RF Design and SDRs

Embedded Interface Design

with **Bruce Montgomery**

Learning Objectives

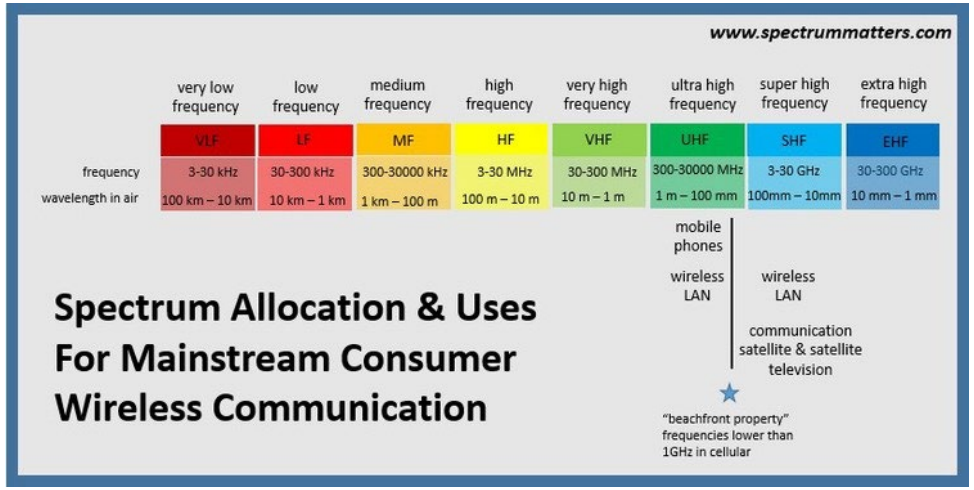
Students will be able to…

- Recognize common issues in RF/wireless embedded devices
- Compare licensed vs unlicensed communications
- Understand the use of SDRs in design and development

RF, Defined

- Radio Frequency (RF) refers to the use of electromagnetic frequencies for communications, radar, or other
- Usually discussing RF implies wireless and not wired communications
- Generally RF for communications is between 3 kHz and 300 GHz
- The UHF bands – between 300 and 30000 MHz are in most demand for desired range and attenuation
- Generally, the lower the frequency, the further distance that a signal can travel
- Lower frequency bands have lower attenuation, so signals traveling in these bands are able to pass more easily through buildings, geography, or other obstacles
- Mobile devices generally run in the 700 MHz to 1.9 GHz bands
- Reference [1]

The 700 Mhz auction, known as Auction 73, raised almost $20 billion in revenue in 2008!



Regulating/Testing RF Communications

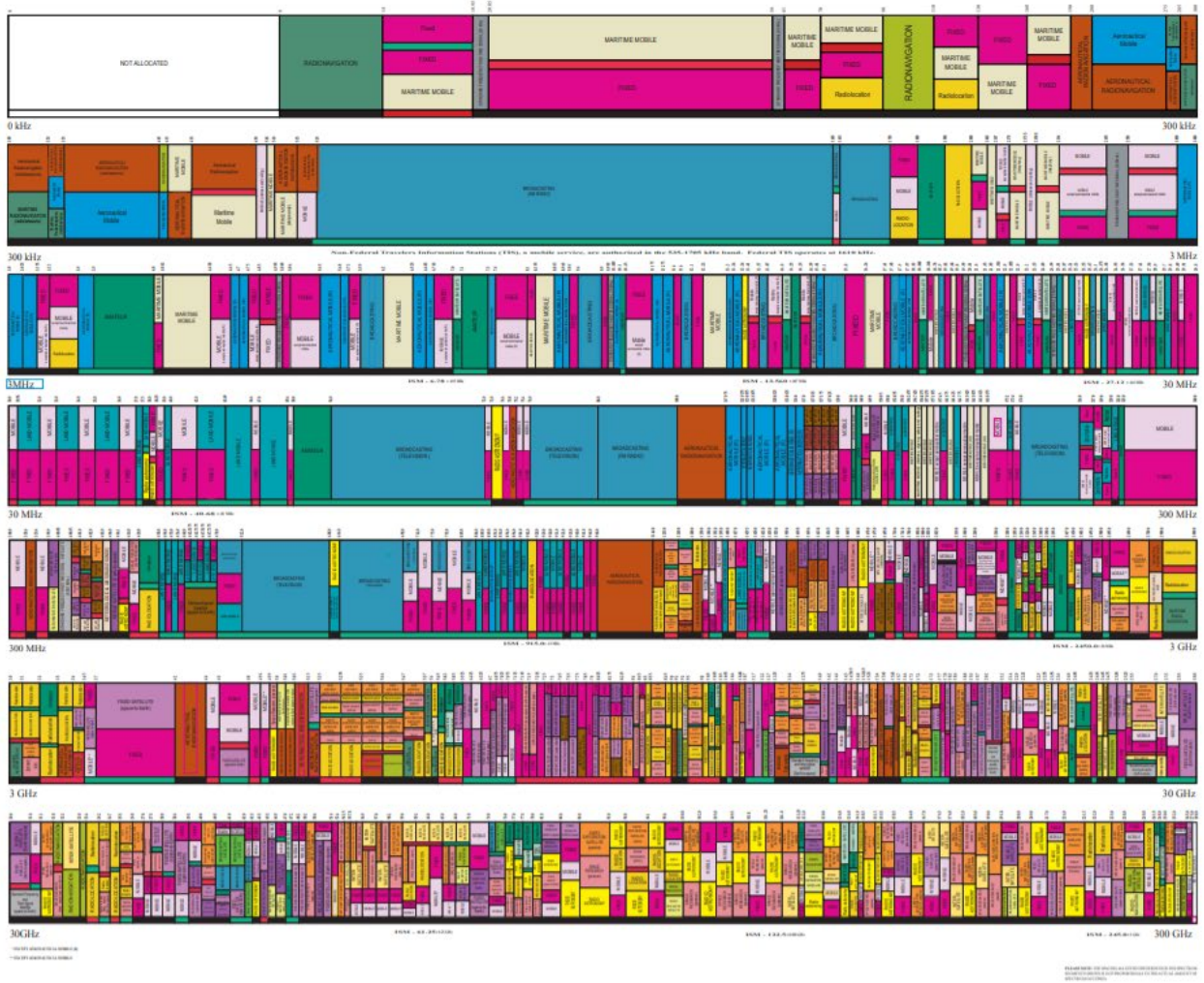
- Use of communication spectrum is highly regulated in industrialized countries
- In the US, the FCC (Federal Communications Commission) regulates, monitors, and controls spectrum use
- The FCC Enforcement Bureau has broad responsibilities for spectrum use and content
- FCC certification is required to show both testing of intentional and unintentional electromagnetic transmissions from commercial devices
- FCC Part 15 classification covers communication devices, Part 18 is for ISM (Industrial/Scientific/Medical) devices
- Other countries have different requirements (CE in Europe or CCC in China, for instance)
- Reference [2]

Certification bodies:

- FCC (US) TCB (Telecomm Certification Body)
- Industry Canada
- EU Notified Body (RED)
- Japan VCCI
- Vietnam MIC
- EPCglobal
- Austrailia ACMA
- A2LA ISO/IEC
- Korea KCC
- Taiwan BSMI
- Verizon ITL

Licensed vs. Unlicensed Communications

- US Frequency Allocation Chart →
- Licensed vs Unlicensed
- Amateur vs Commercial
- Single vs Multi-use
- Power and Bandwidth Use Limits
- Reference [3]



Licensed vs. Unlicensed Communications

- Licensed bands require a user to pay a licensing fee to gain the right to transmit on assigned spectrum in a geographic area
  - An example would be licensed VHF Television channels or Cellular communications
- Unlicensed wireless use does not require a licensing fee, but there are still rules depending on the spectrum in question
  - Examples would include the 902–928 MHz and 2.4 GHz ISM bands, often used for M2M or IoT communications such as WiFi
- Common limitations include occupied bandwidth, maximum transmission power, and other spectrum use limits
  - For instance, higher transmit power may be allowed if the spectrum use is spread via frequency hopping or digital modulation

Challenges in Implementing RF for IoT/M2M

- Primary Tradeoffs: Power, Range, Speed, Data Volume, Reliability, Cost
- Balancing requirements by application
- Interference in unlicensed RF spectrum or with licensed RF spectrum
- Certification requirements
- Variety of development approaches – SDRs, standard RF silicon, custom protocol silicon, custom designs, ASICs
- Antenna design challenges, especially for multiple protocols
- Rate of change in hardware, protocols

Implementing RF with Pre-built Modules

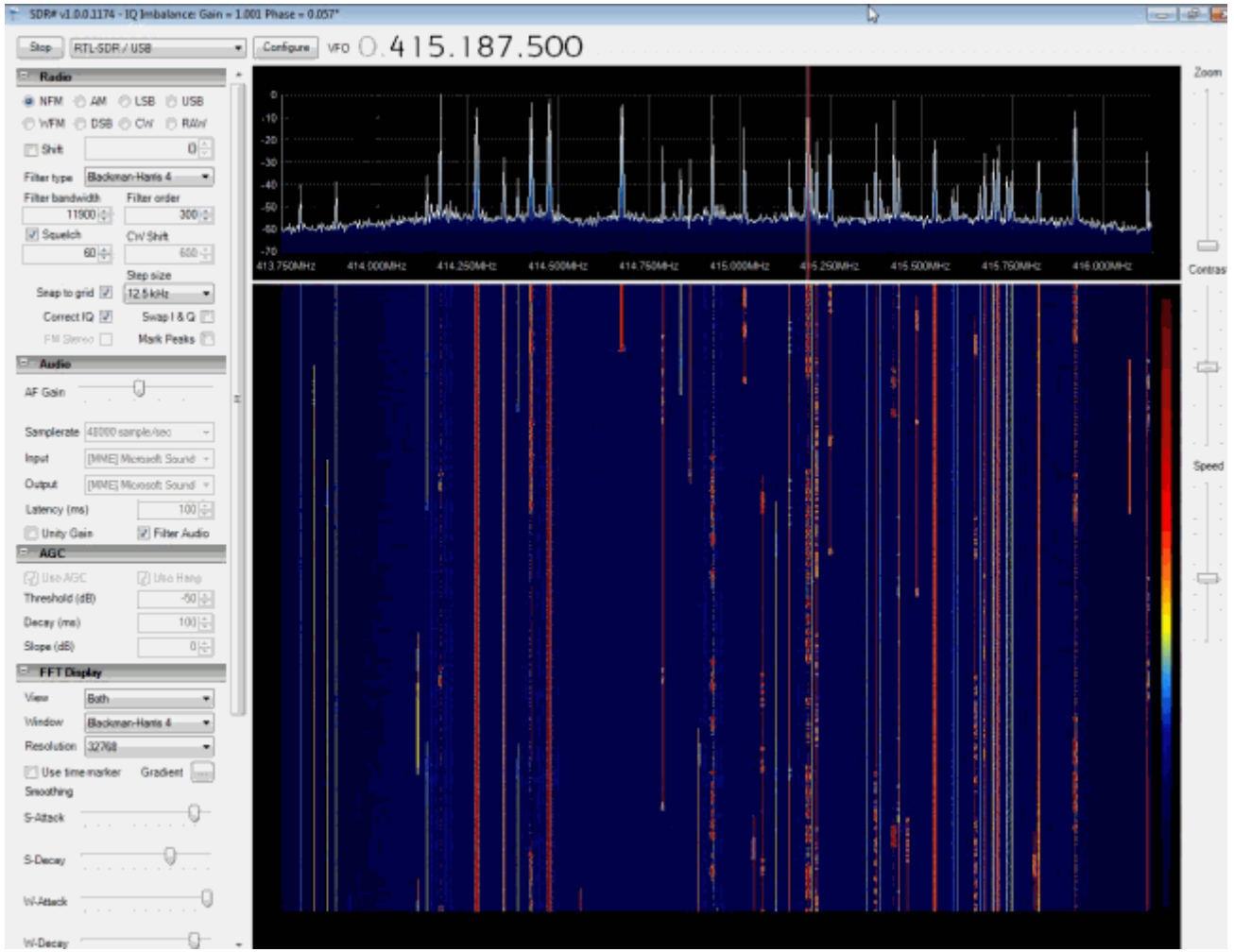
- No (less) RF experience needed
- Doesn’t require costly RF test instruments or lab
- Doesn’t require PCB design, antenna design, or Z matching (impedance matching/antenna tuning)
- Pre-certified modules with modular grants allow you to skip FCC or other standards certification
- Be aware
- Cost of modules (vs. cost of custom development)
- External dependance
- Availability of custom silicon for protocols does not guarantee performance to your needs
- Firmware from vendors often bloated, frequently updated, or never updated
- Reference [4], Image – SiLabs Blue Gecko [5]

SDR, Defined

- SDR = Software Defined Radio
- A basic SDR system has an analog-to-digital converter, an RF front end, and support for connection to a PC
- SDR devices will vary widely in cost and capabilities, including:
  - Duplex model for transmit/receive
  - Operating frequencies
  - Modulations and Data rates
  - Antenna and other interfaces
- An alternative to developing custom hardware for RF applications
- Easy to leverage for prototyping and understanding RF systems
- As costs reduce, becoming an alternative for commercial deployment
- Reference [6]

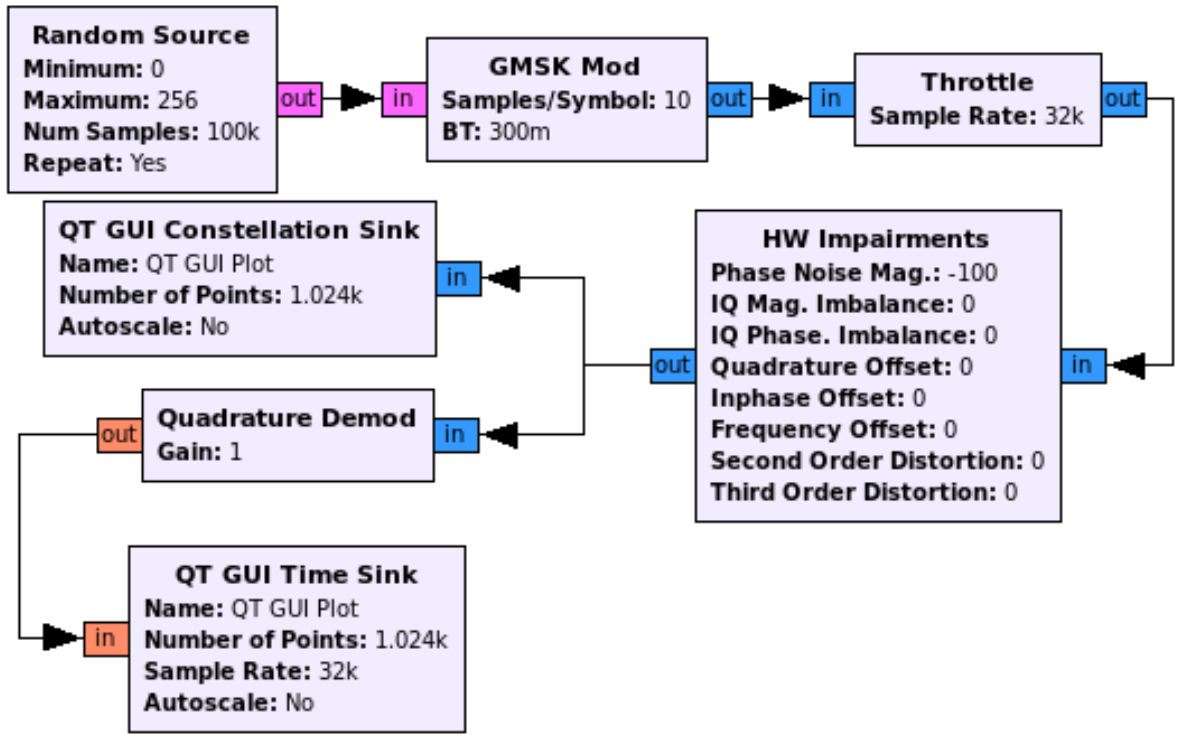
SDR Tools/Uses

- Typical Tools
  - SDR# (Windows)
  - GQRX (Mac/Linux)
  - ShinySDR (Built on GNU Radio)
  - WebRadio (Linux)
  - QtRadio (Windows/Linux)
- Typical Uses
  - Receive broadcast radio/TV
  - Amateur Radio Astronomy
  - Track ships or aircraft
  - Experiment with GSM or LTE
  - Test/examine wireless protocols
- Tool List [7], Uses [8]



GNU Radio

- GNU Radio is an open source framework for enabling design, simulation, and deployment of RF systems
- The GNU Radio Companion provides a modular “flowgraph” visual programming approach to putting together signal processing applications
- GRC visual programming generates Python, and custom processing can be written in Python
- Tutorials help teach filters, modulation, etc.
- Yearly GNU Radio Conference [11]
- Reference [9], [10]



References

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