Introduction

- Superheterodyne receivers can be used to initiate explosive devices
- Potential threats can be detected by locating radio receivers
- Receivers use high-frequency signals in their RF mixers
- These signals escape into the environment as unintended electromagnetic emissions [1, 2]

Unintended Emissions

- Superheterodyne radios use mixers to perform frequency translation [3]
- Mixers have multiple unintended emissions signals
- All signals are either:
  - Local oscillators: locally-generated sinusoids
  - Mixers outputs: a frequency-translated copy of the signal the radio is receiving
- The mixer outputs consist of:
  - \( f_{IF} \): Intermediate frequency
  - \( f_{LO} \): Up-mixing frequency
- Mixer outputs only occur when the radio is receiving a signal

Stimulated Emissions

- The stimulated emissions effect:
  - Mixer outputs (\( f_{LO} \)) contain the original stimulation signal
  - Mixer outputs radiate back into the environment as unintended emissions
- Can use this method to inject a known signal into the \( f_{IF} \) emissions
  - Example: linear frequency modulated (LFM) chirp
  - Works for arbitrary FM signals
  - Known signals are easier to detect than unknown signals

Challenges to Detection

Local Oscillator Duty Cycle

- Two-way radios are designed for intermittent use
- Receiver deactivates its local oscillator (LO) to conserve power
- There are no emissions of any kind when the LO is inactive
- Stimulation improves the duty cycle
  - 20% when unstimulated
  - 60% when stimulated

Emissions’ Frequency Range

- The \( f_{IF} \) frequency depends on
  - The channel the radio is tuned to
  - The radio’s intermediate frequency
- For GMRS radios, this range is about 10 MHz wide

Periodogram Detector

- Passive detector: does not require a stimulation signal
  - First proposed in [4] for detecting television sets
  - Searches for sinusoidal local oscillator emissions
  - Uses periodogram averaging to improve sensitivity
  - The local oscillator duty cycle makes the emissions non-stationary, decreasing the effectiveness of this approach

Matched Filter Detector

- Active detector: uses stimulated emissions
  - Transmits an LFM chirp to the radio receiver
  - Searches for the transmitted chirp with a matched filter [5]
  - Optimal linear filter for detecting a known signal in noise
  - We know what the unintended emissions signal is
- Key advantages:
  - Integration period is not limited by the LO duty cycle
  - Shift-immunity: LFM chirps are resistant to frequency shift

Real-Time Detection of Radio Receivers Using Stimulated Emissions

Colin Stagner, Christopher Osterwise, Daryl Beetner, and Steven Grant
Missouri University of Science and Technology

References


Citation: This material is based upon work supported by the U.S. Army Research Laboratory and the U.S. Army Research Office under Contract W911NF-09-1-0354.