CUTAWAY SECURITY

INFOSEC CONSULTANTS

Detecting Encrypted Radio Communications Using Universal Radio Hacker

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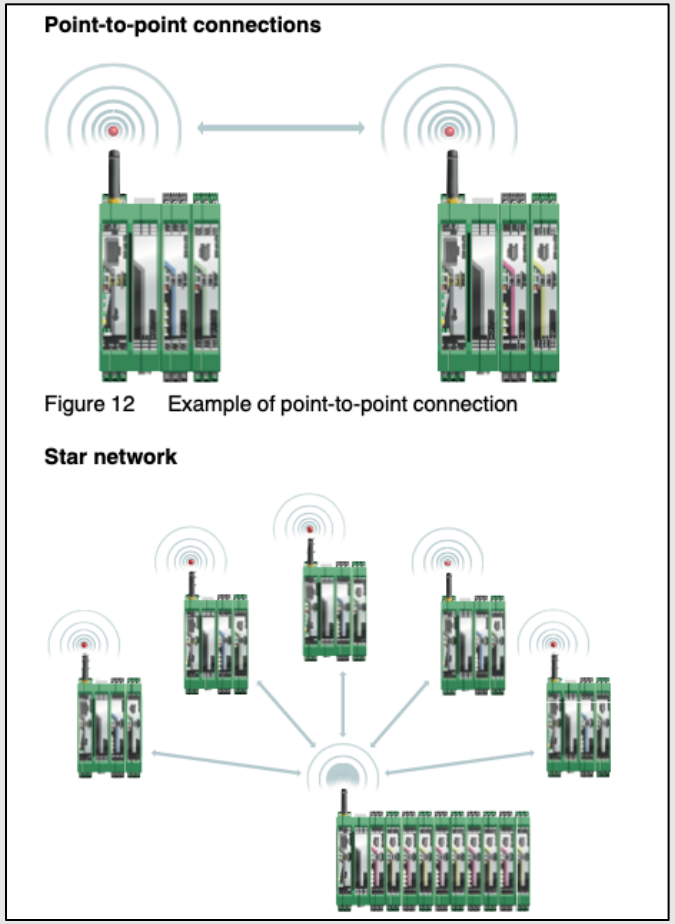
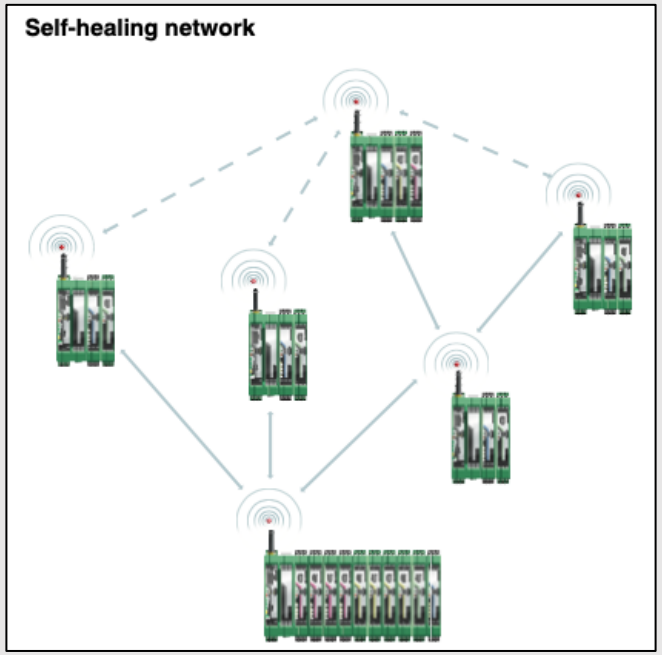
Cutaway Security, LLC / Don C. Weber

- ICS Security Assessments
- Penetration Testing
- Security Research

Why are we here?



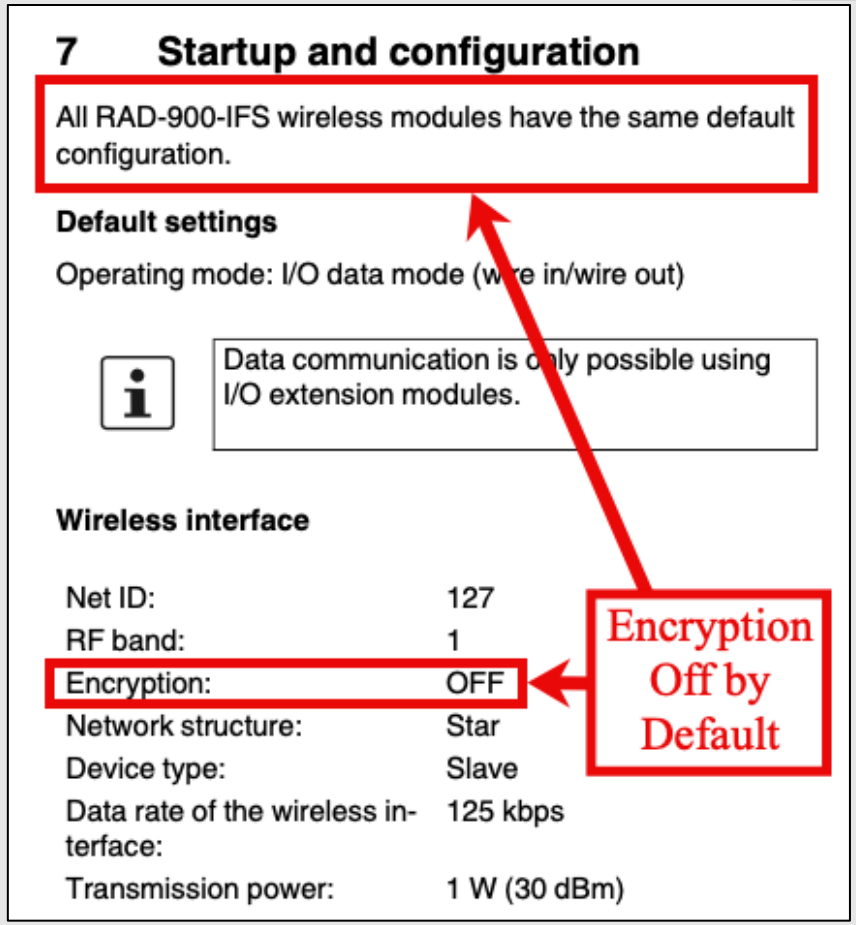
- Radio gateways and end-points provide connectivity where wires cannot be used.
- Radio enabled end-points monitor and control the process.
- Radios will always receive, and attempt to process, any data (malicious or otherwise) sent to it.



Source: Phoenix Contact RAD-900 User Manual
https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=2702877&library=usen&tab=1

Wireless Solutions Provide Encryption

Wireless communication is based on Trusted Wireless 2.0 technology. The high demand for a interference-free data transmission using the license-free 900 MHz band, in particular via the use of the FHSS method (FHSS) and 128-bit data encryption (AES), is fulfilled.



7 Startup and configuration

All RAD-900-IFS wireless modules have the same default configuration.

Default settings

Operating mode: I/O data mode (wire in/wire out)

Data communication is only possible using I/O extension modules.

Wireless interface

Net ID:	127
RF band:	1
Encryption:	OFF
Network structure:	Star
Device type:	Slave
Data rate of the wireless interface:	125 kbps
Transmission power:	1 W (30 dBm)

Source: Phoenix Contact RAD-900 User Manual
https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=2702877&library=usen&tab=1

Three Eternal Truths of Wireless Security + 1

- Denial-of-Service attacks are easier and near impossible to defend against
- Network capture is possible, regardless of frequency or hopping techniques
- Attacker has at least a limited ability to communicate on the wireless network

- "When utilizing industrial wireless for a communication path in a process, ensure the process is designed and engineered to operate safely and reliably without that communication." – Tim Conway, The SANS Institute

Source: SANS ICS410 ICS / SCADA Security Essentials
https://www.sans.org/course/ics-scada-cyber-security-essentials

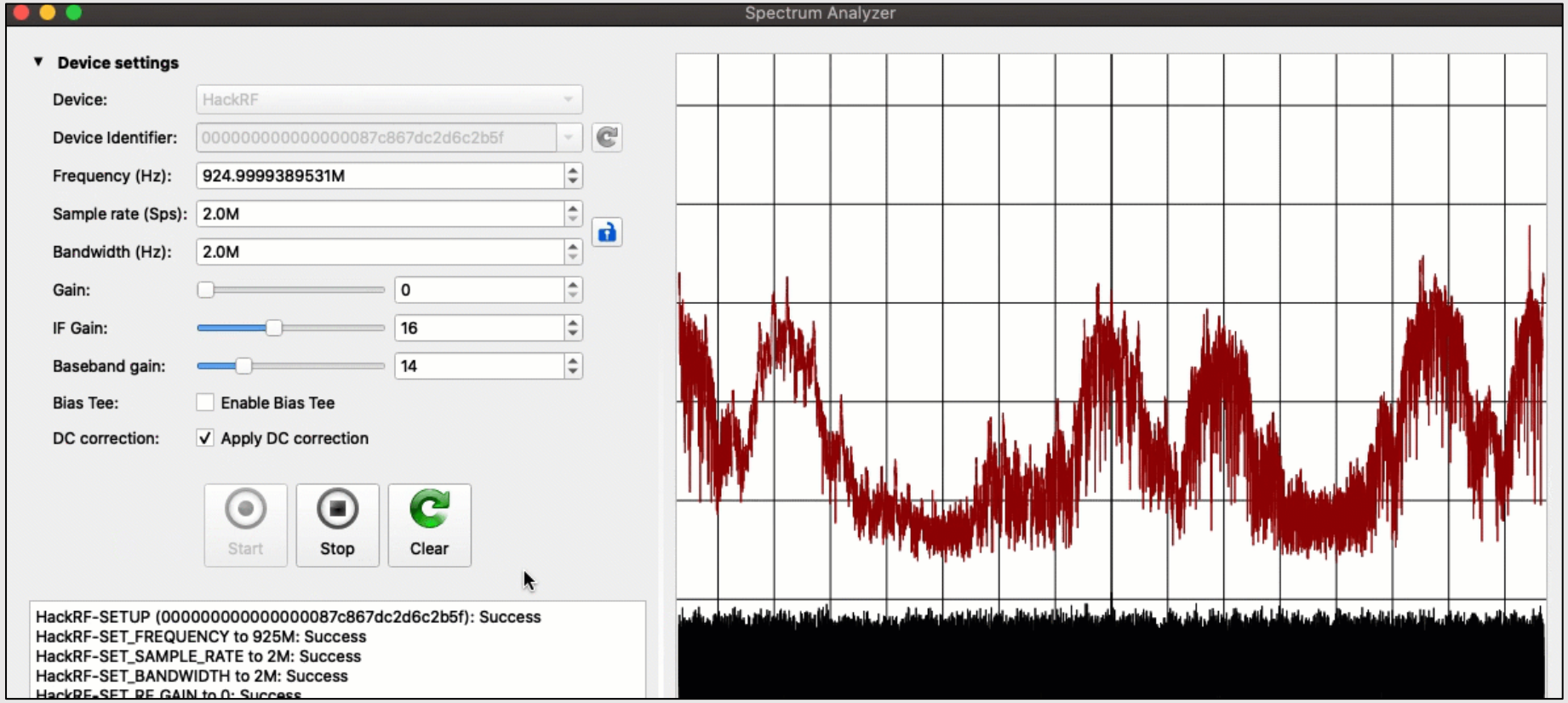
Prepare Equipment

- https://github.com/jopohl/urh
  - `pipenv install ipython, cython, urh, rfcat, pyserial, pyusb, pymodbus, cryptography`

- https://greatscottgadgets.com/hackrf/one

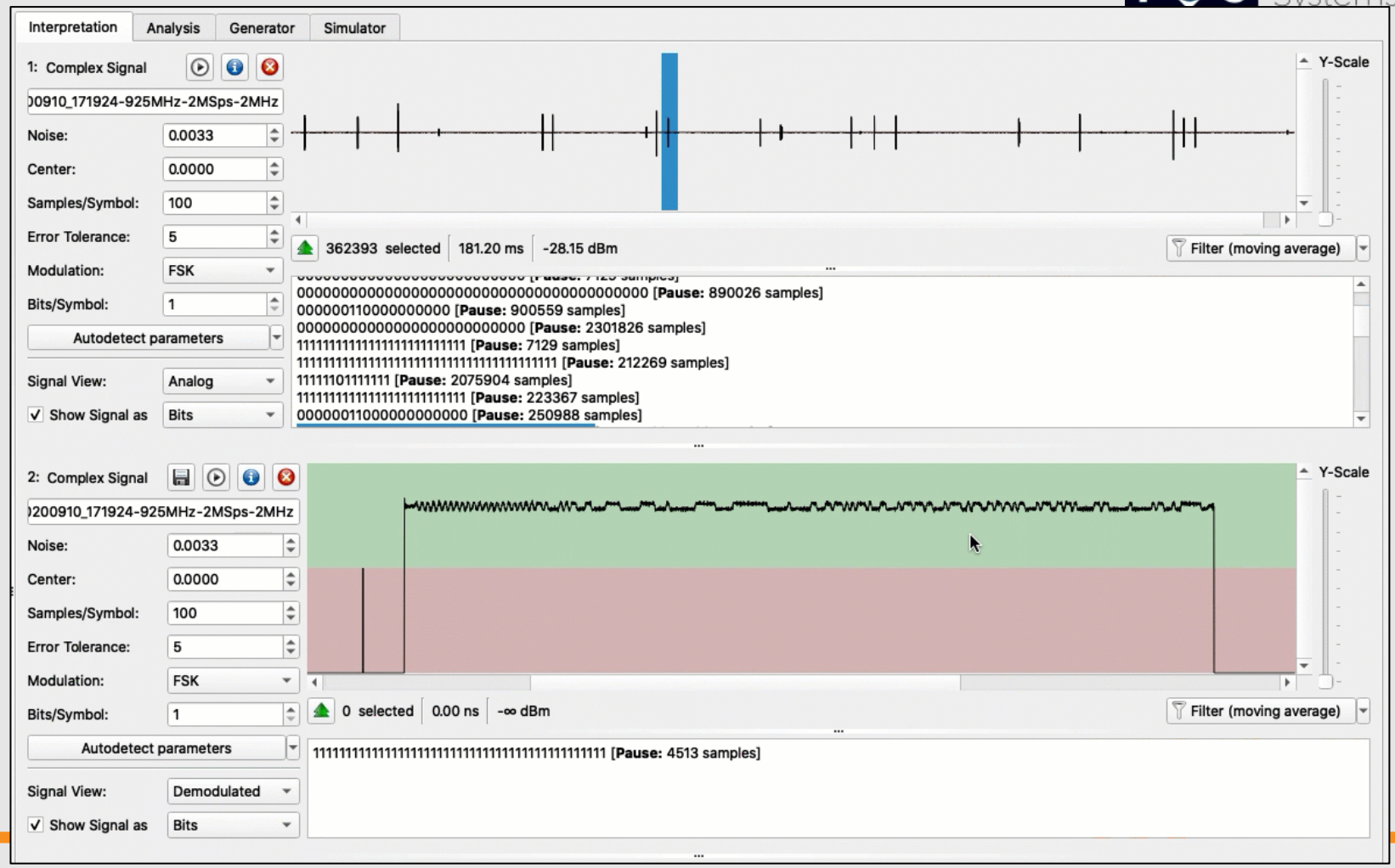
Locate and Record Transmissions

- Select your radio and configure settings.
- Pick a frequency in the 900 MHz range.
- FHSS will hit frequencies over and over. Center on one.



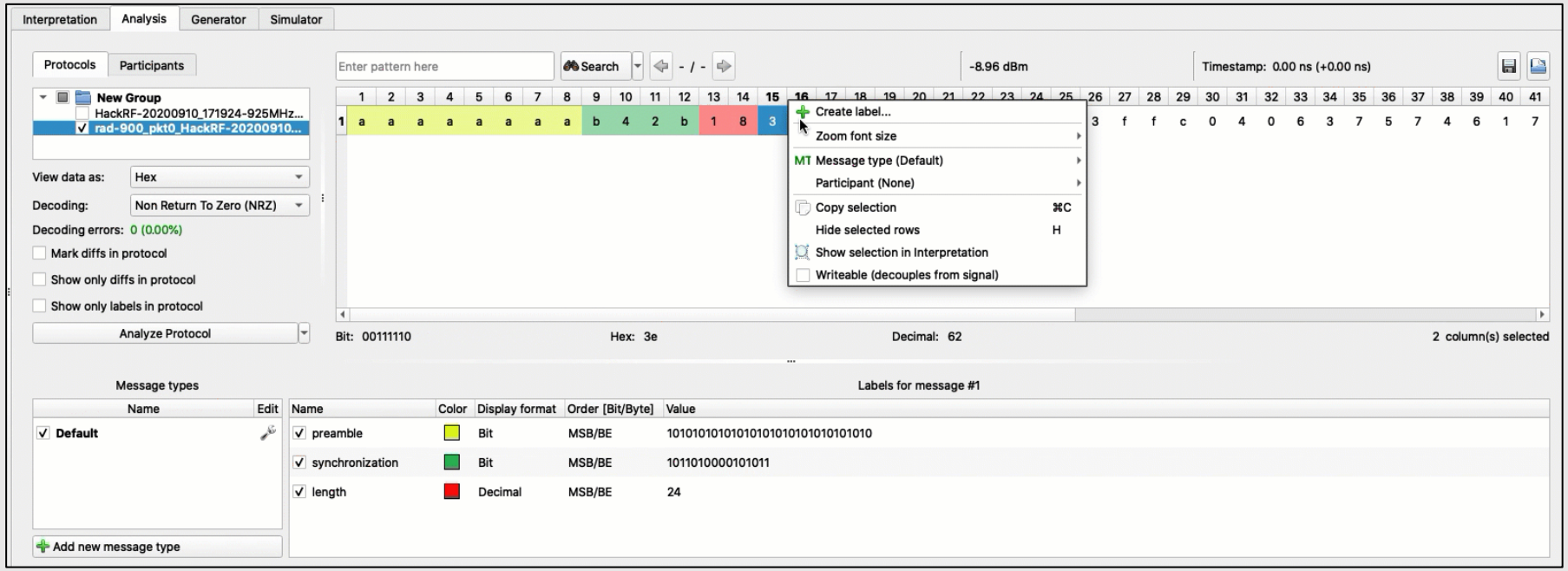
Isolate and Analyze Transmissions

- Select a transmission to analyze.
- Update "Center" setting to analyze transmissions not on center frequency.
- Use waveform patterns to select Samples / Second
- Review demodulated signal for expected patterns.

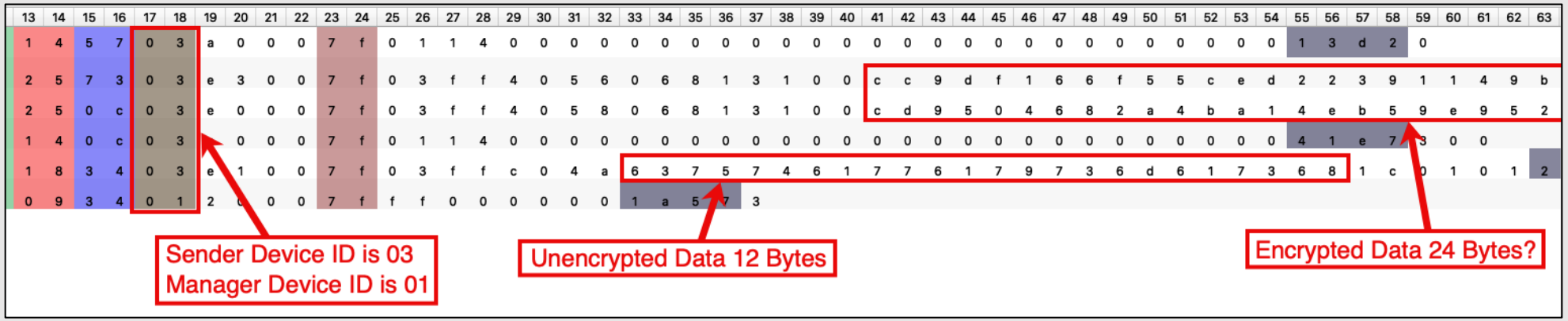


Packet Field Identification

- Use "Analysis" tab to review packet contents.
- Highlight and label packet contents.
- Use these settings to automatically analyze other transmissions.



Analyze Packet Contents



Interesting Encryption Facts

> Wireless communication is based on Trusted Wireless 2.0 technology. The high demand for a interference-free data transmission using the license-free 900 MHz band, in particular via the use of the FHSS method (FHSS) and 128-bit data encryption (AES), is fulfilled.

- RAD-900-IFS datasheet indicates 128-bit data encryption (AES).
- Silicon Labs Si4463 Radio and Si4112 RF Synthesizer datasheets do not describe on-chip encryption or the implementation of AES.
- Texas Instruments MSP430F5438A datasheet does not describe on-chip encryption or the implementation of AES.

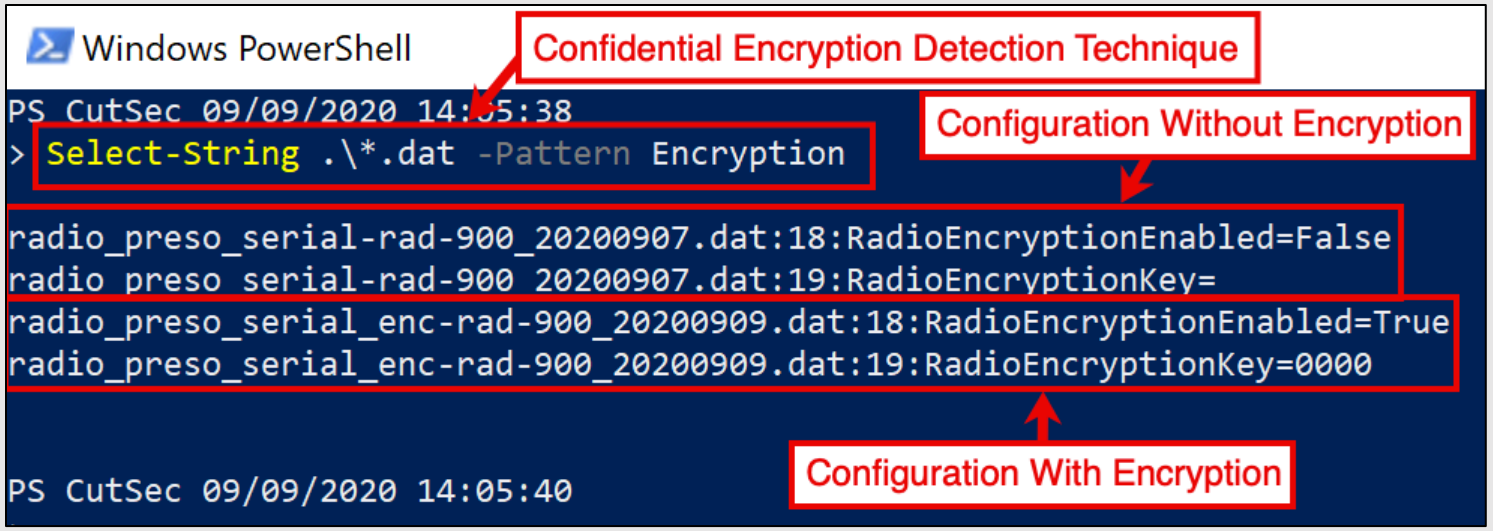
- So many questions:
  - AES uses 16-byte block size and IV should equal block size
    - "cutawaysmash" = 12 bytes
    - Encrypted data = 24 bytes? 16 bytes of data + 8 bytes of IV?
  - Management packets are not encrypted
  - Only data is encrypted, not full packet

Assessment Continued…

- Encryption Analysis
  - Send data with different byte lengths playing with block boundaries.
  - Send same data using different keys and key lengths.
  - Phoenix Contact PSI Conf accepts key lengths of "min. 4, max 16 characters".
- Retransmit packets
  - Properly configure URH to resend captured packets via HackRF
  - Configure Yardstick One to send packet using rfcat
- Determine if radio protocol can be used for Denial-of-Service attacks.
- Redo all testing using Modbus commands to control end-points.

Non-technical Radio Security Assessment

1. Obtain managing radio configuration file. *
2. Grep 'Encryption' **
3. Note results ***
4. ???? ****
5. Profit



* Phoenix Contact RAD-900-IFS, in this example

** You'll be on Windows, so `Select-String .\ -Pattern Encryption`

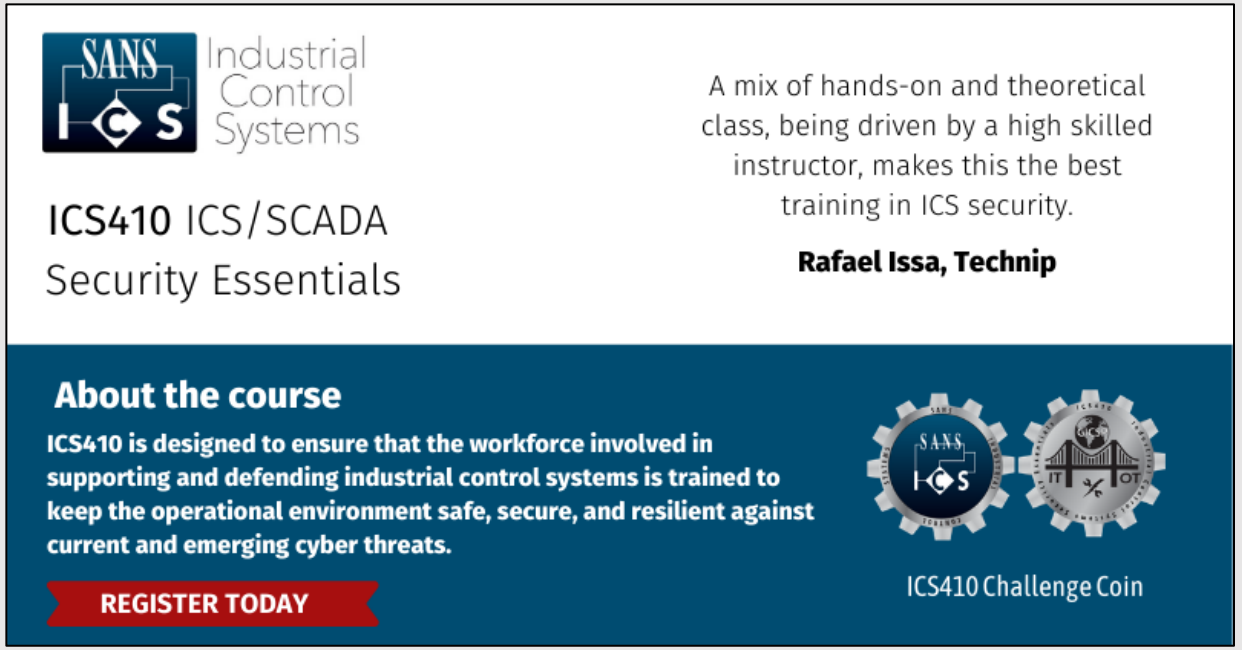
*** Mitigate here, if these are your radios. If not, note "Key" value.

**** ???? is shorthand for Report / Document

Conclusion

- Understand your process and ensure it can operate when the radios cannot communicate.
- Default settings are not encrypted and can be intercepted and analyzed.
- Test to verify requirements after implementation and maintenance.
- Support research into toolsets that help conduct assessments to ensure proper implementation.

Special Thanks



iMovie: Analyzing Radio Transmissions Using URH

https://www.cutawaysecurity.com/wp-content/uploads/2020/09/CutSec_WWHF_URH_HowTo2.mp4

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