

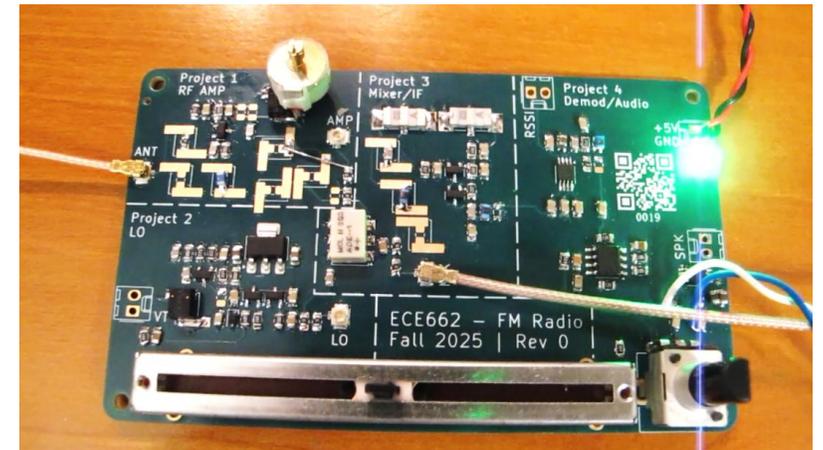
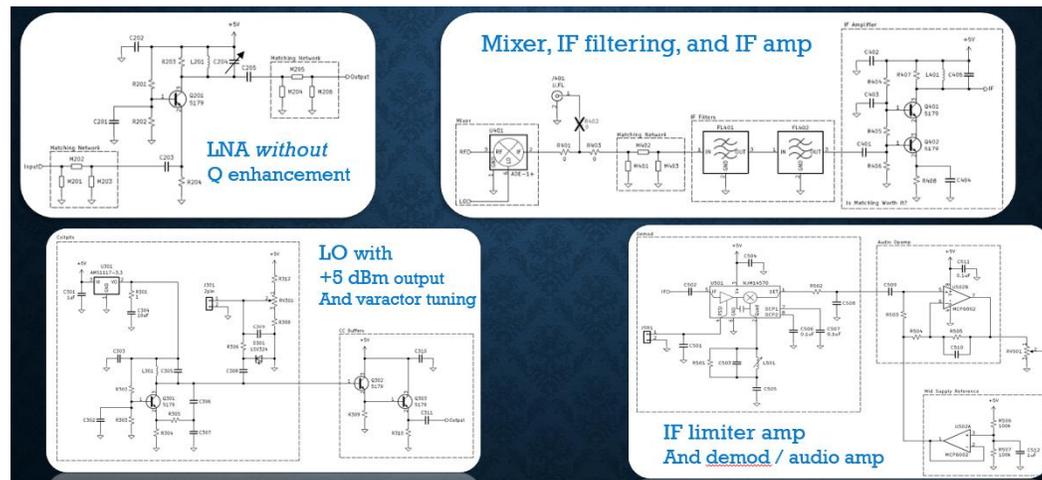
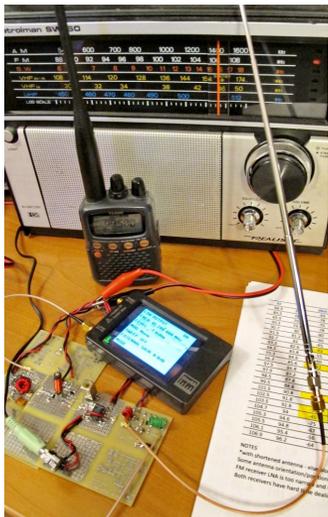
Semester Project – Building a Better Receiver- Radio Design 401, Episode 7

Slides downloaded from: <https://ecefiles.org/>

Companion videos at: <https://www.youtube.com/playlist?list=PL9Ox3wpmB0krNexW2k5JMCaewXN7LoRXd>

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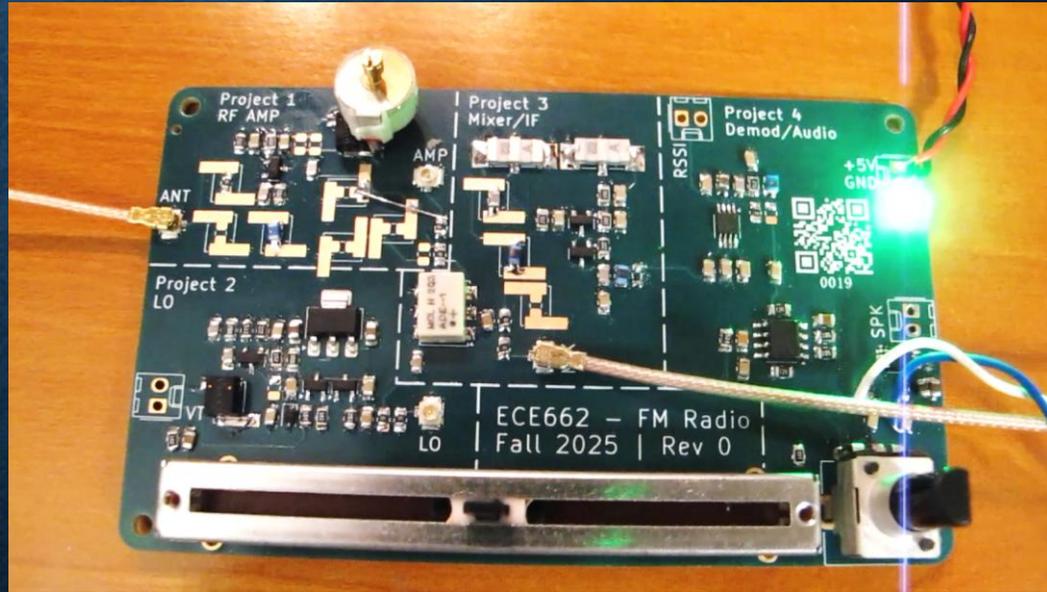
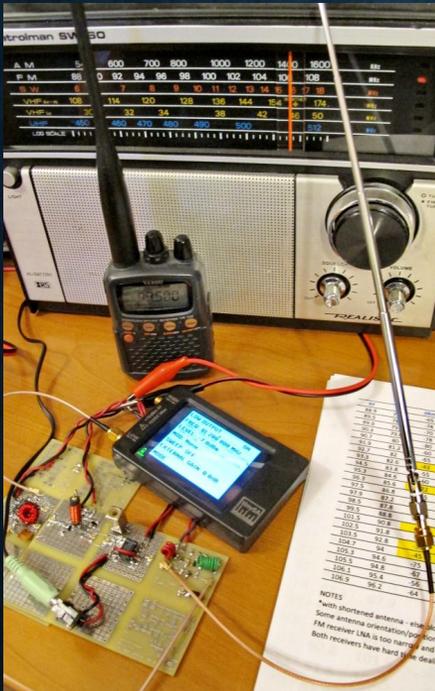
This video covers the full Radio Design 401 receiver at the block diagram and schematic levels, including the PC board and preliminary performance testing. While not the final video planned for the RD401 set, it provides sufficient information to illustrate how all the theory developed to this point comes together. With the prerequisite background (e.g. Radio Design 101), it also provides all the information needed to design, build, and test the new radio.



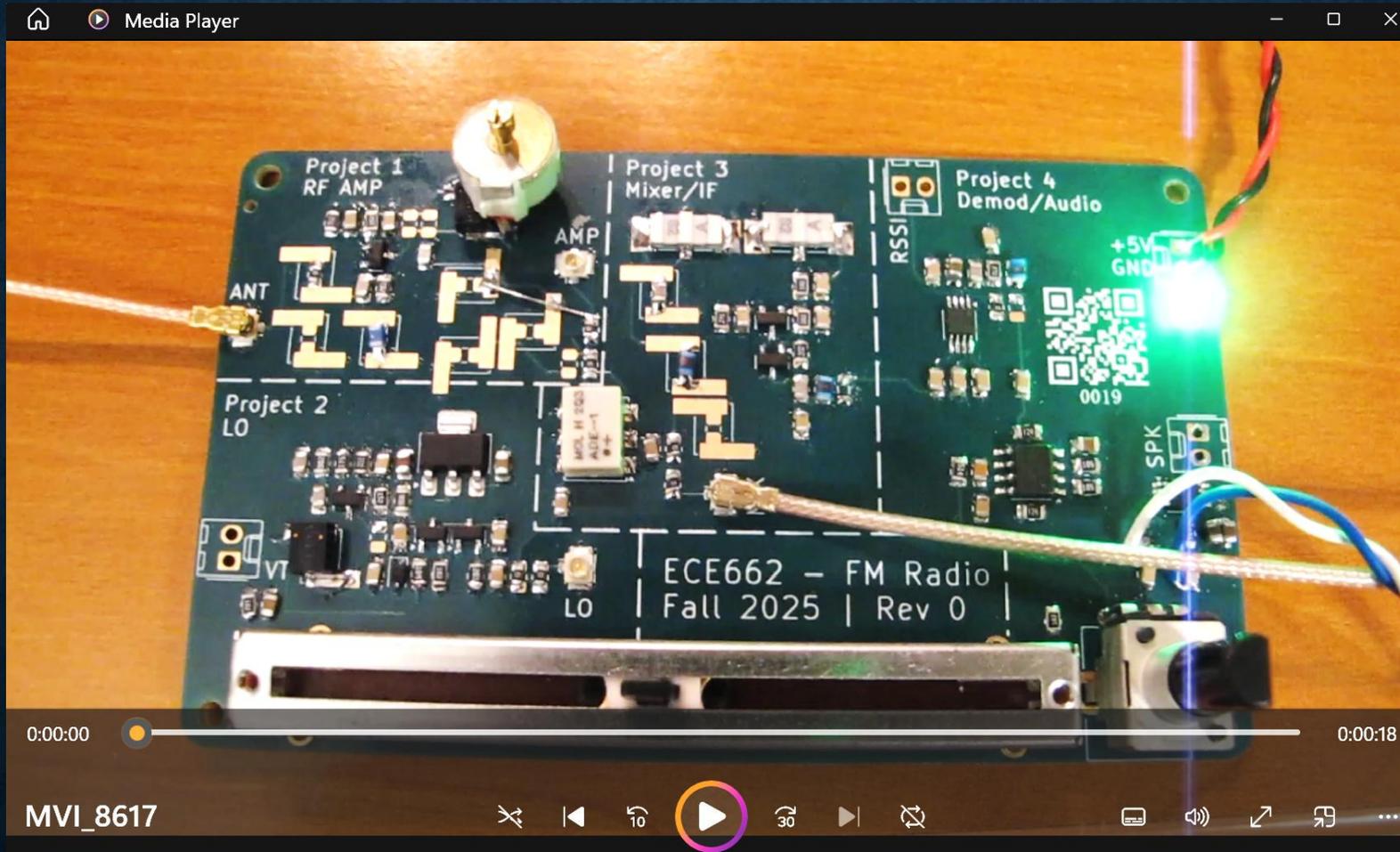
Radio Design 401 – Episode 7

Semester Project

Building a Better Receiver



Radio Design 401 Rev 0.8 Test



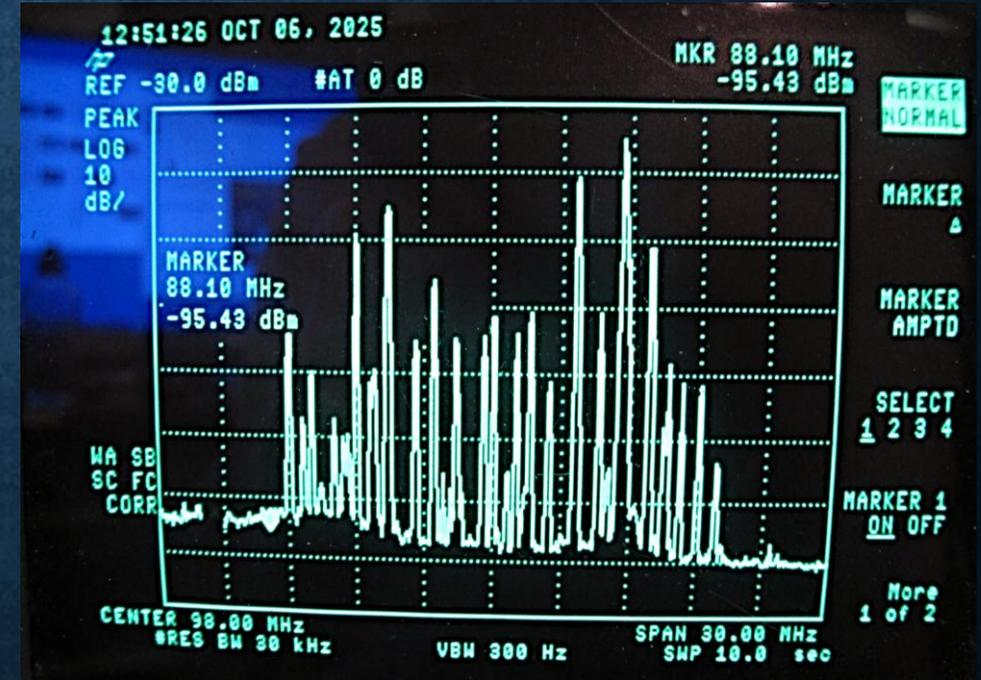
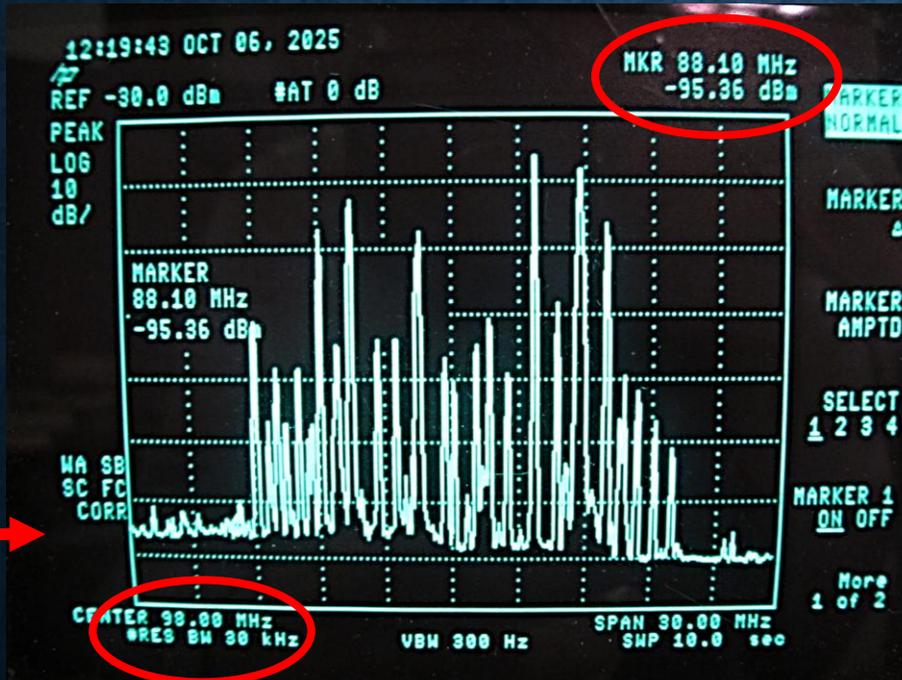
Antenna Position and RFI Effects

Indoor Testing

Computer Monitor Off

Computer Monitor ON

Elevated
Noise
Floor



Noise Floor in 30 kHz RBW should be -129 dBm !

Presentation Outline



Background and Introduction

Receiver Variants and Scoring

RD401 Block Diagram, Schematics, Parts List,
and PCB

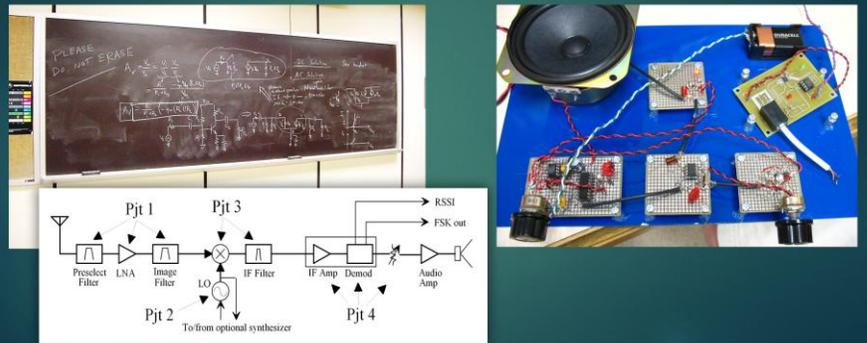
Future Videos

Radio Design 101

YouTube Search + Create

Radio Design 101 series

Abstracted from a senior-design University class



Radio Design 101

by MegawattKS • Playlist • Public • 16 videos • 67,461 views

A collection of videos abstracted from a university course on radio / RF circuit design. ...more

Play all

Radio Design 101

Episode 3

RF Amplifiers



Radio Design 101

Episode 4

RF Oscillators



Radio Design 101

Episode 5

RF Mixers



Radio Receiver Performance

Epilogue 1



32:18

Radio Design 101

Epilogue 2

Debugging / Troubleshooting



33:41

Radio Design 101 - Epilogue 3

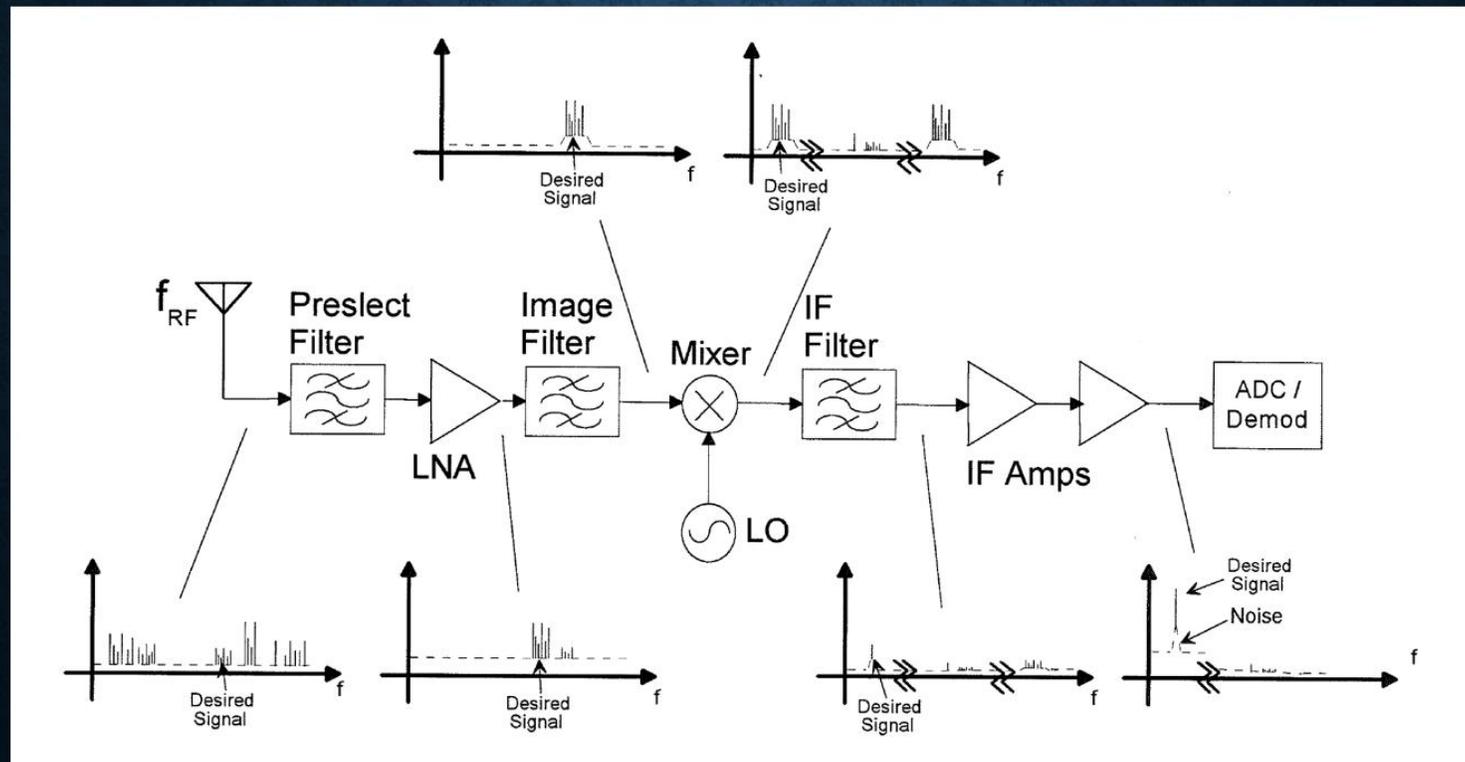
Receiver Architectures



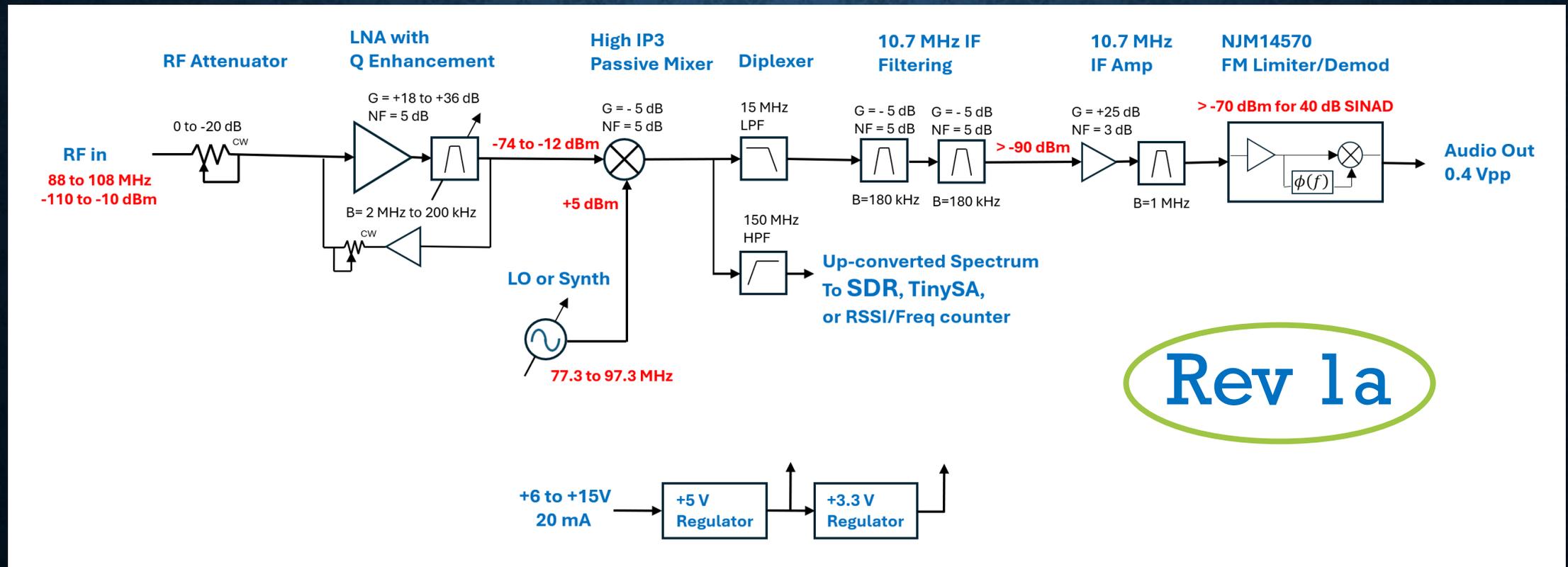
57:42

Receiver Signal Processing

Classic Superhhet Solution



RD401 Goal: Improved Design to receive more stations 😊 (from Episode 5)





Radio Design 401 - Advanced Receiver ...

by MegawattKS

Playlist · Public · 9 videos · 1,050 views

Radio Design 401 will be covering advanced topics and presenting fundamental research into how to improve receiver performance. ...more



Sort

All

Videos

Shorts

1



Low Power Receivers in Crowded Spectrum Environment..

MegawattKS · 1.8K views · 7 months ago

2



Episode 1 Part 2 in Radio Design 401

MegawattKS · 1.2K views · 7 months ago

3



Episode 1, Part 3 (of 3) in Radio Design 401

MegawattKS · 1.2K views · 6 months ago

4



SNR, Noise Figure, and Receiver Sensitivity - Radio Desig..

MegawattKS · 1.3K views · 5 months ago

5



RFI Noise in Buildings -- Radio Design 401, Episode 3

MegawattKS · 1K views · 5 months ago

6



Intermodulation in Real-World Receivers - Radio Design...

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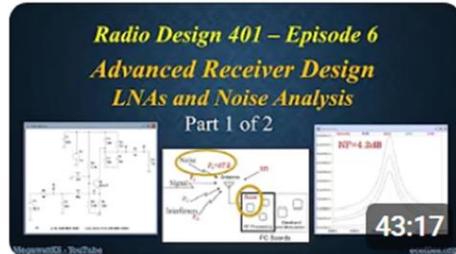
7



High Performance Receiver Design - Radio Design 401,...

MegawattKS • 1.7K views • 2 months ago

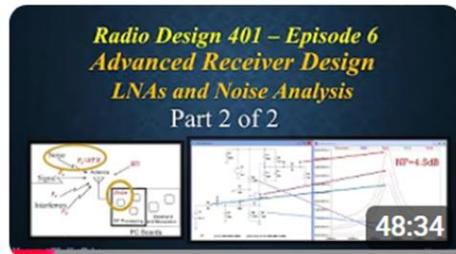
8



LNAs, Noise Figure, and Noise Analysis - Radio Design...

MegawattKS • 917 views • 3 weeks ago

9



LNA Noise Figure Analysis - Radio Design 401, Episode 6,...

MegawattKS • 573 views • 3 weeks ago

Presentation Outline

Background and Introduction

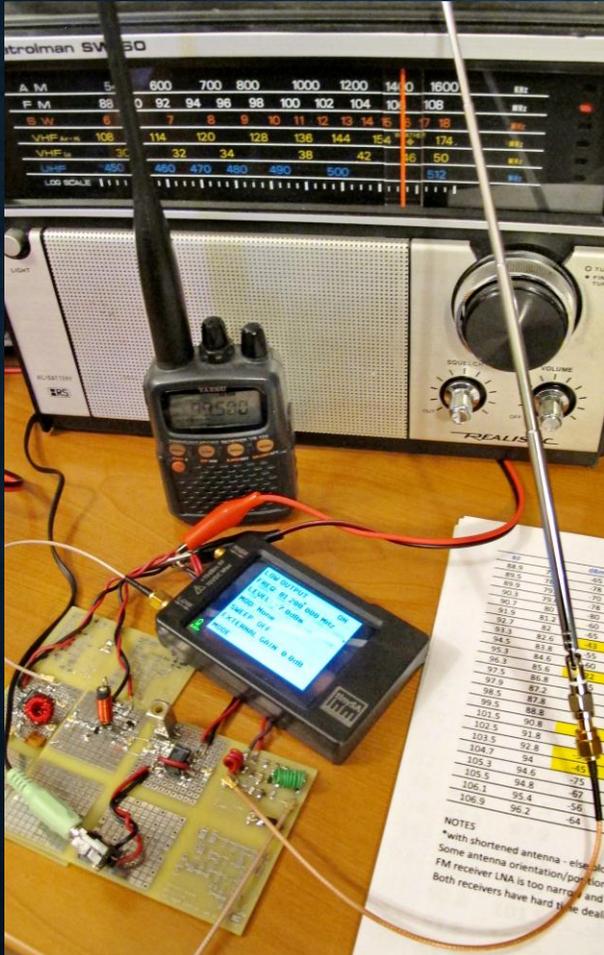


Receiver Variants and Scoring

RD401 Block Diagram, Schematics, Parts List,
and PCB

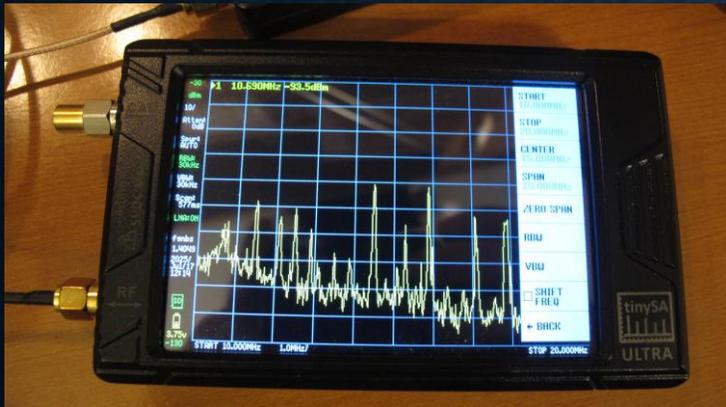
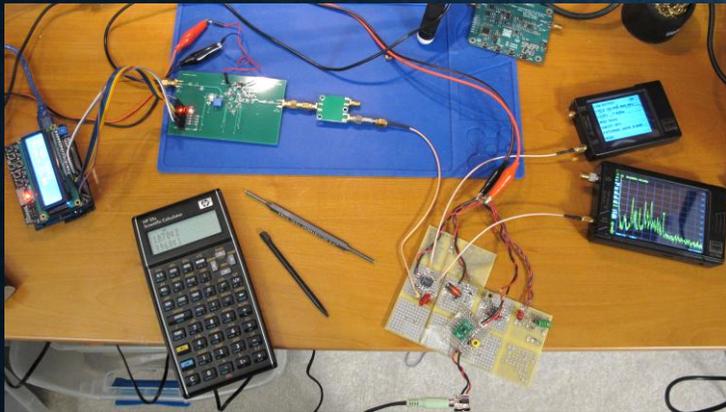
Future Videos

2023 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

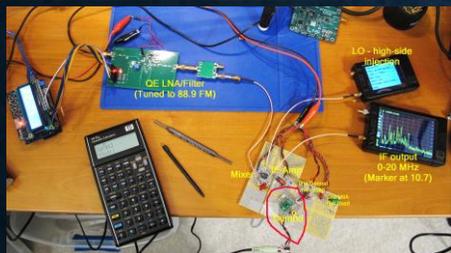
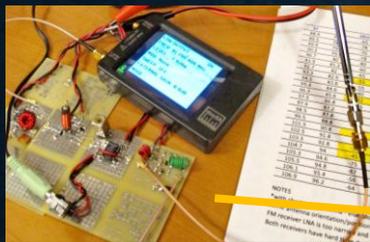
July 2025 Scoresheet



Freq	Station	City	dBm	RD-101 Original	RD-101 - 2025 Upgrade	2018 Honda Clarity	RD-401
87.9							
88.1	KJTY	Topeka	-91		15 dB SNR		
88.3	KYFW	Wichita					
88.5	KAKA	Salina	-97		15 dB SNR		
88.7	KAWZ	Wichita					
88.9	KGLV	Manhattan	-62				
89.1	KMUW	Wichita					
89.3	KHCD-HD-	Salina				6dB SNR	
89.5	KHCD	Salina	-78				
89.7	KHCD-HD+	Salina					
89.9	KJIH	Manhattan	-63	6 dB SNR			
90.1	KHCC	Hutchinson	-100			15 dB SNR	
90.3	KBUZ	Topeka	-90	6 dB SNR			
90.5	KBMP	Enterprise	-88		bleed	6dB SNR	
90.7	KYWA	Wichita	-92				
90.9	WPCS*	Manhattan					
91.1	KCFN	Wichita					
91.3	KANV	Olsburg	-60				
91.5	KANU*	Lawrence	-96			91.3 bleed	
91.7	KCVS	Salina					
91.9	KSDB	Manhattan	-52	10dB SNR			
92.1	KHRI	Tecumseh	-97				
92.3	KKGQ	Newton	-100			2dB SNR	
92.5	KCVT	Silver Lake	-88				
92.7	KQLA-HD2	Manhattan		10dB SNR			
92.9	KMXN	Osage City					
93.1	KHMY	Pratt				MDS	
93.3	KMAN	Manhattan					
93.5	KMAJ*	Topeka					
93.7	KMAN/KYEZ	Wamego/Salina					
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					

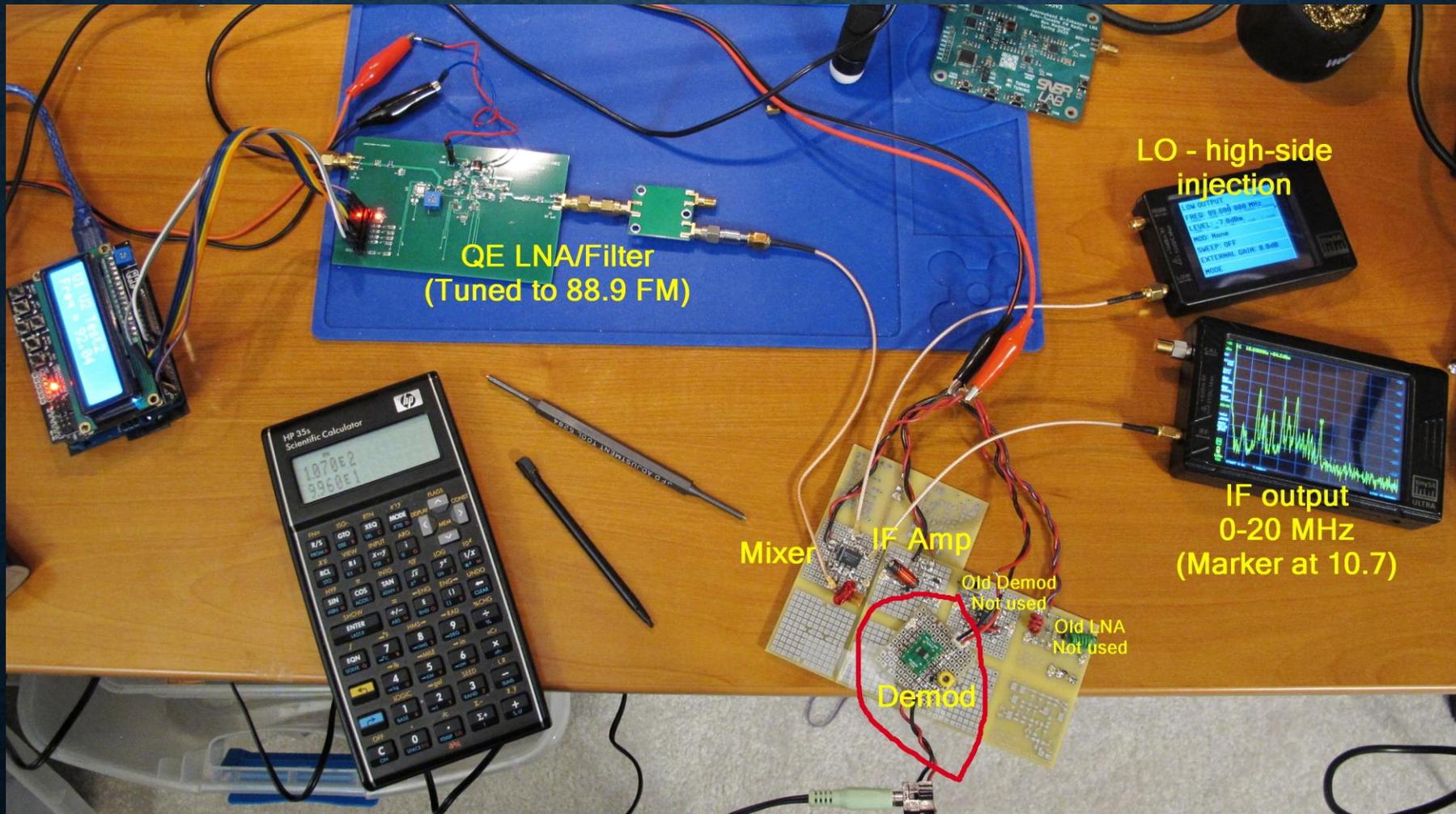
98.7	KNSS	Clearwater					
98.9	KQRC	Leavenworth					
99.1	KTLI	El Durado					4 dB SNR
99.3	KWIC	Topeka					
99.5	KANV	Manhattan					
99.7	KZPT*	KansasCity					
99.9	KSKG	Salina			10 dB SNR		10 dB SNR
100.1	KJTH	Wichita					
100.3	KDVV	Topeka					
100.5	KVWF	Augusta					
100.7	KJAD	Topeka					2dB
100.9	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

August 2025 Scoresheet



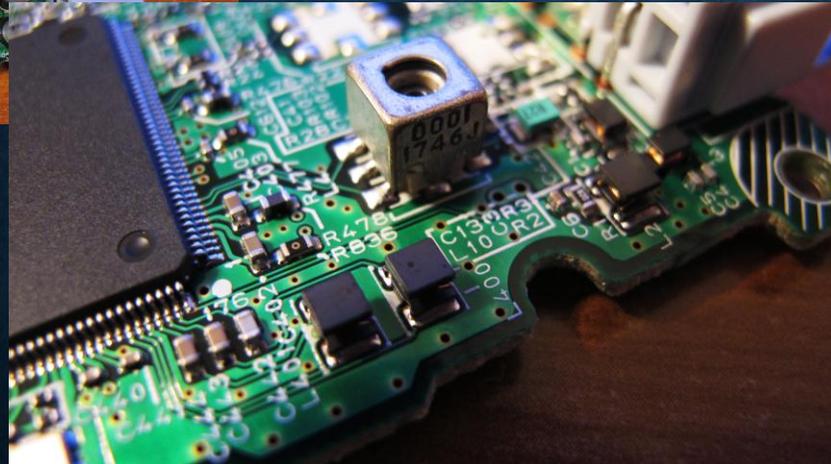
Radio	Location	Antenna	(Real) Stations Received
RD 101 from 2022	Home Office	Lambda/2 Dipole on desk	17
RD 101 with 2025 upgrade (with QE filter and improved IF gain & demod)	Home Office (low RFI day)	Lambda/2 Dipole on desk	29
RD 401 from Q3 2025 (<i>without</i> QE filtering) (about 30 mA Idc)	Home Office (low RFI day)	Lambda/2 Dipole on desk	42
Honda Clarity Car Radio (> 200mA Idc)	Nearby Park	Dipole at rear window	44+ (repositioning car/antenna helps)
RD 401 Q4 2025 (<i>with</i> QE front end)	Home Office and Nearby Park	Lambda/2 Dipole	TBD

2025 RD 101 Upgraded Receiver

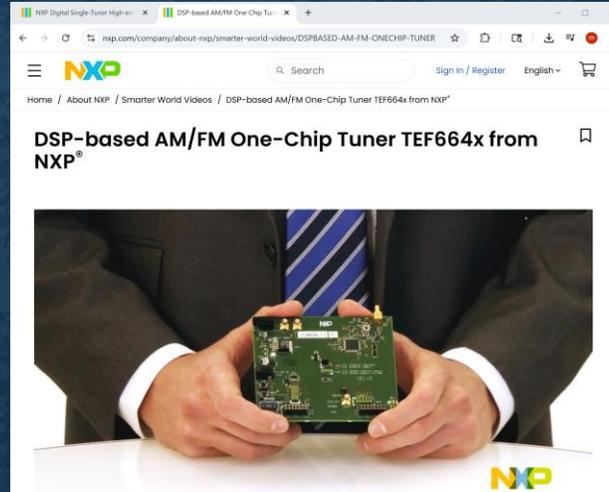


Honda Clarity Radio Tuner

Related NXP Legacy ICs



Main Rcvr ICs:
SAF7751HV/205
SAF3600EL/2



The NXP TEF6640, TEF6642, TEF6644, and TEF6646 are single-chip radio ICs containing an AM/FM radio tuner and software-defined radio signal processing.

Like NXP's other RFCMOS-based solutions, they create a fully scalable family that supports standard and advanced radio features, and can be used in combination with co-processors to support digital radio.

The TEF6644 and TEF6646 are premium versions equipped with the full feature set. The TEF6640 and TEF6642 include a standard feature set.

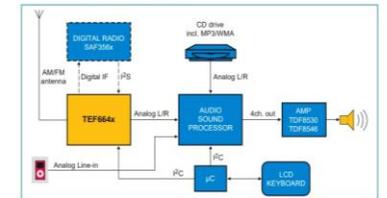
The radio receiver includes the AM/FM front ends, tuning synthesizer, channel filtering, FM multipath improvement, demodulation, FM stereo decoding, weak signal processing, noise blanking, and Radio Data System (RDS) reception.

The ICs take full advantage of CMOS technology to perform a maximum amount of digital signal processing.

The output signals of the radio processing block are provided in digital format on the host IP5 output (only TEF6642 and TEF6646) and in analog format on the audio DAC outputs.

When used in combination with an NXP terrestrial digital radio coprocessor, such as the SAF356x, the TEF6642 and the TEF6646 support the digital standards HD Radio and Digital Radio Mondiale (DRM).

Block Diagram on AM/FM Car Radio with optional Digital Radio



Selection guide

		TEF6640 Lite	TEF6642 Lite DR	TEF6644 Premium	TEF6646 Premium DR
System	Supply	3.3 V	3.3 V	3.3 V	3.3 V
	Advanced radio features	-	-	✓	✓
KIBUS	HD / DRM support	-	-	✓	✓
	Demodulator / decoder	✓ / ✓	✓ / ✓	✓ / ✓	✓ / ✓
AM - Standard Radio Features	LW / MW / SW	✓	✓	✓	✓
	IF & Audio Noise Blanking	✓	✓	✓	✓
AM - Advanced Radio Features	Weak signal processing	✓	✓	✓	✓
	Adjacent and co-channel detection	✓	✓	✓	✓
FM - Standard Radio Features	Software on modulation	-	-	✓	✓
	Low cut control features	-	-	✓	✓
FM - Advanced Radio Features	Japan / EU / US / OIRT bands	✓	✓	✓	✓
	Noise blanker	✓	✓	✓	✓
FM - Advanced Radio Features	PACS	✓	✓	✓	✓
	Basic weak signal processing	✓	✓	✓	✓
FM - Advanced Radio Features	Enhanced multi-path suppression (EMS)	-	-	✓	✓
	Click noise suppression (CNS)	-	-	✓	✓
Key code features	Pause and fast quality change detection	-	-	✓	✓
	High blend and low cut control features	-	-	✓	✓
General	Channel equalizing (CEQ)	-	-	✓	✓
	AM PACS	-	-	✓	✓
General	Package	HTOP94	HTOP94	HTOP94	HTOP94
	AEC-Q100	✓	✓	✓	✓
General	Tamb	-40 to 85 °C	-40 to 85 °C	-40 to 85 °C	-40 to 85 °C

Presentation Outline

Background and Introduction

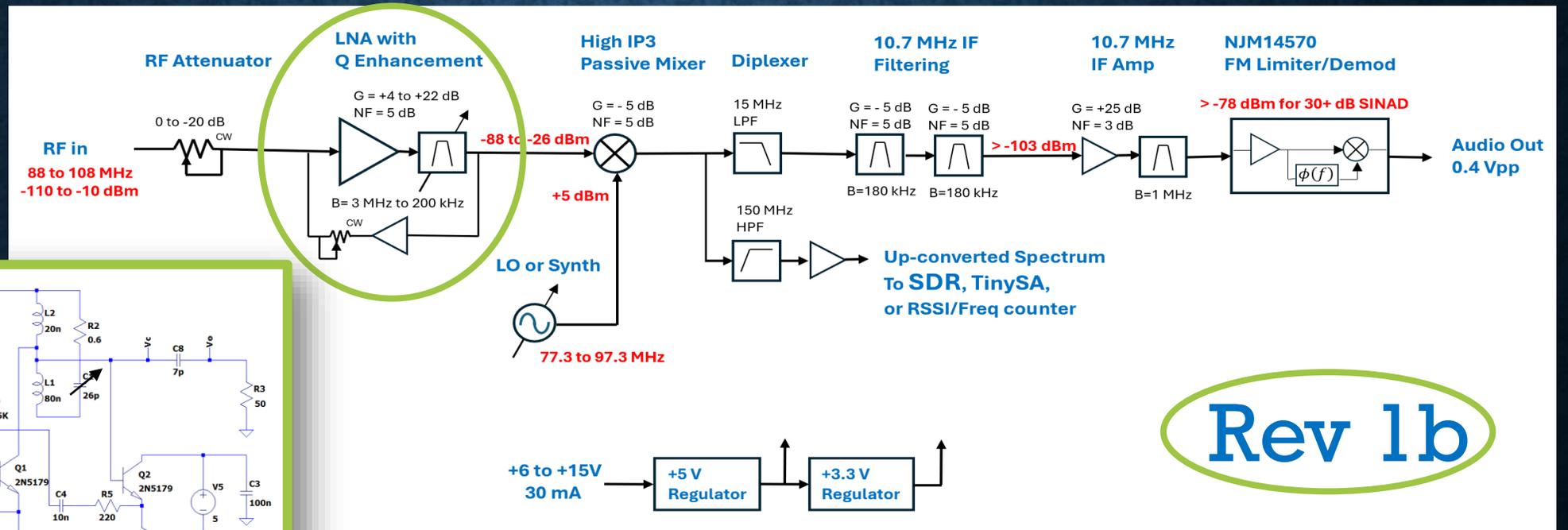
Receiver Variants and Scoring



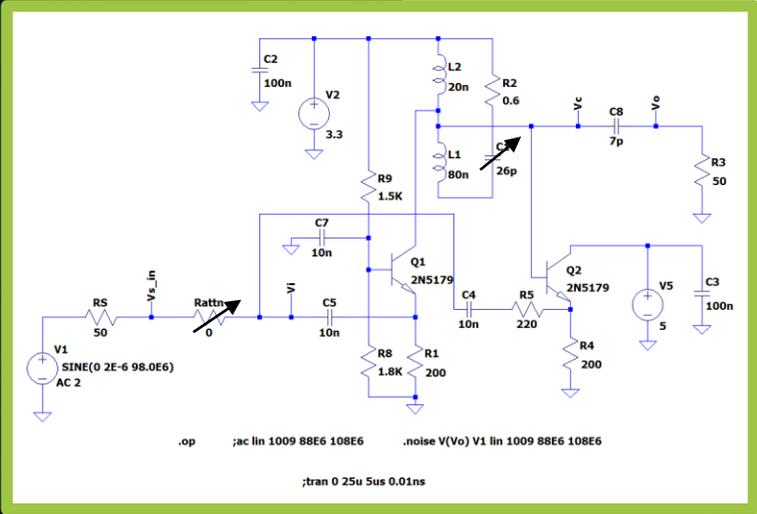
RD401 Block Diagram, Schematics, Parts List,
and PCB

Future Videos

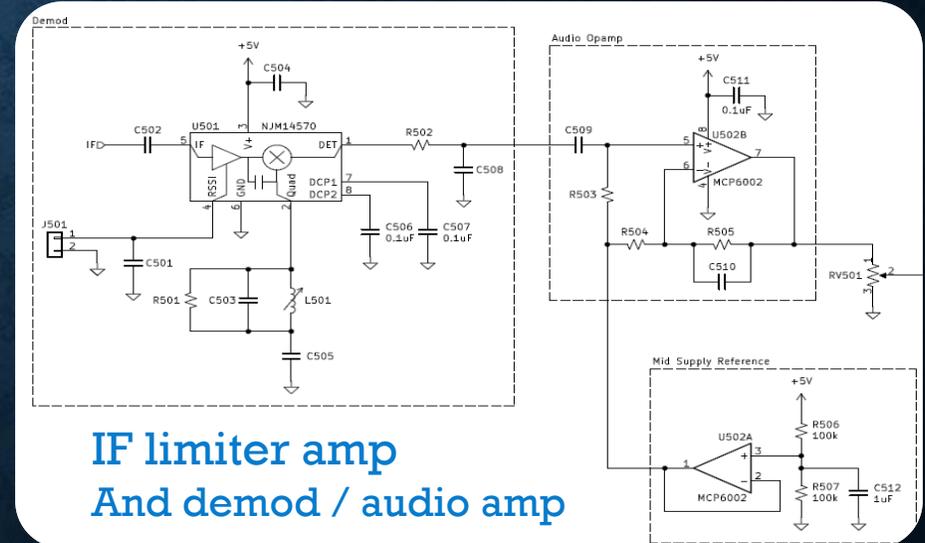
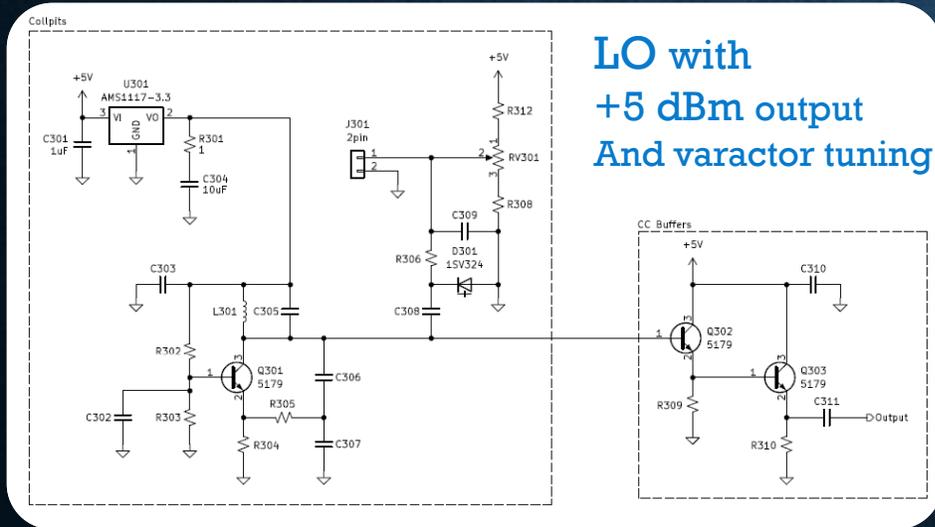
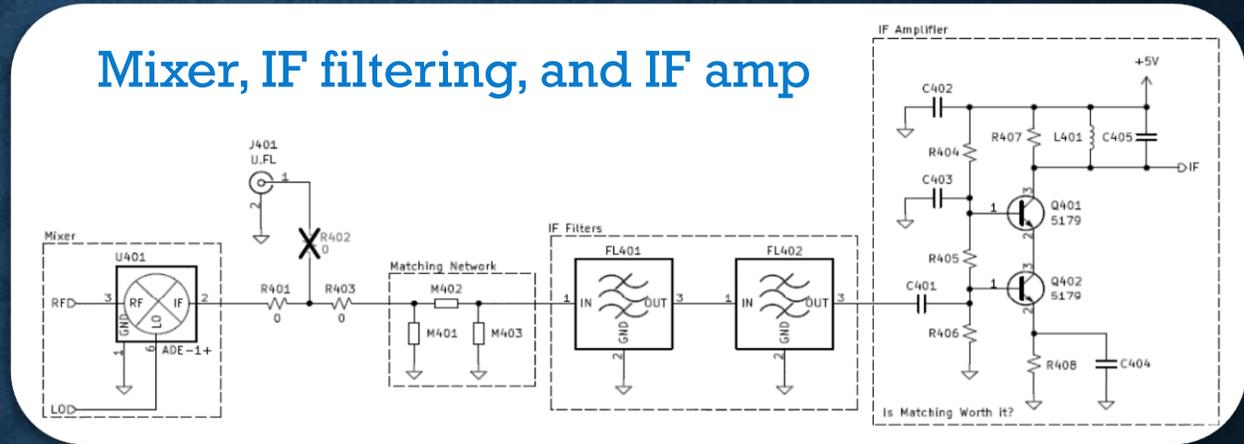
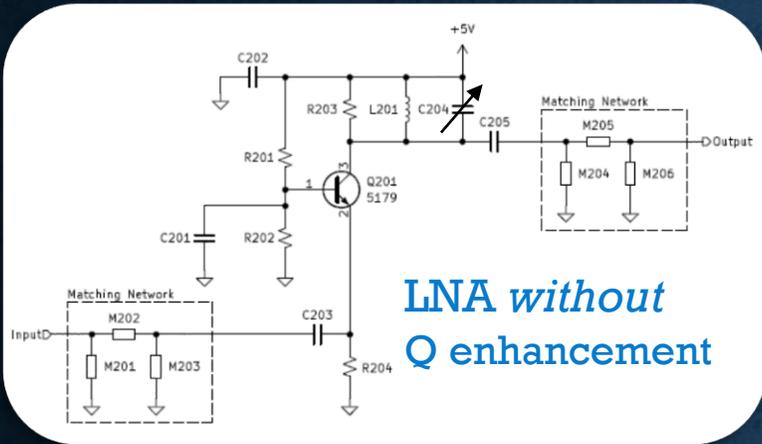
RD401 Goal: More Selectivity (and Good IIP3 & NF) to receive more stations 😊



Rev 1b



Rev 0.8 KiCad Drawings (Courtesy of Garrett Peterson)



Suggested Parts List

Device/Function	Manufacturer	Part Number	Suggested Vendor	Approx Cost (ea)
UHF Transistors	OnSemi	MMBT5179	Digikey	\$0.10
High Q Inductors	Coilcraft	C318 Kit	Coilcraft	\$36
High Q Variable Cap	Vishay	BFC2 808 ...	Digikey	\$7
High IP3 Mixer	Mini-Circuits	ADE-1+	Mini-Circuits	\$5
Tuning Varactor	Toshiba	1SV324	Digikey	\$0.50
3.3V Regulator	EVVO	AMS1117-3.3	Digikey	\$0.30
Linear Potentiometer	Bourns	PTA6043-2010CIB103	Digikey	\$2
10.7 MHz IF Filters	YIC	LTCV10.7MS2	Digikey	\$0.60
FM Limiter/Demod	Nisshinbo	NJM14570	Mouser	\$2
Low Voltage OpAmp	Microchip	MCP6002	Digikey	\$0.50

ADE-1+ Mixer

Surface Mount Frequency Mixer

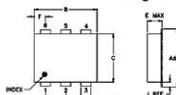
Level 7 (LO Power +7 dBm) 0.5 to 500 MHz

Maximum Ratings
 Operating Temperature -40°C to 85°C
 Storage Temperature -55°C to 100°C
 RF Power 50mW
 IF Current 40mA
 Permanent damage may occur if any of these limits are exceeded. These electrical ratings are not intended for continuous normal operation.

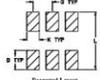
Pin Connections

LO	6
RF	3
IF	2
GROUND	1,4,5

Outline Drawing

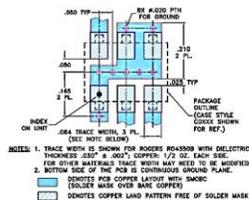


DC Lead Pattern



Outline Dimensions (mm)

A	B	C	D	E	F	G
372	310	220	100	162	865	100
6.91	7.87	5.59	2.54	4.11	1.40	2.54
H	J	K	L	wt		
.030	.026	.065	.300	grams		
0.76	0.66	1.65	7.62	0.25		



Notes
 A. Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.
 B. Electrical specifications and performance data contained in this specification document are based on Mini-Circuits' applicable established test performance criteria and measurement instructions.
 C. The parts covered by this specification document are subject to Mini-Circuits' standard limited warranty and terms and conditions (collectively, "Standard Terms"). Purchases of this part are entitled to the rights and benefits contained therein. For a full statement of the Standard Terms and the exclusive rights and remedies thereunder, please visit Mini-Circuits' website at www.minicircuits.com/MCIS/StandardTerms.jsp

ADE-1+



Generic photo used for illustration purposes only
 CASE STYLE: CD636
 +RoHS Compliant
 The +RoHS identifies RoHS Compliance. See our website for RoHS Compliance methodologies and qualifications

Available Tape and Reel at no extra cost!
 Peel Size Devices/Reel
 7" 20, 50, 100, 200
 12" 500, 1000

- Features**
- low conversion loss, 5.0 dB typ.
 - excellent L-R isolation, 55 dB typ.
 - excellent IP3, 15 dBm typ.
 - low profile package
 - aqueous washable
 - protected by US patent 6,133,525

- Applications**
- VHF/UHF

Electrical Specifications

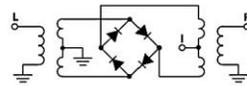
FREQUENCY (MHz)	CONVERSION LOSS (dB)	LO-RF ISOLATION (dB)			LO-IF ISOLATION (dB)			IP3 at center band (dBm)										
		Mid-Band	Total Range	Max	L	M	U		L	M	U							
0.5-500	DC-500	5.0	0.10	6.5	7.8	70	50	55	35	45	30	65	45	40	25	30	20	15

1 dB COMPR. = +1 dBm typ.
 L = low range [1, to 10] U = upper range [10, to 100] M = mid range [10, to 100] U = upper range [10, to 100]

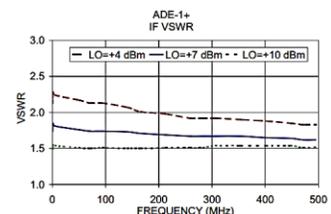
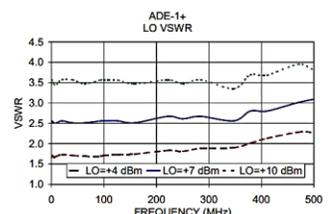
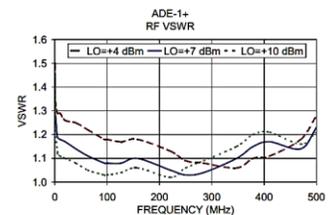
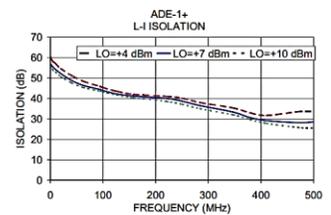
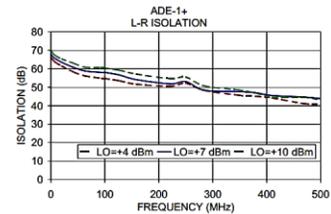
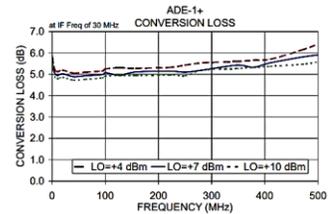
Typical Performance Data

Frequency (MHz)	Conversion Loss (dB)	Isolation (dB)		VSWR RF Port (1)	VSWR LO Port (1)	
		L-R (dB)	L-I (dB)			
RF	LO	LO +7dBm	LO +7dBm	LO +7dBm	LO +7dBm	
0.50	30.50	5.68	67.49	56.67	1.46	2.51
0.80	30.80	5.55	67.50	56.83	1.32	2.56
1.00	31.00	5.35	67.51	56.67	1.29	2.56
5.00	35.00	5.06	66.17	55.50	1.19	2.51
10.00	40.00	4.95	65.17	54.17	1.18	2.51
20.00	50.00	5.02	63.50	52.17	1.17	2.56
40.00	70.00	4.89	61.00	48.83	1.14	2.51
63.25	93.25	4.93	58.84	46.33	1.11	2.51
94.82	124.82	4.99	56.00	44.34	1.08	2.56
100.00	130.00	5.08	58.00	43.84	1.08	2.56
126.39	156.39	4.96	56.67	42.17	1.06	2.56
157.97	187.97	5.11	54.16	41.16	1.10	2.51
221.12	251.12	5.15	51.84	40.00	1.05	2.67
250.00	280.00	5.10	53.00	38.67	1.03	2.61
284.26	314.26	5.20	48.93	36.50	1.04	2.67
347.41	377.41	5.43	47.68	33.34	1.10	2.56
378.98	408.98	5.33	47.00	30.67	1.15	2.80
410.56	440.56	5.54	45.50	29.17	1.17	2.80
470.00	500.00	5.81	44.67	28.16	1.14	3.01
500.00	530.00	5.91	43.82	28.50	1.23	3.09

Electrical Schematic



Performance Charts



Notes
 A. Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.
 B. Electrical specifications and performance data contained in this specification document are based on Mini-Circuits' applicable established test performance criteria and measurement instructions.
 C. The parts covered by this specification document are subject to Mini-Circuits' standard limited warranty and terms and conditions (collectively, "Standard Terms"). Purchases of this part are entitled to the rights and benefits contained therein. For a full statement of the Standard Terms and the exclusive rights and remedies thereunder, please visit Mini-Circuits' website at www.minicircuits.com/MCIS/StandardTerms.jsp

NJM14570 IF Limiter/Demod

JRC
NJM14570

WIDE BAND FM IF DEMODULATOR

■ GENERAL DESCRIPTION

The **NJM14570** is a wide band IF IC with a maximum IF input frequency of 15 MHz. It includes an IF Amplifier, Quadrature Detector and RSSI.

■ MAIN APPLICATIONS

- RF ID
- Radar detector
- Wireless Infrared Communication System
- Voice Transmission System
- A few MHz band Signal Detector

■ FEATURES

- Wide Range Operating Voltage: 1.8V to 9V (recommended supply voltage)
- Low Operating Current: 2.9mA (Typ., No Signal)
- Wide Range IF Input Frequency: 10.7MHz (Standard) up to 15MHz (Reference)
- Wide Band FM Detector Range: DC to 1MHz (Reference)
- High FM Detection Sensitivity: -87dBm (12dB SINAD, typ.)
- Package Outline: MSOP8 (TVSP)*

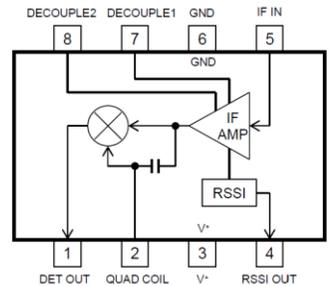
*JEDEC MO-187-DA / thin type

■ PACKAGE OUTLINE



NJM14570RB1

■ BLOCK DIAGRAM



Ver.2017-03-29

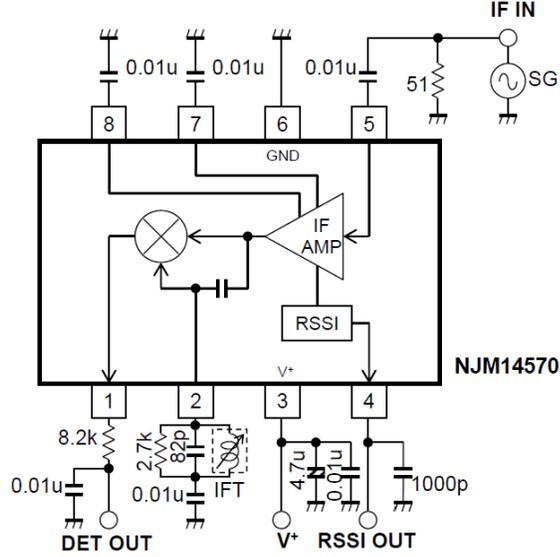
New Japan Radio Co., Ltd.

- 1 -

JRC
NJM14570

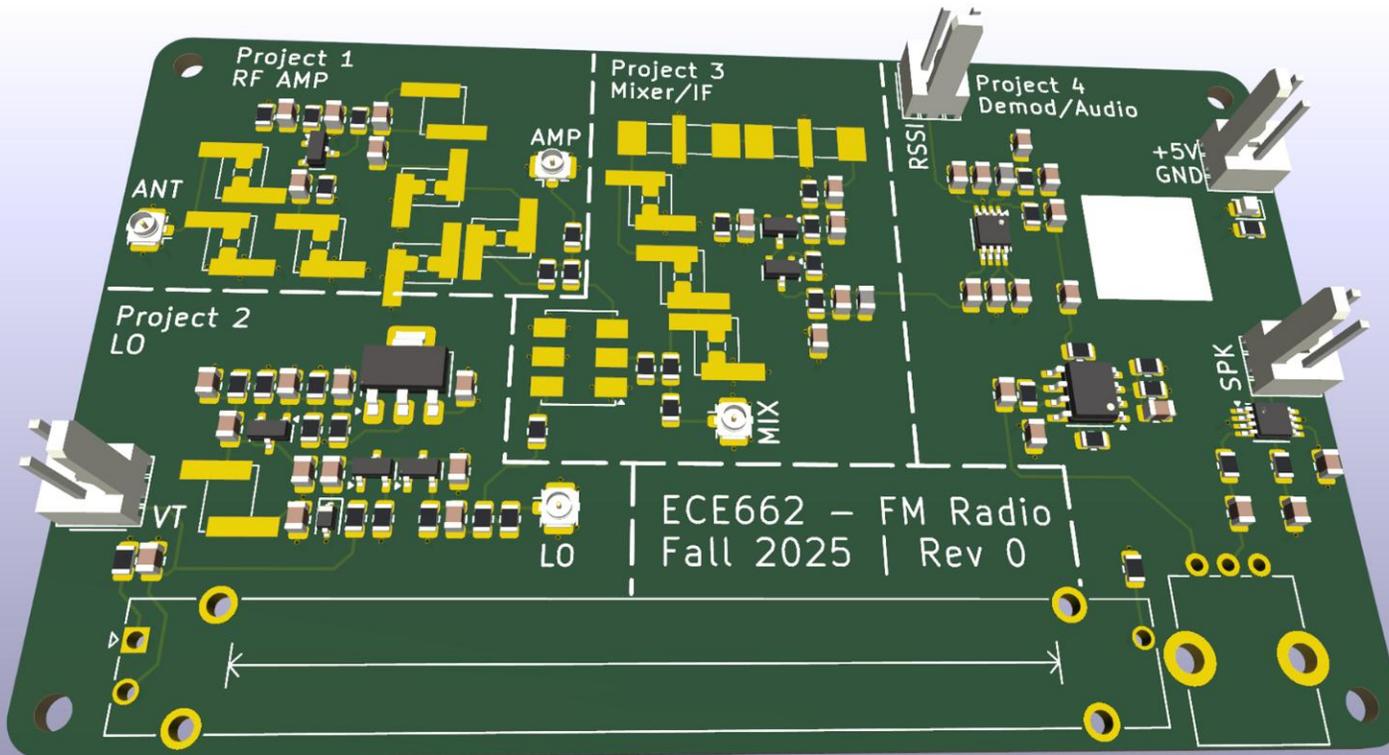
TEST CIRCUIT

This test circuit allows the measurement of all parameters described in "ELECTRICAL CHARACTERISTICS".



IJFT:10.7MHz IF Transformer

KiCad Rev 0 Layout and 4-layer PCB (Layout Courtesy of Garrett Peterson)



Radio Design 101
Appendix C

RF Circuit Construction & EMC
(The How and Why)

30 MHz

77 GHz

Considering E field only:
 $V_{\text{exits}} = V_{\text{gressor}} \frac{(Z_{C2} \parallel R_{\text{out}} \parallel R_{\text{in}})}{Z_{C1} + (Z_{C2} \parallel R_{\text{out}} \parallel R_{\text{in}})}$
 $Z_{C2} = Z_{C2a} + Z_{C2b} \ll Z_{C1}$

4-Layer board, KiCad & JLCPCB

1. Top (front) layer for components, interconnect
2. Internal layer 1 typically used for ground plane
3. Internal layer 2 typically used for power
4. Bottom (backside) layer may be used for components, interconnect

Layout in KiCad

Example Stackup from JLCPCB

Layer	Material Type	Thickness
Top Layer	FR4	0.127mm
Internal Layer 1	Copper	0.035mm
Internal Layer 2	Copper	0.035mm
Bottom Layer	FR4	0.127mm

Presentation Outline

Background and Introduction

Receiver Variants and Scoring

RD401 Block Diagram, Schematics, Parts List,
and PCB



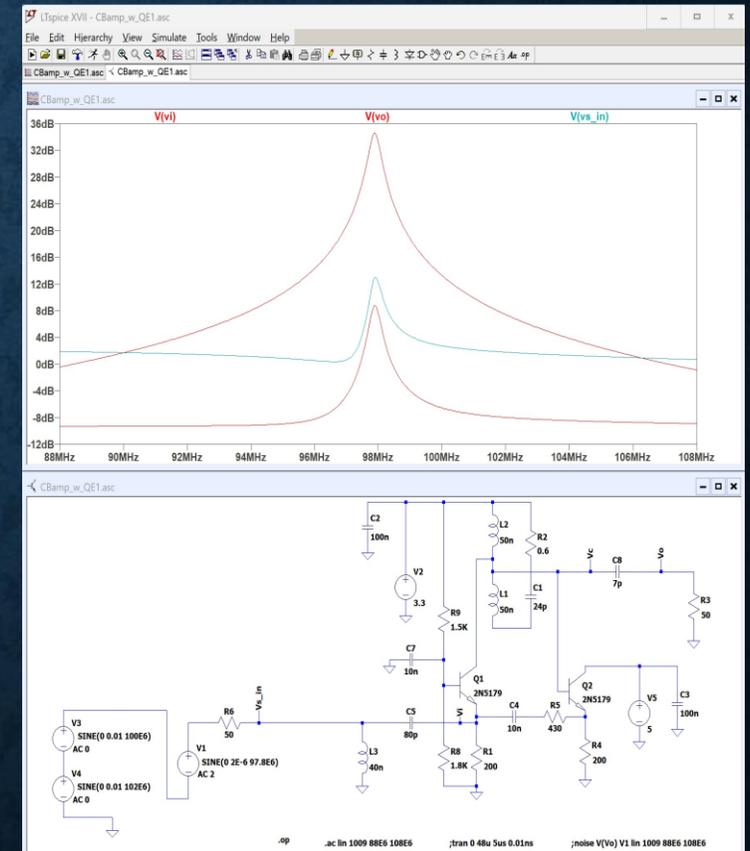
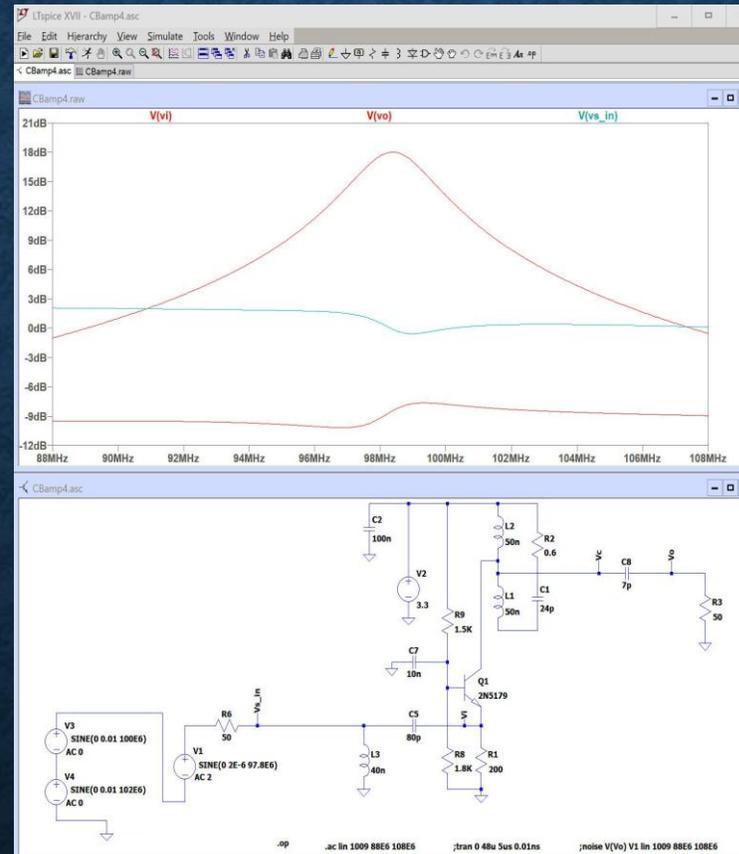
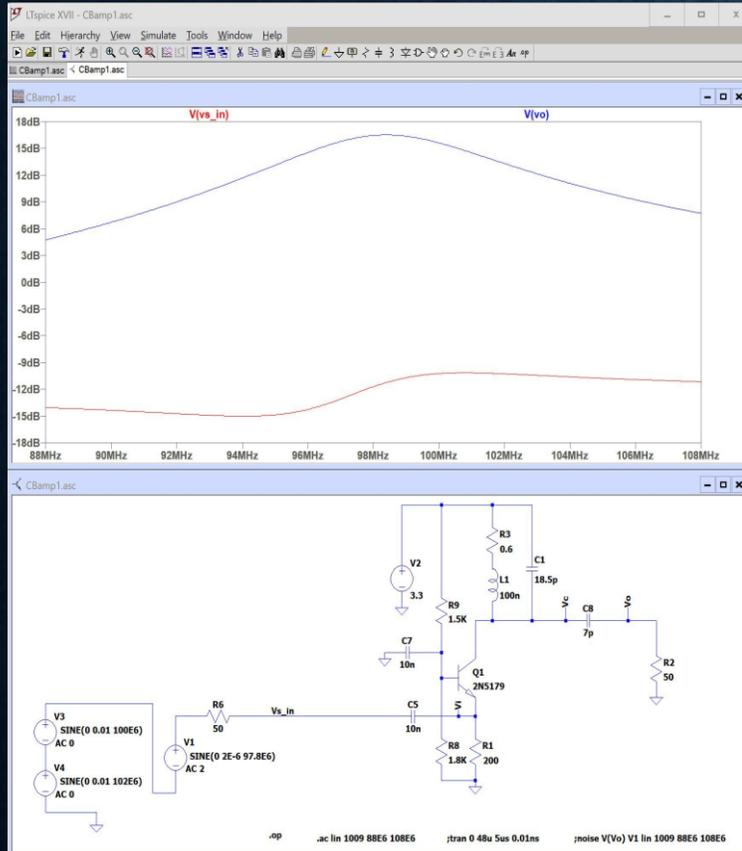
Future Videos

Upcoming Videos

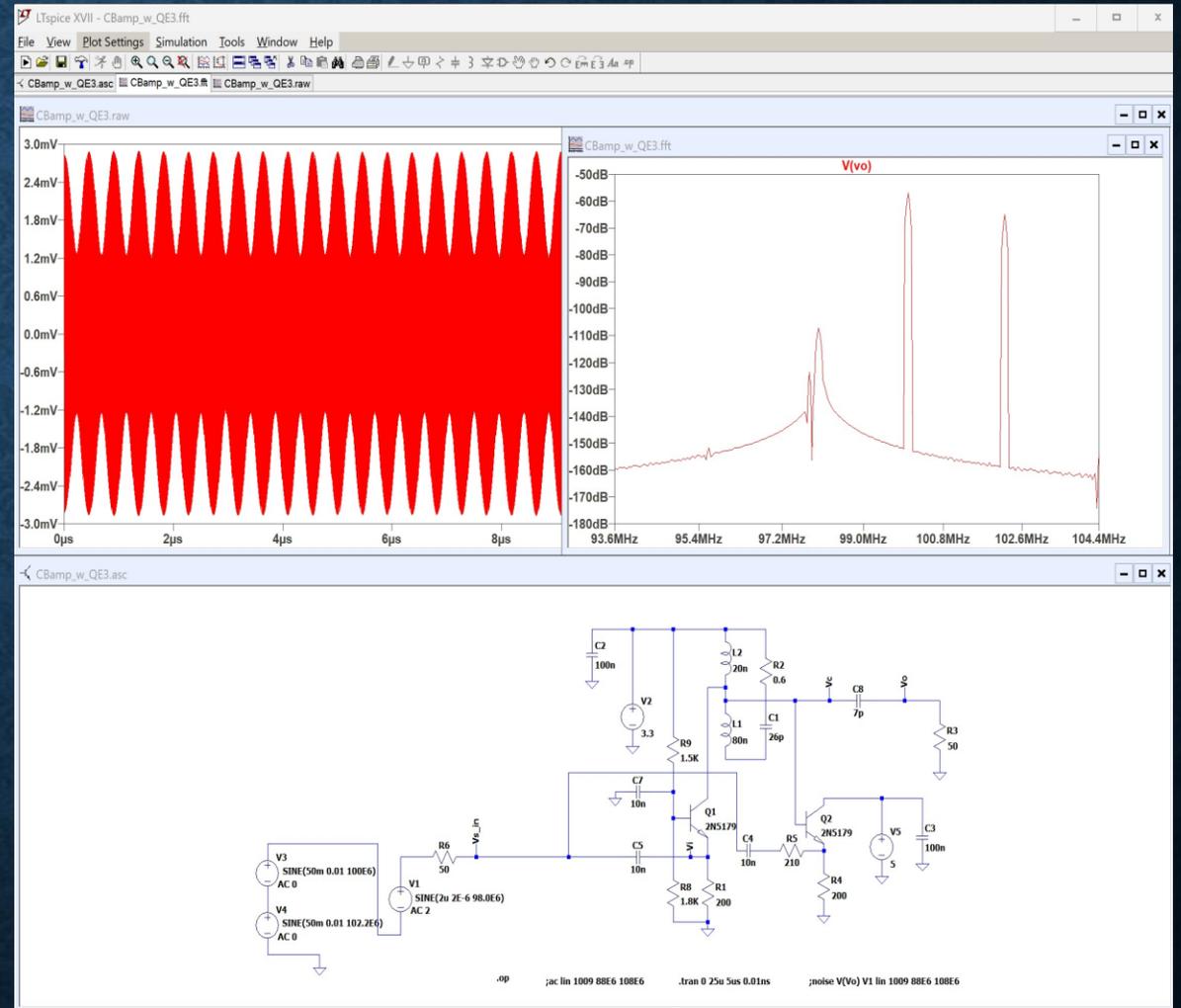
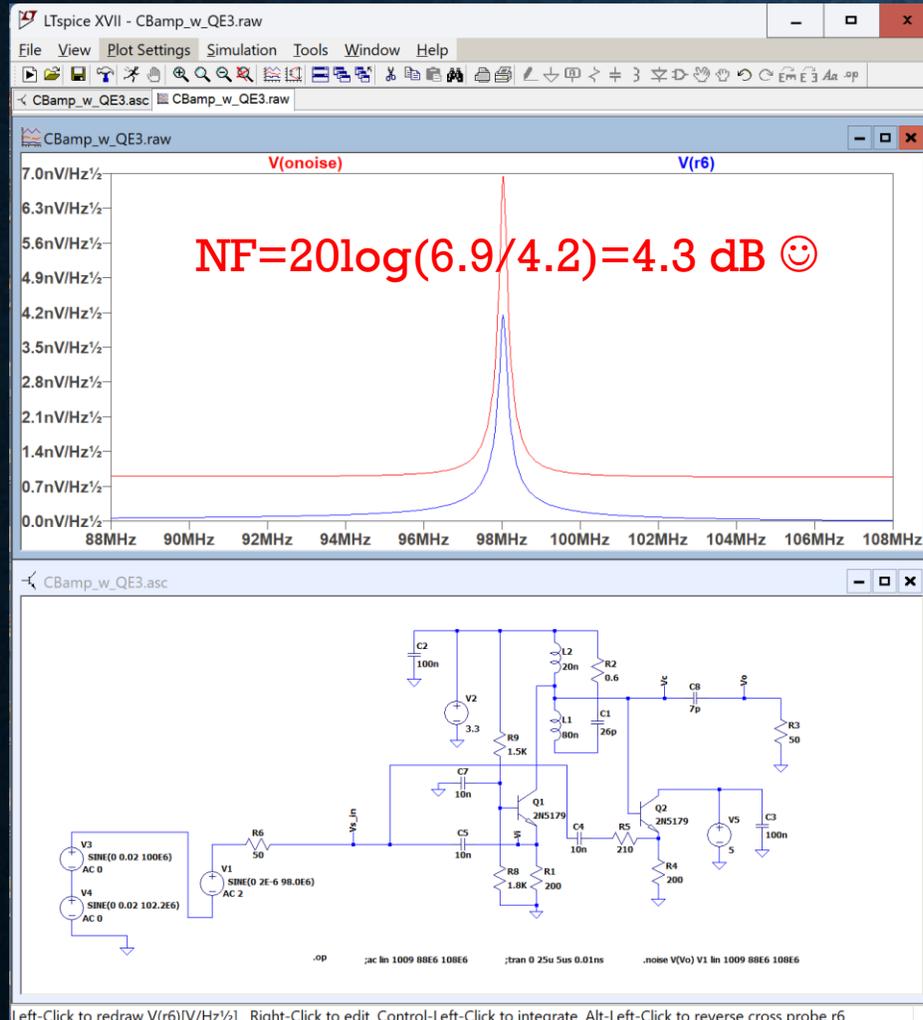
- *Receiver Design and Performance*
 - *RD-401 subcircuit design and simulations*
 - *Fabrication, testing, and more scoring ☺*
- *Design of Q-enhanced Front-ends**
 - *Core CB amplifier design (Q_o of inductors, feedback topology, biasing for desired gain and IP3 performance...)*
 - *Effects of positive feedback on gain, selectivity, input Z, ...*
 - *Self-tuning hardware and software*

* See: Benjamin Madrigal, “Design of ultra-narrowband Q-enhanced LNAs”
<https://krex.k-state.edu/items/cd35ae2c-e4af-4261-a7cd-9118d1e0c7b6>

Preview: Front-End Variants

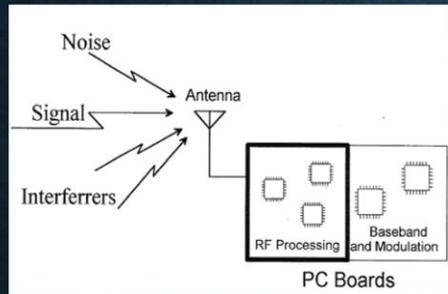


QE Front-End NF and Intermods

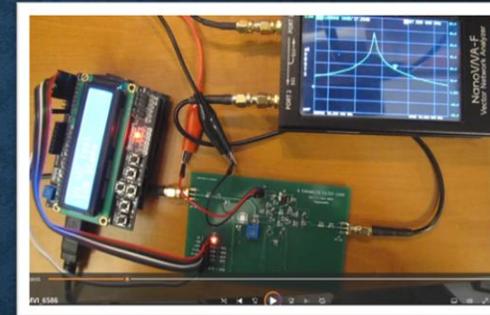


For More on QE Front-Ends, see:

Radio Design 401



Episode 1
Part 3 of 3



Low-power Receivers in Crowded Spectrum Environments

[MegawattKS - YouTube](#)

[ecefiles.org](#)

*Thanks For
Watching !*