Wireless Signal Processing Education

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Outline

Motivation
Curriculum
Standalone Educational Kit - HaKi
Next Steps
Problems

- Complex & Abstract
- Proprietary & Expensive
- Simulation-only
- Hardware-based
- Time&Place Restricted
- Lacking Software
Solution

Open System

Modular

Real-world Signals

Professional Development

Mobility/Remote

Software-based
TOBB ELE361L Course

RF Front-End (RFFE)

Student Laptop
Curriculum

Labs based on Jupyter Notebook

- DSP
- SDR
- Python/Matlab
- AM
- NBFM
- WBFM
- Digital
- ADSB
Goals

● Engagement
  ○ Interesting real-world projects
  ○ Building DSP/Programming/Technical skills

● Unique
  ○ Windows/Linux/Mac
  ○ All-in-one: Apps+GNU Radio+JupyterLab
  ○ Matlab/Python
  ○ Remote-ready
# Learning Outcomes: Weeks 1-5

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
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<tbody>
<tr>
<td>Week-1</td>
<td>Introduction to Communication Systems, SDR Fundamentals</td>
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<td>GitHub, GitHub Classroom, Markdown</td>
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<td>Week-2</td>
<td>DSP Fundamentals</td>
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<td>Conda, GNU Radio</td>
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<td>Week-3</td>
<td>Sound card processing, Basic filtering (filter type: HP/LP/BP, cutoff frequencies, taps, transition bandwidth …), Nyquist Theorem, Aliasing</td>
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<td>Git, GNU Radio Companion, GNU Radio flowgraph creation</td>
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<td>Week-4</td>
<td>Sound card processing, Multirate SP, Decimation, Stereo sound and DTMF tone generation</td>
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<td>Git, GNU Radio</td>
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<td>Week-5</td>
<td>FFT, Frequency resolution, Negative frequencies, Nyquist, Ideal LowPass filter</td>
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<td>Jupyter-lab, Matlab/Python</td>
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<td>Week</td>
<td>Learning Outcomes</td>
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<td>Week 6</td>
<td>AM, HF Band, Airband, IQ record types (RTL-SDR, USRP)</td>
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<td>Week 7</td>
<td>NBFM, VHF band, Handheld Radios, FM Repeaters, CTCSS</td>
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<td>Week 8</td>
<td>Wide Band FM Components: Mono/Stereo, Pilot tones, RDS, Subchannels</td>
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<td>Week 9</td>
<td>Digital Signals, QPSK, Constellation, Pulse shaping, Synchronization, Decoding</td>
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<td>Week 10</td>
<td>Digital Comm. Signal (ASD-B), Preamble, Manchester encoding, Thresholding</td>
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Summer 2021, Fall 2022

All students agree that

- “Course engaged me in learning Communication Systems”
- “I learned new tools I can use in future”

GitHub Classroom is liked by 100%

Python is preferred over Matlab
The winner: GNU Radio
Communication Kit Project

- Low-cost
- FOSS
- Ready-to-go, one-place platform
- Programming skills
- Suitable to IoT, DL, DIY projects
Wireless Signal Processing at the Edge

RF Front-End (RFFE)

7-inch Capacitive Touch Display (Optional)

Single Board Computer (SBC)
HaKi GUI
Grants

NVIDIA Academic Hardware Grant

ARDC Education Grant
Next Steps

More modules

Advanced content (graduate study)

Step-up SDRs

GPU acceleration (CUDA/cuSignal)

Useful Deep Learning applications
Thanks

Teach your students
● to doubt,
● to think,
● to communicate,
● to question,
● to make mistakes,
● to learn from their mistakes, and most importantly
● *have fun in their learning*