

SPF-5043Z

Low-Power LNA With <1dB Noise Figure

Introduction

RFMD has a wide selection of LNAs to suit a variety of applications, however, it is notable that all the LNAs with <1.0dB noise figure are also high linearity parts with relatively high power consumption.

RFMD's LNAs with <1dB NF broadly fall into two families: the RF386x series and the SPF-5xxxZ series. (The RF2815 has an integrated SAW filter which restricts its use over a wide frequency range.) But the single-amplifier RF3861/3863 draw 90mA and the lowest-powered SPF, the SPF-5043Z, consumes >75mW.

Of the low-power LNAs, the RF237x series have typical NFs of 1.6dB. The lowest NF on paper is achieved by the RF2878 (1.3dB at 900MHz) or SGL-0363 (1dB at 200MHz, 1.2dB at 900MHz).

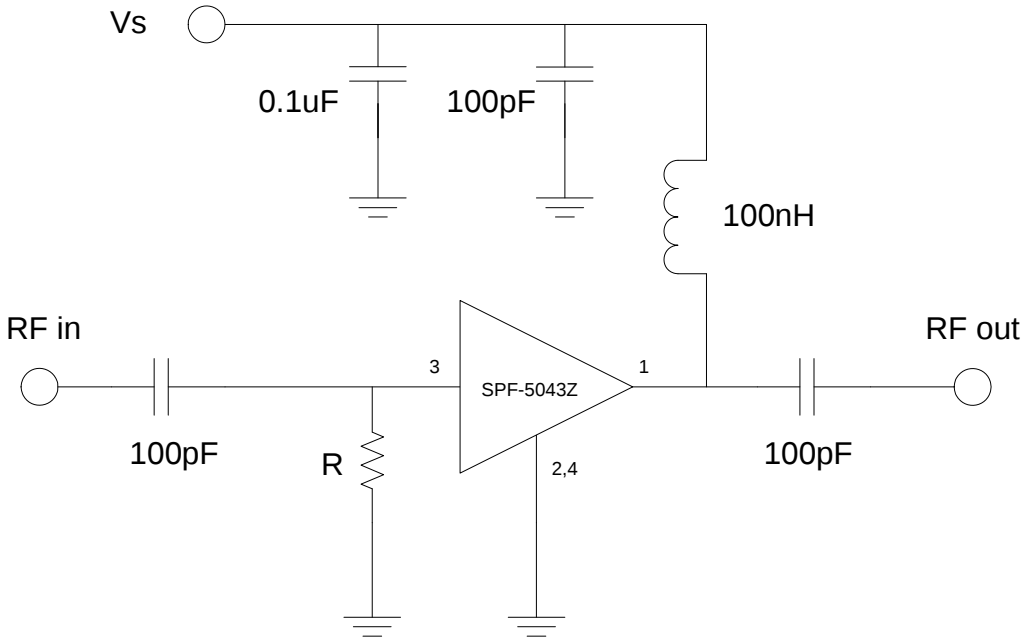
This paper is based on the work done for a customer request of <1dB NF with <50mW power consumption. The lowest-powered of the <1dB LNAs is the SPF-5043Z, which under normal conditions has a lowest bias point of $V_{CC}=3.0V$, $I_{CC}=25mA$. The question became whether it was possible to re-bias it to even lower currents without compromising NF too much, accepting some sacrifice of linearity. There is a technique used on the two-stage SPF-5344Z to limit its current consumption by fitting a shunt resistor from the RF input to ground. Using the same technique, the supply voltage and shunt resistor value were adjusted to give bias currents of 15mA, 10mA, and 5mA.

Measurements were made at the same frequencies as the application schematic in the data sheet, to allow comparison with the two bias settings of 5V at 46mA and 3V at 25mA. (100MHz was omitted because this was measured with a bias tee.) Results are shown below as tables and graphs.

Current	V _S	R	Power Consumption
5mA	3.41V	12kΩ	17.1mW
10mA	3.17V	22kΩ	31.7mW
15mA	4.05V	22kΩ	60.8mW

Note: The bias currents were achieved as follows.

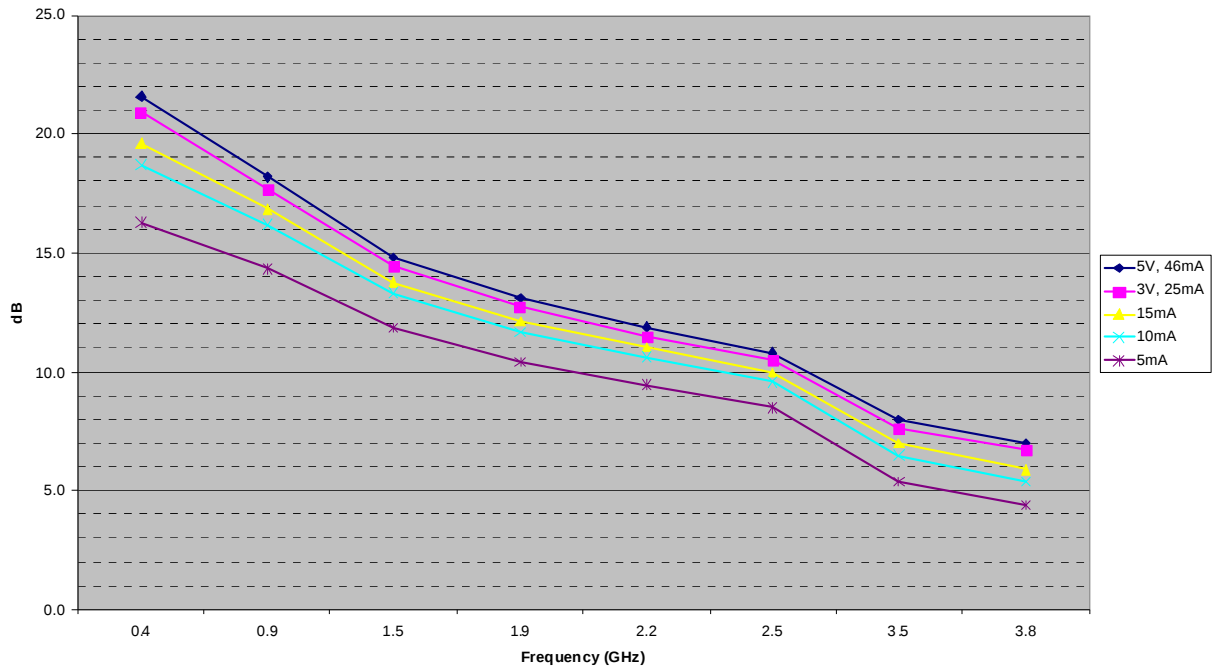
Schematic



Results

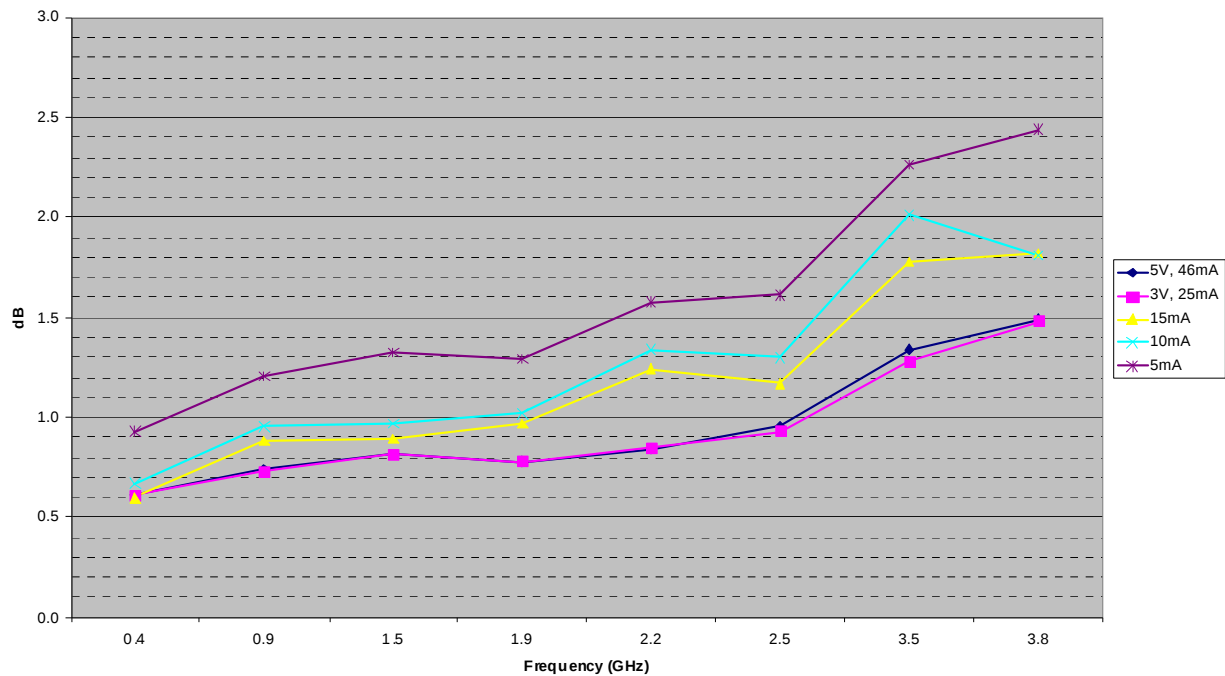
Small Signal Gain	0.4GHz	0.9GHz	1.5GHz	1.9GHz	2.2GHz	2.5GHz	3.5GHz	3.8GHz
5V, 46mA	21.6	18.2	14.8	13.1	11.9	10.8	8.0	7.0
3V, 25mA	20.9	17.7	14.4	12.7	11.5	10.5	7.6	6.7
15mA	19.6	16.9	13.8	12.1	11.0	10.0	7.0	5.9
10mA	18.7	16.2	13.3	11.7	10.6	9.6	6.5	5.4
5mA	16.3	14.3	11.8	10.5	9.5	8.5	5.4	4.4

SPF-5043 Small Signal Gain vs Bias Current

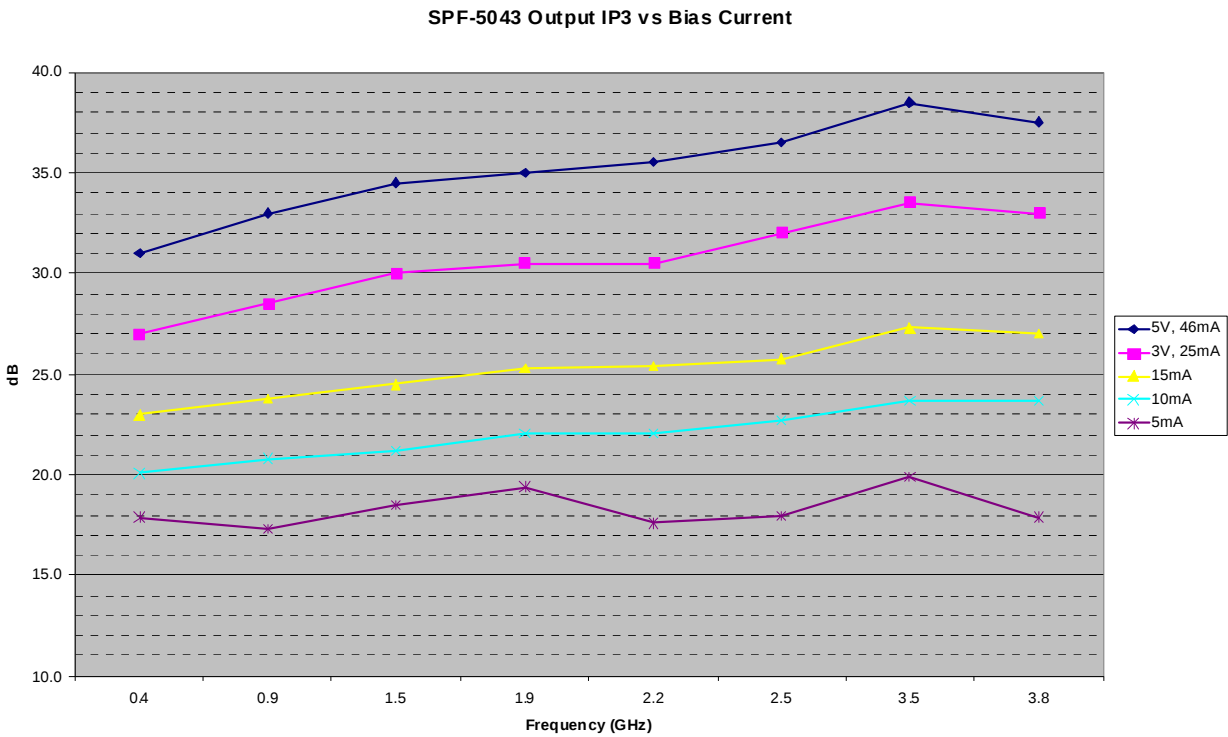


Noise Figure	0.4GHz	0.9GHz	1.5GHz	1.9GHz	2.2GHz	2.5GHz	3.5GHz	3.8GHz
5V, 46mA	0.61	0.74	0.82	0.78	0.84	0.96	1.34	1.49
3V, 25mA	0.61	0.73	0.82	0.78	0.85	0.93	1.28	1.48
15mA	0.60	0.88	0.90	0.97	1.24	1.17	1.78	1.82
10mA	0.67	0.96	0.97	1.02	1.34	1.30	2.01	1.81
5mA	0.93	1.21	1.32	1.29	1.58	1.61	2.26	2.44

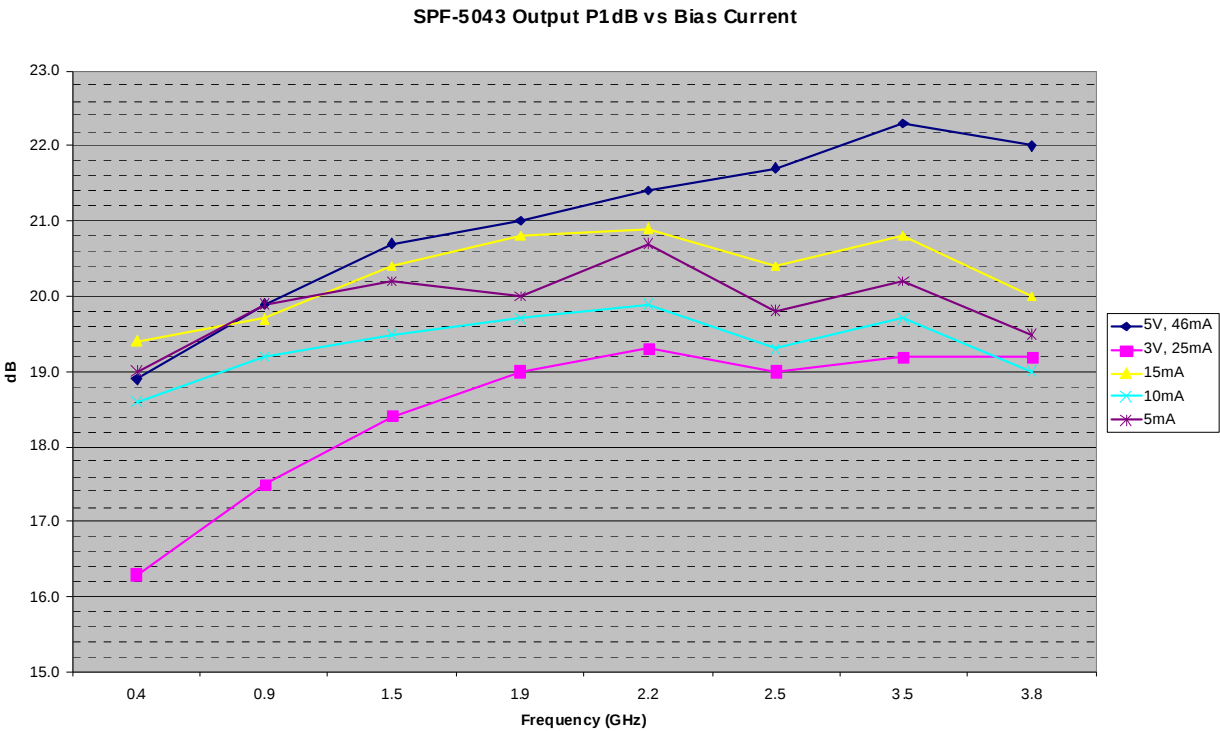
SPF-5043 Noise Figure vs Bias Current



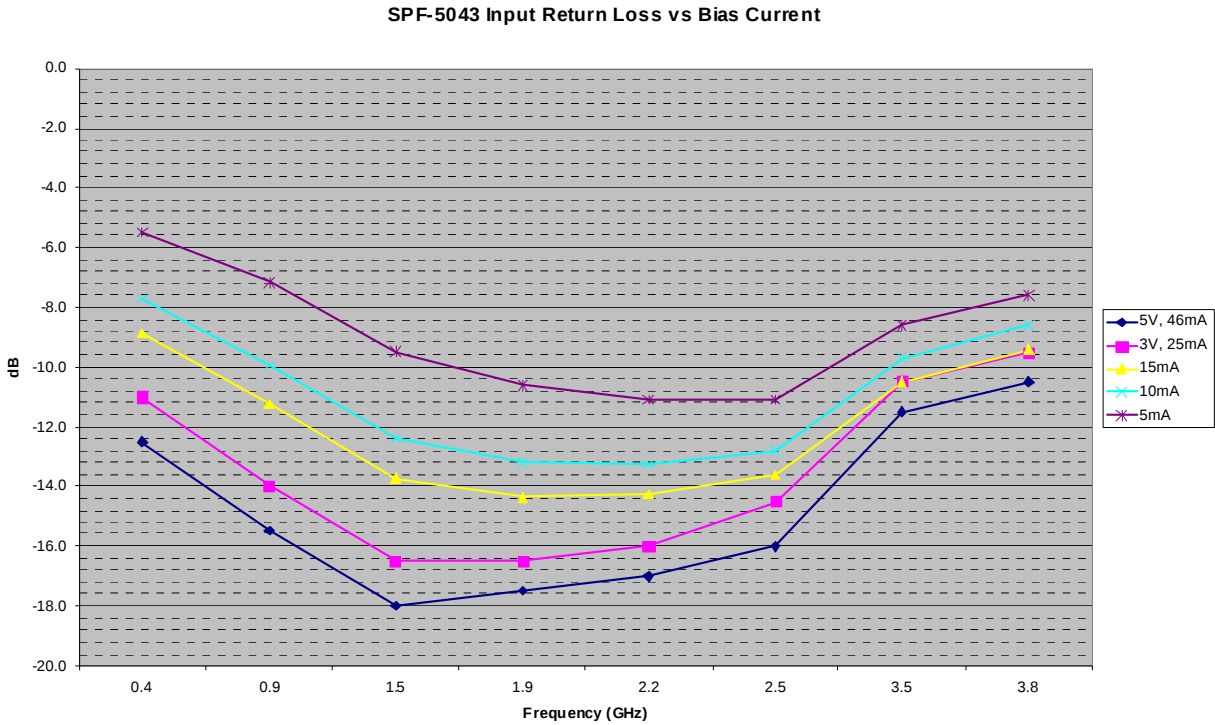
Output IP3	0.4GHz	0.9GHz	1.5GHz	1.9GHz	2.2GHz	2.5GHz	3.5GHz	3.8GHz
5V, 46mA	31.0	33.0	34.5	35.0	35.5	36.5	38.5	37.5
3V, 25mA	27.0	28.5	30.0	30.5	30.5	32.0	33.5	33.0
15mA	23.0	23.8	24.5	25.3	25.4	25.8	27.3	27.0
10mA	20.1	20.8	21.2	22.1	22.1	22.7	23.7	23.7
5mA	17.9	17.3	18.5	19.4	17.6	18.0	19.9	17.9



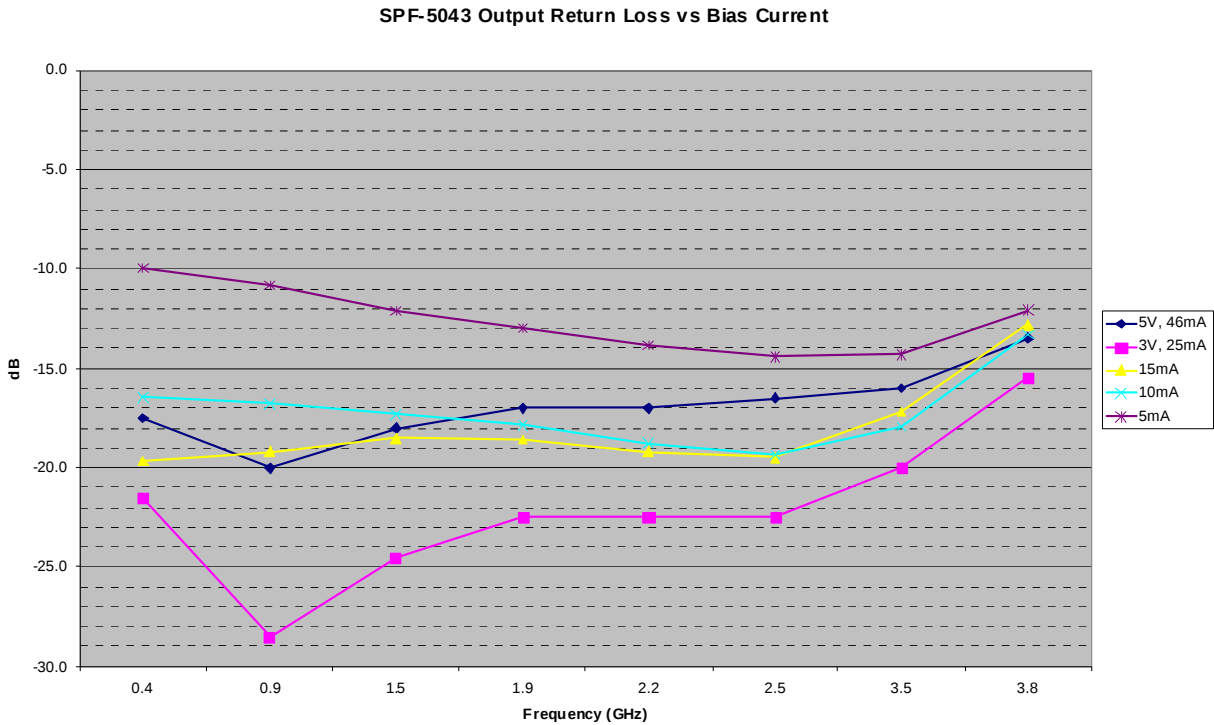
Output IP3	0.4GHz	0.9GHz	1.5GHz	1.9GHz	2.2GHz	2.5GHz	3.5GHz	3.8GHz
5V, 46mA	18.9	19.9	20.7	21.0	21.4	21.7	22.3	22.0
3V, 25mA	16.3	17.5	18.4	19.0	19.3	19.0	19.2	19.2
15mA	19.4	19.7	20.4	20.8	20.9	20.4	20.8	20.0
10mA	18.6	19.2	19.5	19.7	19.9	19.3	19.7	19.0
5mA	19.0	19.9	20.2	20.0	20.7	19.8	20.2	19.5



Input Return Loss	0.4GHz	0.9GHz	1.5GHz	1.9GHz	2.2GHz	2.5GHz	3.5GHz	3.8GHz
5V, 46mA	-12.5	-15.5	-18.0	-17.5	-17.0	-16.0	-11.5	-10.5
3V, 25mA	-11.0	-14.0	-16.5	-16.5	-16.0	-14.5	-10.5	-9.5
15mA	-8.9	-11.2	-13.7	-14.4	-14.2	-13.6	-10.5	-9.4
10mA	-7.7	-9.9	-12.4	-13.2	-13.2	-12.8	-9.7	-8.6
5mA	-5.5	-7.2	-9.5	-10.6	-11.1	-11.1	-8.6	-7.6



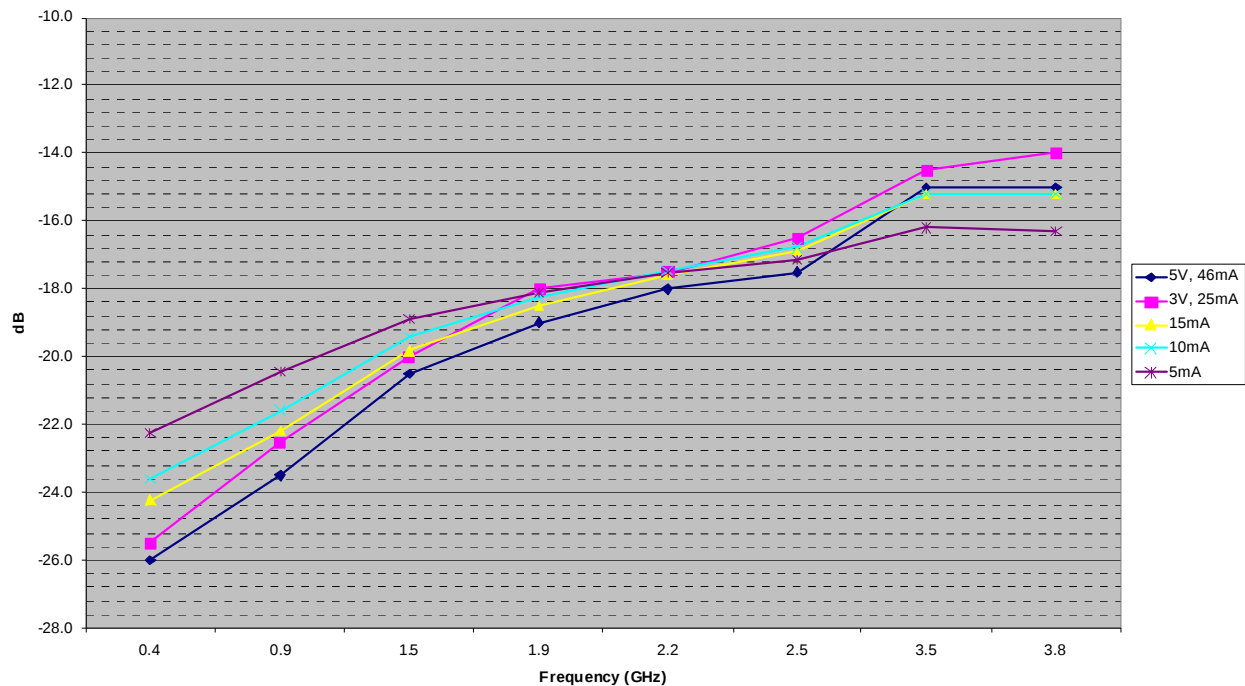
Output Return Loss	0.4GHz	0.9GHz	1.5GHz	1.9GHz	2.2GHz	2.5GHz	3.5GHz	3.8GHz
5V, 46mA	-17.5	-20.0	-18.0	-17.0	-17.0	-16.5	-16.0	-13.5
3V, 25mA	-21.5	-28.5	-24.5	-22.5	-22.5	-22.5	-20.0	-15.5
15mA	-19.7	-19.2	-18.5	-18.6	-19.2	-19.5	-17.2	-12.8
10mA	-16.5	-16.8	-17.3	-17.9	-18.8	-19.3	-17.9	-13.3
5mA	-10.0	-10.8	-12.1	-13.0	-13.8	-14.4	-14.3	-12.1





Reverse Isolation	0.4GHz	0.9GHz	1.5GHz	1.9GHz	2.2GHz	2.5GHz	3.5GHz	3.8GHz
5V, 46mA	-26.0	-23.5	-20.5	-19.0	-18.0	-17.5	-15.0	-15.0
3V, 25mA	-25.5	-22.5	-20.0	-18.0	-17.5	-16.5	-14.5	-14.0
15mA	-24.2	-22.2	-19.8	-18.5	-17.6	-16.9	-15.2	-15.2
10mA	-23.6	-21.6	-19.4	-18.2	-17.4	-16.8	-15.2	-15.2
5mA	-22.2	-20.4	-18.9	-18.1	-17.5	-17.1	-16.2	-16.3

SPF-5043 Reverse Isolation vs Bias Current



Conclusions

It can be seen that the performance degrades with decreasing current, the one exception being P1dB. The P1dB results for 5mA are surprisingly high; it is assumed that the SPF-5043Z is heavily-self-biased in this case. Although the SPF-5043Z is specified to 4GHz, the usable frequency range as an LNA (i.e. where gain > 10dB) is normally restricted to < 2.5GHz.

Where the noise figure is < 1dB (up to 2GHz, > 10mA) this application of the SPF-5043Z fills a gap in the RFMD portfolio not addressed by other parts. It is suitable for LNA applications where < 1dB NF is needed over 50MHz to 2GHz, with power consumption of 30mW to 75mW.

For applications where power consumption < 30mW and/or NF > 1dB, the RF2878 and RF2373/74 are recommended instead due to their lower cost and better OIP3.