Chinese preamplifiers

When surfing on the Internet, a lot of very nice, very low noise preamplifiers can be found for a very reasonable price. In the latest ones, sophisticated transistors or FET's are used, providing high gain and low noise, even on higher frequencies.

I purchased some of these amplifiers and tested them with my, limited, noise measuring system.

Measurement setup

In the past I made a CANFI (http://www.canfi.eu/) but the results were not very satisfactory. I also own a Signalhound spectrum analyser, BB60C and with this instrument, the Spike software and a noise source, it is possible measuring the gain and the noise factor of an amplifier.

As a poor radio amateur I cannot afford an expensive 346B noise source from HP but I bought an RFD 2305 from RF Design in the UK:

To make measurements possible, the noise source is calibrated and the calibration table (ENR table) is provided with each device. I do not know if the noise sources are still available but you can look to the website g8fek.com.

I measured the gain and noise figure at fixed frequencies and taking an average over 25 samples.

Reference

Of course it is important to know what you are measuring and therefore I used a Mini Circuits amplifier: ZKL-2R7. This amplifier is well documented:

FREQUENCY (MHz)	GAIN (dB)			DIRECTIVITY (dB)			VSWR (:1)		NOISE FIGURE (dB)	POUT at 1 dB COMPR. (dBm)
	9V	12V	13V	9V	12V	13V	IN	OUT	12V	12V
10.00	23.43	24.35	24.33	12.93	13.06	13.09	1.19	1.47	5.54	16.51
210.00	23.77	24.89	24.99	12.05	11.69	11.75	1.18	1.36	4.88	17.07
460.00	23.76	24.88	24.97	11.97	11.65	11.64	1.24	1.41	4.97	17.26
710.00	23.77	24.83	24.92	11.97	11.72	11.76	1.32	1.49	5.02	17.66
910.00	23.78	24.80	24.88	12.01	11.85	11.83	1.41	1.54	5.08	17.65
1010.00	23.74	24.73	24.82	12.05	11.81	11.84	1.41	1.57	5.08	17.78
1210.00	23.70	24.66	24.74	11.92	11.83	11.89	1.45	1.56	5.05	17.75
1460.00	23.67	24.61	24.69	12.09	12.01	11.93	1.44	1.49	5.01	17.78
1710.00	23.76	24.72	24.82	11.80	11.57	11.55	1.37	1.37	5.10	17.43
1910.00	23.70	24.69	24.79	11.91	11.56	11.48	1.29	1.25	5.21	17.40
2010.00	23.56	24.59	24.70	12.05	11.64	11.55	1.26	1.17	5.25	17.28
2210.00	23.34	24.41	24.52	12.43	11.85	11.73	1.20	1.06	5.26	17.42
2360.00	23.16	24.18	24.28	12.82	12.26	12.10	1.20	1.09	5.29	17.07
2560.00	22.75	23.72	23.81	13.52	12.96	12.67	1.25	1.21	5.31	16.62
2700.00	22.09	23.09	23.16	14.33	13.66	13.74	1.32	1.30	5.36	16.49

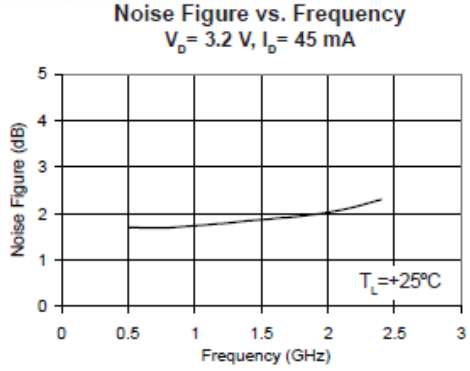
On 144.3 MHz, I measured a noise figure of 4.36 and a gain of 24.52 dB. That seems to be good. Let's try 1296.3 MHz: noise figure 4.80 dB and 25.48 dB gain.

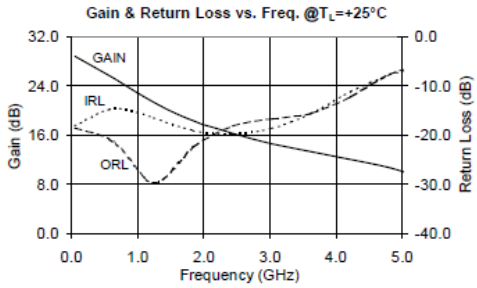
The measurements seem to reliable and according to the Mini Circuits specifications.

Measuring results

4 GHz, 1.9 dB NF

The first amplifier was one in a small box, specified for 50 kHz to 4 GHz and a noise figure of 1.9 dB. The MMIC inside is an RFMD SGA4586Z. The supply voltage is 3.6 Volt. Two resistors of 360 Ohm each in parallel are used for biassing the MMIC.



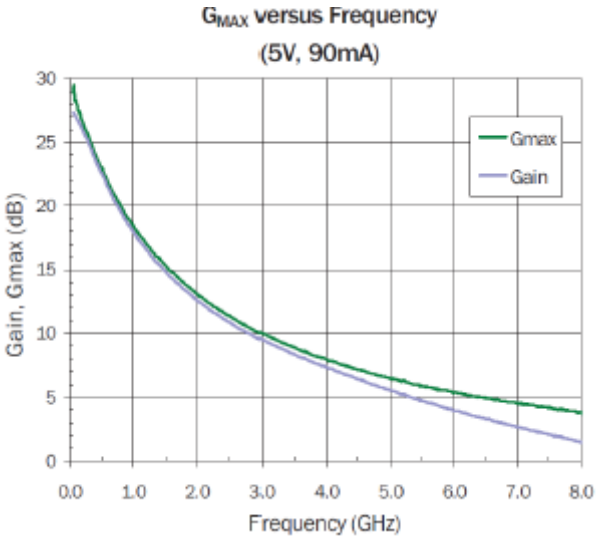


According to the specifications, the noise figure is 1.9 dB for frequencies between 500 MHz and 1 GHz. Below 500 MHz, there is no specification for the noise figure. For 144 MHz the noise figure is at the lowest point: 2.05 but I did not measure over the whole frequency band (only on for us radio amateur interesting frequencies). The amplifier did draw 45 mA at 12 VDC. That is according to the specifications.

Frequency MHz	Gain dB	Noise Figure dB
28	22.23	3.95
50	22.01	3.24
144.3	28.96	2.05
432.2	27.05	2.39
1296.3	22.20	2.61

4 GHz, 0.6 dB NF

I also have a later model amplifier: specified for 50 MHz to 4 GHz with a noise figure of 0.6 dB. This amplifier is equipped with an SPF5189 from Qorvo. When I look to the specs of this pHEMT MMIC, the noise figure should be lower. This is probably caused by low cost, low quality components used in the amplifier. The gain seems to be as specified.



Typical RF Performance on Evaluation Boards

Parameter	0.8GHz	0.9GHz	1.0GHz	1.7GHz	1.8GHz	1.9GHz	2.0GHz	2.1GHz	2.2GHz	Unit
Small Signal Gain	19.6	18.7	17.9	13.8	13.5	12.9	12.7	12.2	11.9	dB
Noise Figure	0.52	0.55	0.79	0.75	0.81	0.83	0.90	0.91	0.98	dB
Output IP3	38.4	38.5	39.0	39.2	39.5	39.5	39.8	39.8	39.9	dBm
Output P1dB	22.3	22.4	22.5	22.6	22.6	22.7	22.7	22.7	22.7	dBm
Input Return Loss	17.1	17.5	17.5	17.5	17.5	18.5	18.5	18.5	18.0	dB
Output Return Loss	16.0	16.0	15.5	14.0	14.0	14.5	15.0	15.5	16.0	dB
Reverse Isolation	24.5	24.0	23.0	18.5	18.5	18.0	18.0	17.5	17.0	dB

Test conditions: VD +5V, ID 90mA, OIP3 0dBm/tone Δf 1MHz, T_{LEAD} +25°C, 50Ω system impedance

Frequency MHz	Gain dB	Noise Figure dB
28	26.38	1.85
50	26.76	1.19
144.3	26.91	1.05
432.2	23.37	1.26
1296.3	15.93	1.25

Both the SGA4586Z and the SPF5189 are obsolete but the Chinese manufacturers seem to have more than enough in stock: the amplifiers are widely available on AliExpress
When we radio amateurs use a better quality PCB and good quality components (especially capacitors), I think we will be able to improve the noise figure for the boards. Nowadays there are better components available but these are hard to process (for my 70 year old eyes and hands these components are a bit too small). I enjoy playing around with RF stuff and I hope many others do the same.

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