Noise in Home Networks

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Introduction and Agenda

- Overview of U-Verse Home Network Architecture
- Grounding and Bonding
- Types of Home Networks
  - HomePlug
  - HPNA Coax
  - CAT3 and CAT5
  - HPNA CAT3
  - POF
- Types of Noise in Home Networks
  - Static
  - Impulse
- Noise Detection and Mitigation
  - Treadmill Interference
  - AM Radio Noise
  - WiFi Interference
  - CFL Interference
  - Rogue TV Interference
- Summary
Home Network Architecture

Unstructured Wiring
Home Network Architecture

Structured Wiring

[Diagram showing structured wiring in a home with labels for Home Office, Bedroom 1, Bedroom 2, Living Room, Wiring Closet, and connections for VDSL, NID, Cat-5 Jack, Coax Jack, and 4-way coax splitter in the wiring closet.]
Types of Noise in Home Network

Static and Impulse Noise

• Narrowband Impulse
  • Radiated and Conducted
  • Vacuum Cleaners, Pool pumps, hairdryers, Washing machines, Treadmills, Transformers

• Wideband Steady state
  • Radiated and Conducted
  • AM Radio Noise
  • Rogue TV
  • HAM radio
  • Unlicensed Radio Frequency
Noise Detection and Mitigation

- Radio Frequency Interference Hunting tools
  - RF Sniffers (Radar Engineers)
  - Tektronix RF Hawk Wideband Low Noise Spectrum Analyzers
  - Andrew, Pacific Wireless Wideband Antennas
    - YAGI
    - Omin Directional Mag Mounts
  - Software Defined Radio (SDR)
    - Flex Radio
  - Ground Resistance Testers
  - VOM
  - HPNA Noise test software
  - Air Magnet WiFi Analyzer
  - HomePlug Adapters for Noise Detection
  - Tektronix AC-DC Power Clamp-on Probes
Bonding and Grounding in Homes

- Electrical Service Drop Cable
- Satellite Dish
- Min #14 AWG Ground Wire
- Universal Ground Rod Clamp
- Driven Ground Rod not less than 25 Ohms
- Steel Conduit to be bonded to ground Wire
- #6 AWG ground Wire
- Min #14 AWG Ground Wire
- Universal Ground Rod Clamp
- Water Meter
- Metallic Water Pipe
- Underground metallic Water pipe not be solely used for grounding as per NEC. To be used along with other ground electrode
Treadmill Noise Test Setup

Figure 1: Noise Measurement Test Setup at U-verse Customer home
Noise Spectral Captures

Figure 2: Radiated RFI with Treadmill ON

Figure 3: RFI Detected on the Audio Cable from Treadmill

*Spectrum Analyzer capture radiated noise to 30 MHz when treadmill was turned-on and RFI measured on the Audio cable of the Treadmill
Noise Spectral Captures

Figure 4: RFI Detected on the Power Cable from Treadmill

Figure 5: RFI Detected after Belkin Surge Noise suppressor from Treadmill

*Spectrum Analyzer capture radiated noise to 30 MHz when treadmill was turned-on and RFI measured on the Audio cable of the Treadmill
Noise Spectral Captures on HPNA Coax

Figure 6: Treadmill Noise on Coax-Treadmill Off

Figure 7: Treadmill Noise on Coax-Treadmill ON

*Noise measured on HPNA Cox band using Noise test
Treadmill Noise Pickup on IW

Figure 8: Treadmill Noise on Twisted Pair

*Spectrum Analyzer capture radiated noise to 12 MHz when treadmill was turned-on and RFI measured on the Cat3 IW
Rogue TV Noise

Figure 9-10: Rogue TV Radiated and Conducted Noise
Noise Pickup by Different Media

Figure 11: Treadmill Noise on Coax-Treadmill ON
AM Noise on IW

Figure 12: AM Radio Noise on IW
Treadmill and Coax Interference

Figure 13: TV and Treadmill Setup

Figure 14: TV and Coax connection to STB
Location of Power and Coax Cable

Figure 15: Location of Single Shield RG6 next to the Power Cable
Single and Quad Shield Coax

Figure 16: Quad Shield RG6 Coax Cable

Figure 17: Single Shield RG6 Coax Cable
WiFi Interference

Figure 18: WiFi Interference Home
WiFi Spectral Captures

Figure 19: WiFi Camera Transmitting in 2.443GHz Band

Figure 20: WiFi Camera Transmitting in 2.432GHz Band
WiFi Spectral Captures

Figure 21: WiFi Camera Transmitting in 2.414GHz Band

Figure 22: WiFi Camera Transmitting in 2.450 GHz Band
YAGI Antenna Setup

Figure 23: Omi and Directional WiFi Antenna Mounted on a Telescopic pole
### Channel Summary

<table>
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<tr>
<th>BSSID Channel</th>
<th>Center Frequency (MHz)</th>
<th>BSSID Present?</th>
<th>Duty Cycle (%)</th>
<th>Avg Power (dBm)</th>
<th>Max Power (dBm)</th>
<th>Interfered Present</th>
<th>Max Transmit Power (dBm)</th>
<th>Interfered Duty Cycle (%)</th>
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### Interferers

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<th>Start Time</th>
<th>End Time</th>
<th>Interferer</th>
<th>BSSID/ESS</th>
<th>Channel</th>
<th>Duration</th>
<th>Bandwidth</th>
<th>Avg Power</th>
<th>Channels Affected</th>
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<td>8:03:32</td>
<td>8:03:35</td>
<td>DCTC2 Slave Station</td>
<td>0.136 sec</td>
<td>2454.39 MHz</td>
<td>0.4 MHz</td>
<td>79 dB</td>
<td>1-4-6-13</td>
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Figure 24: Air Magnet Laptop analyzer Channel Interference Summary
Air Magnet Analyzer

Figure 25: Air Magnet Laptop Spectrum Analyzer 2.4GHz-2.5GHz
Plastic Optical Fiber (POF)

Size Comparison, POF, CAT5 and Coax

POF Optical Switch

POF Cutting tool

Note: Back panel labeling not updated. RJ45 on top of POF connector built by hand for sample units [not representative of final look and feel].
Summary and Next Steps

• Currently, all home networks have limitations to RFI and loss of customer service, many cases the offending source will have to be removed and alternative mitigation methods are not effective

• Noise in home networks continues to be a problem as new electronic homes devices are coming on line and RFI detection is a problem

• Built in noise suppression and compliance to FCC radiated emission requirements are not followed in many instances

• Stricter adherence to FCC mandated RFI emission will need to be enforced

• Improve WiFi, HomePlug and HPNA Noise detection and mitigation techniques