AN1352
APPLICATION NOTE

A LNA OPTIMIZED FOR HIGH IP3out AT 1.9GHz USING THE NPN Si START420 TRANSISTOR

F. Caramagno - G. Privitera

Data at 1.9GHz (3V, 20mA)

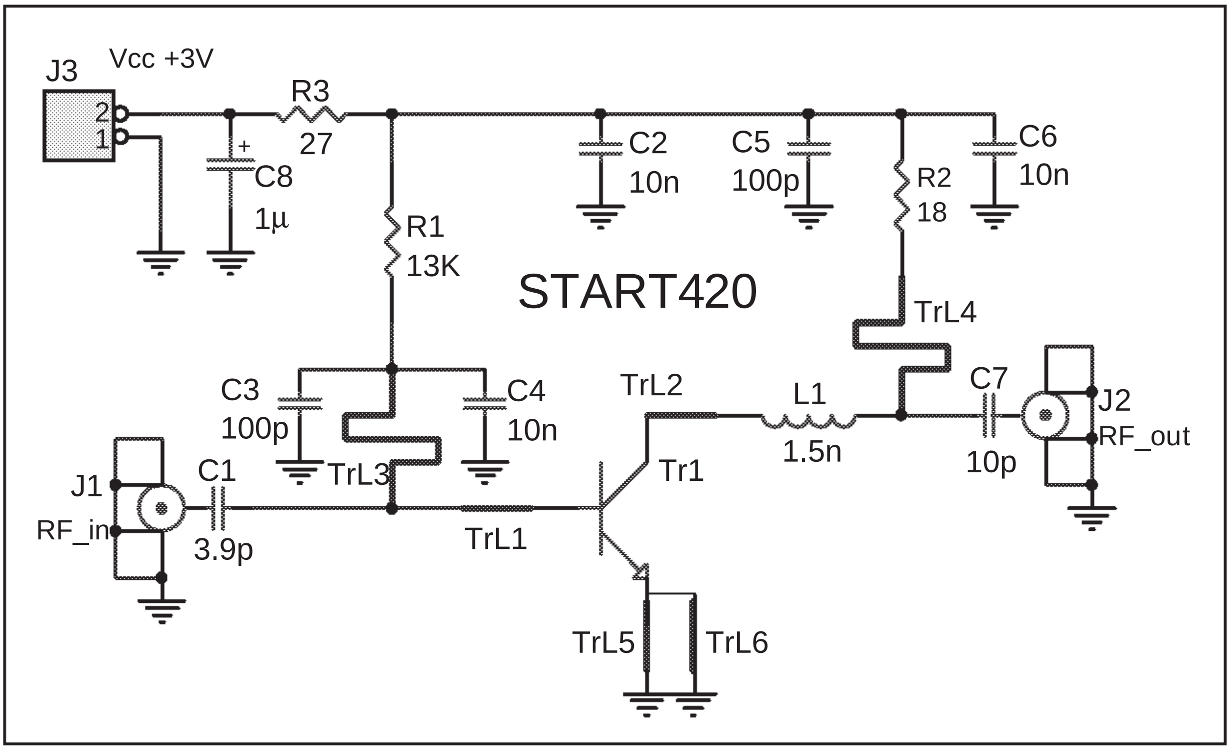
Gain = 18dB, $IP3_{out}$ = 23dBm, N_F = 1.9dB, $R_{Lin/out}$ > 13dB

1. INTRODUCTION.

START420 is a product of the START Family (ST Advanced Radio frequency Transistor). It is a high performance silicon bipolar transistor housed in the ultra miniature 4-lead SC-70 (SOT-343) surface mount plastic package. The amplifier is designed for use with 30mils thickness FR-4 printed circuit board material. The amplifier application circuit has been optimized to achieve a good compromise among IP3, noise figure and return loss at 1.9GHz, with V_{ce}=2V and I_c=20mA. The amplifier has 18dB of Gain, 1.9dB of Noise Figure a Input and Output Return Loss >13dB and an output IP3 of +23dBm (1.9GHz, 3V, 20mA).

2. LNA DESIGN.

Figure 1: Schematic Design



This amplifier is realized with a microstrip line as matching elements and a small number of surface-mount components. A single pin (V_{cc}=3V) for voltage supply is used. A 1µF bypass capacitor to filter the supply at the common V_{cc} node is also used. The transistor's base is connected to the power supply through a choke inductor (microstrip line TrL3) and the transistor's collector is connected to the voltage supply through a choke inductor (microstrip line TrL4). The collector's voltage is 2V. The input matching is realized with both a chip-capacitor (C1) and a 60ohm series transmission line of 15° electrical length (TrL1). The output matching is realized with both a chip-inductor (L1) and a 60ohm series transmission line of 16° electrical length (TrL2). Resistor (R2) is used to improve RF circuit stability.

Figure 2: Demoboard Layout

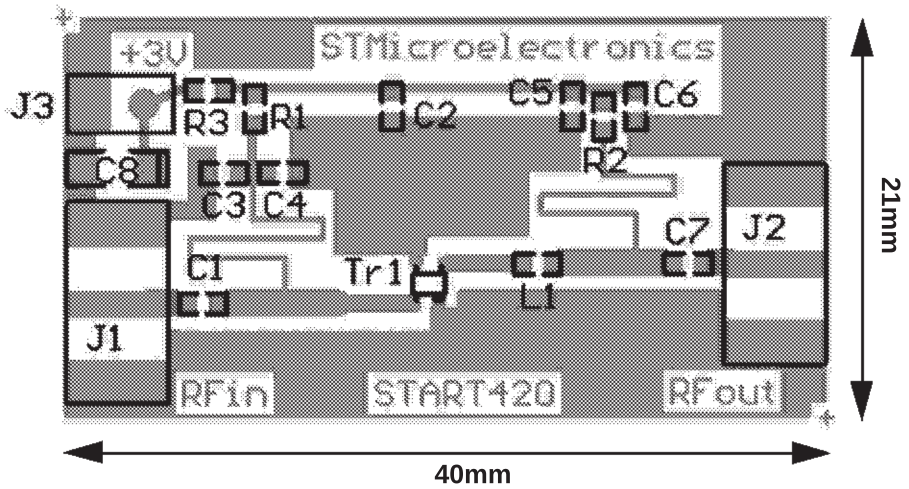


Table 1: Bill of Materials

Component	Value	Unit	Size	Comment
R1	13	KΩ	0603	
R2	18	Ω	0603	
R3	27	Ω	0603	
C1	3.9	pF	0603	
C2	10	nF	0603	
C3	100	pF	0603	
C4	10	nF	0603	
C5	100	pF	0603	
C6	10	nF	0603	
C7	10	pF	0603	
C8	1	µF	0603	
L1	1.5	nH	0603	
Tr1			SOT-343	Start420
TrL1				Inputmatch, w=1mm
TrL2				Outputmatch, w=1mm
TrL3				Dc-bias, w=0.3
TrL4				Dc-bias, w=0.3
TrL5				emitter-microstrip-line, w=0.7mm
TrL6				emitter-microstrip-line, w=0.7mm
J1				RF Connector; sma-f
J2				RF Connector; sma-f
J3				DC Connector
Substrate	FR4			h= 0.03 inch; Er=4.5

3. LNA PERFORMANCE.

The high intercept point START420 amplifier is biased at Vce=2V and Ic=20mA. The measured gain and noise figure is shown in figures 3 and 4. The optimum amplifier noise figure is 1.9dB and the associated gain between 1800MHz and 1900MHz is about 18dB. Measured input and output return loss are shown in figures 5 and 6. The Input Return Loss is about 18dB from 1800MHz through 1900MHz.

Figure 3: Power Gain vs. Frequency

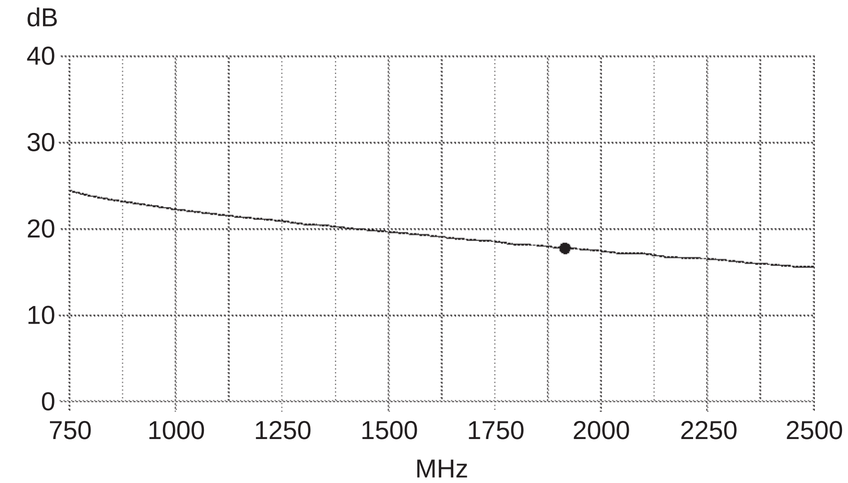


Figure 4: Noise Figure vs. Frequency

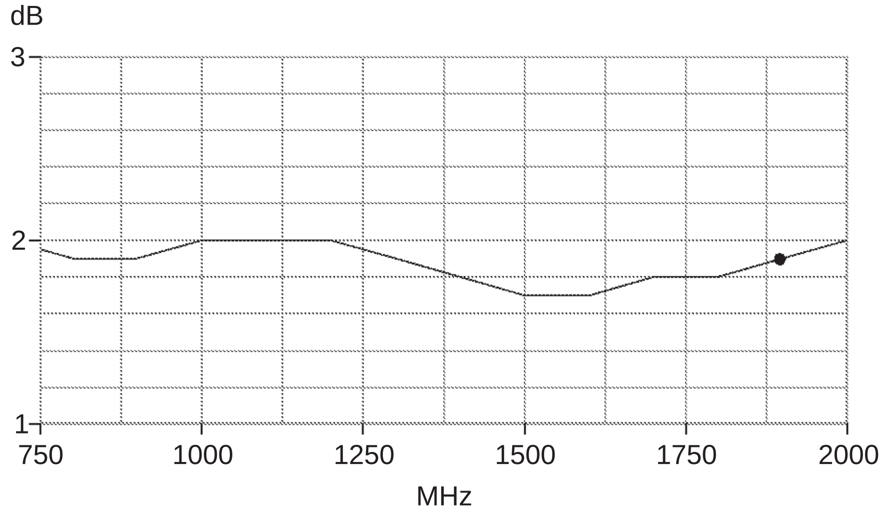


Figure 5: Input Return Loss vs. Frequency

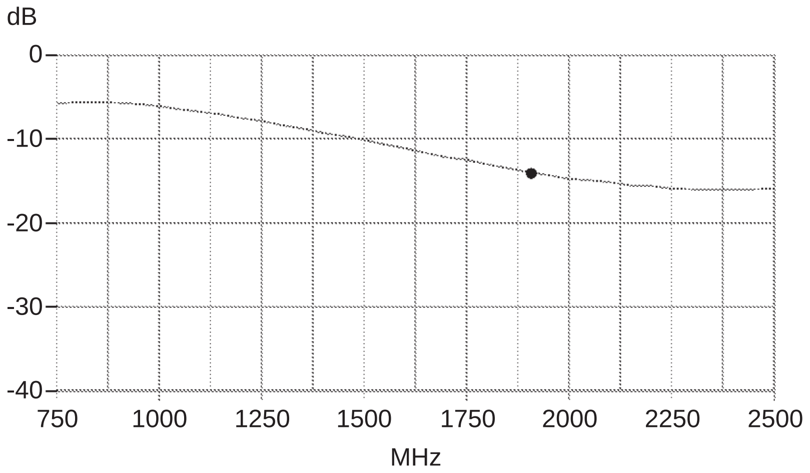


Figure 6: Output Return Loss vs. Frequency

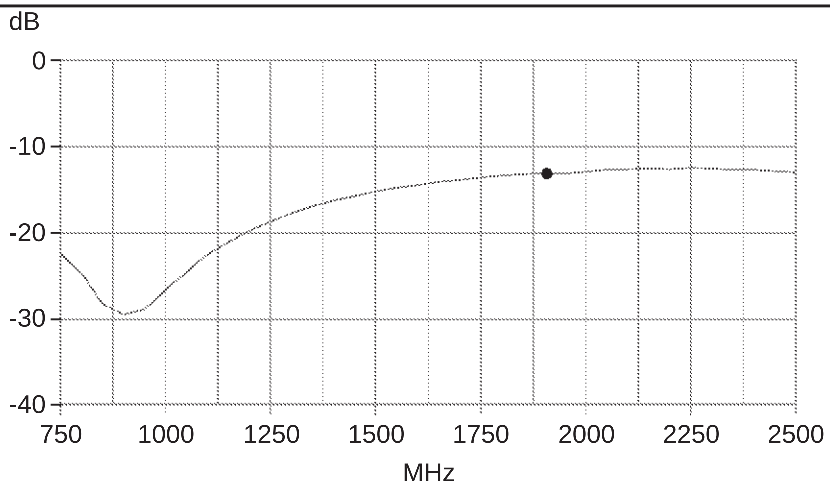


Figure 7: In-band Third Order Intermodulation Product Distorsion

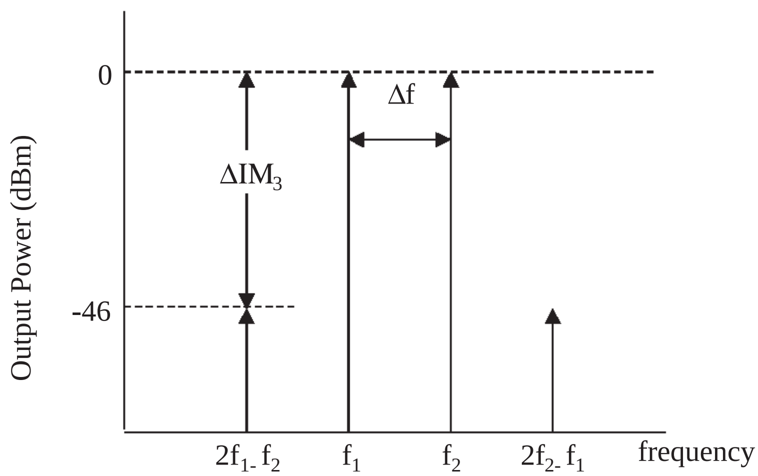


Figure 7 is a partial representation of the LNA output spectrum. f_1=1900MHz and f_2 =1901MHz are equal amplitude input test tones. For this LNA we use -18dBm input power in order to reach 0dBm of output power for each test tones. Other signals besides f_1 and f_2 are generated as a result of non-linear device behavior.

The Output IP3 is calculated as follows:

$$IP3out = \frac{\Delta IM3}{2} + Pout$$

where ΔIM3 (please refer figure 7) is the difference between one of two equal amplitude test tones present at the amplifier output, and the level of the highest 3rd -order distortion product. The ΔIM3 measured is 46dB.

So we have:

$$IP3out = \frac{\Delta IM3}{2} + Pout = \frac{46}{2} + 0 = 23dBm$$