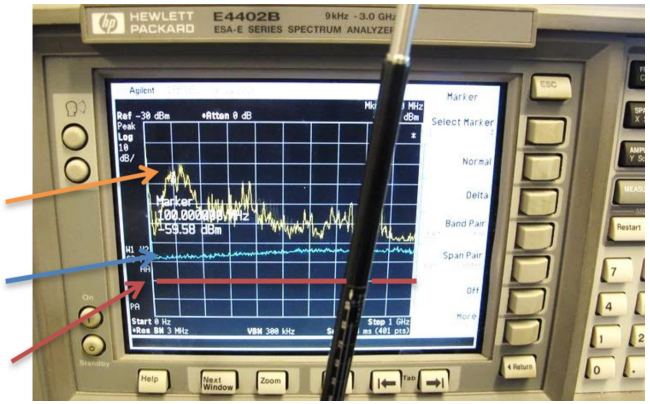
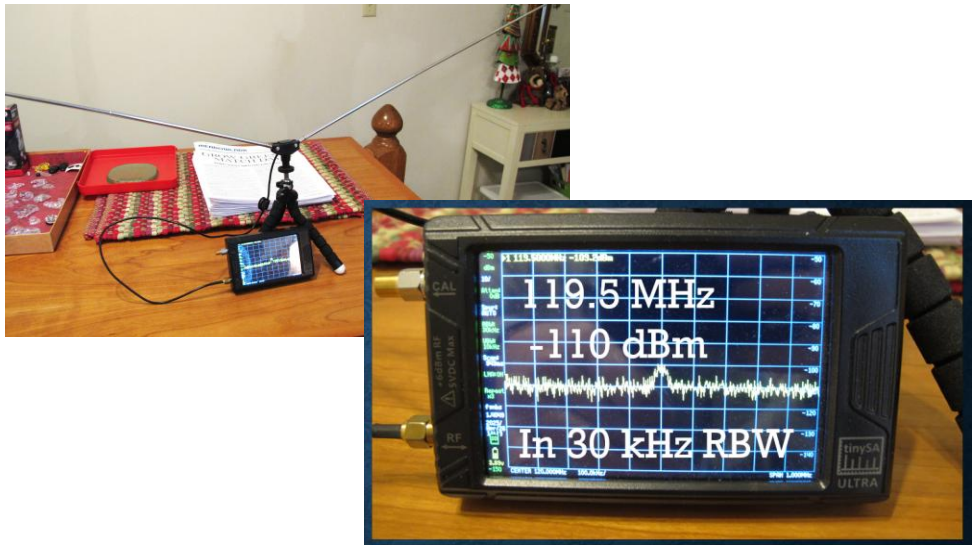
Radio Design 401, Episode 3 – RFI Noise in Buildings

Slides downloaded from: https://ecefiles.org/
Companion videos at: https://www.youtube.com/playlist?list=PL9Ox3wpnB0krNexW2k5JMCaewXN7LoRXd

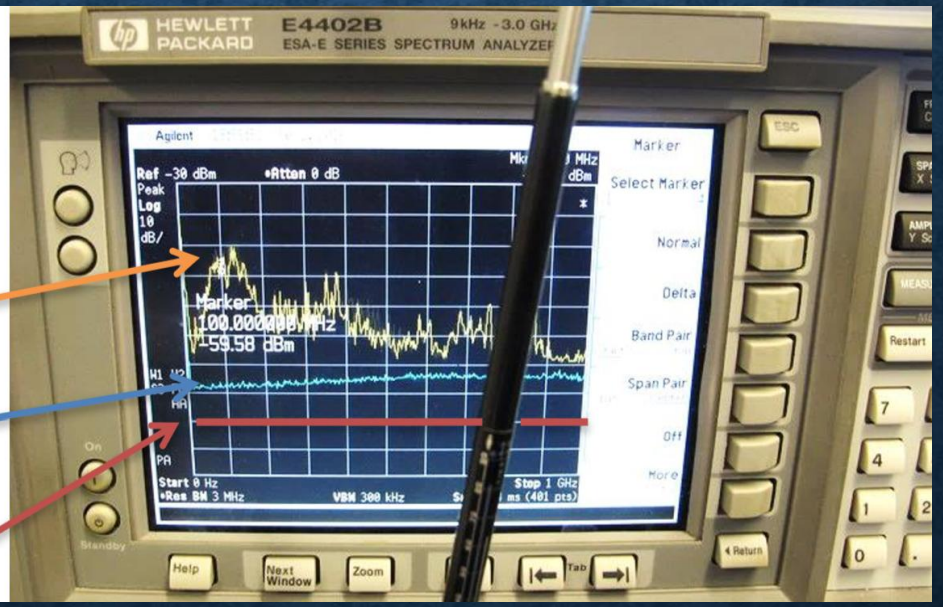
This episode examines radio frequency interference in commercial and residential buildings. We concentrate on RFI at VHF and UHF frequencies, but the theory is general and many examples are shown in detail. At the end, we consider the full set of issues that limit a radio receiver's ability to receive weak signal, including Thermal noise, RFI, and intermodulation, and discuss the value of Q-enhanced front-end amplifiers / filters to help address these issues.

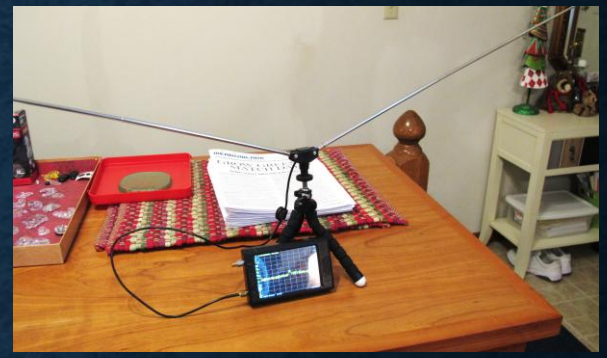


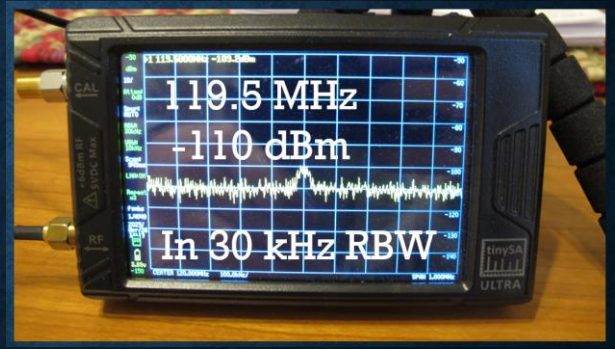


Radio Design 401

Episode 3







RFI Noise in Buildings

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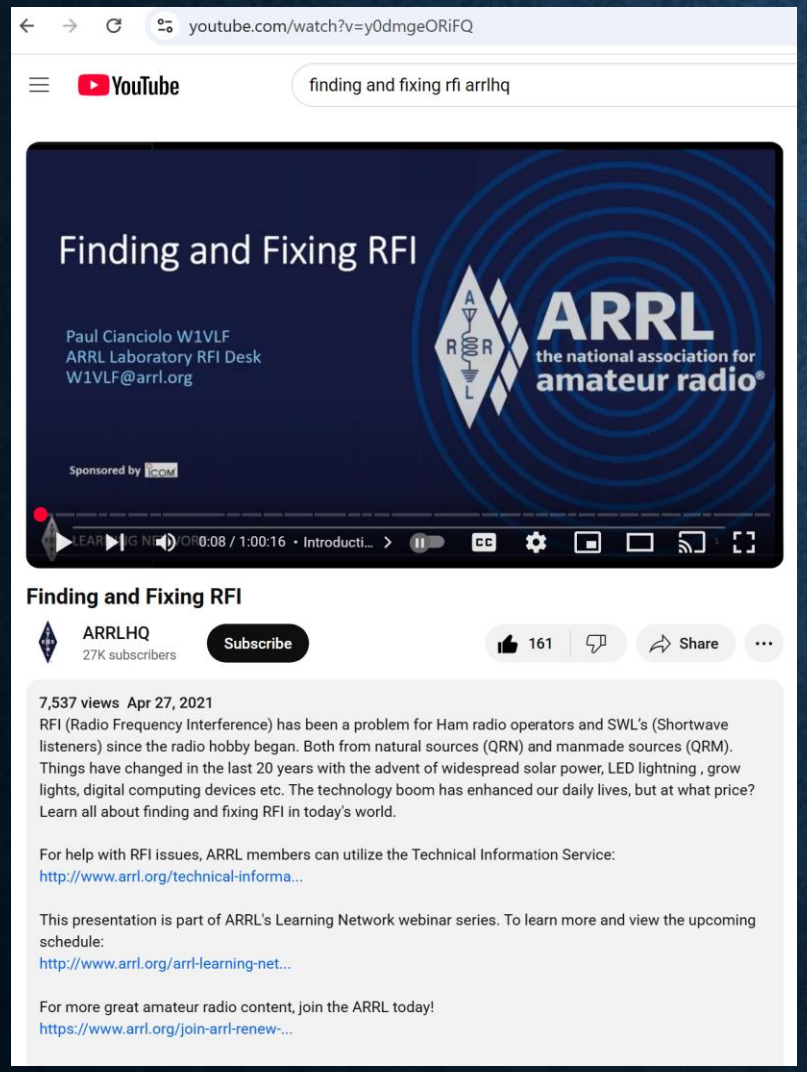
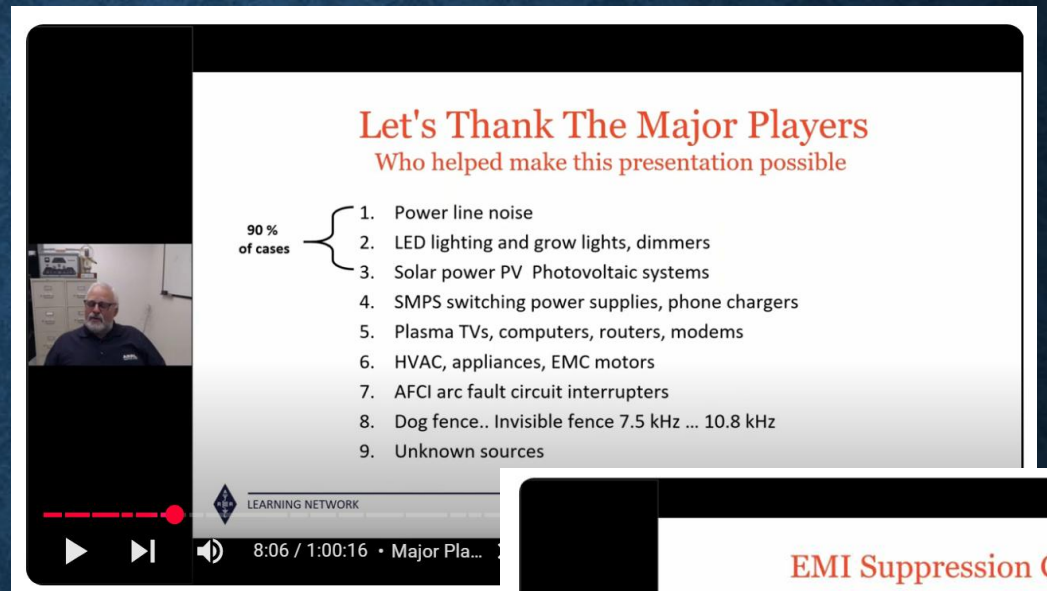
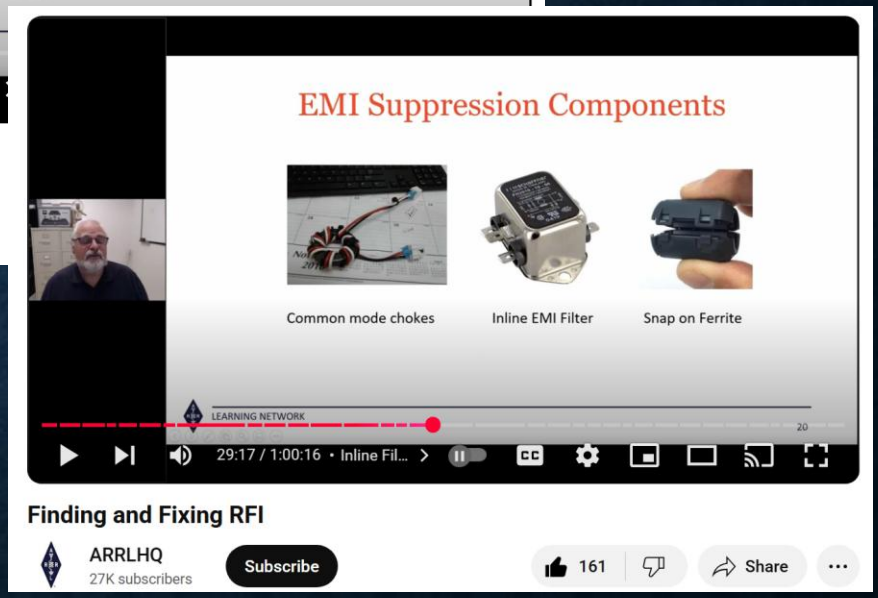
An Excellent Video from ARRL







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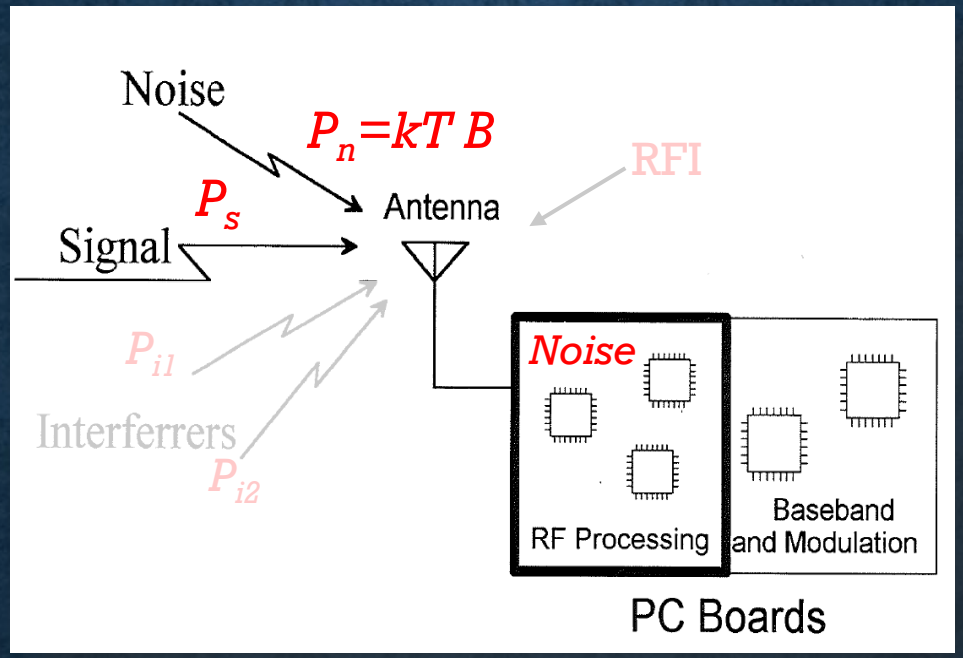
Receiver Sensitivity *Without* RFI

From Episode 2



$$P_{s\_min} = -174\ dBm + 10\log(B) + S/N_{min} + NF_{rcvr}$$

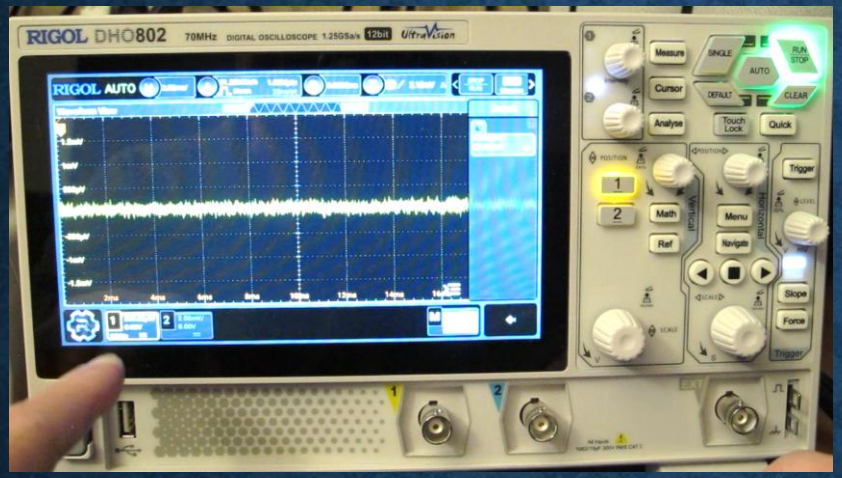
Caveats: Assumes $T \approx 290K$ no RFI, and High Dynamic Range receiver (no receiver intermod issues)

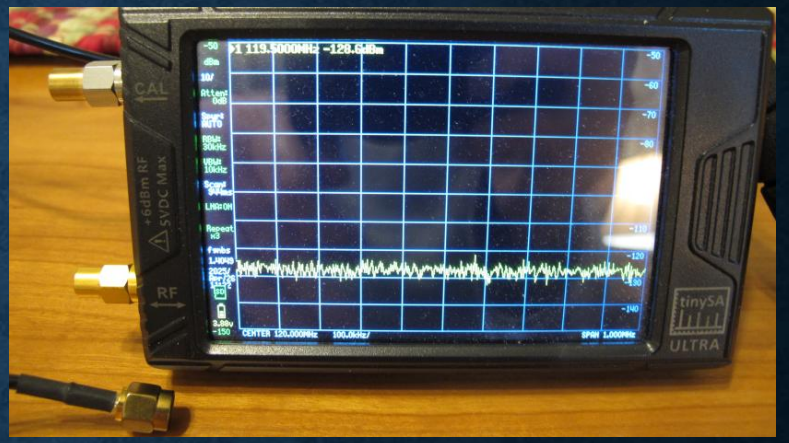
Noise vs RFI

Time Domain

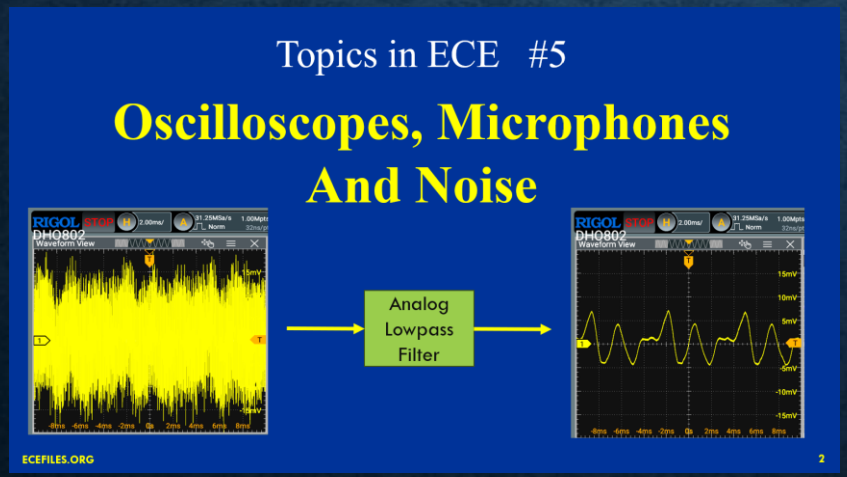
Frequency Domain

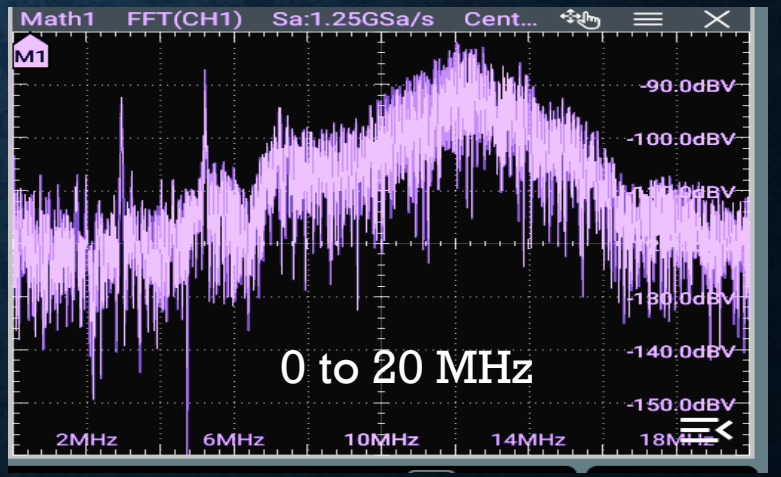
Additive White Gaussian Noise (AWGN)





Radio Frequency Interference (RFI) "Noise"





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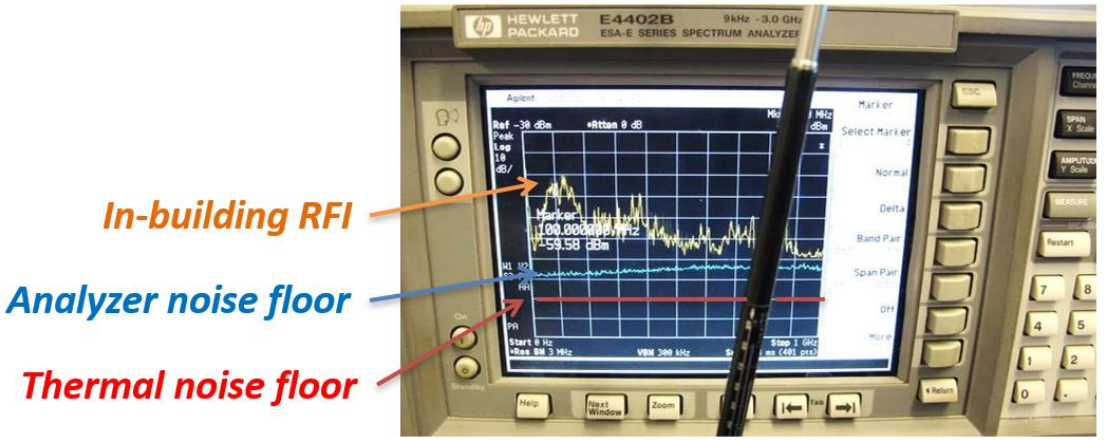
RFI and Attenuation in Buildings

See: "Wireless communication problems in energy-efficient building construction," IEEE International Symposium on Electromagnetic Compatibility (EMC), 2016

- The problem is two-fold:
  - ***Energy efficient exterior glass attenuates signals entering (or leaving) the building***
  - ***Interior lights produce high levels of RFI***
- Glass was measured and found to attenuate by up to 30 dB
- RFI from interior lighting is up to 60 dB or more above thermal noise floor
- ***Wireless communication links (especially at VHF) can be strongly impacted***



Outdoor vs Indoor Spectrums

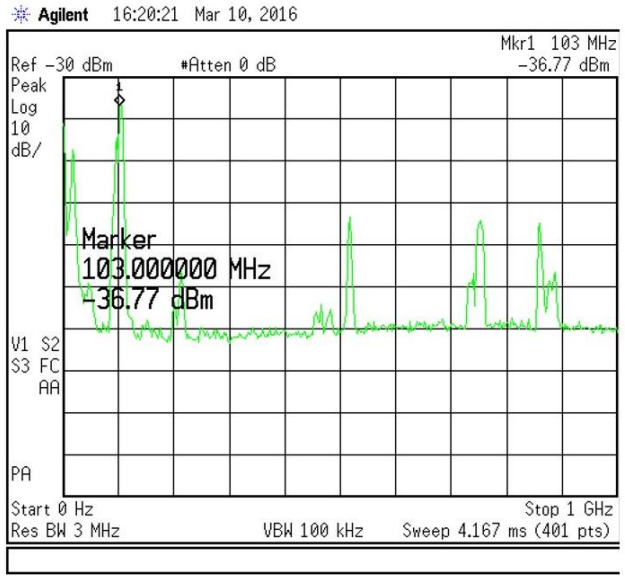
See: "Wireless communication problems in energy-efficient building construction," IEEE International Symposium on Electromagnetic Compatibility (EMC), 2016

25 - 29 July 2016 Ottawa, Canada

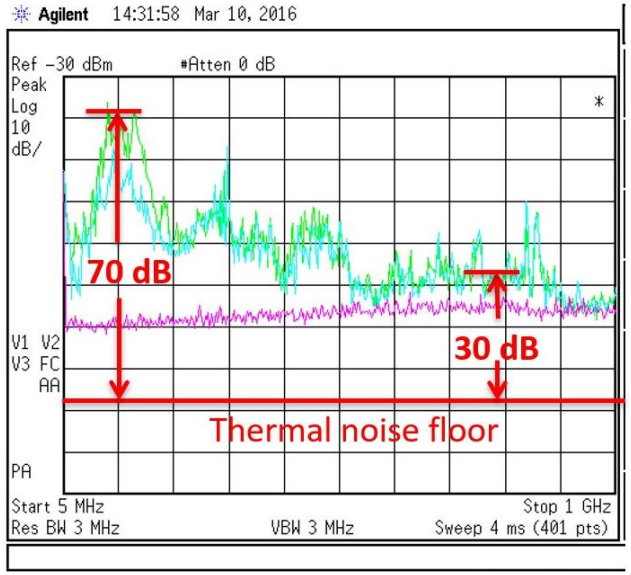
0 to 1 GHz Spectrums

- RFI is most concentrated from about 50 MHz to 500 MHz
- Still quite strong at 800 MHz and above
- ***Indoor*** RFI is above noise floor by 30 dB in lower cell-bands
- Cellphone tests indicated 20 to 30 dB attenuation as well
- **Combined hit is 50+ dB**
- **Worse in VHF band (up to 90 dB total !)**

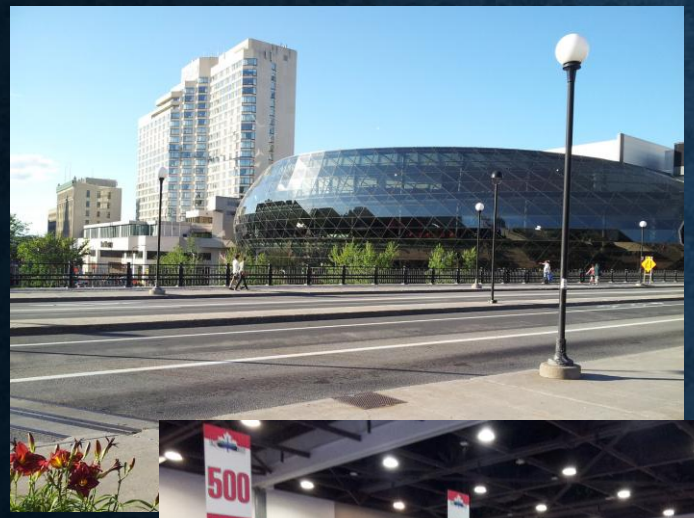
Outside building



Inside building



IEEE EMC Conference
2016 Ottawa Canada



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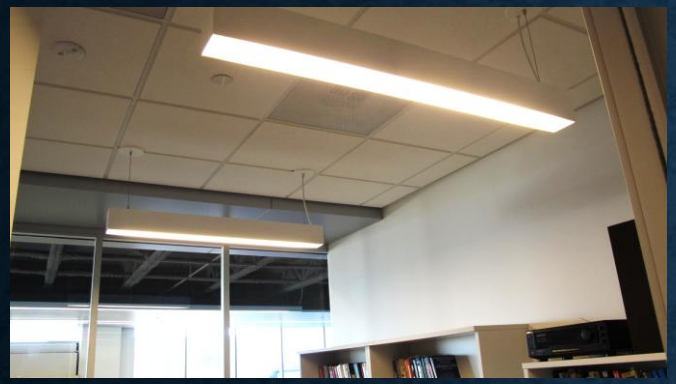
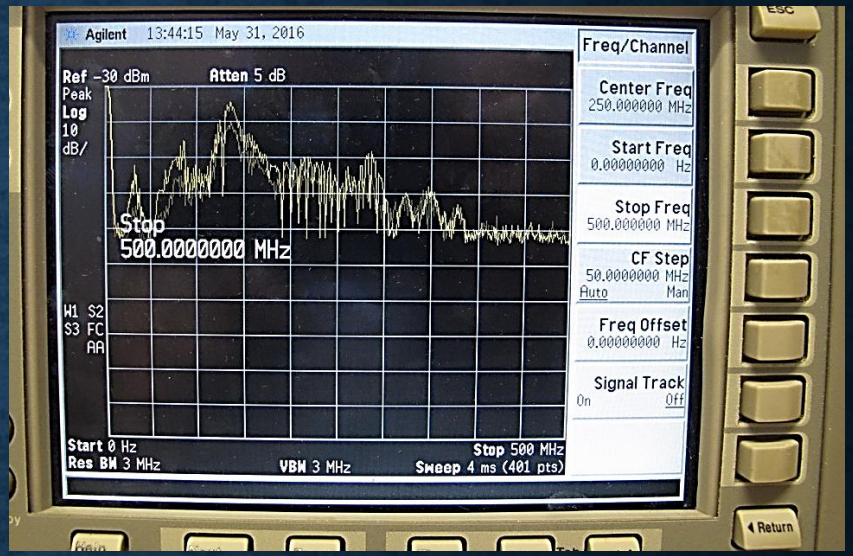
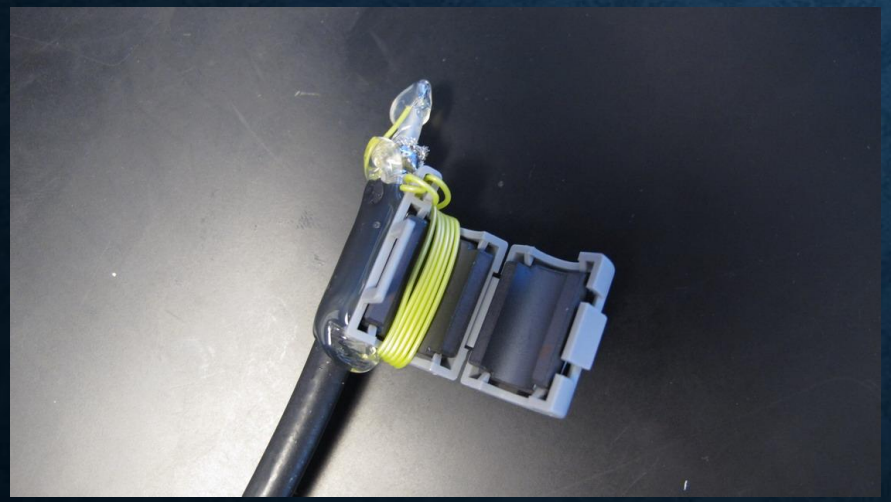
Tracking Down the “Noise”







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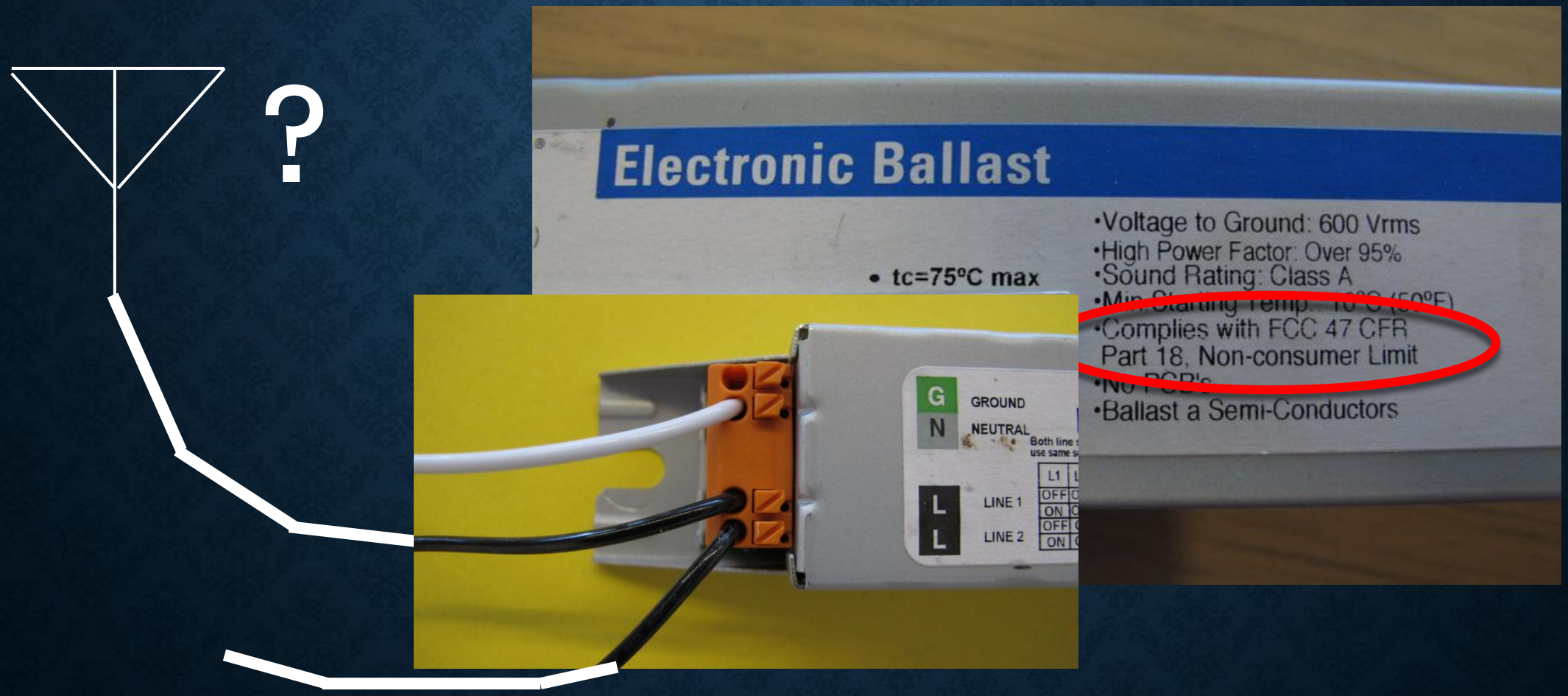
Building Wiring is Antenna



Time Domain Observations

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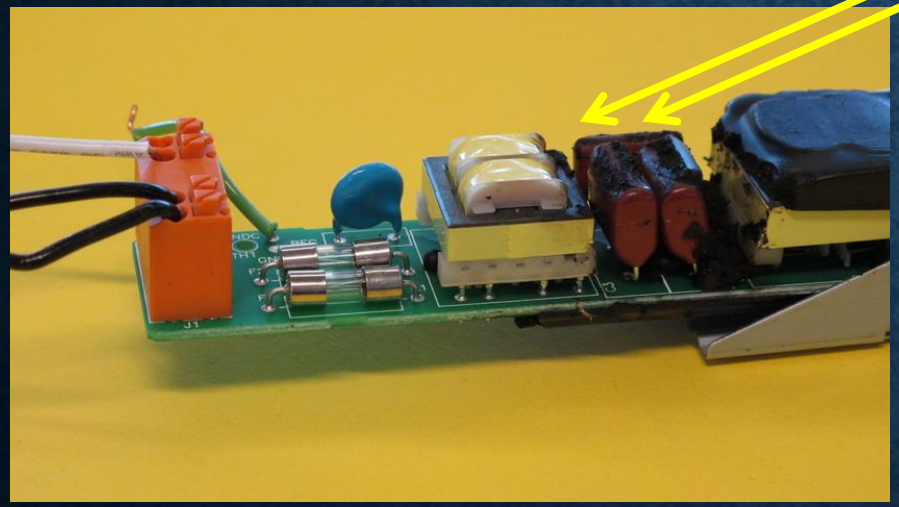
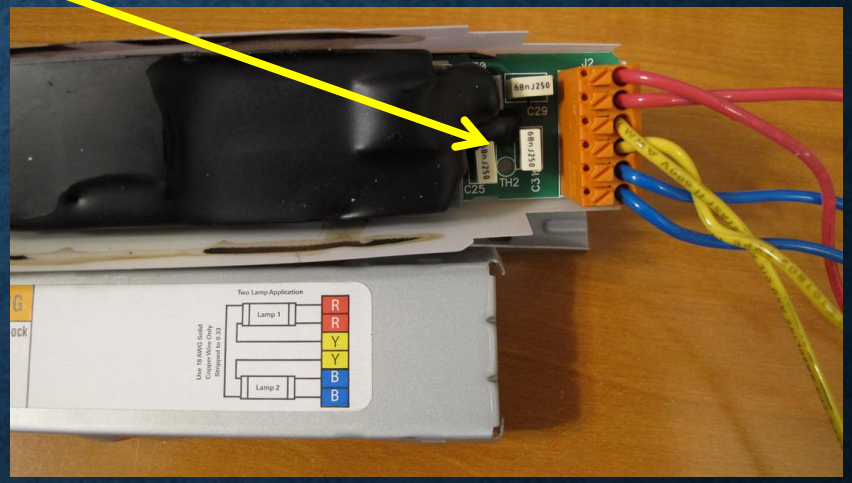
Theories and Solutions

At 100 MHz and above, these capacitors are inductors, not capacitors, and common-mode choke is an AC coupling cap !

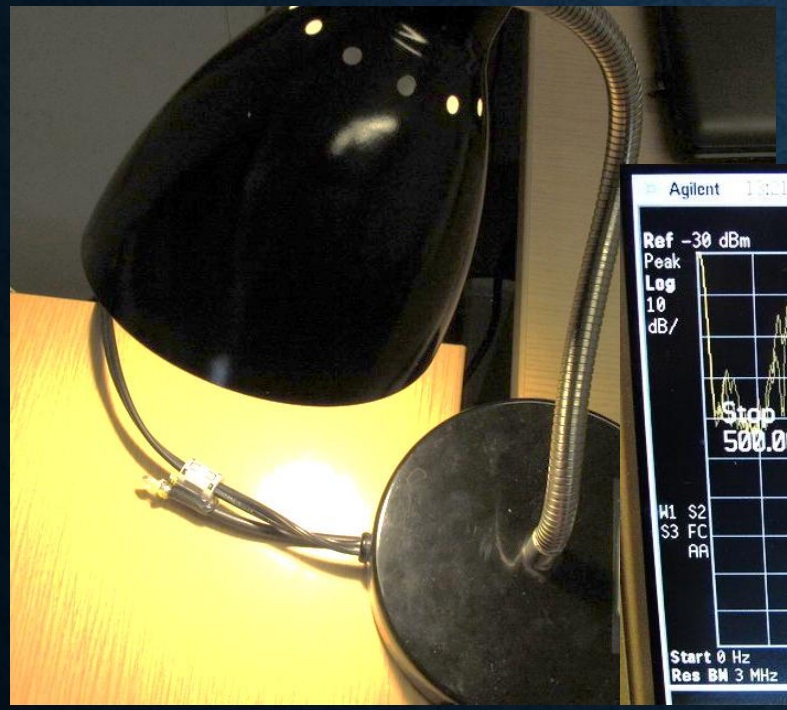


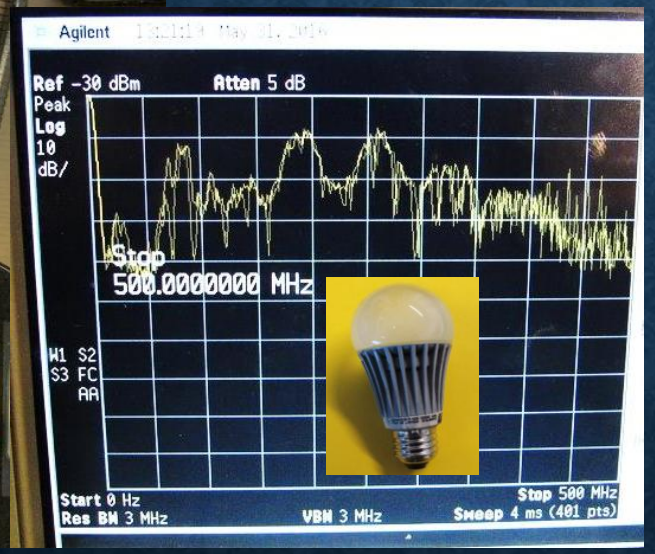


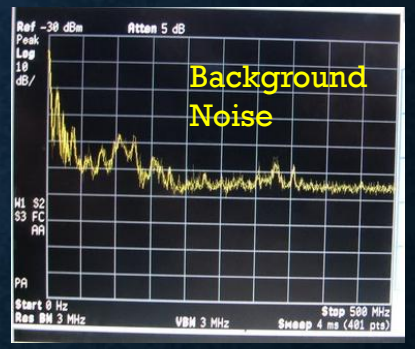
Products need better diff-mode and common-mode filtering.
(Tradeoffs with cost, but still …)

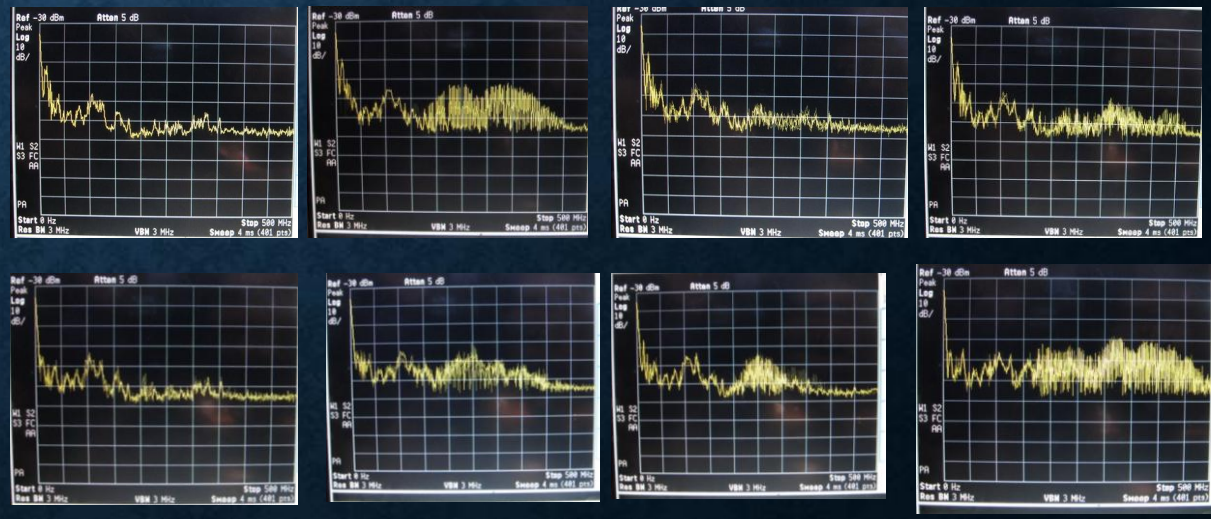
Regular Bulbs (2015)

Some 60W A19-base LED bulbs may be similar or worse in conducted emissions ! (2015 Vintage bulbs shown)









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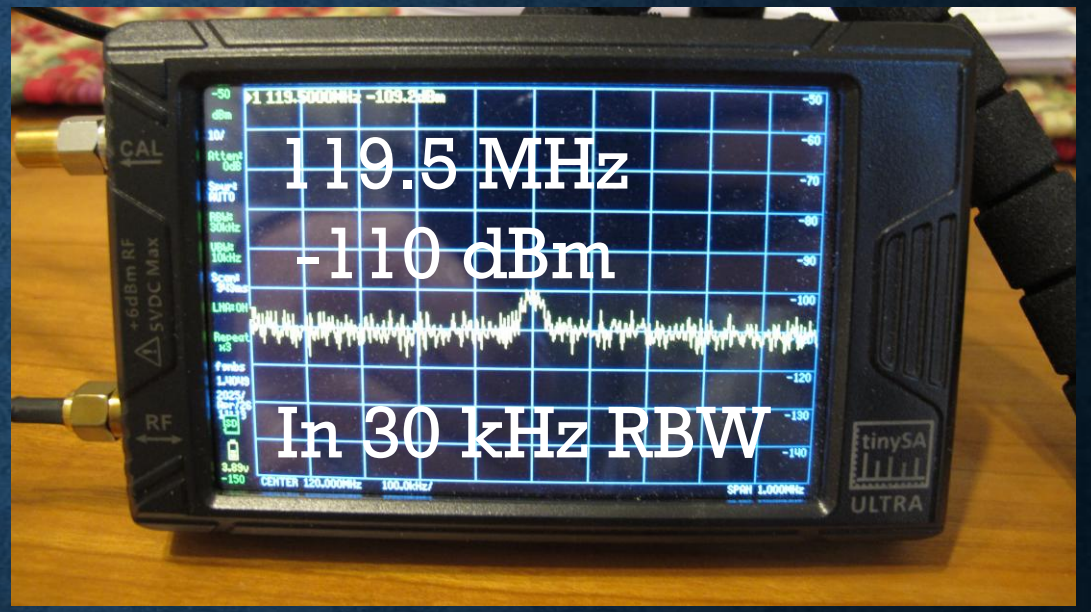
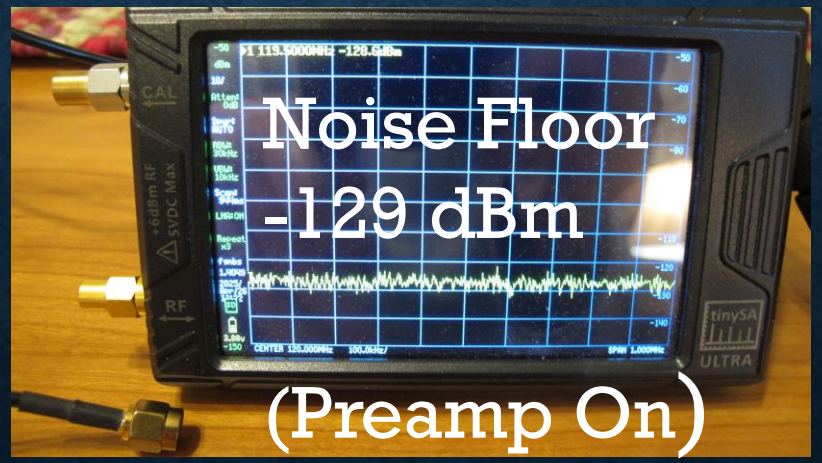
Residential “Noise” Levels





TinySA-Ultra Noise Figure is about 3 dB with Preamp ON

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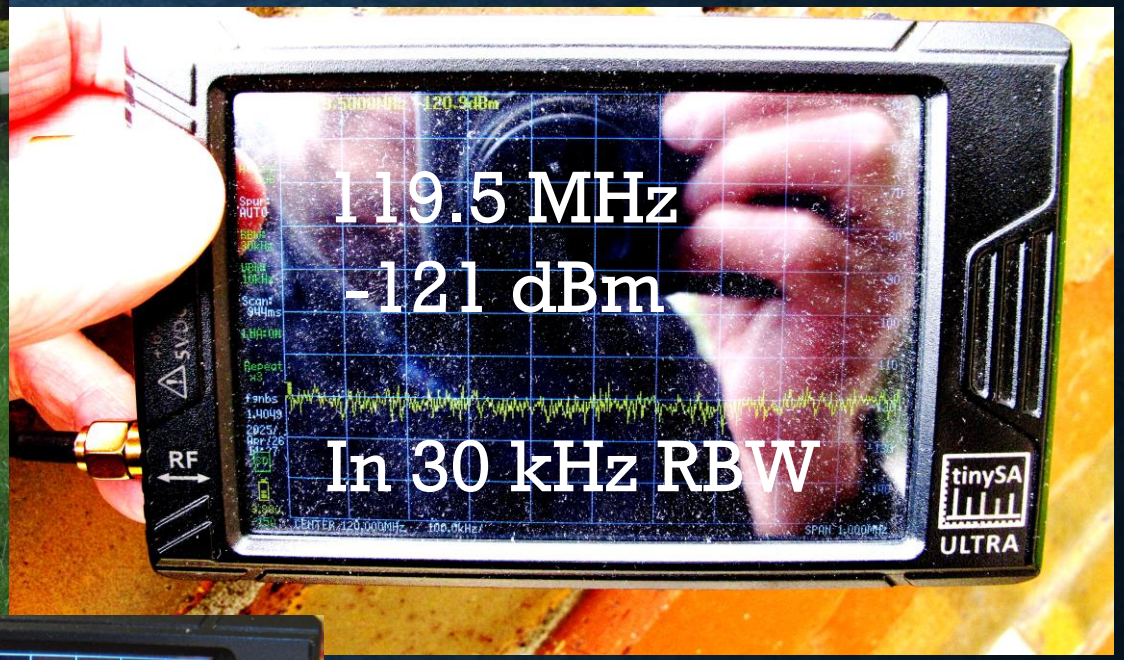
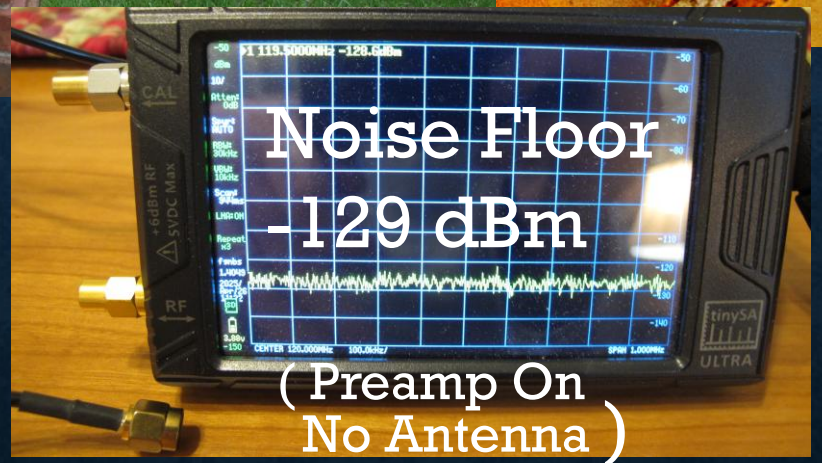
Residential “Noise” Levels





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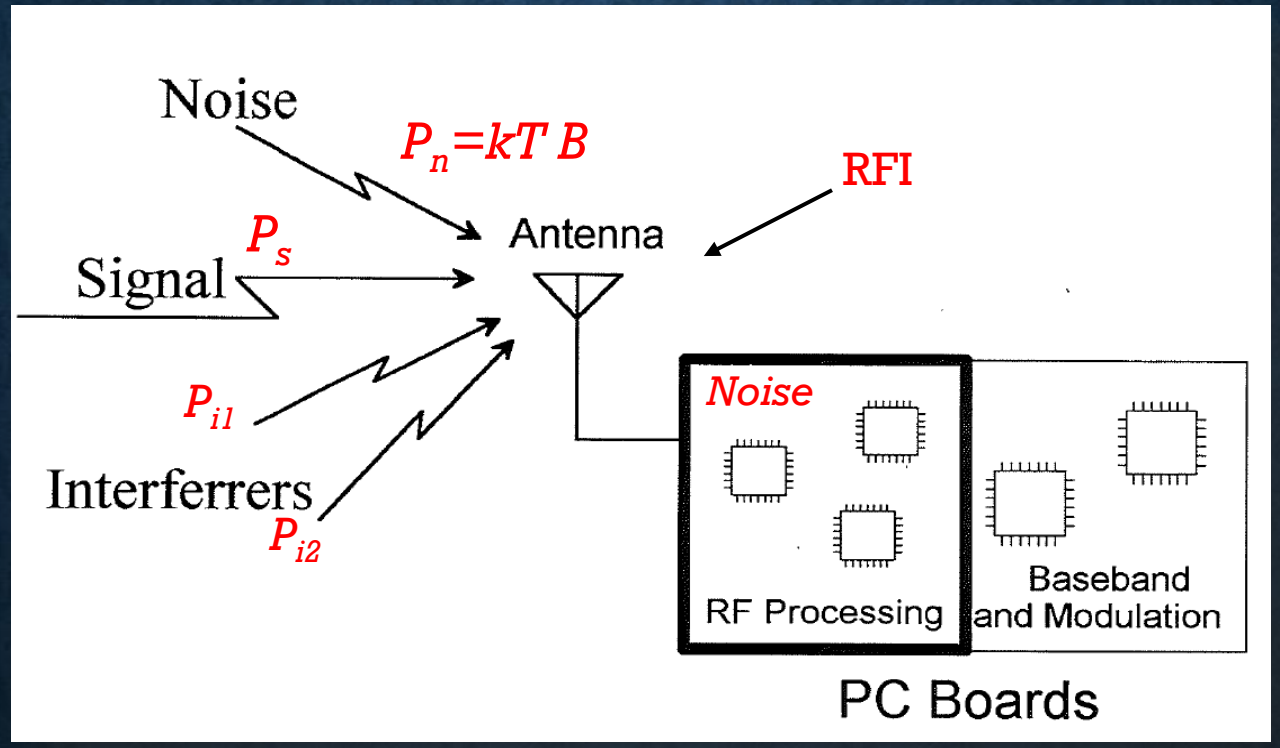
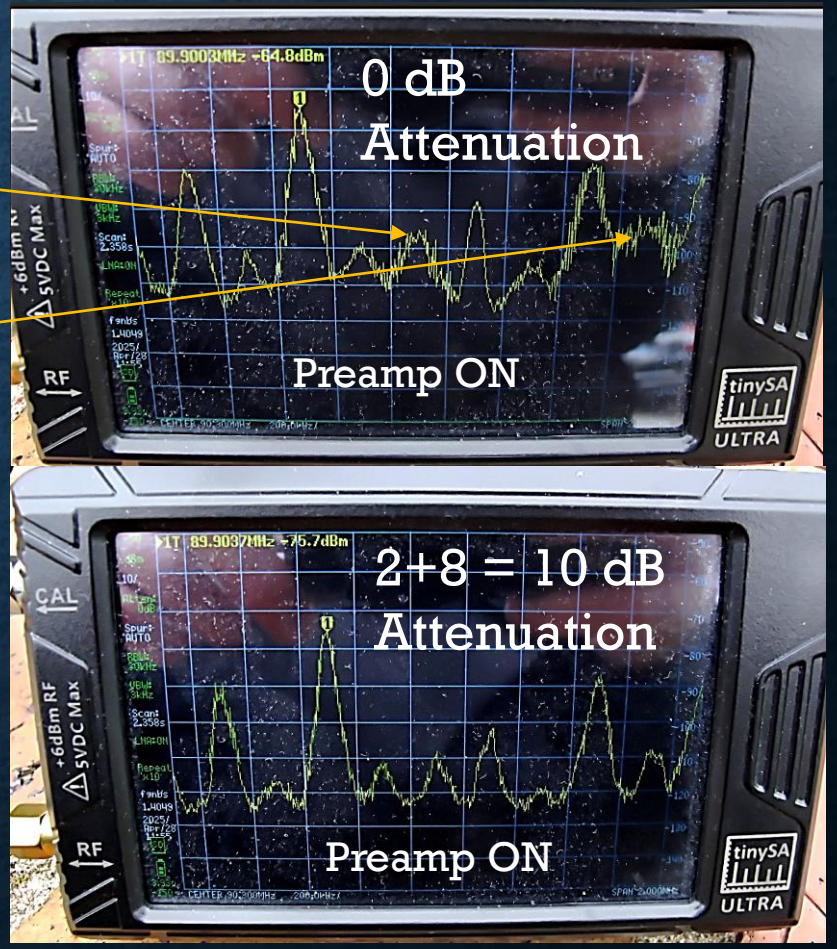
Limits to Receiver Sensitivity



Residential Reception
Noise + RFI + Intermods

Intermod
Corrupted
Stations



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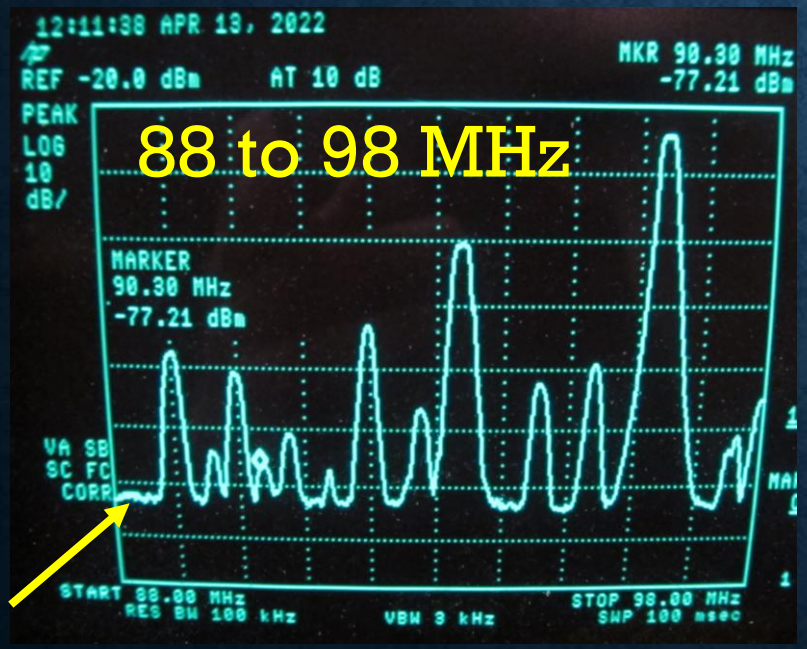
From Radio Design 401 - Episode 1

RD101 Radio Out-performed all 3 Commercial Ones !

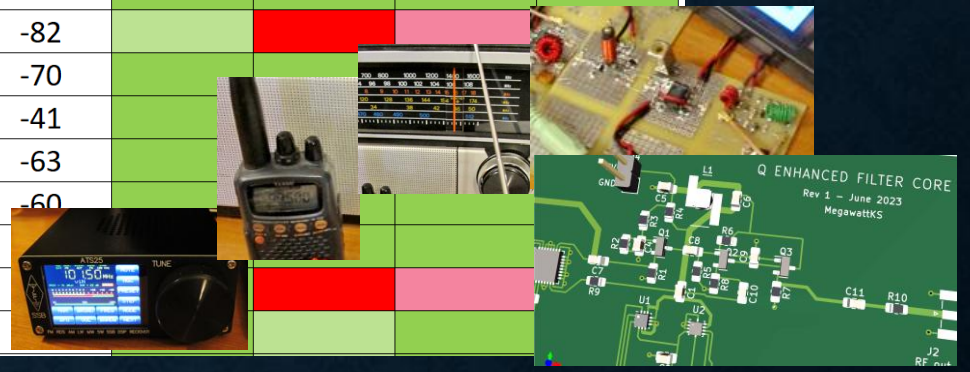
(when using 200 kHz bandwidth Q-enhanced Front-End filter)



88.1 MHz

Station	dBm	ATS 25	VR-120	SW-60	RD-101*
88.1	-96				
88.9	-58				
89.5	-75				
89.9	-61				
90.3	-77				
90.5	-85				
90.7	-71				
91.3	-80				
91.9	-55				
92.5	-82				
92.7	-70				
93.3	-41				
94.5	-63				
95.3	-60				
96.3					
97.5					
97.9					

With Q-enhanced filter front-end added



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Possible Future Videos

- ***Receiver Performance*** ***(Including the math)***
  - *Compression, Intermodulation, 3rd Order Intercept Point, and SFDR*
  - *Noise Figure Tradeoffs with Intermod Performance (including CTB ?)*
  - *Noise analysis and simulation in circuits*

- ***Design of Q-enhanced Front-ends*** ***(Follow-up to Episode 1)***
  - *Effects of positive feedback on gain, selectivity, input Z, ...*
  - *Core CB amplifier design (Q_o of inductors, feedback topology, biasing for desired gain…)*
  - *Self-tuning hardware and software ?*

Thanks For Watching !