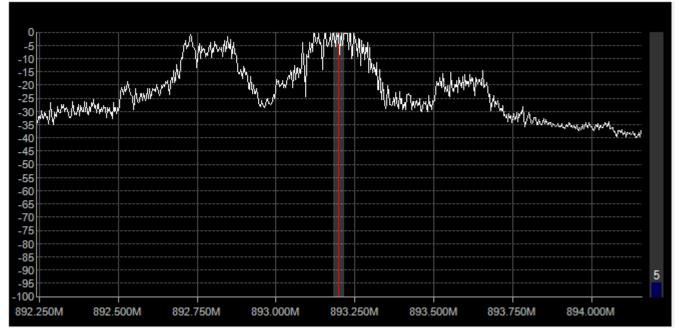
Disclaimer:

This document is intended to document and analyze the performance of the Open Source ADS-B Receiver (aka Stratux) Project. All data in this analysis was collected from the author's Open Source ADS-B Receiver Build. Due to variations in component selection and packaging of the Receiver project the performance of other Open Source ADS-B Receivers may differ from those of the author.

This a series of notes I took while testing the gain on a pair of Nano 2 SDRs.

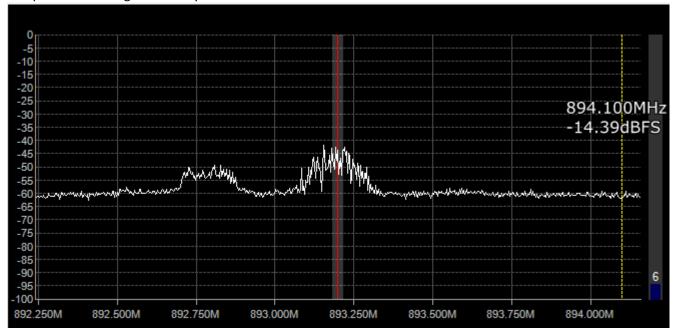
I set up a Nano 2 running SDR# as a spectrum analyzer and monitored the GSM850 band. One thing I discovered is how much "junk" these devices receive when the gain is set to 48 dB. I am running a cell phone booster at my house and as a sanity check I turned it off and observed the GSM signal drops about 30 dB which correlates with the published gain of my booster. For each of these tests I am monitoring GSM850 channel 248 (893.2 MHz). The antenna is the dmurray14 High Gain 978 MHz antenna. The antenna was connected to the SDR via a 6" MCX to SMA pig tail.



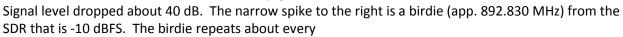
This figure is with the SDR gain set at 48 dB. The peak GSM signal is approximately -2.5 dBFS.

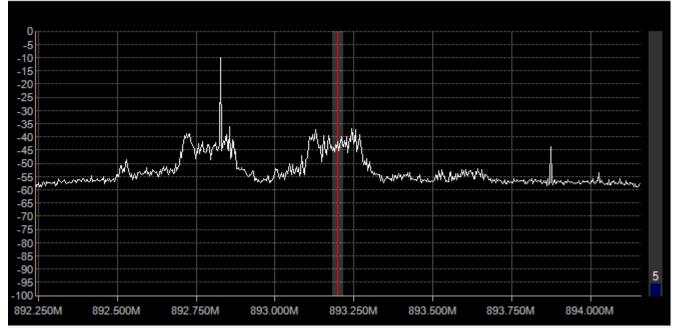
Same signal, Gain = 0 dB:

The signal level drops about 46 dB to 48 dB. This shows the receiver amplifier is not driven into compression at full gain with my cell booster.

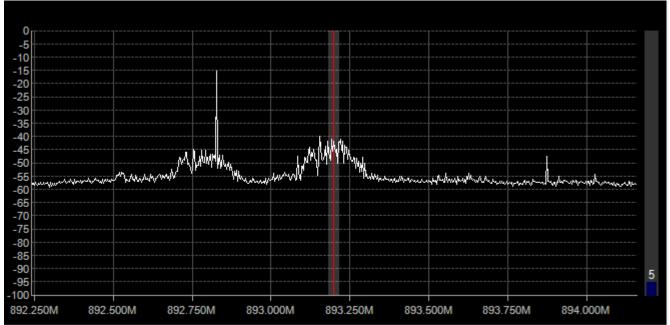


Gain 48 dB, Antenna disconnected from the pig tail.

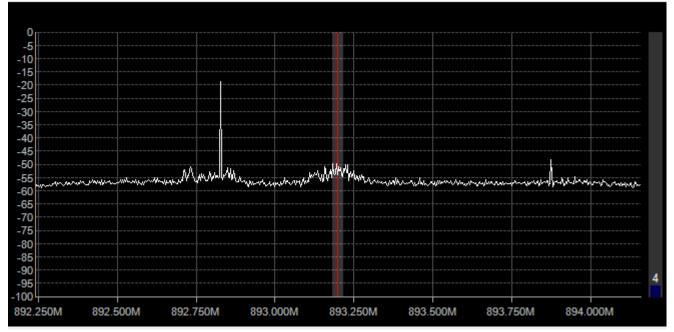


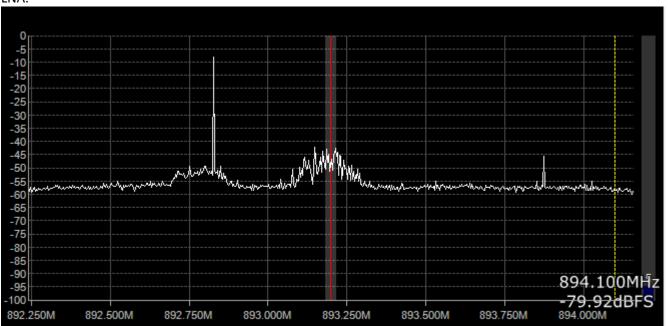






Gain 48 dB, Antenna 50 ohm load, shield of aluminum foil around dongle. This is the best I could get with a crude shield around the dongle. Even with the shield, the GSM signal is still about 5 dB above the noise floor.

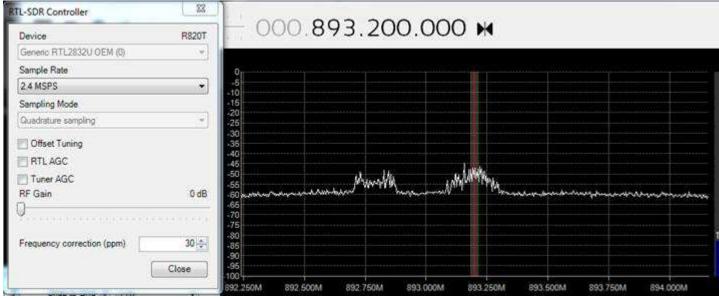




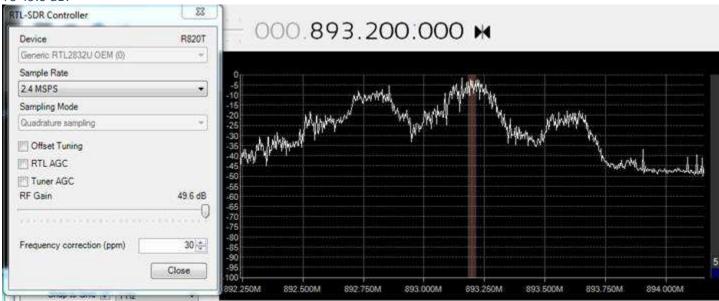
Gain 48 dB. Pig tail removed from the SDR. All received signal is coupled in to SDR and amplified by the LNA.

Note:









Gain measurements using kalibrate:

Using kalibrate, -1 dB is appears be minimum gain, 0 dB appears to be AGC enabled, and 49.6 dB is maximum gain. Also note the change in the "channel detect threshold" at each setting.

root@raspberrypi:/stratux# kal -v -d 0 -g -1 -s GSM850 Found 1 device(s): 0: Generic RTL2832U OEM Using device 0: Generic RTL2832U OEM Found Rafael Micro R820T tuner Exact sample rate is: 270833.002142 Hz [R82XX] PLL not locked! Setting gain: -1.0 dB kal: Scanning for GSM-850 base stations. channel detect threshold: 24502.637734 GSM-850: chan: 248 (893.2MHz - 37.098kHz) power: 29255.77 root@raspberrypi:/stratux# kal -v -d 0 -g 0 -s GSM850 Found 1 device(s): 0: Generic RTL2832U OEM Using device 0: Generic RTL2832U OEM Found Rafael Micro R820T tuner Exact sample rate is: 270833.002142 Hz [R82XX] PLL not locked! kal: Scanning for GSM-850 base stations. channel detect threshold: 39190.954479 GSM-850: chan: 151 (873.8MHz + 6.693kHz) power: 78836.78 chan: 231 (889.8MHz - 37.367kHz) power: 40040.07 chan: 246 (892.8MHz - 38.167kHz) power: 307061.84 chan: 248 (893.2MHz - 38.068kHz) power: 346263.35 chan: 250 (893.6MHz - 37.025kHz) power: 75486.58 root@raspberrypi:/stratux# kal -v -d 0 -g 49.6 -s GSM850 Found 1 device(s): 0: Generic RTL2832U OEM Using device 0: Generic RTL2832U OEM Found Rafael Micro R820T tuner Exact sample rate is: 270833.002142 Hz [R82XX] PLL not locked! Setting gain: 49.6 dB kal: Scanning for GSM-850 base stations. channel detect threshold: 307018.126667 GSM-850: chan: 231 (889.8MHz - 37.043kHz) power: 341677.82 chan: 246 (892.8MHz - 37.838kHz) power: 2687356.63 chan: 247 (893.0MHz + 36.455kHz) power: 1710824.27 chan: 248 (893.2MHz - 37.745kHz) power: 3701857.70

Testing gain with RTL1090:

Test Conditions:

Two Nano 2 dongles fed by the same antenna through a splitter. A phase variable line was utilized to tune the system to minimize the interaction between and maximize the signal to each dongle.

One dongle was connected to a PC running RTL1090 and the second dongle was installed in Stratux. Both dongles were turned to 1090 MHz. RTL1090 was used to tune and monitor the performance of the PC dongle while the Web UI and an EFB App was used to monitor Stratux.

Test Case #1:

RTL1090 was configured with the AGC active for both the IF amp and the LNA. The results are below.

This is the screenshot of the user's interface. The AGC is activated fit both amplifiers. This screenshot shows the receiver threshold is -83 dB. It also allows there are 77 aircraft being received including both Mode A/C and Mode S.



This is a screenshot of the RTL1090 map plot. It shows traffic from Southern Iowa through Northern Oklahoma. 20 unique Mode S targets are being tracked.

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AUH_KOYEKOJIKSHT_KLNK AAL17969A_KICL	K1Y3 RK0E9 KTAK RK4K
IX BRANZ BROCK F369	370 K46 0 K1Y3 0 0 K0E9 KTVK 0 K4K0 N168N3 0 K1H0 0 K0E9 KTVK 0 K4K0
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This is a signal plot from RTL1090. It provides a visual representation of the received signal. The long lines are Mode S signals. The shorter vertical in mic center through min bottom are Mode A/C signals. The shorter "dots" are noise bursts.

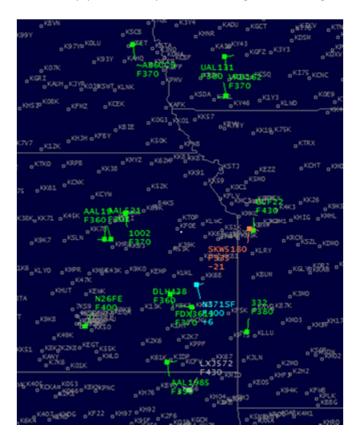
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Test Case #2:

In this condition the Tuner AGC is set to 49.6 dB (Max) and the LNA AGC is enabled. The receiver threshold increased to -88 dB. The total number of aircraft tracked dropped to 49.

CLSE	RTL109	0 - (c) jetvisi	on,de	- B:161		_	_ x
1090	0.0	0 0	N	1 H	z	ST	OP
Tuner AGC	OFF	ļ.	49.	6 dB	-	?	Test
RTL AGC	OFF S	end UDP		OFF			
Mode S	Mode AC	Config	, IIII	OFF	SISEX		OFF
ICAO C/S	ALT. MCP	V/S GS	TT	SSR	G#456^	5% M	SGS
882F40	F338						2
3C64EE DLH438	F360	\$15	190	6062			197
A14700 UAL131	F380	446	257				386
A7D651	F370			2663			310
AA3966	F390						410 E
AAF485	F370			1603			033
ABEBEO 1002	F370	478	085				197
ASDSED	F350						\$36
A29271	F342			2104			518
AB1183	F225			1165		3 1	155
A4344D FDX3613	F370	496	079				542
A3A986	F350			3643			\$30
AD0538 AAL1985	F390		081	1572			328
AA1BEO	F370			2475			996
AA7AE8 332	F380	404	276	7236			171
A57F42	F370			2033		4 1	791
A9A750 AAL51		\$33	193	2410			496
A03765 AAL19	F360	417	252				451
AA2ABC	F390			1541			162 👻
List Table Sta	its I/SI	Scope Pl	ug-ins		RTL	1090 hc	mepage
>10 >20 >40 >8	>120 >180				JOP BS	TCF	HTTP
78 ms 270/sec T	HR: -88db [3]	Port:3100	01 AJ	C: 49	R820T-	000000	01

In this map plot 15 unique Mode S targets are being tracked.



In this signal plot the number of received aircraft is down. Also, there is less noise presented to the detector.

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Test Case #3:

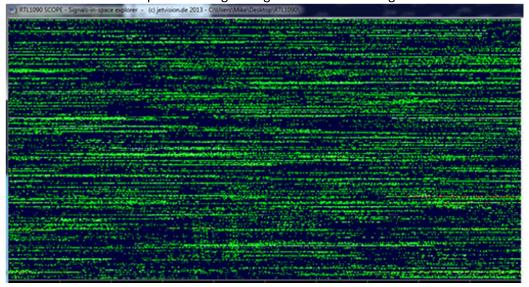
In this condition the Tuner AGC is set to 49.6 dB (Max) and the LNA AGC is disabled. I believe this sets the LNA gain to full. The receiver threshold increased to -77 dB enabled. The total number of aircraft being tracked increased to 67.

CLSE	RTL109	0 - (c) jetvisi	on.de - B:161		×	
1090	0.0	0 0	ΜH	z	STOP	
Tuner AGC	OFF	ļ.	49.6 dB	•	? Test	
	OFF S	end UDP	OFF			
Mode S	Mode AC	Config	OFF	SISEX	OF	F
ICAO C/S	ALT. MCP	V/S GS	TT SSR	G#456^	SK MSGS	
A80 65 6	F306		2147		11 316	1
3C64EE DLH438	F360	513	190 6062		15 5488	I
A14700 UAL131	F380	443	256		11 974	I
C397DB	G				11 3	
A86717 VRD409	F360	426			12 382	I
5A0819	F350				5 3	
8CA854	F350				9 8	
AA3966	F390		1407		20 712	
AAF485	F370		1603		18 3880	
ABEBE0 1002	F370	477	085 7360		21 987	
A805 60	F350		4130		11 1053	
AD5369					7 2	
A29271	F370		2104		18 1504	
AB1183	F260		1165		11 1619	1
A3A986	F350				6 7	1
A4344D FDX3613	F370	496			19 1092 18 794	
AD0538 AAL1985 AA18E0	F390	512	082 1572			
AA16E0 AA7AEB 332	F370 F380	202	2475		9 2170	
					14 1974	
List Table Sta	its IVSI	Scope P	ug-ins	RTL	1090 homepage	
>10 >20 >40 >80	5120 5180			UDP BS	TCP HTTP	
94 ms 525/sec T	HR: -77db [10	0] Port:310	01 A/C: 67	R820T	00000001	1

There are 17 unique Mode S aircraft in track.

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		KNOV? LOG N	ANNE KOGT			
KAKEZ OKTIKO	0 ^{KRPS} _ KR3	8	1664 F164 +22	SKST3 KEZ	z e ^{KOIT}	a ^{K3105}
	V Day		1664	KSHO KSHO		
0 ¹⁰⁰⁷⁵ 0 ¹⁰⁰⁰	11 0	aK\$2K	F164	100400		
	o KCVW	2.44	+22 \	di LEBCARIO	IEX _NOC26	
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e10(51 e10	signande ^{ezter} ikssik	F360				More
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The signal plot shows an increase in the amount of noise that is presented to the detector. It is getting difficult for a human to pick out the good signals from the bad signals.

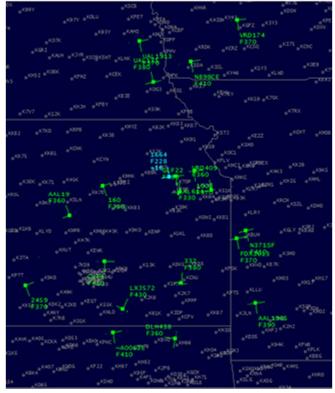


Test Case #4:

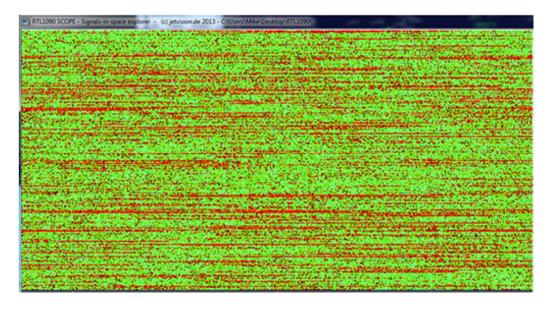
The Tuner AGC is enable and the LNA AGC is disabled. The receiver threshold increased to -72 dB. This a 11 dB decrease in receiver sensitivity over Test Case #1. Also at 70 it is tracking 7 few aircraft than Test Case #1.

CLSE RTL1090 - (c) jetvision.de - 8:161 X
1090.000 MHz stop
Tuner AGC
RTL AGC OFF Send UDP OFF
Mode S Mode AC Config OFF SISEX
<pre>*50 AA 7A EB 00 00 01; [131] *50 AO 53 69 00 00 07; [79] *59 A2 AF EB 00 00 00; [167] *50 A0 53 69 00 00 07; [100] *50 A0 53 69 00 00 07; [100] *50 AD 53 69 00 00 07; [72] *50 AD 53 69 00 00 07; [72] *50 AD 53 69 00 00 07; [79] *50 AD 53 69 00 00 07; [79] *50 A0 53 69 00 00 07; [79] *50 A0 53 69 00 00 07; [60] *50 A0 51 84 00 00 00; [70] *50 A0 56 23 00 00 01; [173] *50 A0 56 23 00 00 01; [174] *50 A0 56 23 00 00 01; [171] *50 A0 56 23 00 00 01; [171] *50 A7 56 6A 00 00 07; [66]</pre>
List Table Stats IVSI Scope Plug-ins RTL1090 homepage
5101 5201 5401 5001 5100 5100 UDP BS TCP HTTP 140 ms 390/sec THR: -72db [18] Port:31001 A/C: 70 R820T-00000001

This map plot shows 19 Mode S aircraft in track.



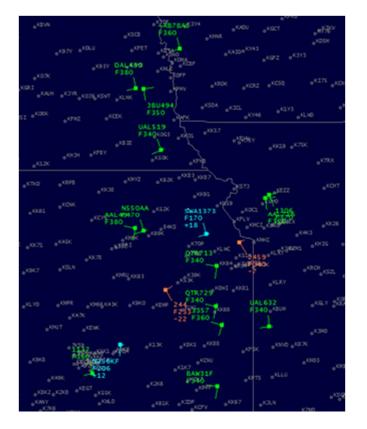
The signal plot shows excessive noise to the point that it is almost impossible for a human to see the aircraft signals.



As stated earlier, Stratux was monitored in parallel with the RTL1090 data collection. Below is a screenshot of the Stratux Traffic page. At no point in the testing did the Stratux Nano 2 track as much 1090 traffic as the RTL1090 Nano 2 device.

Flight	Speed	Altitude	Course	Location	Power (dB)	Age
+ AB6203	KTS	35,000	*	39" 3' 27" -96" 54" 33"	-35.17	40.5s
+ UAL131	440 KTS	38,000	255°	40° 30' 45" -96° 12' 0"	-37.45	6.7s
+ VRD409	425 KTS	36,025	260°	38° 58' 7" -95° 1' 14"	-33.42	45.8s
+ AAL614	450 KTS	33,000	080°	39° 12' 4" -95° 28' 0"	-33.55	0.4s
+ 1664	435 KTS	24,725 1900	260°	39" 8' 55" -95" 55' 39"	-34.75	0.25
+ FDX3613	510 KTS	37,0501100	080*	38° 18' 7" -94° 18' 30"	-34.17	0.7s
+ 1002	475 KTS	37,0001100	085°	39° 15' 57" -95° 5' 33"	-31.12	1.55
+ GUF22	435 KTS	43,0001100	270°	38° 56' 19" -95° 44' 42"	-28.90	1.15
+ N3715F	410 KTS	41,000	075°	38° 24' 24" -94° 12' 4"	-34.05	2.05

As a sanity check, data was collected a few hours later from each device. The Stratux Nano still tracks fewer targets than the RTL1090 Nano.





Menu		Stratux						O HELP
🕷 Staturi	3	Traffic Contract						
Weather	>	Flight	Speed	Altitude	Course	Location	Power (d8)	Age
	X0	4-1306	450 KTS	37,0001100	070*	39* 39' 31* -94* 30' 16*	-33,40	11.6s
K Traffic	•	- AALAN	525 KTS	38,000	195*	39" 23' 42" -96" 26' 29"	-32.48	0.1s
and a state of the second s		+ RAL716	455 KTS	35,0251100	085*	39" 38' 51" -94" 34' 18"	-35.85	14.96
GPS/AHRS	>	4 2367	490 KTS	36,0001100	195*	38' 13' 17" -95' 4' 18"	-29.82	0.26
_d Towers	>	+ 078729	555.KTS	34,000	195*	38" 27" 30" -95" 10' 7"	-29.76	0.5s
2 c		4 2459	255 KTS	4,67511700	060*	39' 5' 41" -94' 52' 19'	-34.98	0.7s
0Logs	>	Ar. 1010	KTS	38,000		41" 1" 56" -96" 14' 2"	-37.90	59.40
2023273311	242	4 244	380 KTS	25,07512400	060*	381 301 41 -961 41 471	-31.41	0.8s
Settings	>	+ HEREAN	445 KTS	47,000,1100	255*	39" 17' 23" -96" 12' 50"	-33.3Z	2.16
		4 141519	450 KTS	34,000	250*	40' 17' 26" -95" 54' 54"	-34.60	12.75
		-+ CAL632	435 KTS	33,975	265*	38" 5" 52" -94" 14' 36"	-30.21	0.1s
		4 SHA1373	385 KTS	15,32510400	255*	39' 14' 43' -95' 14' 38'	-29.75	0.3s
		+ 018713	560 KTS	33,975	190*	33" 0" 4" - 95" 9" 14"	-29.42	20.7s