Low noise, low current preamplifier for 1.9 GHz at 3 V

Application report

In this short note some results of measurements are derscribed performed on a LNA for the 1.8 - 2.0 GHz frequency range.
The amplifier is build with a low cost bipolar transistor on a low cost epoxy PCB.
The design was done at a DC voltage of 3 Volts, 2.5 mA.
Even under this low dissipation conditions an amplifier with low noise figure and associated high gain can be build while keeping the input impedance within reasonable limits from 50 Ohm.
Most low noise concepts give high mismatch at the input port. This design matches better than a 1:2 VSWR making it easier to connect to 50 Ohm designed bandpass filters or aerials.

General characteristics:

Supply voltage	2.5 - 3.6 V	
Gain	> 10 dB typ. 11 dB	
Noise Figure	< 2.5dB typ. 2.4 dB	with PCB and cap. losses
Linearity	IP3 > 7 dBm typ. 9 dBm (output)	
VSWR	input < 1:2 typ. 1.5 output < 1:2.5	
PCB material	FR4 (ϵ_r=4.7, h=0.5 mm	Epoxy
Components	BFG505 resistors capacitors	SOT143 Philips 0603/0805 Philips 0603

Circuit diagram

The circuit diagram is straightforward.
Biasing is simply done by resistive feedback. The stabilisation factor might be too small to compensate for the HFE spread (or temperature) of the device, but since the supply dependency of gain is proven not to be very large (appendix C) this way of biasing is preferable because of reduced component count. The current setting can be lowered to about 1 mA while maintaining high gain and low noise figure.

The decoupling network (R1 - C3) might be omitted but serves to improve linearity.
The source and load match (S2, S3 resp. S4, S5) are designed to give a good compromise between noise, gain and matching performance. The matching striplines represent 70 Ohm transmisssion lines with S2 and S5 acting as short-circuited stubs with electrical lenght of ca. 1/6λ and S3 and S4 even shorter.

They can be replaced by any inductive element giving the same induction at the operation frequency.
Proper grounding is essential in GHz design. If no proper ground is available, an estimate of parasitic series induction must be made to take into account while designing.
The 10pF capacitors serve only as DC blocking capacitors and are not critical in value. They are at series resonance at about 2 GHz. No attempt has been made to make the circuit as small as possible, since it only represents a sub-circuit.
Reducing the size can be done by chosing narrower lines for S2, S5 so that they can become shorter and folded more.
Also a higher epsilon material can reduce the size.

900 MHz version

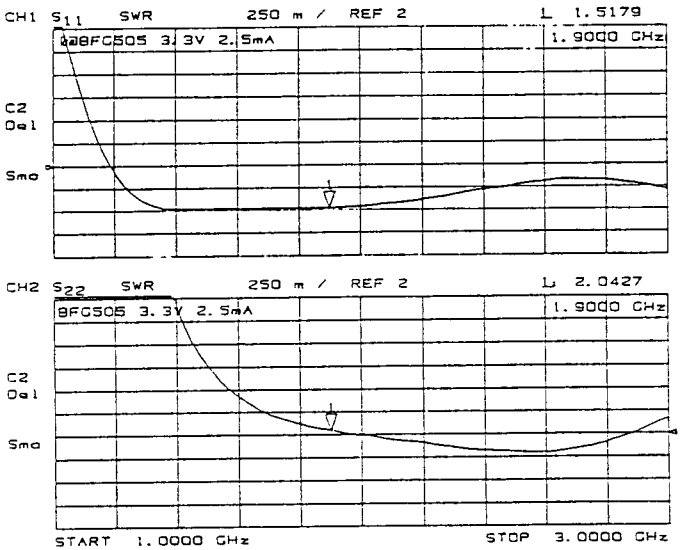
With the same transistor an amplifier at 900 MHz can be build.
Providing 50 Ohm input/output impedance, 1.3 dB Noise Figure, a Gain of over 10 dB and a current of only 1 mA it is very suitable for low power applications.
Observe the schematic diagram in appendix G, where the input impedance is realized through feedback in the emitter (L3).
The coils are made of closely wound enamelled Cu- wire, d=0.4 mm; int. diam=1.6 mm. (at 900 MHz, coils are preferably used because of their small size)

Measurement results

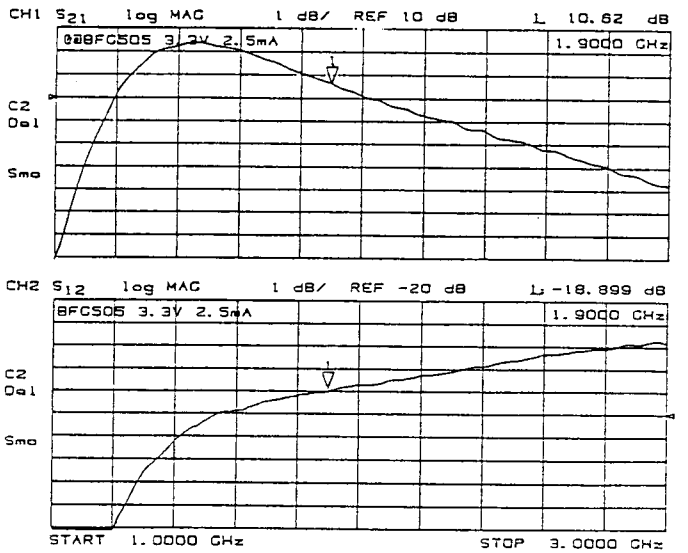
A: VSWR versus frequency
B: Gain/isolation versus frequency
C: Gain and current versus supply voltage
D: Intermodulation behaviour (IP3)
E+F: schematic diagram and layout
G: schematic diagram 900 MHz version

Measurements

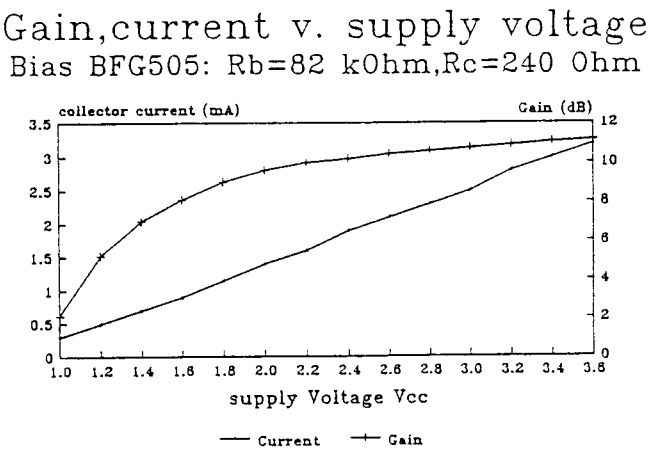
A



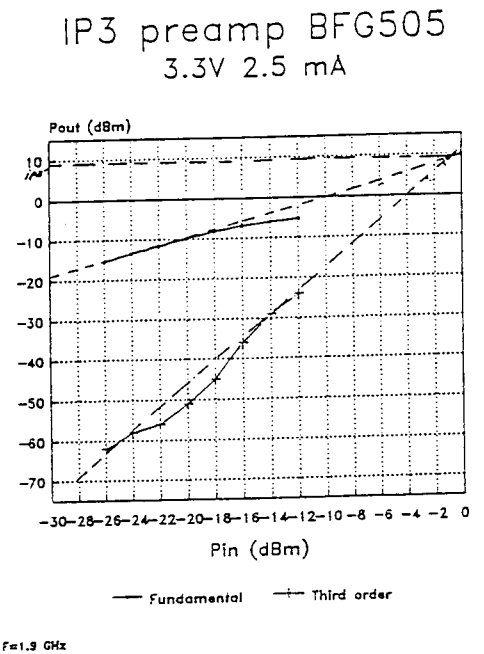
B



C

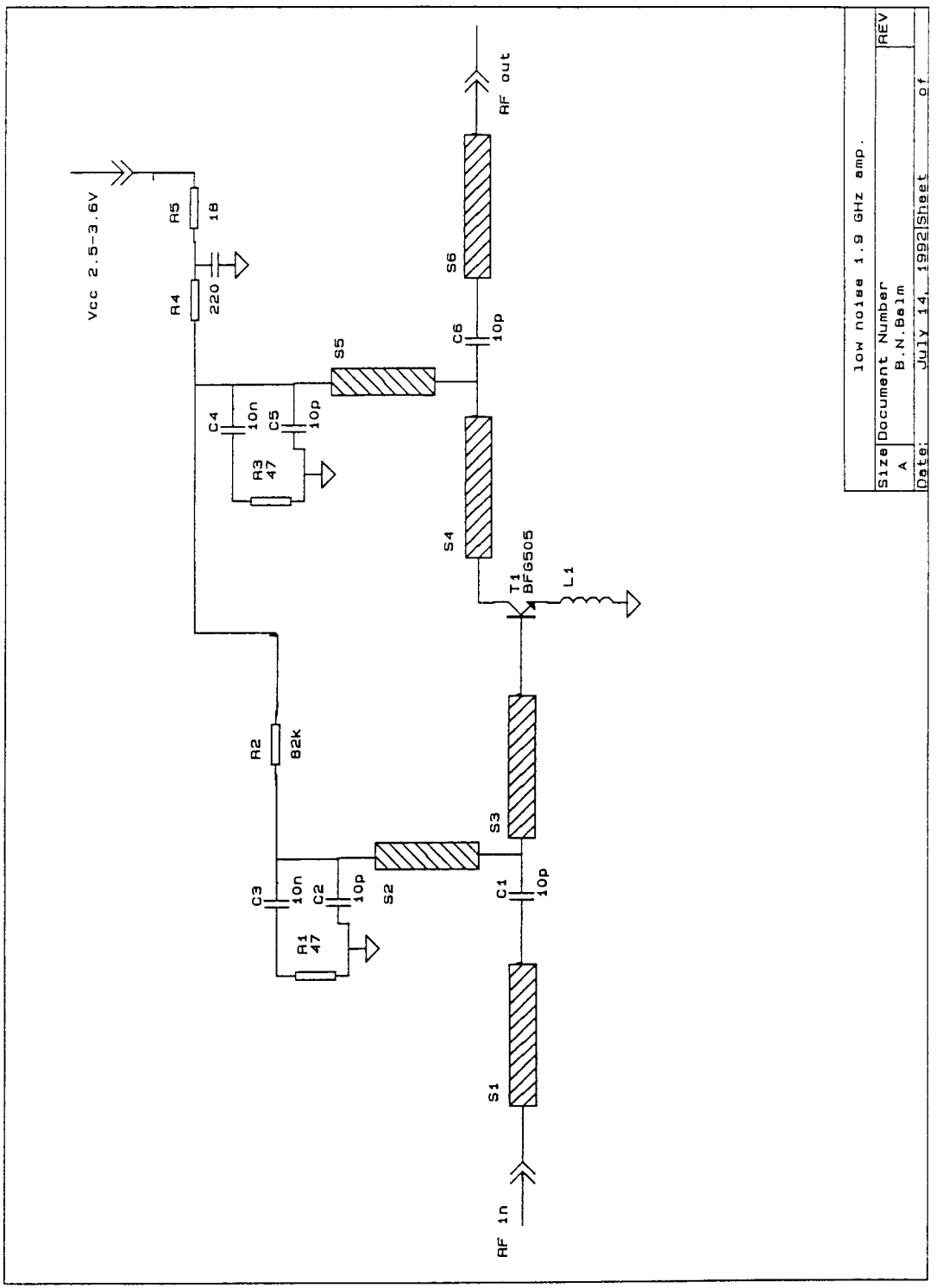

Gain,current v. supply voltage
Bias BFG505: Rb=82 kOhm,Rc=240 Ohm
collector current (mA)
Gain (dB)
3.5
3
2.5
2
1.5
1
0.5
0
12
10
8
6
4
2
0
1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6
supply Voltage Vcc
Current
Gain
frequency=1.9GHz

D


IP3 preamp BFG505
3.3V 2.5 mA
Pout (dBm)
10
0
-10
-20
-30
-40
-50
-60
-70
-30 -28 -26 -24 -22 -20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0
Pin (dBm)
Fundamental
Third order
F=1.9 GHz

Low noise, low current preamplifier for 1.9 GHz at 3 V

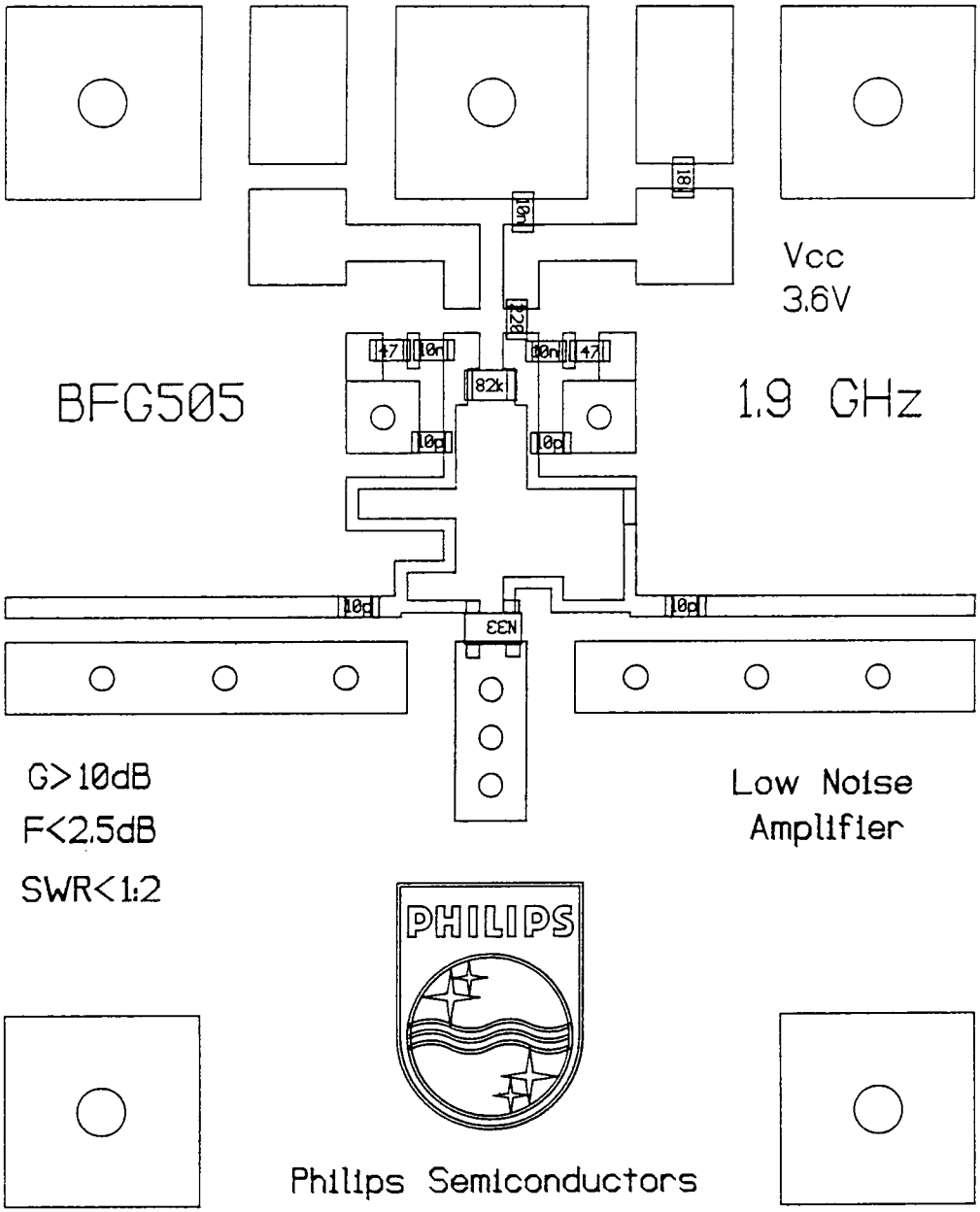
Application report



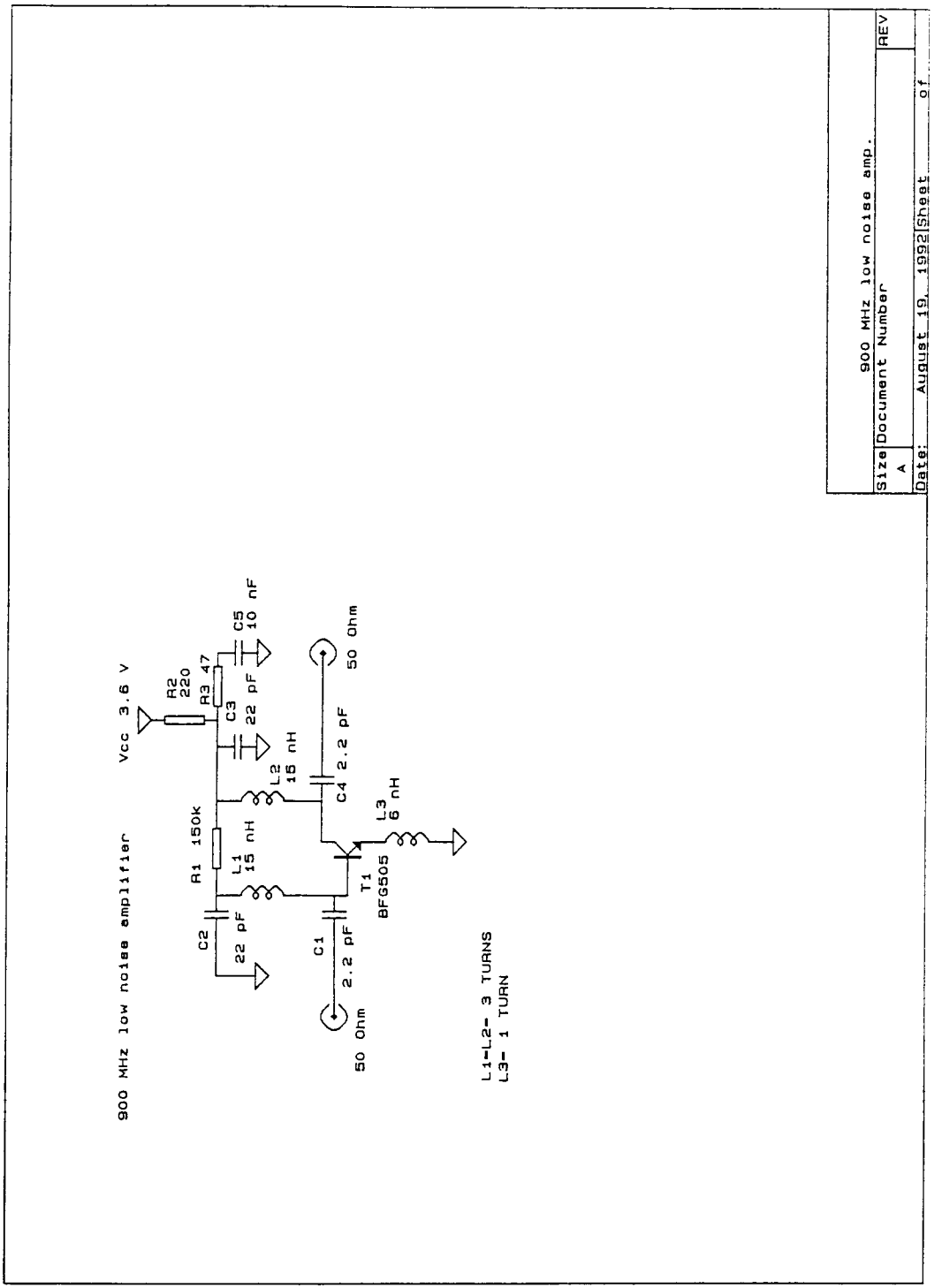
Low noise, low current preamplifier
for 1.9 GHz at 3 V

Application report

F



G


900 MHz low noise amplifier
Vcc 3.6 V
R2 220
R3 47
C5 10 nF
C3 22 pF
L2 15 nH
C4 2.2 pF
50 Ohm
L3 6 nH
R1 150k
L1 15 nH
T1 BFG505
C2 22 pF
C1 2.2 pF
50 Ohm
L1-L2- 3 TURNS
L3- 1 TURN
900 MHz low noise amp.
Size
Document Number
REV
A
Date: August 19, 1992
Sheet of