular.com/tutorials/bandsandfrequencies.html>
  + Frequency bands for cellular signals

# Notes

* Combination of temperature drift and RF drift could cause a severe change in clock frequency, which could result in a controller collecting false data
  + For example, an MCU checking how much power is being delivered to a circuit too quickly, due to an increased clock speed, could result in a premature shutdown attempting to prevent damage to the powered circuit. Conversely, checking too slowly, due to a decreased clock speed, could result in too much power being delivered to the circuit, damaging it.
* Could a smart phone’s own radio emissions affect the phones processor detrimentally? This question may provide adequate justification for our investigation of radiation of clock sources. May provide insight as to the possibility of using an internal oscillator to reduce cost.
  + What kind of sources do smart phones use?
  + This may be more applicable to peripheral devices in the phone, as the main CPU probably is using a really good clock source.
    - Do I now need to research how a smartphone operates…? Sigh.