SGA-9289 Amplifier Application Circuits

Abstract

Sirenza Microdevices' SGA-9289 is a high performance SiGe amplifier designed for operation from DC to 3500 MHz. This application note illustrates several application circuits for key frequency bands in the 800-2500 MHz spectrum.

Introduction

The application circuits were designed to achieve the optimum combination of P_{1dB} and OIP_3, while maintaining flat gain and reasonable return losses. Special consideration was given to insure amplifier stability at low frequencies, where the device exhibits high gain. These designs were created to illustrate the general performance capabilities of the the device under CW conditions. Users may wish to modify these designs to achieve optimum performance under specific input conditions and system requirements.

The circuits contain only surface mountable parts and were designed with automated manufacturing requirements in mind. All recommended components are standard values available from multiple manufacturers. The components specified in the bill of materials (BOM) have know parasitics, which in some cases are critical to the circuit's performance. Deviating from the recommended BOM may result in a performance shift due to varying parasitics - primarily in the inductors and capacitors.

Circuit Details

SMDI will provide the detailed layout (AutoCAD format) to users wishing to use the exact same layout and PCB material shown in the following circuits. The circuits recommended within this application note were designed using the following PCB stack up:

- Material: GETEK^{TM} ML 200C
- Core thickness: 0.031"
- Copper cladding: 1 oz. both sides
- Dielectric constant: 4.1
- Dielectric loss tangent: 0.0089 (@ 1 GHz)

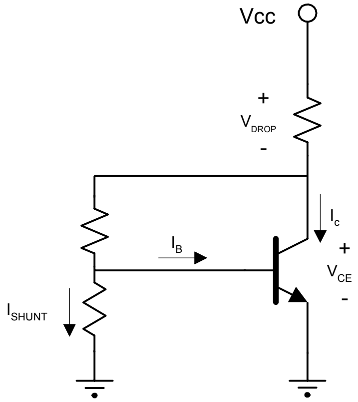
Customers not wishing to use the exact material and layouts shown in this application note can design their own PCB using the critical transmission line impedances and phase lengths shown in the BOMs and layouts.

Design Considerations and Trade-offs - Biasing Techniques

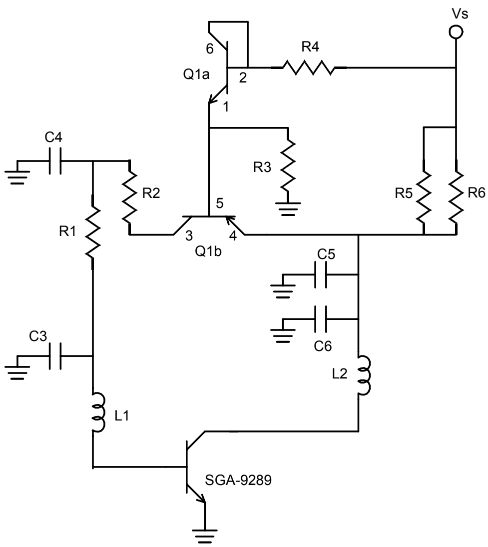
These SiGe HBT amplifiers exhibit a "soft" breakdown effect (V_{BCEO}=7.5V minimum) which allows for large signal operation at V_{CE}=5V. The user should insure that under large signal conditions, the source and load impedances presented to the device don't result in excessive collector currents near breakdown.

All HBT amplifiers are subject to device current variation due to the decreasing nature of the internal V_{BE} with increasing temperature. In the absence of an active bias circuit or resistive feedback, the decreasing V_{BE} will result in increased base and collector currents. As the collector current continues to increase under constant V_{CE} conditions, the device may eventually exceed its maximum dissipated power limit resulting in permanent device damage. The designs included in this application note contain passive bias circuits that stabilize the device current over temperature and desensitize the circuit to device process variation.

The passive bias circuits used in these designs include a dropping resistor in the collector bias line and a voltage divider from the collector-to-base. Using this scheme, the amplifier can be biased from a single supply voltage. The collector dropping resistor is sized to drop 2-3V, depending on the desired V_{CE}. The voltage divider from collector-to-base, in conjunction with the dropping resistor, will stabilize the device current over temperature. Configuring the voltage divider such that the shunt current is 5-10 times larger than the desired base current desensitizes the circuit to beta variation. These two feedback mechanisms are sufficient to insure consistent performance over temperature and device process variations. Note that the voltage drop is clearly dependent on the nominal collector current and can be adjusted to generate the desired V_{CE} from a fixed supply rail. The user should test the circuit over the operational extremes to guarantee adequate performance. An active bias circuit can be implemented if the user does not wish to sacrifice the voltage required by the aforementioned passive circuit. There are various active bias schemes suitable for HBTs. The user should choose an active bias circuit that best meets his/her cost, complexity, and performance requirements.



Passive Bias Circuit Topology

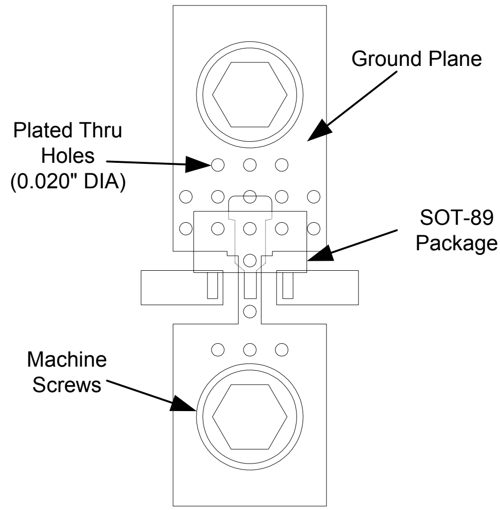


Active Bias Circuit Topology

- Mounting and Thermal Consideration

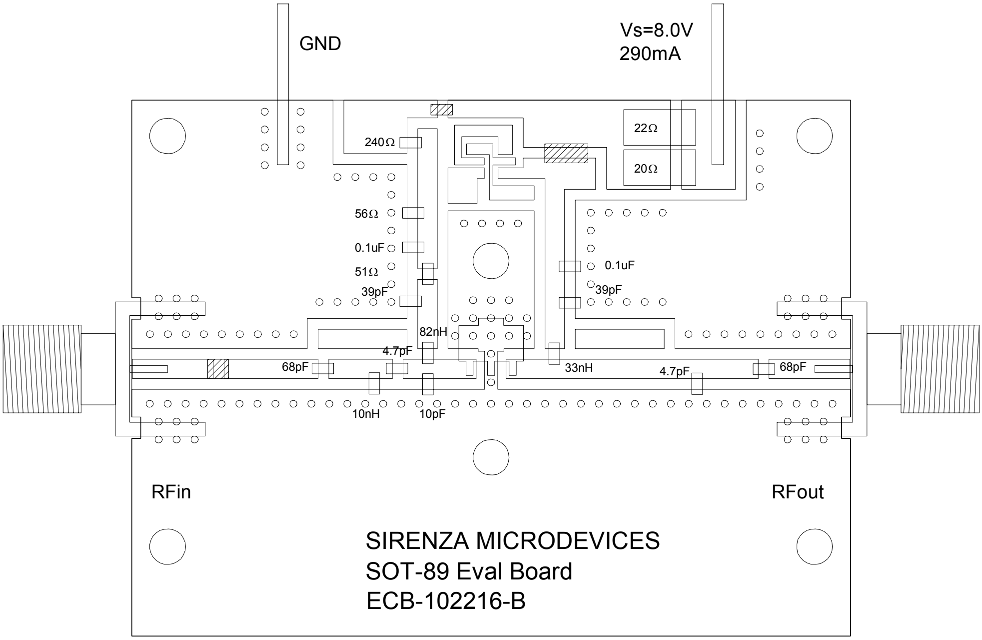
It is very important that adequate heat sinking be provided to minimize the device junction temperature. The following items should be implemented to maximize MTTF and RF performance.

1. Multiple plated-thru vias are required directly below the ground tab (pin 4). [CRITICAL]
2. Incorporate a large ground pad area with multiple plated-through vias around pin 4 of the device. [CRITICAL]
3. Use two point board seating to lower the thermal resistance betwee the PCB and mounting plate. Place machine screws as close to the ground tab (pin 4) as possible. [RECOMMENDED]
4. Use 2 ounce copper to improve the PCB's heat spreading capability. [RECOMMENDED]
5. Thermal transfer paste should be used between the PCB and the mounting plate to improve heat spreading capability. [RECOMMENDED]



Recommended Mounting Configuration

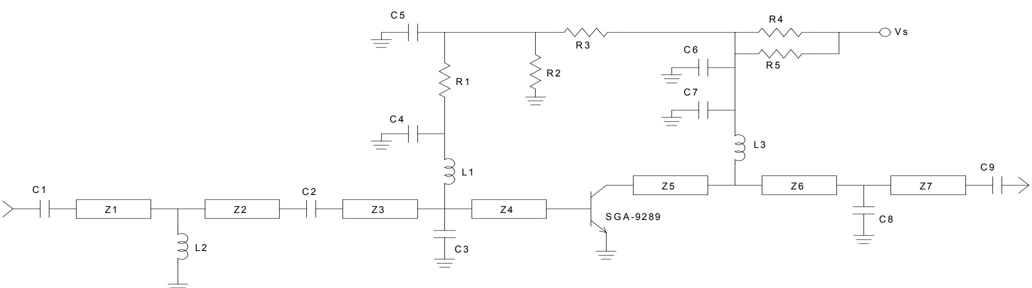
870-960 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA)



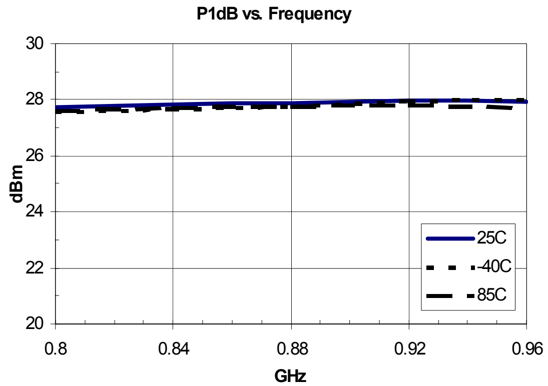
Ref. Des.	Part Number	Value
C1, C9	ROHM MCH185A680JK	68pF
C2, C8	ROHM MCH185A4R7CK	4.7pF
C4, C7	ROHM MCH185A390JK	39pF
C3	ROHM MCH185A100DK	10pF
C5, C6	Samsung CL10B104KONC	0.1uF
L1	TOKO LL1608-FS82NJ	82nH
L2	TOKO LL1608-FS10NJ	10nH
L3	TOKO LL1608-FS33NJ	33nH
R1	ROHM MCR03J510	51 Ω
R2	ROHM MCR03J560	56 Ω

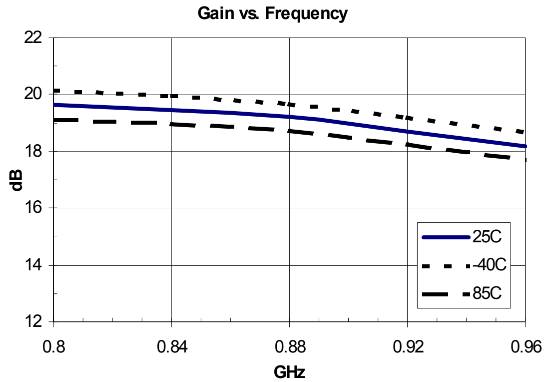
Ref. Des.	Part Number	Value
R3	ROHM MCR03J241	240 Ω
R4	ROHM MCR03J200	20 Ω
R5	ROHM MCR50J220	22 Ω
Z1	non-critical	50 Ω
Z2	2.3 degrees @ 900 MHz	50 Ω
Z3	3.2 degrees @ 900 MHz	50 Ω
Z4	6.2 degrees @ 900 MHz	50 Ω
Z5	6.2 degrees @ 900 MHz	50 Ω
Z6	18.5 degrees @ 900 MHz	50 Ω
Z7	non-critical	50 Ω

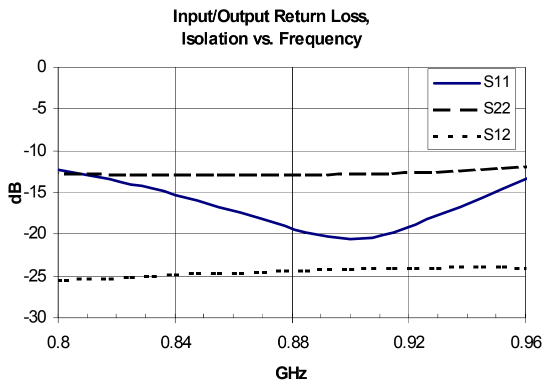
SGA-9289 870-960 MHz Schematic

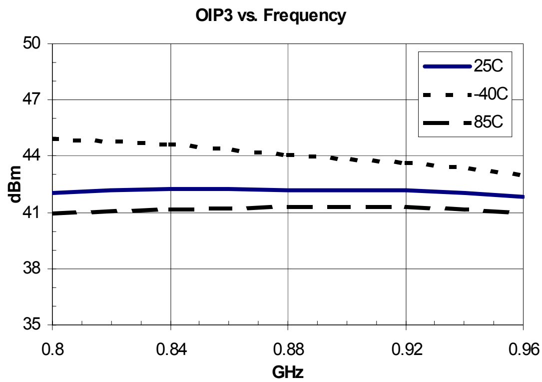


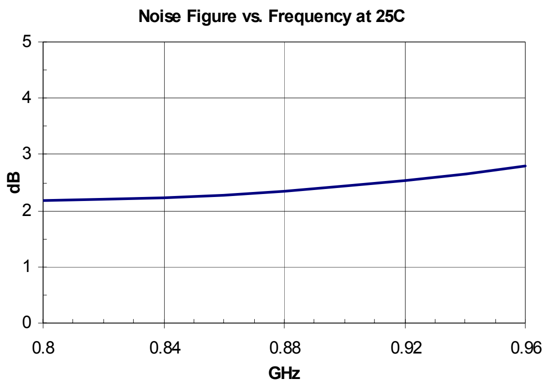
Typical Performance: 870-960 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA)

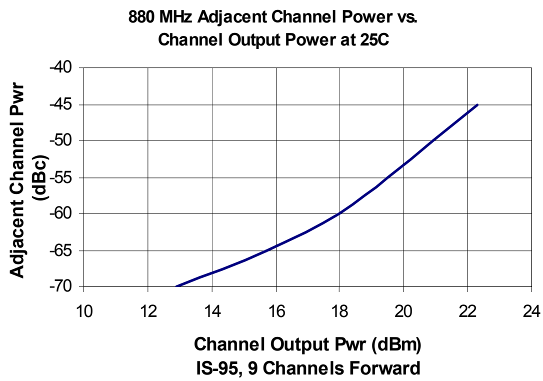






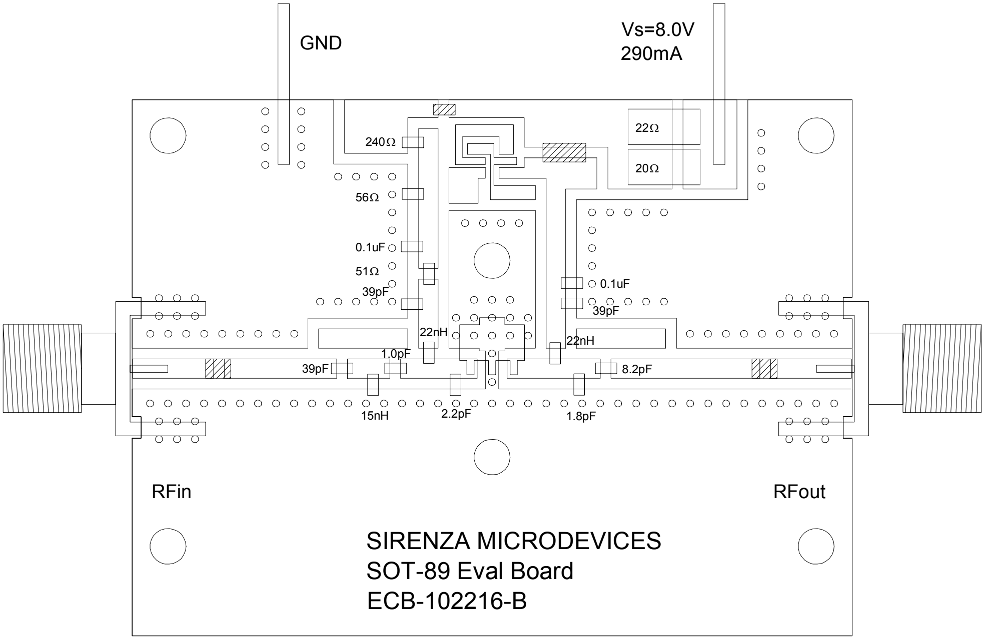






Freq (GHz)	P1dB (dBm)	OIP3 (dBm)	Gain (dB)	S11 (dB)	S22 (dB)	NF (dB)
0.880	28	42	19.2	-19	-13	2.4
0.920	28	42	18.7	-19	-13	2.5
0.960	28	42	18.2	-13	-12	2.8

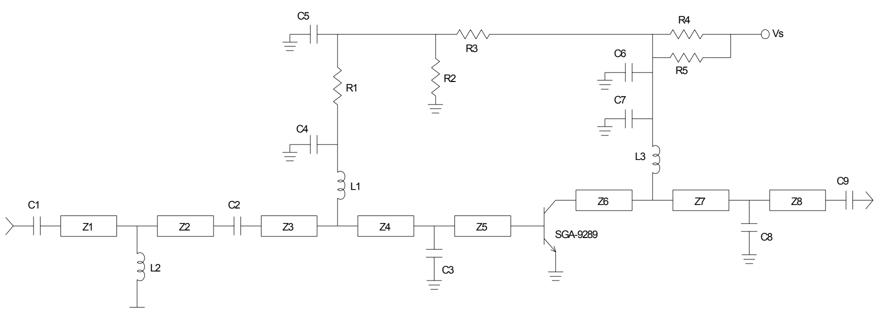
1930-1990 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA)



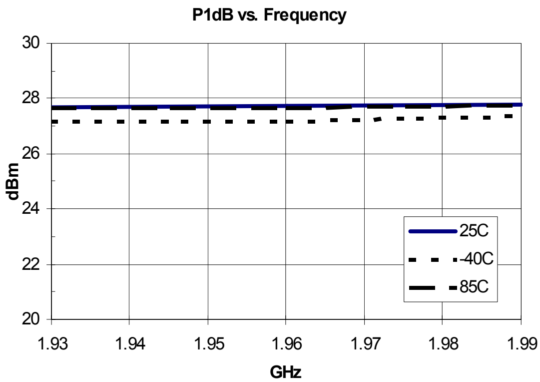
Ref. Des.	Part Number	Value
C1, C4, C7	ROHM MCH185A390JK	39pF
C2	ROHM MCH185A010CK	1.0pF
C3	ROHM MCH185A2R2CK	2.2pF
C5, C6	Samsung CL10B104KONC	0.1uF
C8	ROHM MCH185A1R8CK	1.8pF
C9	ROHM MCH185A8R2DK	8.2pF
L1, L3	TOKO LL1608-FS22NJ	22nH
L2	TOKO LL1608-FS15NJ	15nH
R1	ROHM MCR03J510	51 Ω
R2	ROHM MCR03J560	56 Ω
R3	ROHM MCR03J241	240 Ω

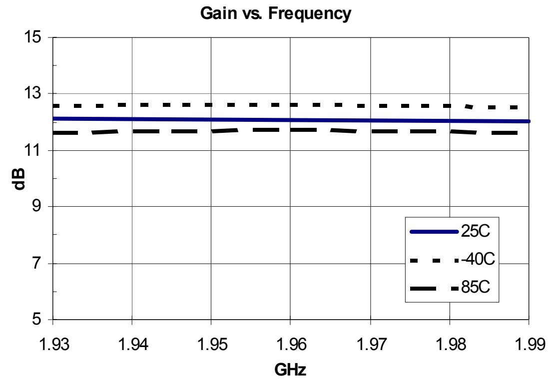
Ref. Des.	Part Number	Value
R4	ROHM MCR03J200	20 Ω
R5	ROHM MCR50J220	22 Ω
Z1	non-critical	50 Ω
Z2	4.8 degrees @ 1960 MHz	50 Ω
Z3	7.9 degrees @ 1960 MHz	50 Ω
Z4	7.6 degrees @ 1960 MHz	50 Ω
Z5	6.0 degrees @ 1960 MHz	50 Ω
Z6	13.5 degrees @ 1960 MHz	50 Ω
Z7	6.8 degrees @ 1960 MHz	50 Ω
Z8	non-critical	50 Ω

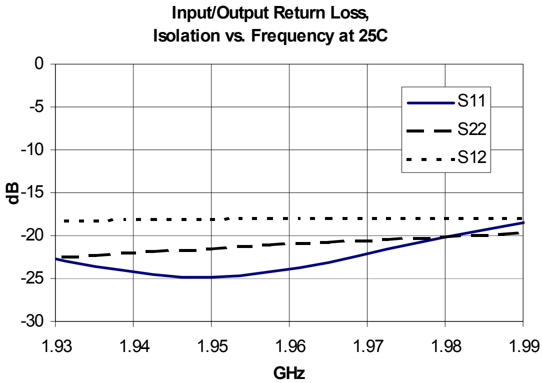
SGA-9289 1930-1990 MHz Schematic

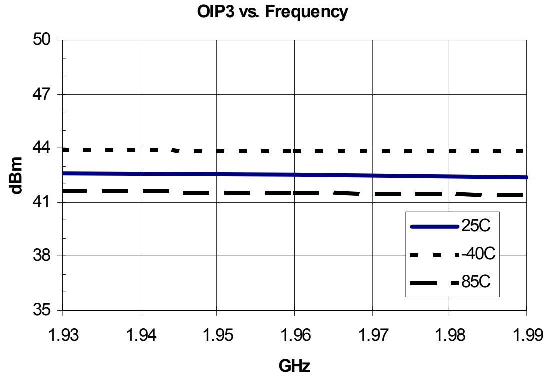


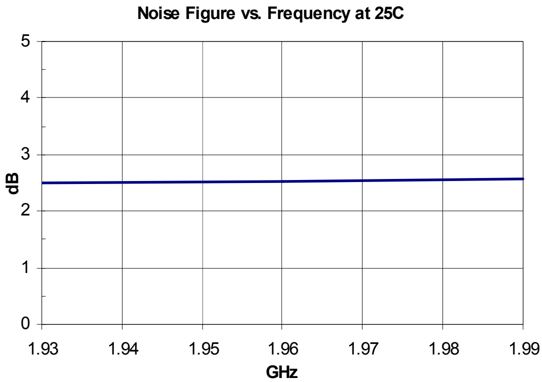
Typical Performance: 1930-1990 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA)

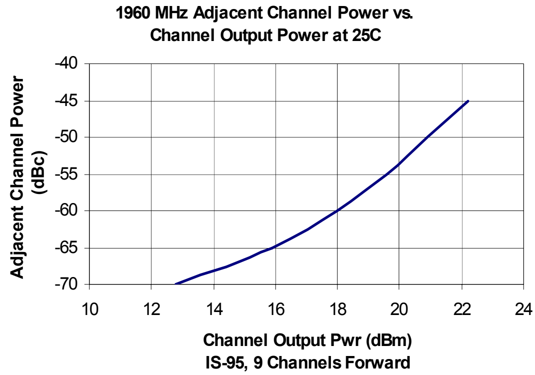






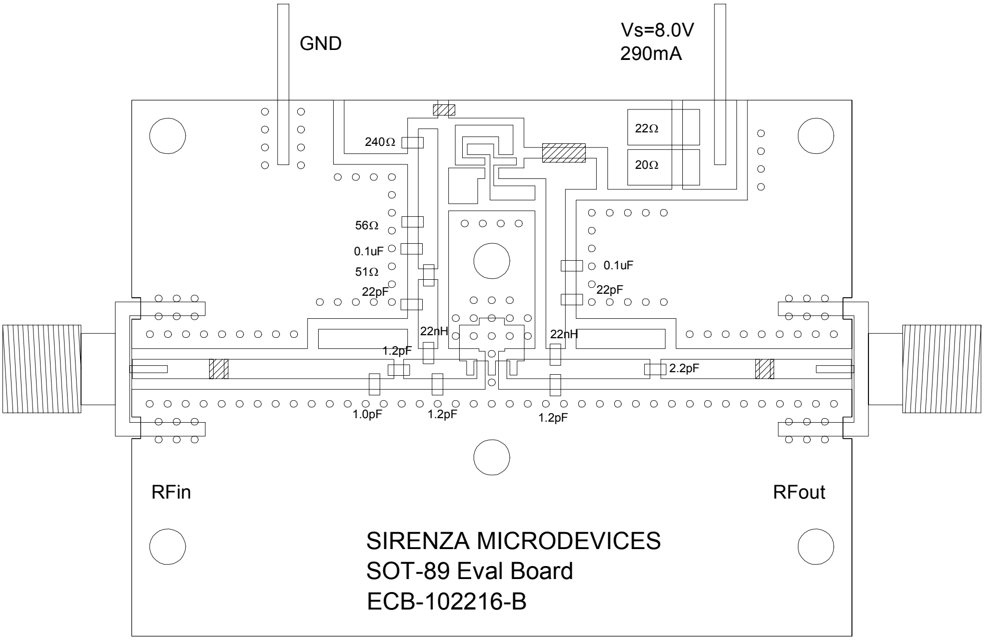






Freq (GHz)	P1dB (dBm)	OIP3 (dBm)	Gain (dB)	S11 (dB)	S22 (dB)	NF (dB)
1.93	27.4	42	12.1	-22	-22	2.5
1.96	27.5	42	12.1	-24	-21	2.5
1.99	27.6	42	12.0	-19	-19	2.6

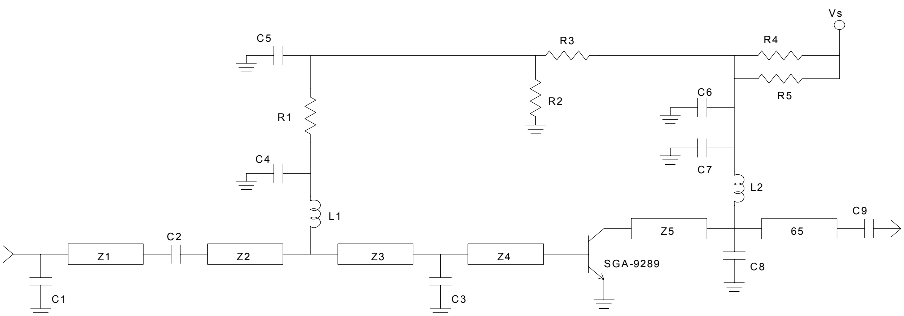
2110-2170 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA)



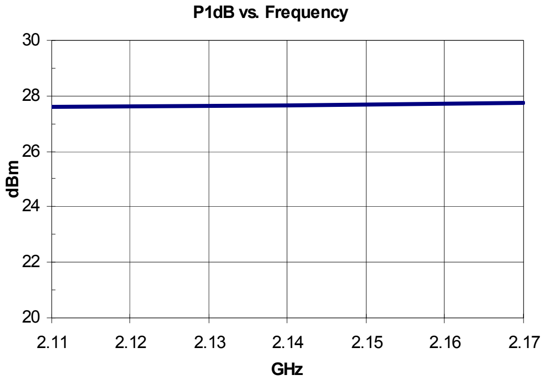
Ref. Des.	Part Number	Value
C1	ROHM MCH185A010CK	1.0pF
C2, C3, C8	ROHM MCH185A1R2CK	1.2pF
C4, C7	ROHM MCH185A220JK	22pF
C9	ROHM MCH185A2R2CK	2.2pF
C5, C6	Samsung CL10B104KONC	0.1uF
L1, L2	TOKO LL1608-FS22NJ	22nH
R1	ROHM MCR03J510	51 Ω
R2	ROHM MCR03J560	56 Ω
R3	ROHM MCR03J241	240 Ω

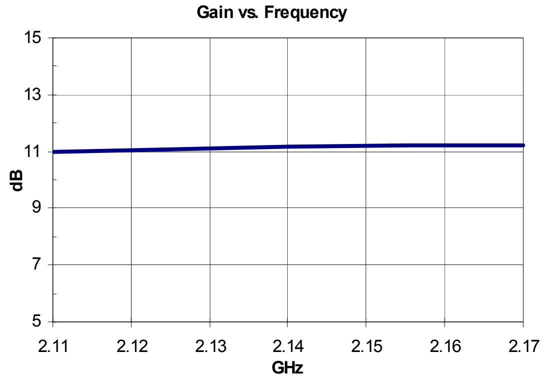
Ref. Des.	Part Number	Value
R4	ROHM MCR03J200	20 Ω
R5	ROHM MCR50J220	22 Ω
Z1	6.0 degrees @ 2140 MHz	50 Ω
Z2	7.6 degrees @ 2140 MHz	50 Ω
Z3	2.8 degrees @ 2140 MHz	50 Ω
Z4	12.1 degrees @ 2140 MHz	50 Ω
Z5	14.9 degrees @ 2140 MHz	50 Ω
Z6	29.0 degrees @ 2140 MHz	50 Ω

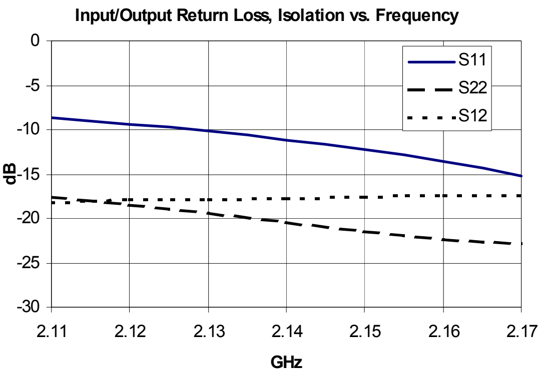
SGA-9289 2110-2170 MHz Schematic

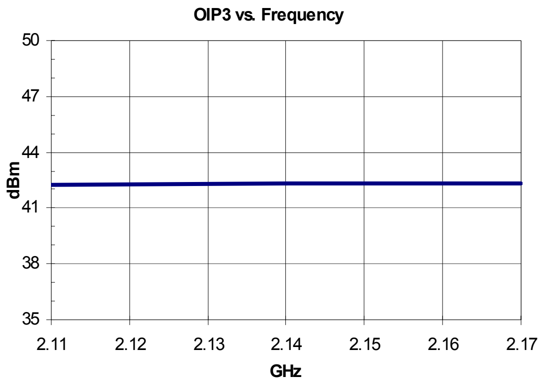


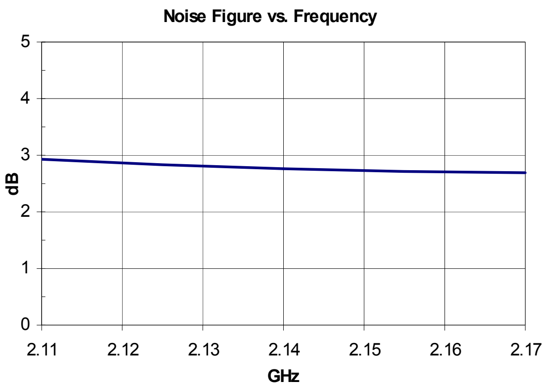
Typical Performance: 2110-2170 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA, 25C)

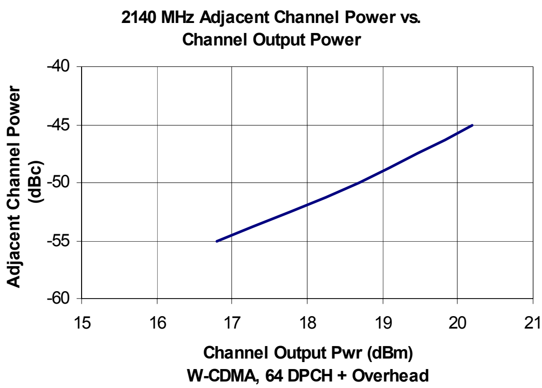






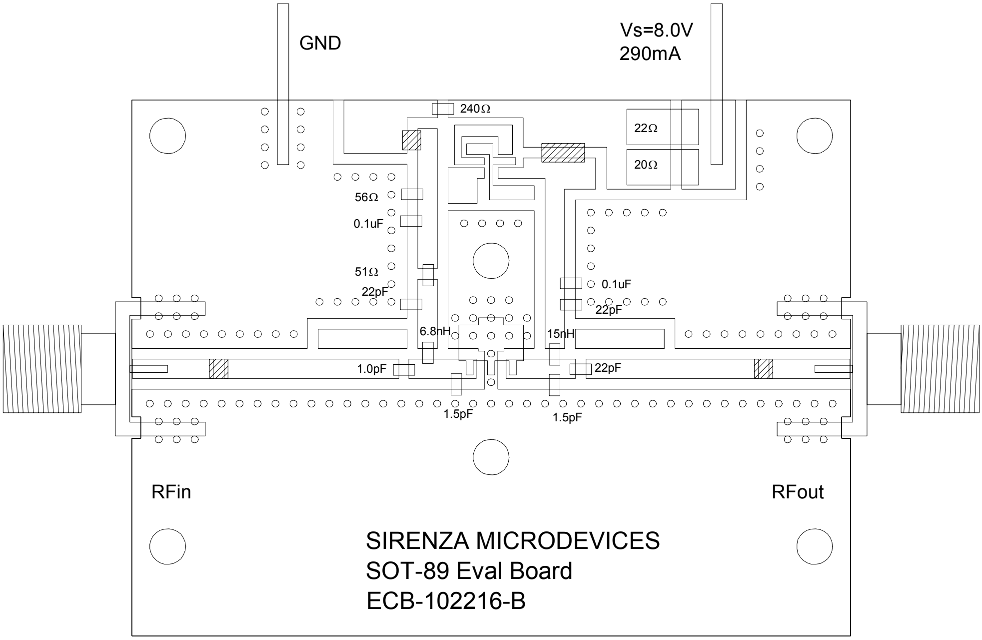






Freq (GHz)	P1dB (dBm)	OIP3 (dBm)	Gain (dB)	S11 (dB)	S22 (dB)	NF (dB)
2.11	27.6	42	11.0	-9	-17	2.9
2.14	27.7	42	11.1	-11	-20	2.8
2.17	27.7	42	11.2	-15	-22	2.7

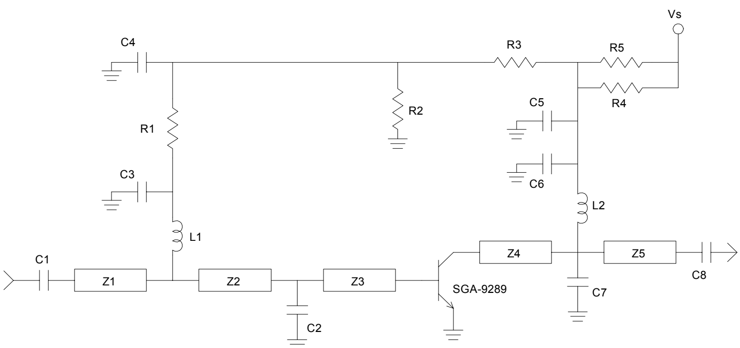
2400-2500 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA)



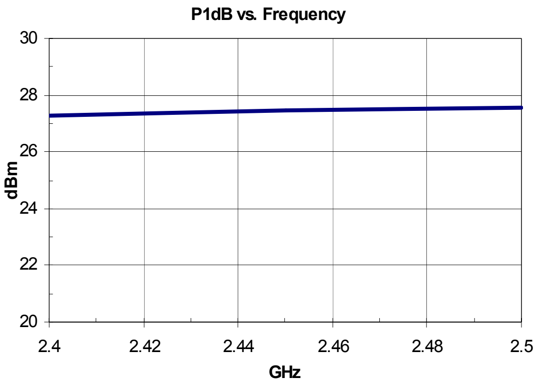
Ref. Des.	Part Number	Value
C1	ROHM MCH185A010CK	1.0pF
C3, C6, C8	ROHM MCH185A220JK	22pF
C2, C7	ROHM MCH185A1R5CK	1.5pF
C4, C5	Samsung CL10B104KONC	0.1uF
L1	TOKO LL1608-FS6N8J	6.8nH
L2	TOKO LL1608-FS15NJ	15nH
R1	ROHM MCR03J510	51 Ω
R2	ROHM MCR03J560	56 Ω
R3	ROHM MCR03J241	240 Ω

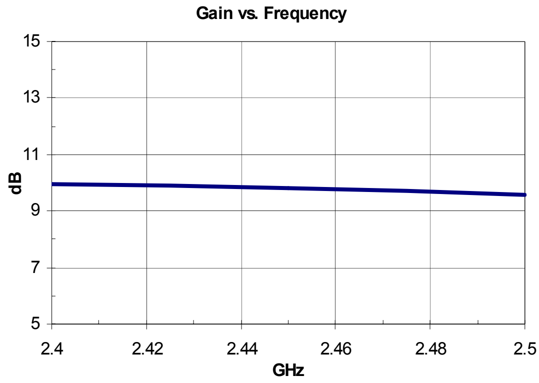
Ref. Des.	Part Number	Value
R4	ROHM MCR03J200	20 Ω
R5	ROHM MCR50J220	22 Ω
Z1	6.8 degrees @ 2450 MHz	50 Ω
Z2	10.0 degrees @ 2450 MHz	50 Ω
Z3	7.0 degrees @ 2450 MHz	50 Ω
Z4	17.1 degrees @ 2450 MHz	50 Ω
Z5	non-critical	50 Ω

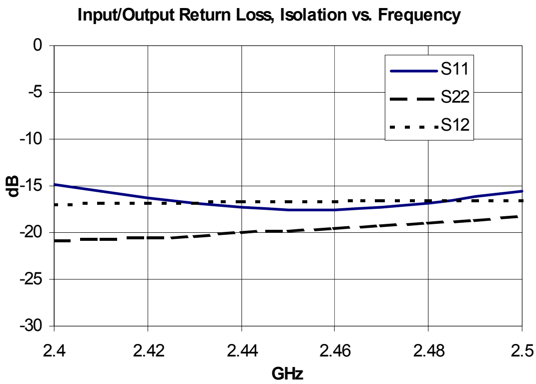
SGA-9289 2400-2500 MHz Schematic

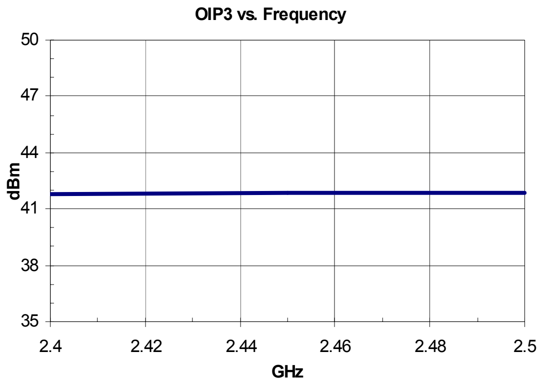


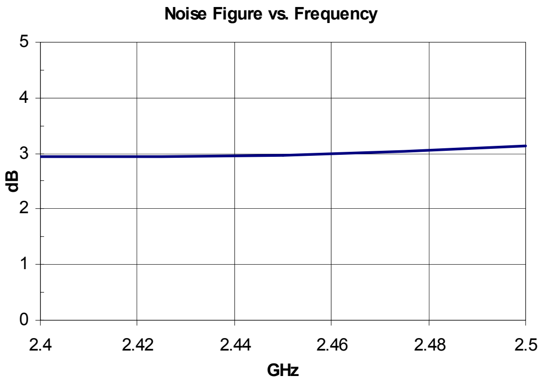
Typical Performance: 2400-2500 MHz Application Circuit (V_S=8V, V_{CE}=5V, I_{CQ}=290mA, 25C)











Freq (GHz)	P1dB (dBm)	OIP3 (dBm)	Gain (dB)	S11 (dB)	S22 (dB)	NF (dB)
2.40	27.3	42	10.0	-15	-20	2.9
2.45	27.5	42	9.8	-17	-20	3.0
2.50	27.6	42	9.6	-15	-18	3.1