

Power amplifier for 900 MHz at 6 V

Application report

POWER AMPLIFIER for 900 MHz at 6V

In this note some results of measurements are described performed on a RF amplifier for 900 MHz applications. The amplifier is able to deliver 1.2 W RF output power with an efficiency better than 45%. The amplifier is build up with three bipolar transistors, the broadband transistor BFG540/x and the RF power transistors BLT80 and BLT81.

The amplifier, a demonstration board showing the BFG540, BLT80 and BLT81 line-up, is developed for maximum gain and efficiency under the conditions : output power 1.2W, supply voltage 6V, and frequency 900MHz. If more or less output power is needed some changes have to be made to the matching circuitry, to obtain a good gain and efficiency at the desired output power.

The amplifier has about 30dB gain at 1.2W output power. Since the amplifier is build up with bipolar transistors no supply voltage is lost, caused by switches, as in GaAs FET designs. The total 6V supply voltage is available for operation. No negative voltage is needed.

General characteristics:

Supply voltage $U[V_s]$	6V	
Frequency range	872 - 905 MHz	
Output power	1.2 W	$P_{drive} = 1 \text{ mW}$
Efficiency	46 %	$P_{out} = 1.2 \text{ W}$
Gain	30.8 dB	
Load & Source impedance	50 Ohm	
Printed circuit board	FR4, ($\epsilon_r=4.7$, $h=0.51 \text{ mm}$)	Epoxy, Size=23 x 42 mm, could be reduced to half this size by a relayout.
Rugged	Output VSWR = 4.4:1	$V_s=8V$, $P_{out}=1.5W \text{ max.}$
Harmonic content	-39 dBc	$P_{out}=1.2W$
Dynamic range	$P_{out} = 0 - 30.8 \text{ dBm}$	$V_c=0 - 4.6 \text{ V}$
Off-state Current dissipation	< 200 μA	$V_c > 5.4V$
Control current $i[V_c]$	-1.1mA	$V_c=0V$
Components	BFG540/x BLT80 BLT81 BC807/BC817 resistors capacitors	in SOT143/X in SOT223 in SOT223 small PNP and NPN transistors for biasing Philips 0603 Philips 0603

Circuit diagram

For the development of a 900 MHz amplifier, impedance information is needed about the RF transistors for designing the matching circuits. The amplifier is build up with 3 stages, a BFG540 operating in class A, and the BLT80 and BLT81 operating in class AB. The design of the class A, BFG540 stage can be done with S-parameter information available on floppy disc. The design of the class AB stages, the BLT80 and BLT81 can be done with the spice parameters and package parameters. These data is also available on floppy disk.

In appendix A1 the circuit diagram of the amplifier is shown. The bottom half of the circuit is the RF amplification part. It consists of the three RF transistors (BFG540/x, BLT80 and BLT81), matching circuitry (striplines, capacitors) and bias stubs. (striplines & decoupling capacitors) Because of expected instability the BFG540/x transistor is not loaded with the optimum load for maximum gain, but with 50Ω . The transformation from the input impedance of the BLT80 to a load impedance of 50Ω is done by shunt capacitors C15, C16 and C33.

The top half of the circuit shows the circuit, to assure a class A bias for the BFG540/x, and a 0.6V bias voltage to supply the BLT80 and BLT81.

The BFG540/x transistor is operating in class A with a maximum collector current of 35mA. At this current the BFG540/x gives optimum performance.

The stabilization of the collector current is done by a low frequency PNP transistor(BC807) which compares the voltage drop on a resistance in the collector (R3) of the BFG540/x with a voltage determined by the voltage on external pin Vc. This bias circuit gives a biasing which is independent of temperature and Hfe. The voltage drop on R1 is about 0.35V.

A voltage of 0V on pin Vc gives a collector current of 35mA. A voltage of 5V on pin Vc switches the BFG540/x off. Any value above 0V on pin Vc reduces the DC collector current of the BFG540/x. As a result of this the RF output power from the BFG540/x, and from the total amplifier is limited.

The low frequency transistor BC817 is also used as a diode. Connecting the collector to the emitter gives a forward voltage of about 0.7V at a low current (1mA).

The BLT80 and BLT81 transistors are operating in class AB. The bias voltage on the base of these transistors is supplied by transistor T4, which is functioning as an emitter-follower. The voltage on the base of T4 is about 1.3V. This voltage is dependent on the base-emitter voltage of the BFG540/x and the forward voltage of transistor T3. This bias circuit has a temperature coefficient of $-2\text{mV}/^\circ\text{C}$, equal to the temperature coefficient of the knee voltage of the BLT80 and BLT81.

The maximum power at the output is available when a 0V is applied to pin Vc. A voltage higher than 0V on pin Vc will reduce the output power.

This function can be reversed by using an extra BC817 transistor in the bias circuitry. If this is needed the control circuit has to be changed as shown in appendix A2. With the changed Vc-circuit maximum output power is available with Vc' at 4V. With 0V on pin Vc' no output power is generated.

A layout of the circuit can be found in appendix B1 & B2. Appendix B2 shows a part of layout, including the component numbers.

Measurement results

In appendix C, D and E the results of measurements are shown.

Unless otherwise given the measurement conditions are :

Gnd: 0V,

Vc: set to a voltage to between 0 and 4.6V to get 1.2W output power.

Vs: 6V

Pin: 1mW, available from a source with a 50 Ohm impedance

Pout: measured in a 50 Ohm load.

T_{amb}. 25°C

Appendix C1 Gain and efficiency vs. control voltage

This figure shows the output power and efficiency as a function of the control voltage Vc. The best efficiency is obtained at an output power of about 1.2W. A control voltage of 0V gives the highest output power.

Appendix C2 Efficiency vs. frequency

This figure shows the efficiency of the amplifier vs. the frequency. The output power is set to 1.2W. The optimum efficiency is obtained in the band from 870 to 905 MHz.

Appendix D1 Output power vs. supply voltage

This plot shows the maximum output power (Vc=0V) at a supply voltage range from 5V to 6.6V. The amplifier is able to deliver already 1.2W at 5.5V.

Appendix D2 Harmonics vs. frequency

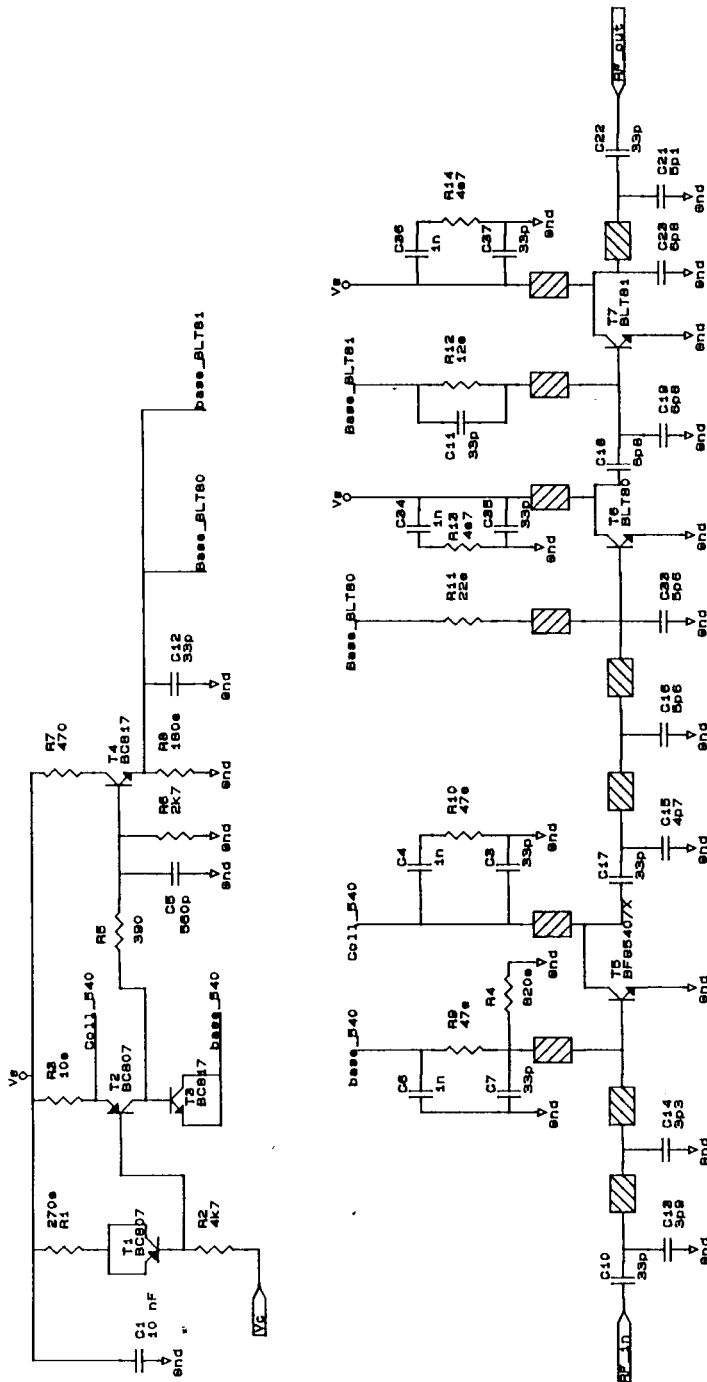
The harmonics are about 39dB below the carrier for all frequencies in the band.

Appendix E Pout vs. Pin

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App. A1

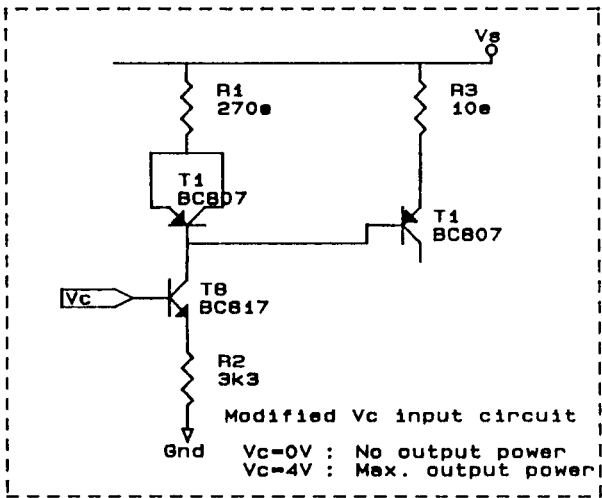
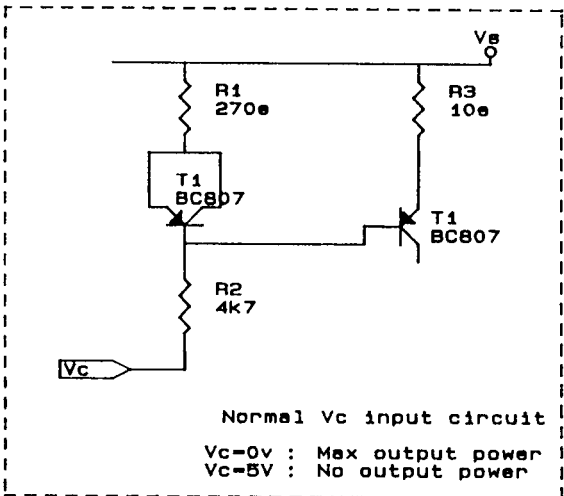


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Date:	January 13, 1992	Sheet 1 of 1

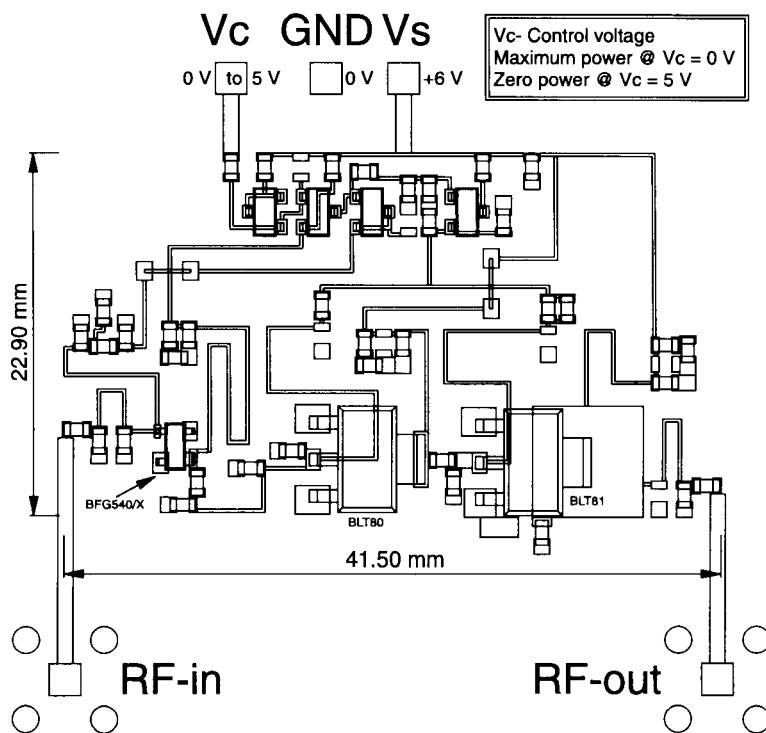
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App. A2



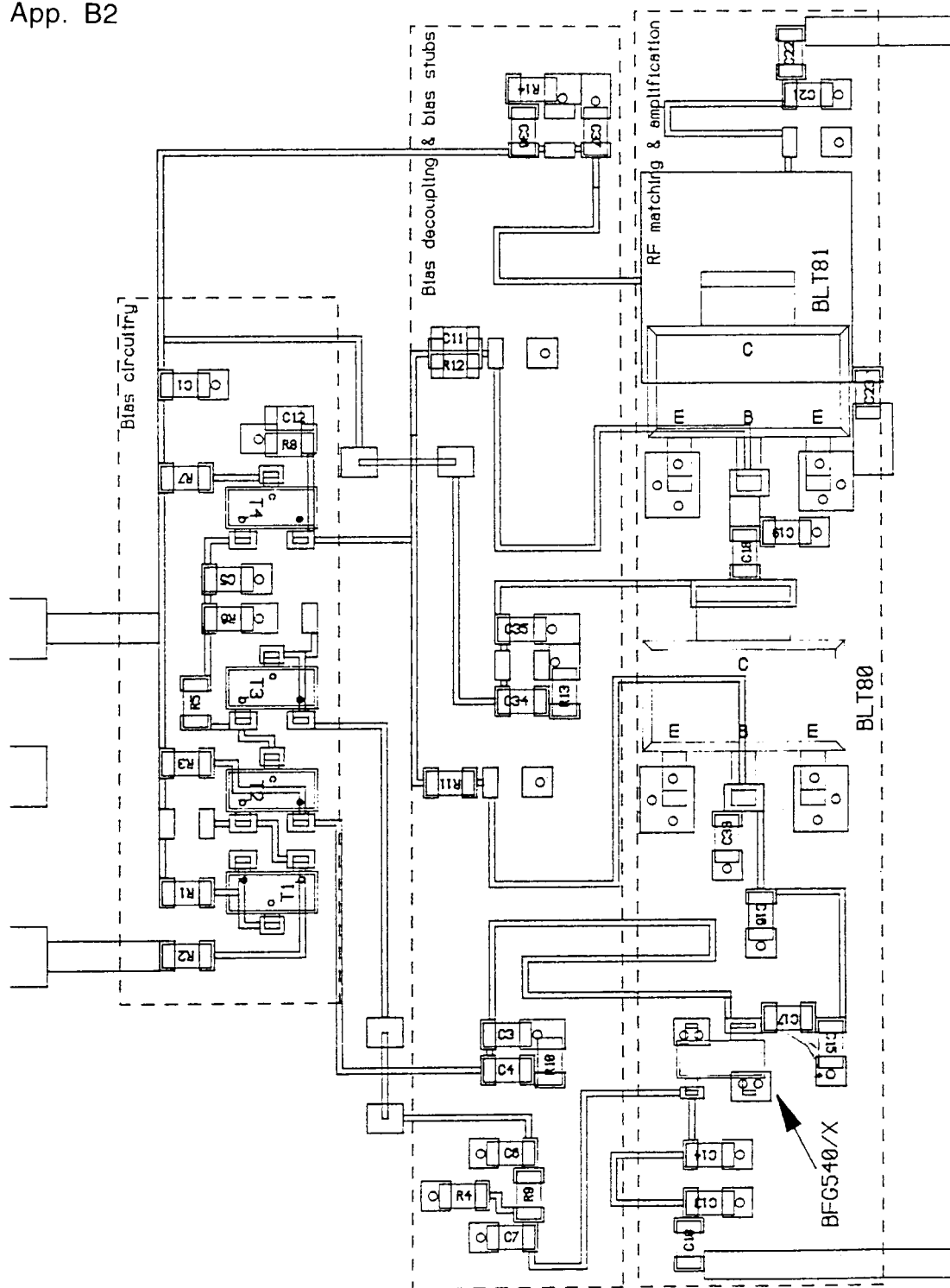
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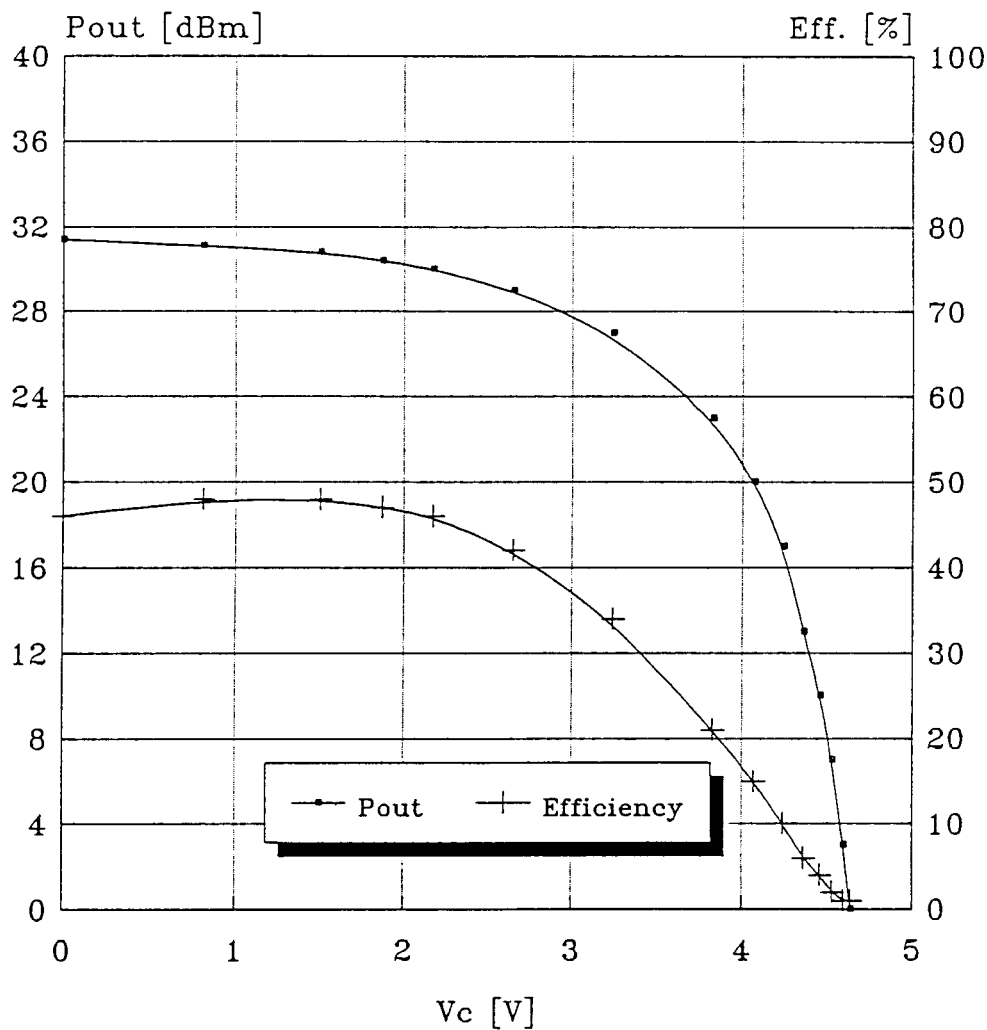
App. B2



Pout & Eff. vs. Control voltage

900 MHz amplifier

BFG540/x - BLT80 - BLT81



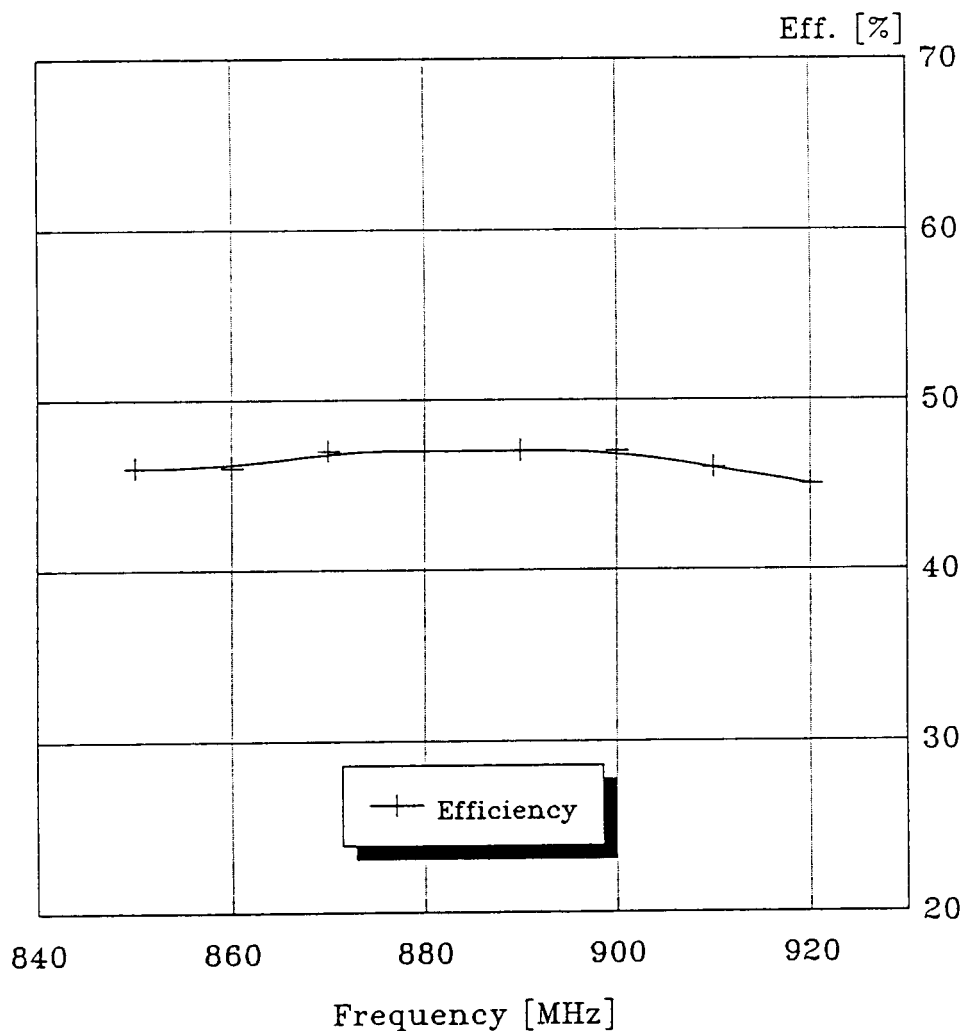
$F=900\text{MHz}$, $P_{in}=0$ dBm, $V_s=6\text{V}$

"r10_v01\v001"

Efficiency vs. Frequency

900 MHz amplifier

BFG540/x - BLT80 - BLT81



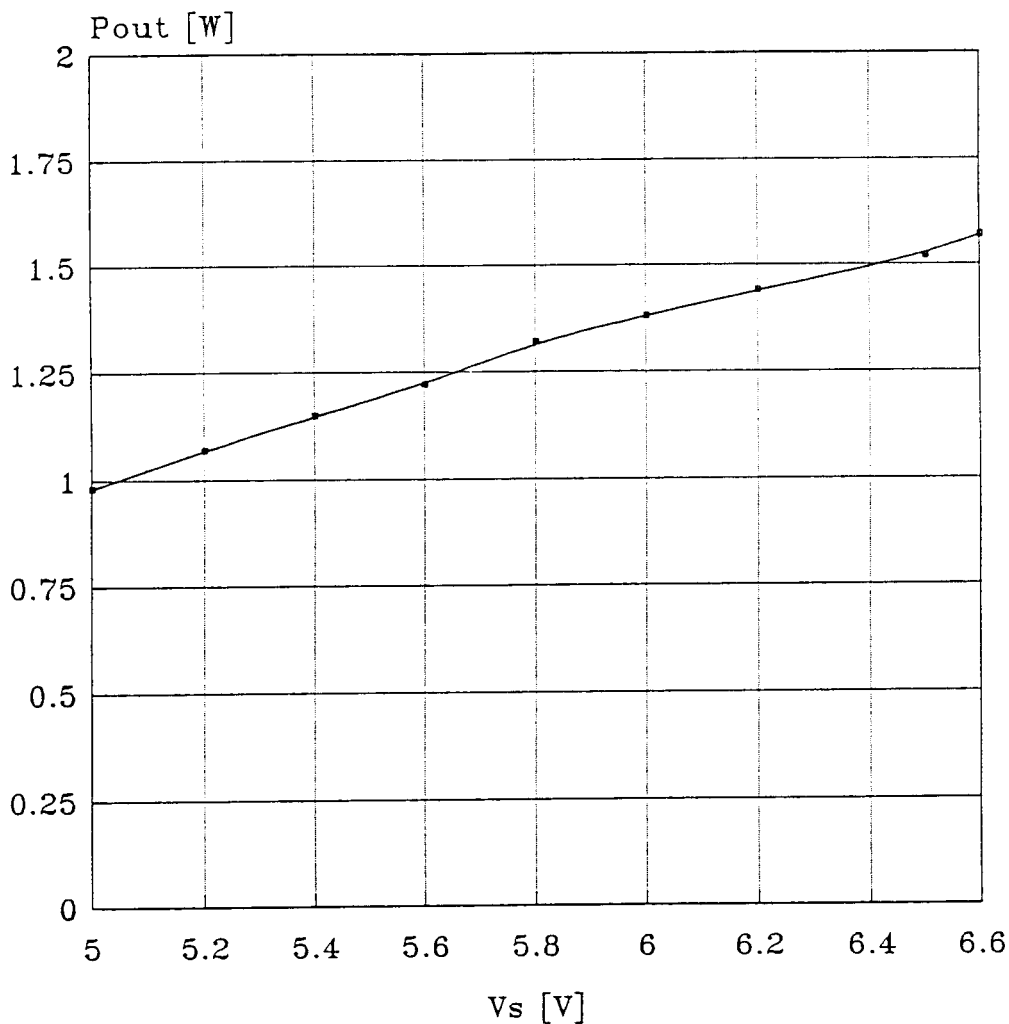
$P_{in}=0\text{dBm}$, $P_{out}=1.2\text{W}$, $V_s=6\text{V}$

"r10_v01\v002"

Max. Pout vs. Supply voltage

900 MHz amplifier

BFG540/x - BLT80 - BLT81



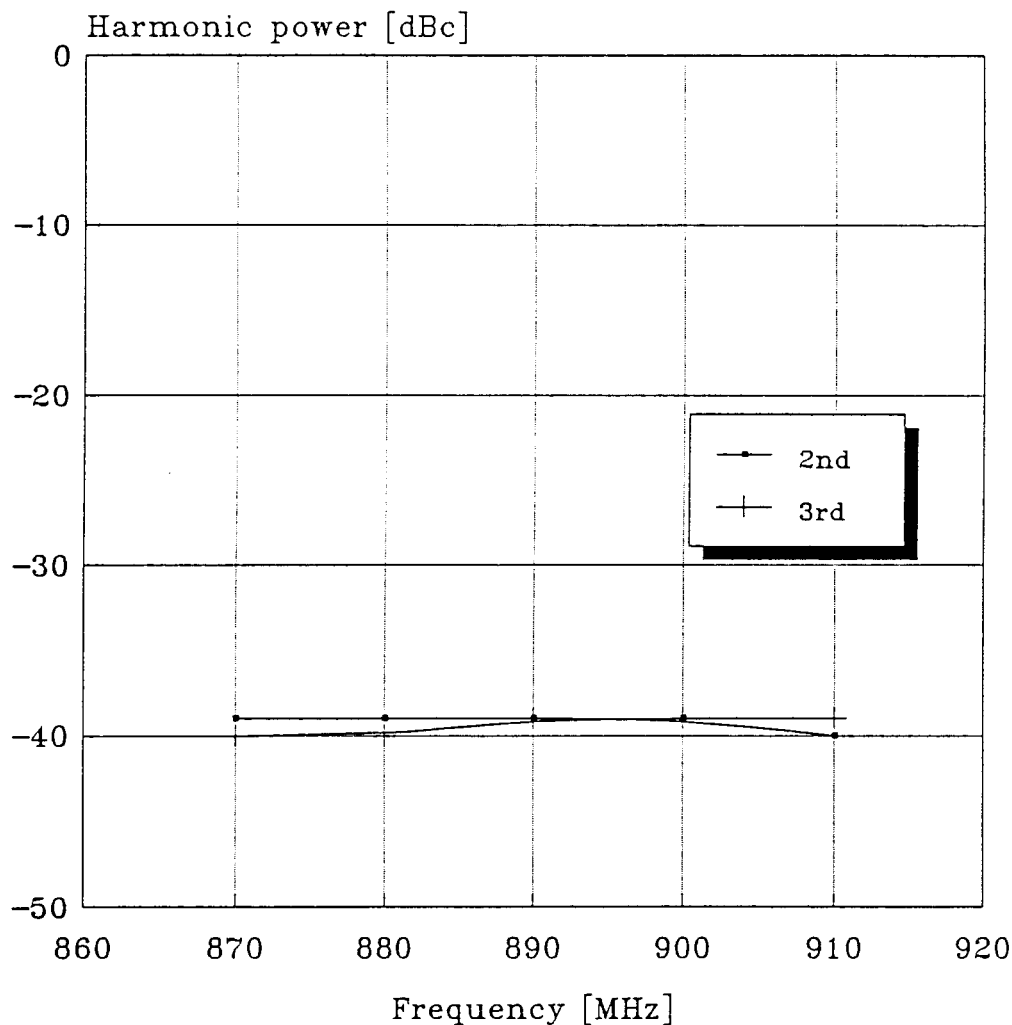
F=900Mhz, Pin=0dBm, Vc=0V

"r10_v01\003"

Harmonics. vs. Frequency

900 MHz amplifier

BFG540/x - BLT80 - BLT81



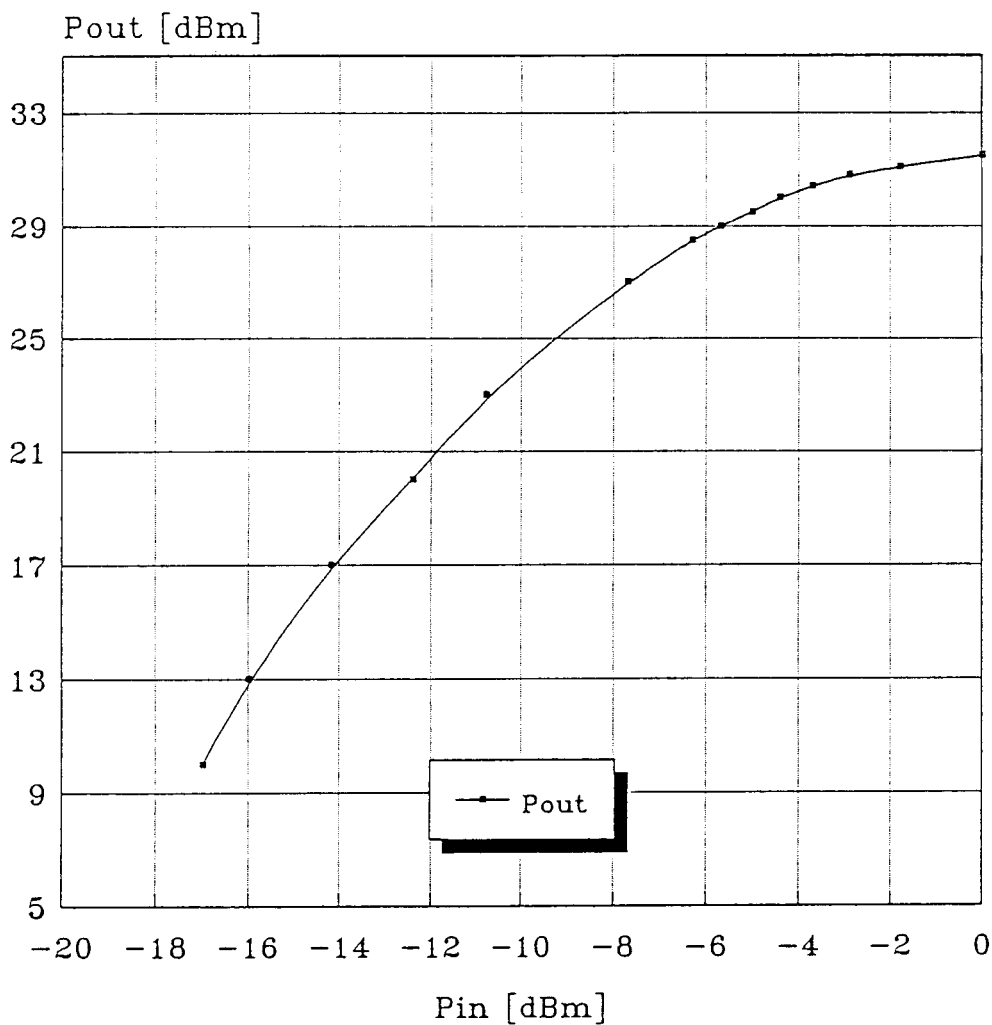
$P_{in}=0\text{dBm}$, $P_{out}=1.2\text{W}$, $V_c=6\text{V}$

"r10_v01\v004"

Pout vs. Pin

900 MHz amplifier

BFG540/x - BLT80 - BLT81



F = 900 Mhz, Vc=0V, Vs=6V

"r10_v01\v001"