# High Performance Receiver Design – Radio Design 401, Episode 5

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

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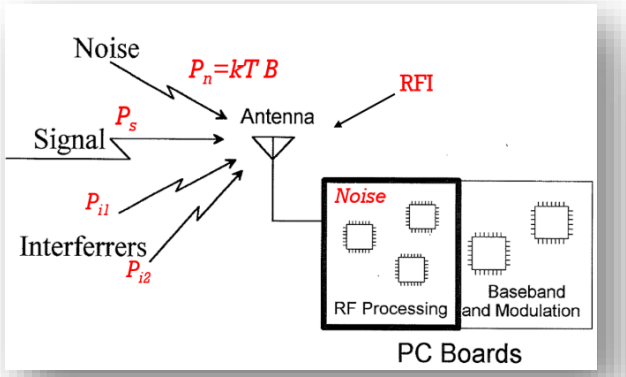
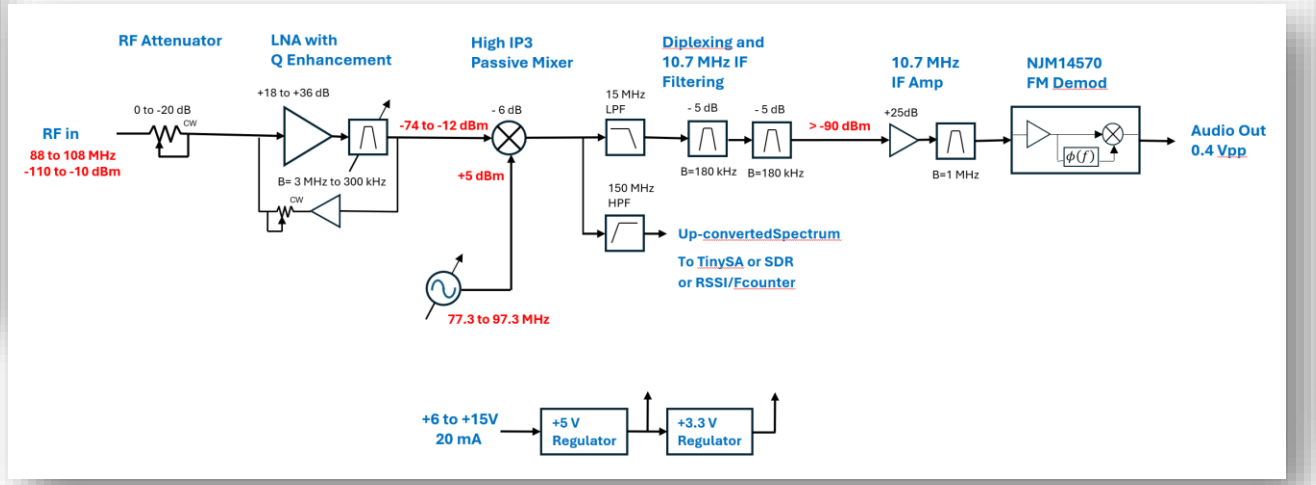
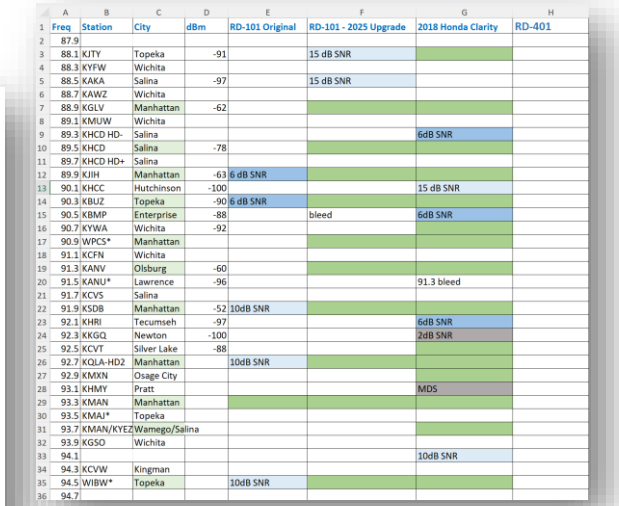
In this episode, we launch our "semester project" by reviewing key points from the Radio Design 101 and 401 video series and then presenting the block diagram of our planned receiver. The goal is to match or exceed the performance of some of the best receivers and to do so at lower power consumption by leveraging a Q-enhanced front end similar to that discussed in Episode 1, and paying close attention to mixer/filter choices and gain distribution. Future videos will elaborate the design with detailed circuits, simulations, and test results.



| | Freq | Station | City | dBm | RD-101 Original | RD-101 - 2025 Upgrade | 2018 Honda Clarity | RD-401 |
|---|---|---|---|---|---|---|---|---|
| 2 | 87.9 | | | | | | | |
| 3 | 88.1 | KJTY | Topeka | -91 | | 15 dB SNR | | |
| 4 | 88.3 | KYFW | Wichita | | | | | |
| 5 | 88.5 | KAKA | Salina | -97 | | 15 dB SNR | | |
| 6 | 88.7 | KAWZ | Wichita | | | | | |
| 7 | 88.9 | KGLV | Manhattan | -62 | | | | |
| 8 | 89.1 | KMUW | Wichita | | | | | |
| 9 | 89.3 | KHCD HD- | Salina | | | | 6dB SNR | |
| 10 | 89.5 | KHCD | Salina | -78 | | | | |
| 11 | 89.7 | KHCD HD+ | Salina | | | | | |
| 12 | 89.9 | KJIH | Manhattan | -63 | 6 dB SNR | | | |
| 13 | 90.1 | KHCC | Hutchinson | -100 | | | 15 dB SNR | |
| 14 | 90.3 | KBUZ | Topeka | -90 | 6 dB SNR | | | |
| 15 | 90.5 | KBMP | Enterprise | -88 | | bleed | 6dB SNR | |
| 16 | 90.7 | KYWA | Wichita | -92 | | | | |
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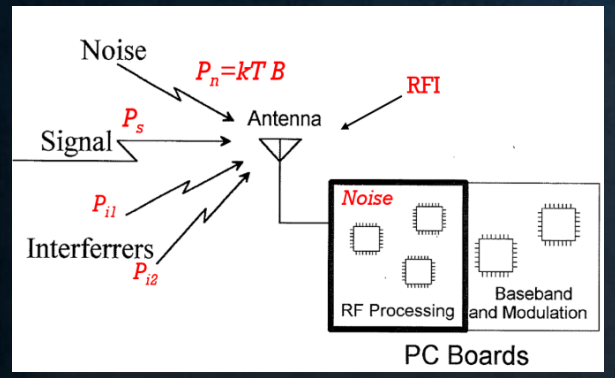
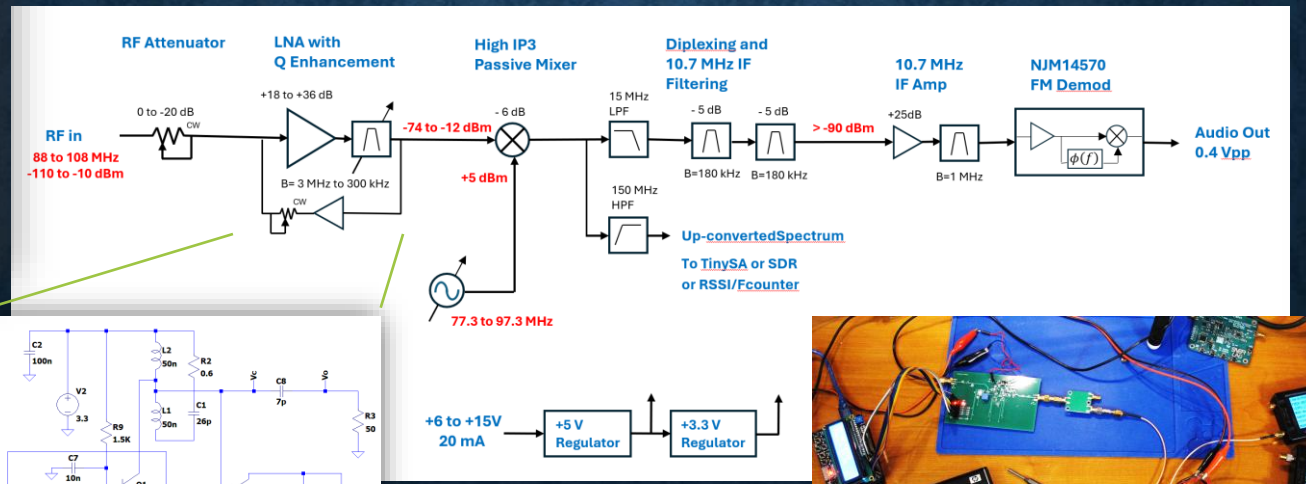
| 19 | 91.3 | KANV | Olsburg | -60 | | | | |
| 20 | 91.5 | KANU* | Lawrence | -96 | | | 91.3 bleed | |
| 21 | 91.7 | KCVS | Salina | | | | | |
| 22 | 91.9 | KSDB | Manhattan | -52 | 10dB SNR | | | |
| 23 | 92.1 | KHRI | Tecumseh | -97 | | | 6dB SNR | |
| 24 | 92.3 | KKGQ | Newton | -100 | | | 2dB SNR | |
| 25 | 92.5 | KCVT | Silver Lake | -88 | | | | |
| 26 | 92.7 | KQLA-HD2 | Manhattan | | 10dB SNR | | | |
| 27 | 92.9 | KMXN | Osage City | | | | | |
| 28 | 93.1 | KHMY | Pratt | | | | MDS | |
| 29 | 93.3 | KMAN | Manhattan | | | | | |
| 30 | 93.5 | KMAJ* | Topeka | | | | | |
| 31 | 93.7 | KMAN/KYEZ | Wamego/Salina | | | | | |
| 32 | 93.9 | KGSO | Wichita | | | | | |
| 33 | 94.1 | | | | | | 10dB SNR | |
| 34 | 94.3 | KCVW | Kingman | | | | | |
| 35 | 94.5 | WIBW* | Topeka | | 10dB SNR | | | |
| 36 | 94.7 | | | | | | | |

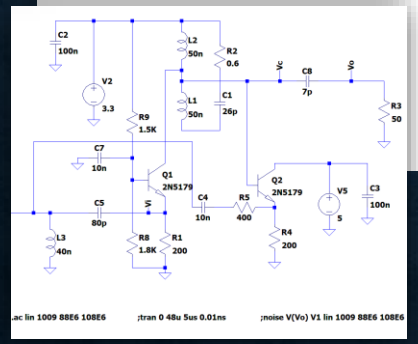
# *Radio Design 401 – Episode 5*

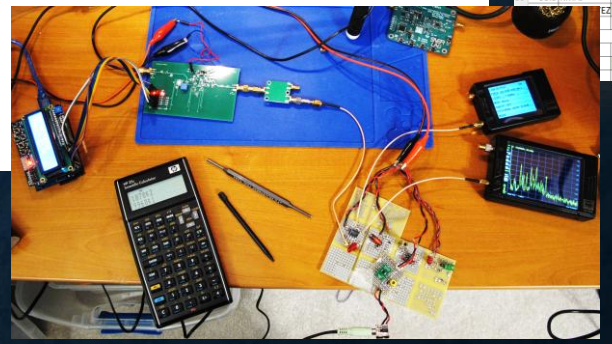
## "Semester Project"

# *High Performance Receiver Design*





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| 91.5 | KANU* | Lawrence | -96 | | | 91.3 bleed | |
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| 93.3 | KMAN | Manhattan | | | | | |
| 93.5 | KMAJ* | Topeka | | | | | |
| | EZ | Wamego/Salina | | | | | |
| | | Wichita | | | | | |
| | | | | | | 10dB SNR | |
| | | Kingman | | | | | |
| | | Topeka | | 10dB SNR | | | |

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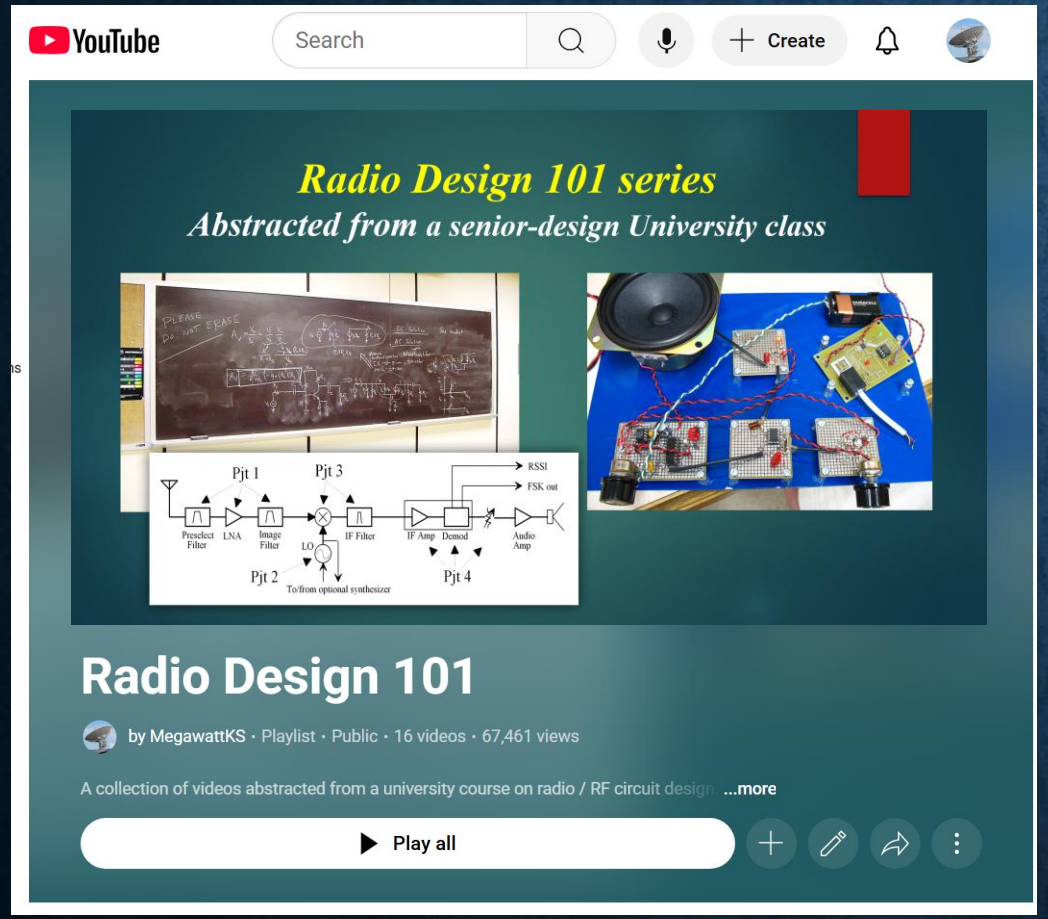
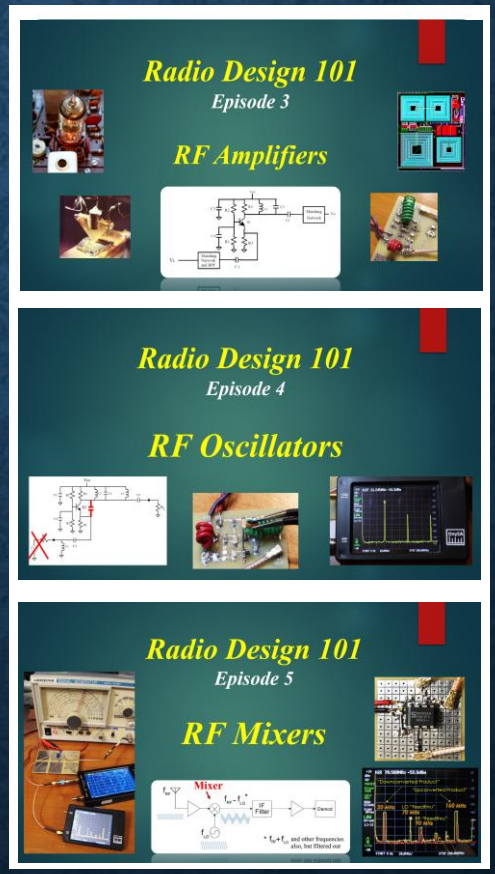
# RD-101 Background / Review




*Radio Design 101*
*Epilogue 1*
*Receiver Performance*

*Radio Design 101*
*Epilogue 2*
*Debugging / Troubleshooting*

*Radio Design 101*
*Epilogue 3*
*Receiver Architectures*

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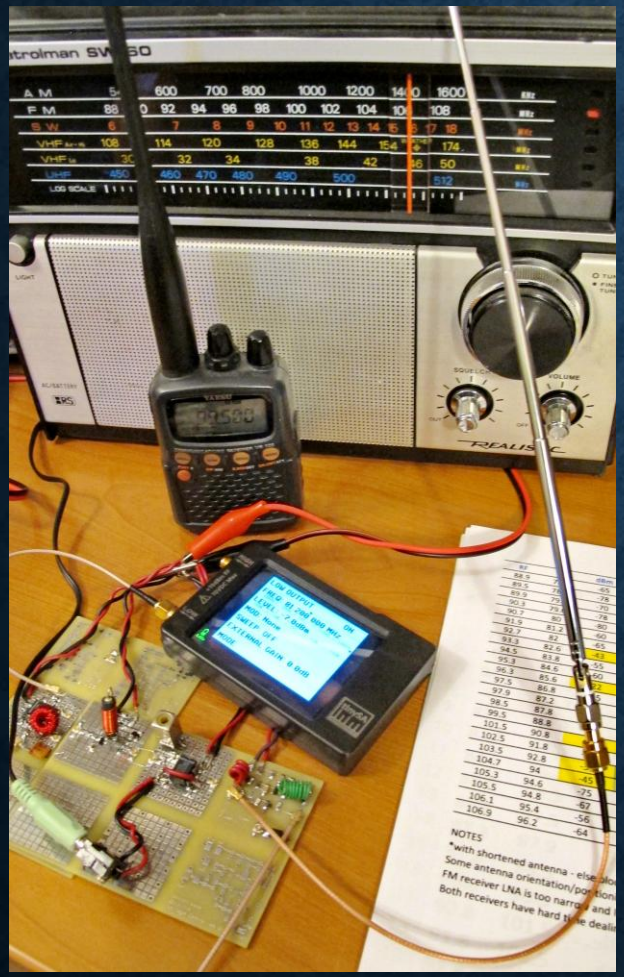
# Reception Scoresheet



| RF | LO | dBm | FMrx | FMrxFixed | VR120 | VR120atten | Old Radio |
|---|---|---|---|---|---|---|---|
| 88.9 | 78.2 | -65 | | | | yes | yes |
| 89.5 | 78.8 | -78 | | | yes | | yes |
| 89.9 | 79.2 | -70 | quiet | quiet | yes | yes | yes |
| 90.3 | 79.6 | -78 | | quiet | | yes | yes |
| 90.7 | 80 | -80 | | | | | yes |
| 91.9 | 81.2 | -60 | quiet | good | yes | yes | yes |
| 92.7 | 82 | -65 | | good | | yes | yes |
| 93.3 | 82.6 | -43 | excellent | excellent | yes | yes | yes |
| 94.5 | 83.8 | -55 | quiet | good | yes | yes | yes |
| 95.3 | 84.6 | -60 | quiet | good | yes | yes | yes |
| 96.3 | 85.6 | -22 | excellent | excellent | yes | yes | yes |
| 97.5 | 86.8 | -65 | | good | | yes | yes |
| 97.9 | 87.2 | -67 | quiet | quiet | yes | yes | yes |
| 98.5 | 87.8 | -80 | | | | | ? |
| 99.5 | 88.8 | -61 | ? | excellent* | | yes | yes |
| 101.5 | 90.8 | -40 | excellent | excellent | yes | yes | yes |
| 102.5 | 91.8 | -62 | | | | | yes |
| 103.5 | 92.8 | -30 | excellent | excellent | yes | yes | yes |
| 104.7 | 94 | -45 | good | excellent | yes | yes | yes |
| 105.3 | 94.6 | -75 | | | | | yes |
| 105.5 | 94.8 | -67 | | | yes | yes | yes |
| 106.1 | 95.4 | -56 | | very quiet | yes | yes | yes |
| 106.9 | 96.2 | -64 | | | yes | yes | yes |

# Car Radio Testing

MITSUBISHI
*Changes for the Better*

NR-000 Internal Photo

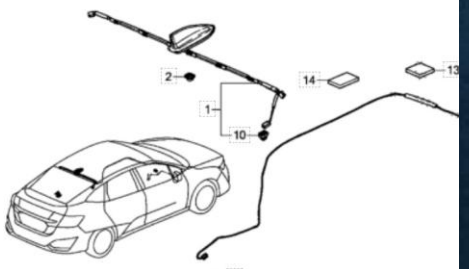
Change

9. Top cover is removed

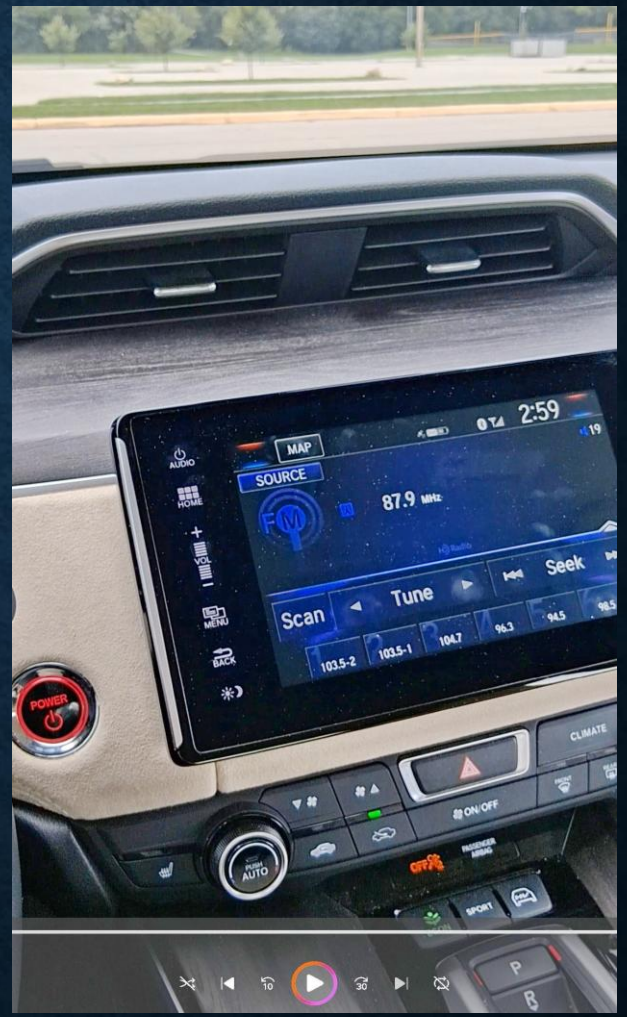
https://fcc.report/FCC-ID/UJHNR000/

2018 Honda Clarity Plug-In Hybrid 4 Door PLUGIN

Diagram (1 of 1): Radio Antenna



https://www.hondapartsnow.com/2018-honda-clarity_plug_in_hybrid--4dr_trng_clarity_phev-ka_cvt-parts.html

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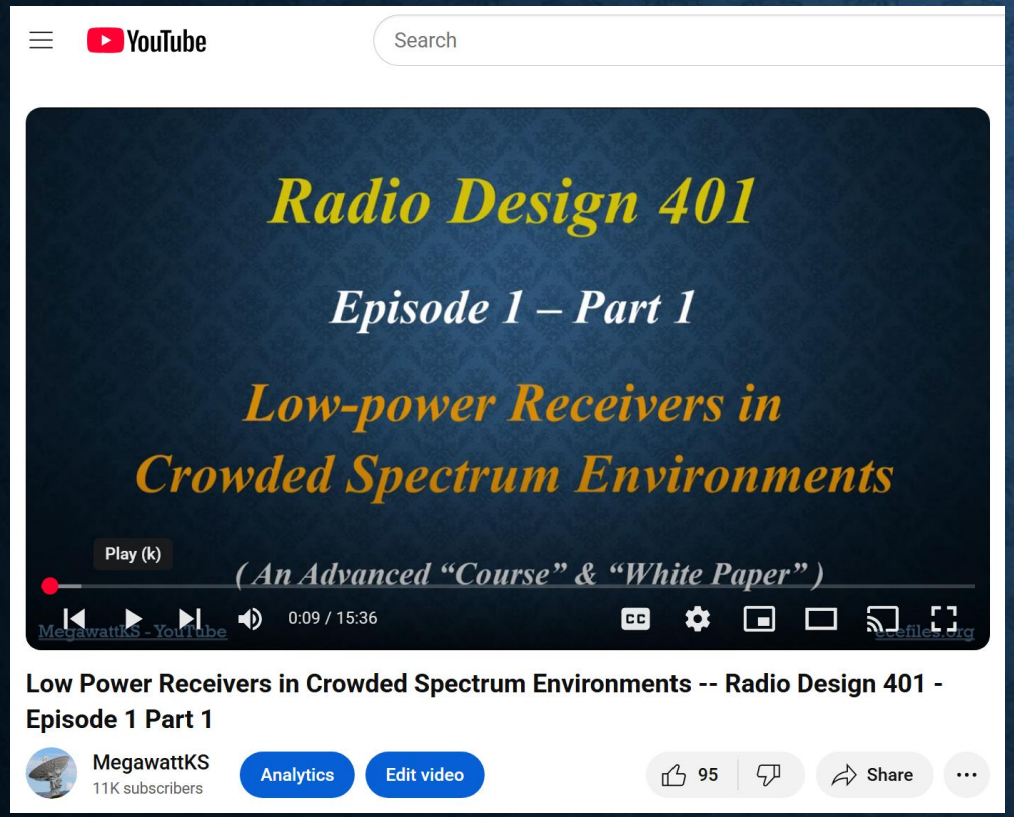
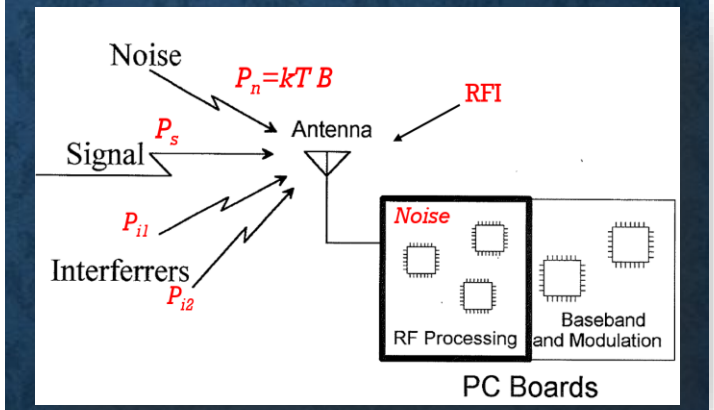
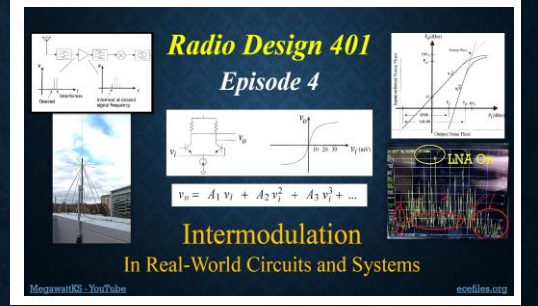
# RD-401 Background / Review



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# Receiver Architectures

See Radio Design 101 video series, Epilogue 3

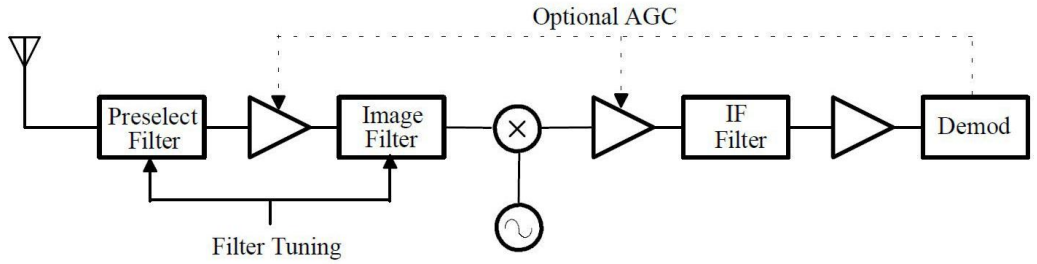



Figure 4.7: Single conversion superheterodyne with tracking preselect.

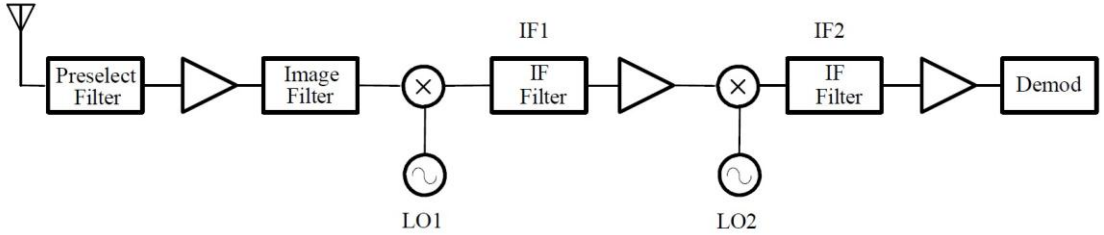



Figure 4.8: Multiple conversion superheterodyne.

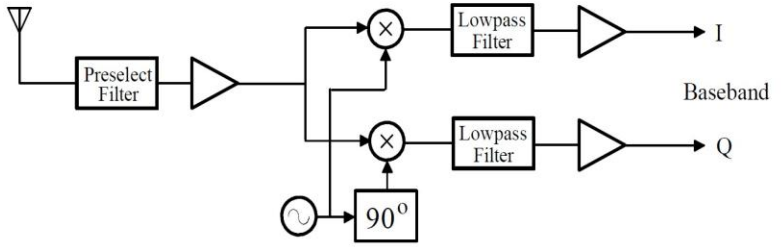



Figure 4.13: Direct conversion receiver architecture.

From: "Design of Integrated, Low Power, Radio Receivers in BiCMOS Technologies", PhD dissertation, Virginia Tech, 1995

# *Ideal Low Power Receiver*

Reduce Preselect Filter bandwidth to signal bandwidth !

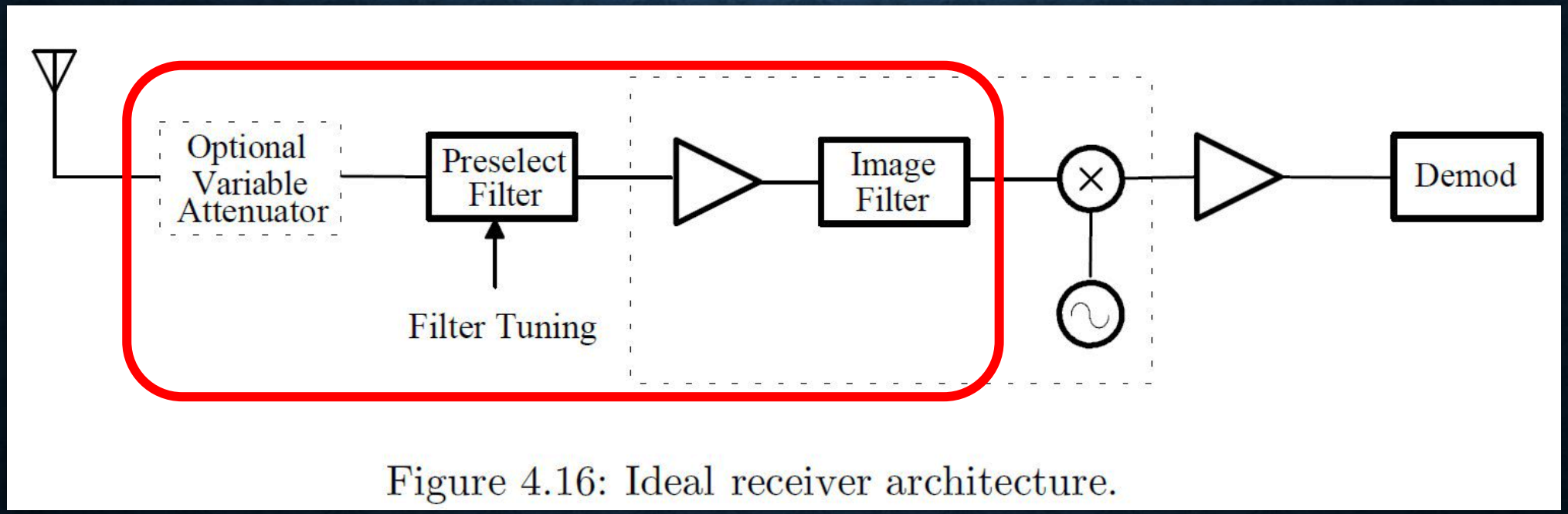



Figure 4.16: Ideal receiver architecture.

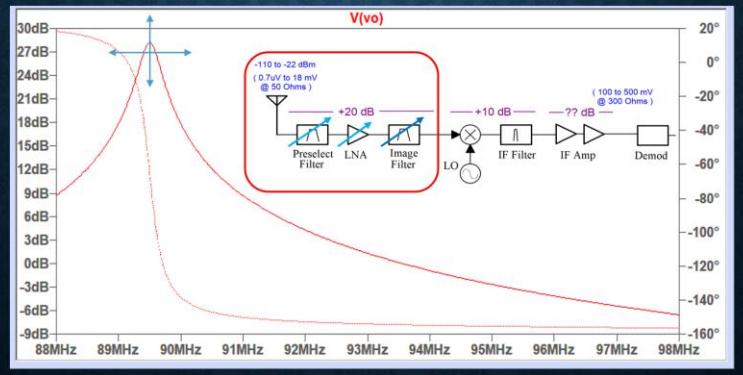
From: "Design of Integrated, Low Power, Radio Receivers in BiCMOS Technologies", PhD dissertation, Virginia Tech, 1995

# Prototype Q-enhanced LNA

## From Episode 1 of Radio Design 401

### Proposed Low Power Solution

*Reduce front end bandwidth to signal bandwidth, not just width of service-band*

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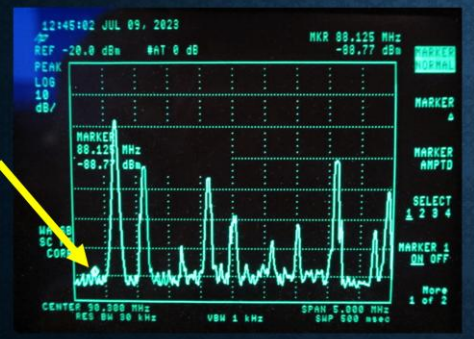
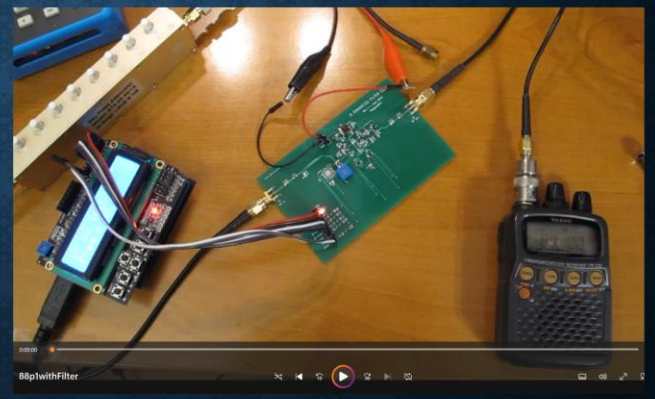
### Pulling out Really Weak Signals !

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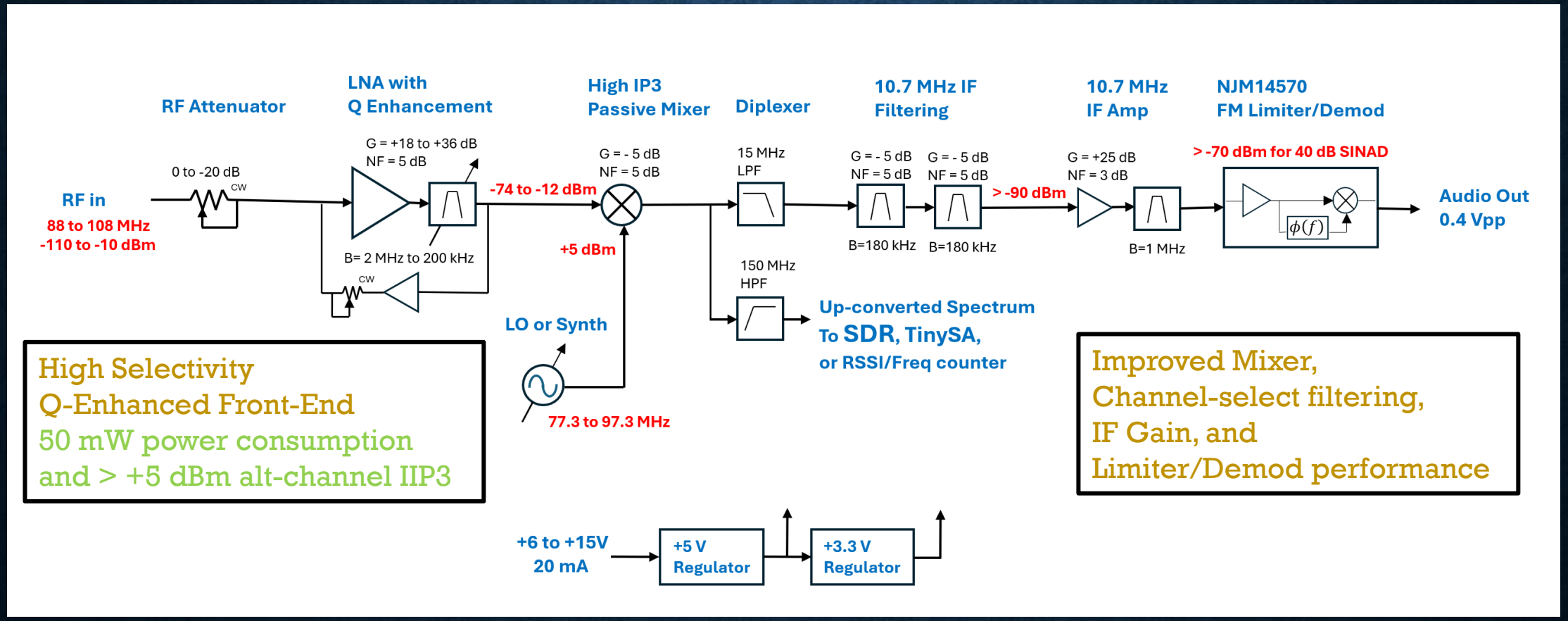
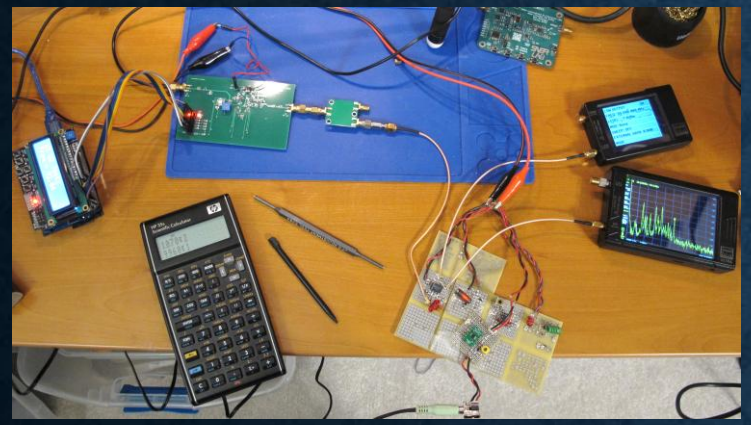
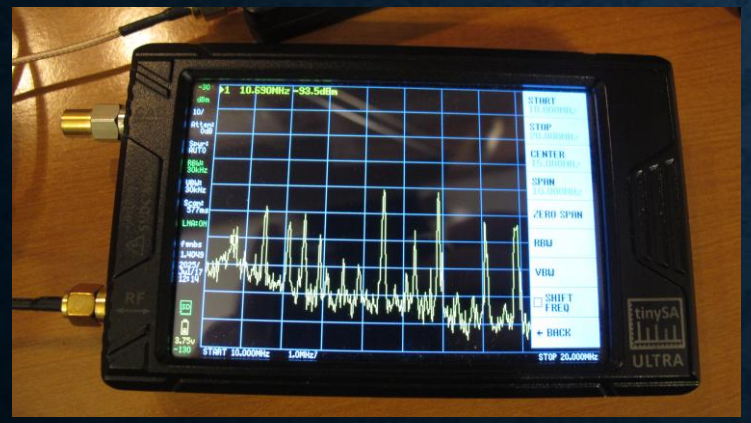
# Project Block Diagram (Rev 1a)



# July 2025 Scoresheet
# (using early QE-Filter, and IC Demod)



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| 93.9 | KGSO | Wichita | | | | | |
| 94.1 | | | | | | 10dB SNR | |
| 94.3 | KCVW | Kingman | | | | | |
| 94.5 | WIBW* | Topeka | | 10dB SNR | | | |
| 94.7 | | | | | | | |
| 94.9 | KCMO | Shawnee | | | | 15dB SNR | |
| 95.1 | KICT | Wichita | | | | | |
| 95.3 | KHCA | Wamego | | 10dB SNR | | | |
| 95.5 | KLBG* | Lindsborg | | | | 6dB SNR | |
| 95.7 | KCHZ | Ottawa | | | | MDS | |
| 95.9 | | | | | | | |
| 96.1 | | | | | | 96.3 bleed | |
| 96.3 | KACZ | Riley | | | | | |
| 96.5 | KLBG* | Salina | | | | 96.3 bleed | |
| 96.7 | KPHN | Wichita | | | | | |
| 96.9 | KLBG* | Salina | | | | 2dB SNR | |
| 97.1 | KBOB | Haven | | | | | |
| 97.3 | | | | | | | |
| 97.5 | KJCK | JcnCity | | 10dB SNR | | | |
| 97.7 | KFGB | Topeka | | | | 2dB SNR | |
| 97.9 | KANV-HD2 | Manhattan | | 6 dB SNR | | | |
| 98.1 | KMBZ | KansasCity | | | | 10dB SNR | |
| 98.3 | | | | | | | |
| 98.5 | KSAJ | Burlingame | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 98.7 | KNSS | Clearwater | | | | | |
| 98.9 | KQRC | Leavenworth | | | | | |
| 99.1 | KTLI | El Durado | | | | 4 dB SNR | |
| 99.3 | KWIC | Topeka | | | | | |
| 99.5 | KANV | Manhattan | | | | | |
| 99.7 | KZPT* | KansasCity | | | | | |
| 99.9 | KSKG | Salina | | | 10 dB SNR | 10 dB SNR | |
| 100.1 | KJTH | Wichita | | | | | |
| 100.3 | KDVV | Topeka | | | | | |
| 100.5 | KVWF | Augusta | | | | | |
| 100.7 | KJAD | Topeka | | | | 2dB | |
| 100.9 | KCLY | Clay Center | | | | | |
| 101.1 | KCFX | HarrisonvilleMO | | | | 3dB SNR | |
| 101.3 | KFDI | Wichita | | | | 101.5 bleed | |
| 101.5 | KMKF | Manhattan | | | | | |
| 101.7 | KJDM | Lindsborg | | | | 101.5 bleed | |
| 101.9 | KVJH | Topeka | | | | | |
| 102.1 | KCKC* | KansasCity | | | | 2dB SNR | |
| 102.3 | | | | | | | |
| 102.5 | KBLS | Ft Riley | | | | | |
| 102.7 | | | | | | | |
| 102.9 | KTOP | St. Marys | | | | | |
| 103.1 | | | | | | | |
| 103.3 | KQLA-HD1* | Ogden | | | | | |
| 103.5 | KQLA | Ogden | | | | | |
| 103.7 | KQLA-HD2* | Ogden | | | | | |
| 103.9 | KNZA | Hiawatha | | | | 10 dB SNR | |
| 104.1 | | | | | | MDS | |
| 104.3 | | | | | | MDS | |
| 104.5 | KFXJ | Augusta | | | | 104.7 bleed | |
| 104.7 | KXBZ | Manhattan | | | | | |
| 104.9 | WIBW* | Topeka | | | | 104.7 bleed | |
| 105.1 | | | | | | 6 dB SNR | |
| 105.3 | KSWZ* | St George | | | | | |
| 105.5 | KRMI | Manhattan | | | | | |
| 105.7 | KJRL | Herington | | | | | |
| 105.9 | KKSW* | Lawrence | | | | | |
| 106.1 | KBMP | Manhattan | | 4 dB SNR | | | |
| 106.3 | | | | | | MDS | |
| 106.5 | KYQQ | ArkansasCity | | | | 4 dB SNR | |
| 106.7 | KSAL | Salina | | | | | |
| 106.9 | KTPK | Topeka | | | | | |
| 107.1 | | | | | | | |
| 107.3 | KTHR | Wichita | | | | | |
| 107.5 | KINA | Salina | | | | | |
| 107.7 | KMAJ* | Carbondale | | | | | |
| 107.9 | KJCK | JunctionCity | | | | 15 dB SNR | |

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# Upcoming Videos

- *Receiver Design and Performance*
  - *Noise analysis and simulation in RF circuits*
  - *RD-401 subcircuit design and simulations*
  - *Fabrication, testing, and scoring !*
- *Design of Q-enhanced Front-ends*
  - *Core CB amplifier design ($Q_o$ of inductors, feedback topology, biasing for desired gain and IP3 performance…)*
  - *Effects of positive feedback on gain, selectivity, input Z, ...*
  - *Self-tuning hardware and software ?*

# *Thanks For Watching !*