

17-21GHz 5W BARE DIE GaN POWER AMPLIFIER

ICP1937



Product Overview

MICROCHIP's ICP1937 is a three stage MMIC power amplifier in bare die form, fabricated using GaN on SiC technology. The PA operates from 17-21GHz with 37dBm output power, 34% PAE and 28dB small signal gain. The die has integrated DC blocking capacitors and is matched to 50ohms on the RF input and output ports. The operating frequency provides flexible operation for a variety of applications including satellite and point to point radio. The ICP1937 is 100% DC and RF tested on-wafer to ensure compliance with electrical specifications.

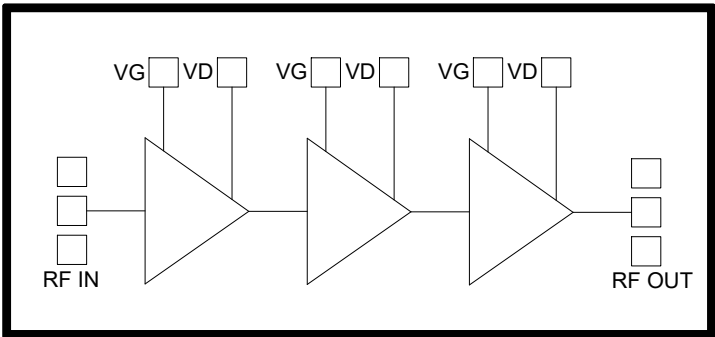
Key Features

- Frequency Range: 17 - 21GHz
- P_{out}: 37dBm @ 15dBm P_{in}
- PAE: 34%
- Small Signal Gain: 28dB
- Bias: V_D=24V, I_{DQ}=84mA
- Technology: GaN on SiC
- Lead-free and RoHS compliant
- CW operation
- Die Size: 3.2mm x 2.6mm
- Unconditionally Stable

Applications

- Point to Point Radio
- Satellite Communications

Functional Block Diagram



Electrical Specifications

Parameter	Min.	Typ.	Max.	Units	Conditions ⁽¹⁾
Frequency	17.2		21.2	GHz	
Output Power at P _{sat}		37		dBm	P _{in} = 15dBm
Power Added Efficiency, PAE at P _{sat}		34		%	P _{in} = 15dBm
Small Signal Gain, S ₂₁		28		dB	
Input Return Loss		12		dB	
Output Return Loss		8		dB	
I _{DQ}		84		mA	
V _{GS}		1.85		V	
I _D drive		900		mA	P _{out} =37dBm

Note: (1) Test conditions unless otherwise stated V_D = 24V, I_{DQ} = 84mA, T_A = 25°C, CW

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1. Electrical Specification

1.1 Absolute Maximum Ratings

Parameter	Absolute Maximum
Drain Voltage (V_D)	30V
Gate Voltage (V_G)	-5 to 0V
Gate Current (I_G)	5mA
Drain Current (CW) $T_A=25^{\circ}\text{C}$	1.34A
Power Dissipation (CW) $T_A=25^{\circ}\text{C}$	32W
Power Dissipation (CW) $T_A=85^{\circ}\text{C}$	22W
CW Input Power 50ohm $T_A=25^{\circ}\text{C}$	+20dBm
Channel Temperature	275°C
Storage Temperature	-65°C to +150°C
Input Power VSWR (2:1), $V_D=20\text{V}$, $I_{DQ}=84\text{mA}$ $V_D=24\text{V}$, $I_{DQ}=84\text{mA}$	20dBm
Eutectic Die Attach Temperature (30s)	320°C

Note:

Exceeding any one or combination of these limits may cause permanent damage to this device.

Microchip Technology Inc. does not recommend sustained operation near these survivability limits.

1.2 Small Signal Performance

Typical Data over Temperature

Test conditions: $V_D=24V$, $I_{DQ}=84mA$

Figure 1-1. S_{21} vs Freq

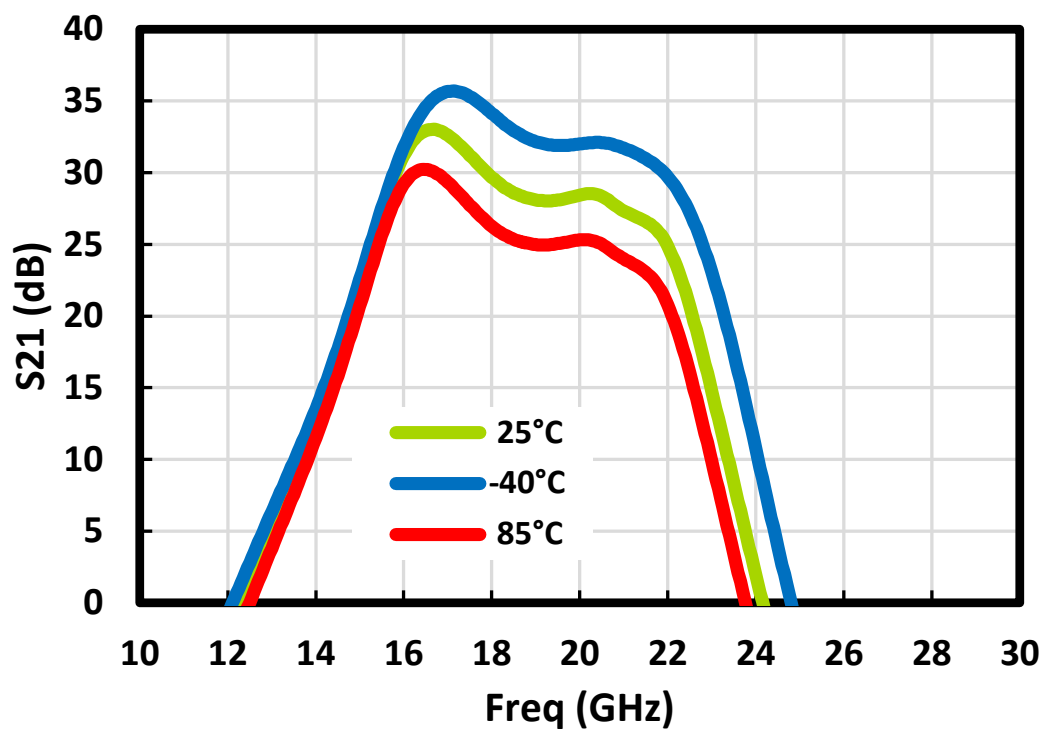


Figure 1-2. S_{11} vs Freq

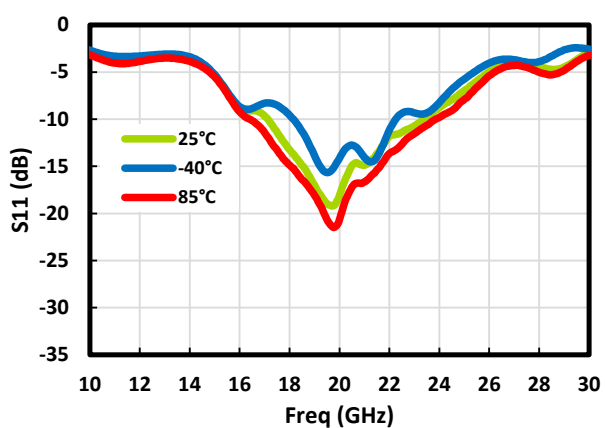
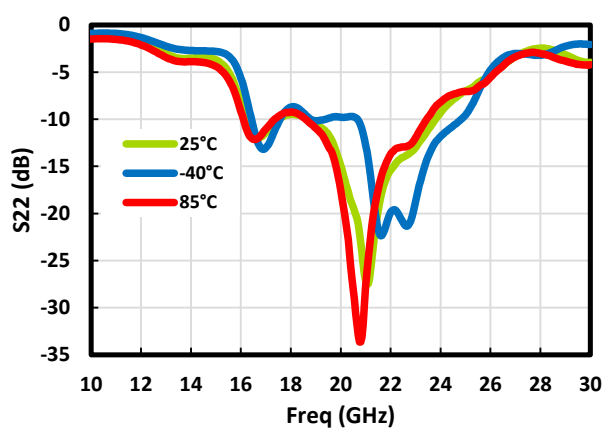


Figure 1-3. S_{22} vs Freq



Large Signal Performance

Typical Power Data

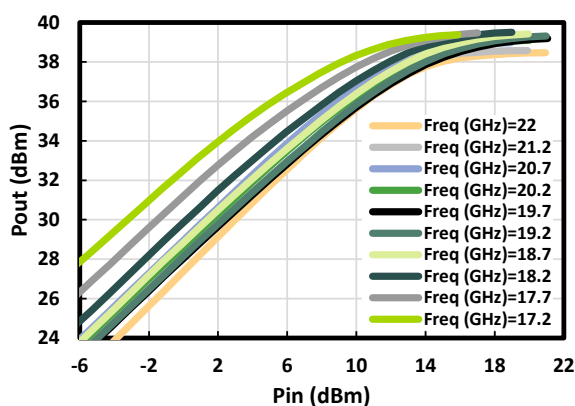
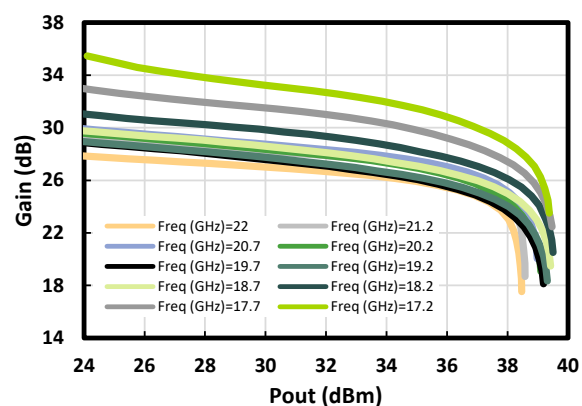
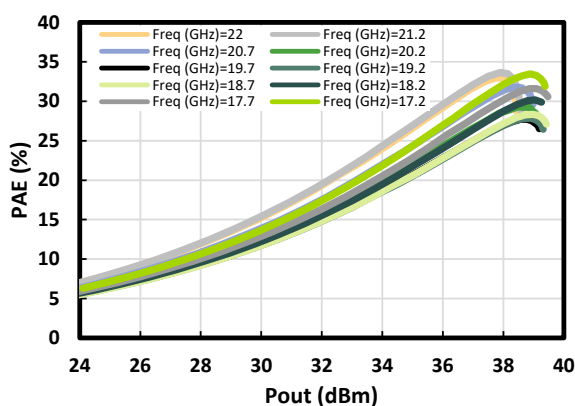
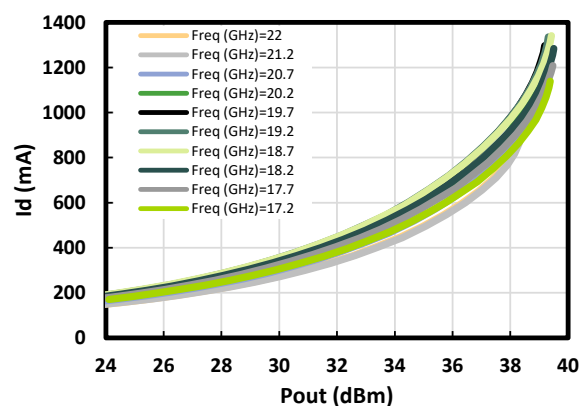
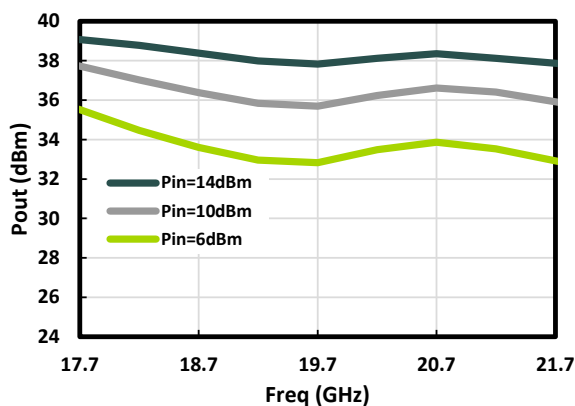
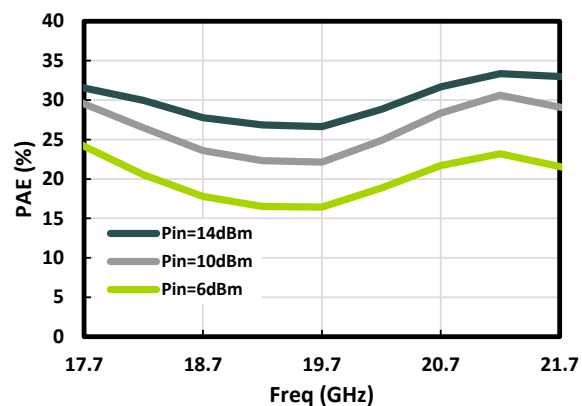
Test conditions: $V_D=24V$, $I_{DQ}=84mA$, $T_A=25^\circ C$, CWFigure 1-4. P_{out} vs. P_{in} Figure 1-5. Gain vs. P_{out} Figure 1-6. PAE vs. P_{out} Figure 1-7. I_D vs. P_{out} Figure 1-8. P_{out} vs. Freq

Figure 1-9. PAE vs. Freq



Typical Power Data over Bias Conditions

Test conditions: $I_{DQ}=84\text{mA}$, $T_A=25^\circ\text{C}$, CW

Figure 1-10. P_{out} vs. P_{in} , Freq=17.2GHz

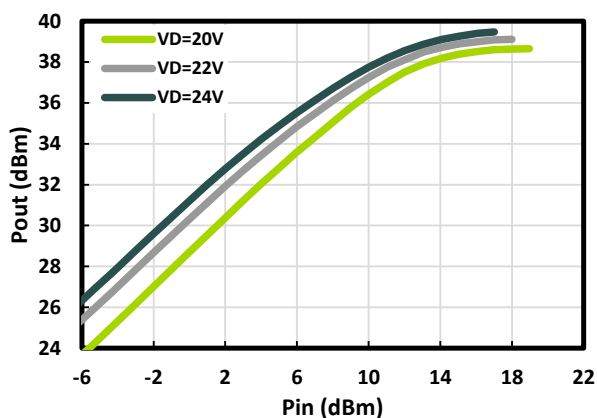


Figure 1-11. Gain vs. P_{out} , Freq=17.2GHz

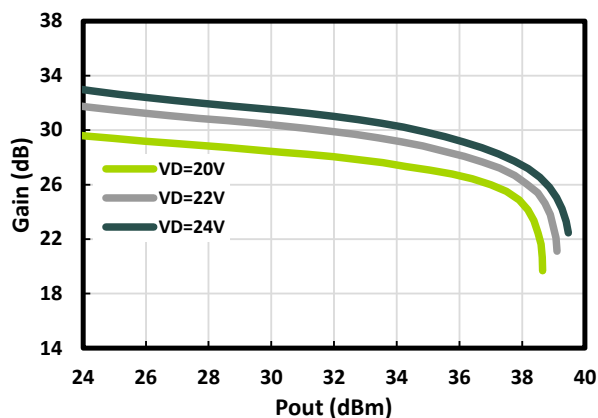


Figure 1-12. PAE vs. P_{out} , Freq=17.2GHz

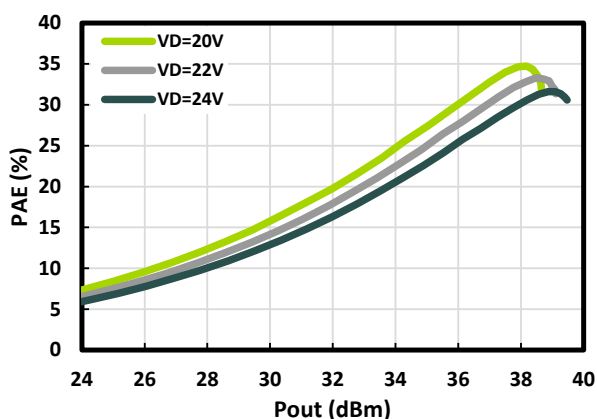


Figure 1-13. I_D vs. P_{out} , Freq=17.2GHz

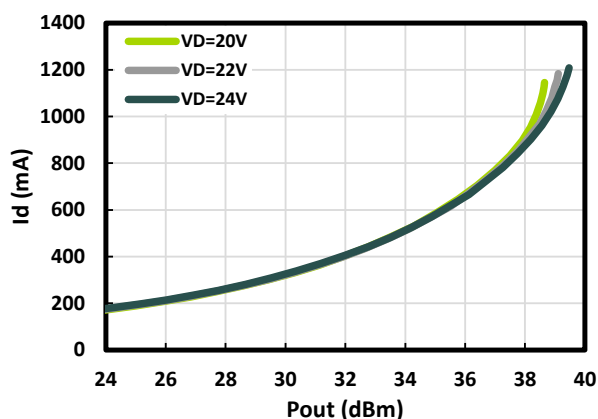


Figure 1-14. P_{out} vs. P_{in} , Freq=19.7GHz

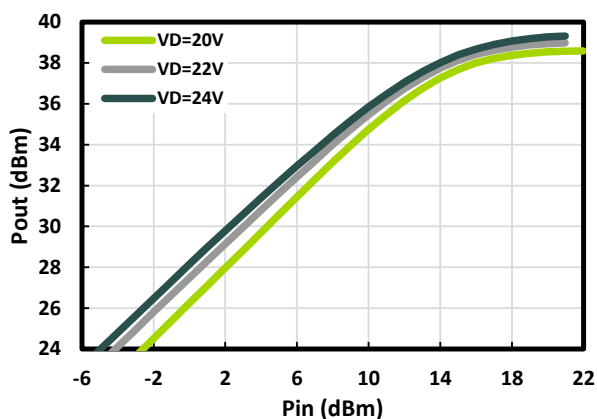
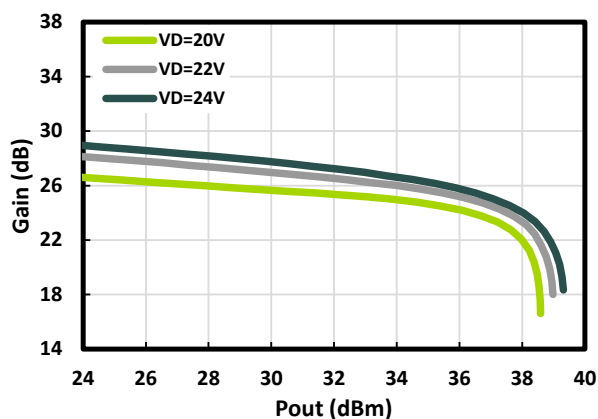


Figure 1-15. Gain vs. P_{out} , Freq=19.7



Typical Power Data over Bias Conditions (Continued)

Test conditions: $I_{DQ}=84\text{mA}$, $T_A=25^\circ\text{C}$, CW

Figure 1-16. PAE vs. P_{out} , Freq=19.7

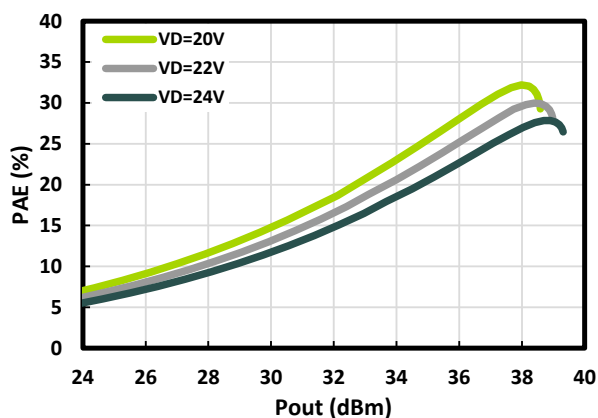


Figure 1-17. I_D vs. P_{out} , Freq=19.7

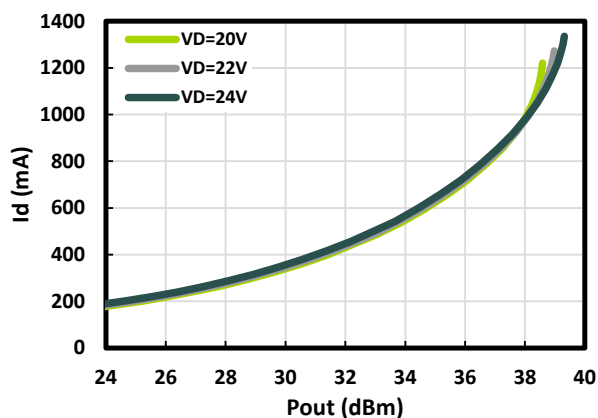


Figure 1-18. P_{out} vs. P_{in} , Freq=21.7

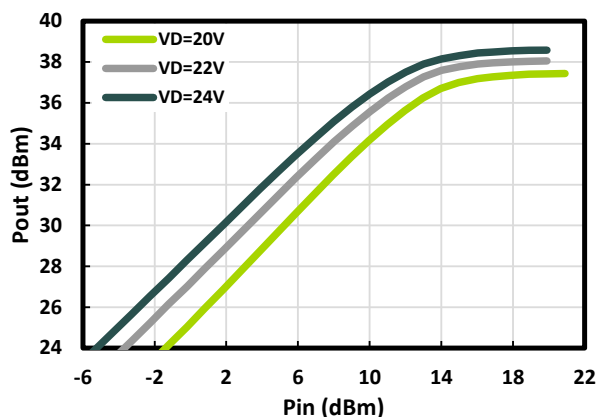


Figure 1-19. Gain vs. P_{out} , Freq=21.7

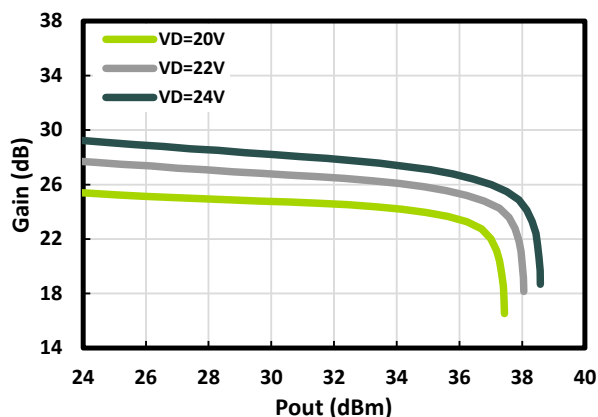


Figure 1-20. PAE vs. P_{in} , Freq=21.7GHz

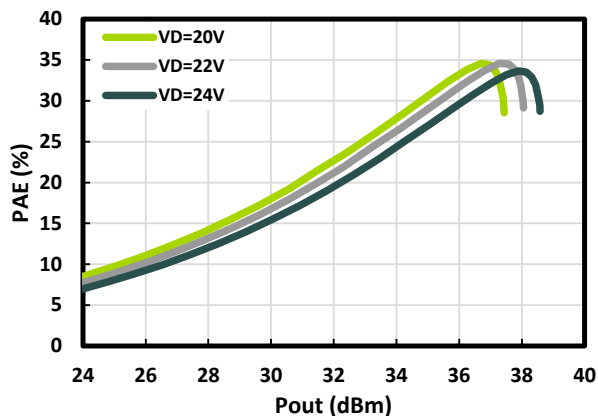
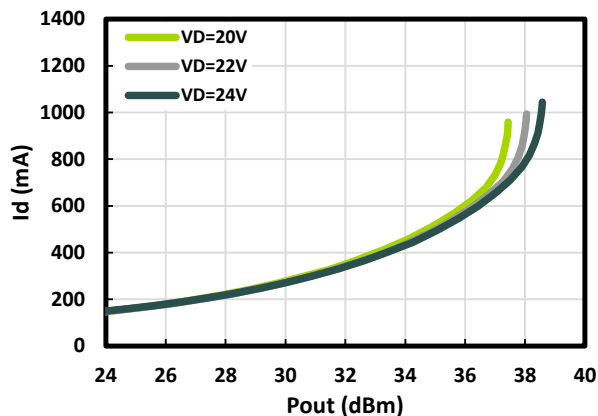


Figure 1-21. I_D vs. P_{out} , Freq=21.7GHz



Typical Power Data over T_A Conditions

Test conditions: $V_D=24V$, $I_{DQ}=84mA$, CW

Figure 1-22. P_{out} vs. P_{in} , Freq=17.2GHz

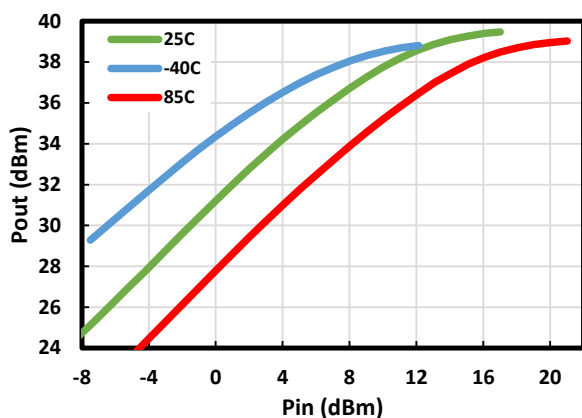


Figure 1-23. Gain vs. P_{out} , Freq=17.2GHz

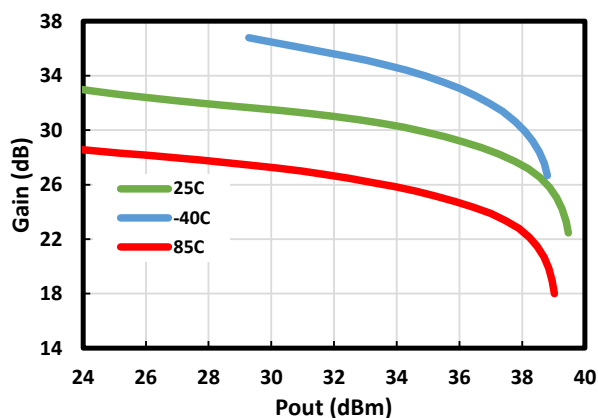


Figure 1-24. PAE vs. P_{out} , Freq=17.2GHz

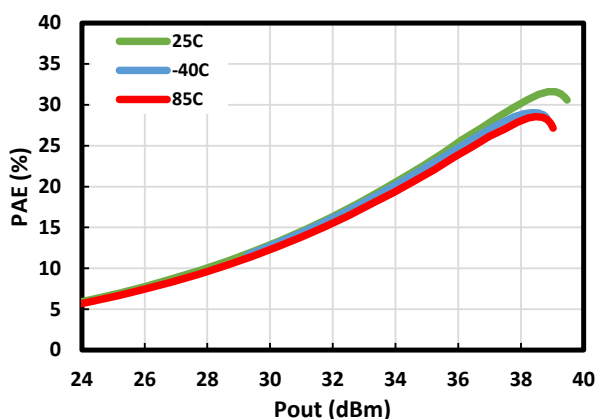


Figure 1-25. I_D vs. P_{out} , Freq=17.2GHz

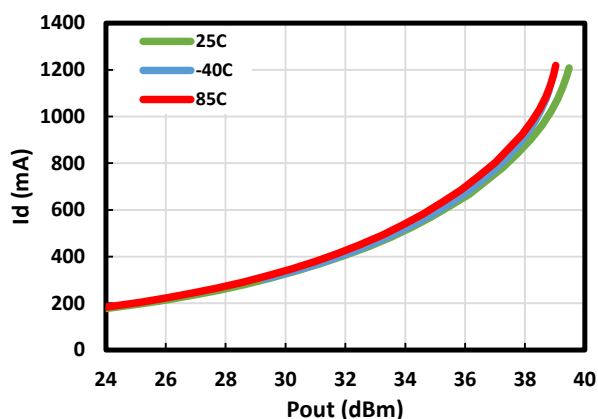


Figure 1-26. P_{out} vs. P_{in} , Freq=19.7GHz

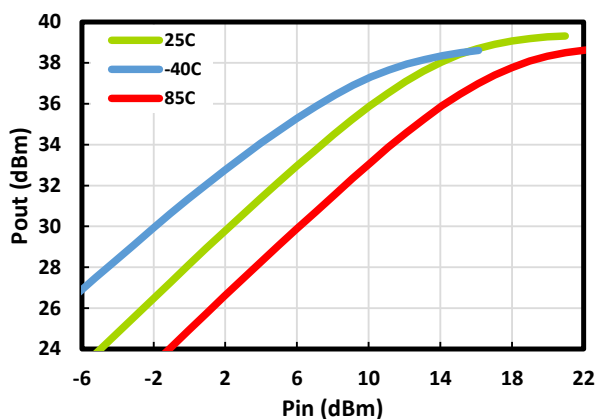
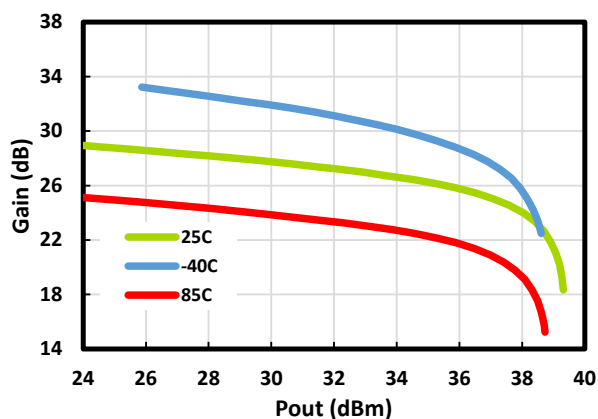


Figure 1-27. Gain vs. P_{out} , Freq=19.7GHz



Typical Power Data over T_A Conditions (Continued)

Test conditions: $V_D=24V$, $I_{DQ}=84mA$, CW

Figure 1-28. PAE vs. P_{out} , Freq=19.7GHz

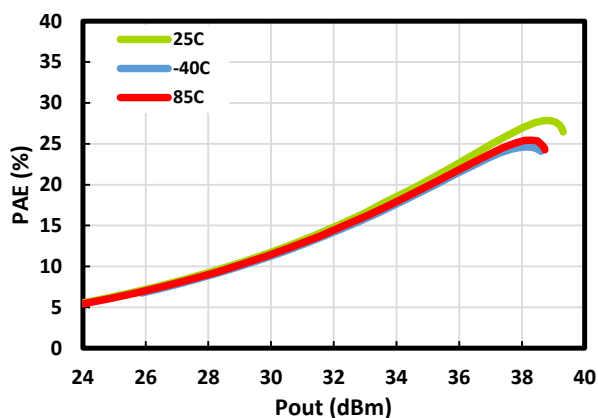


Figure 1-29. I_D vs. P_{out} , Freq=19.7GHz

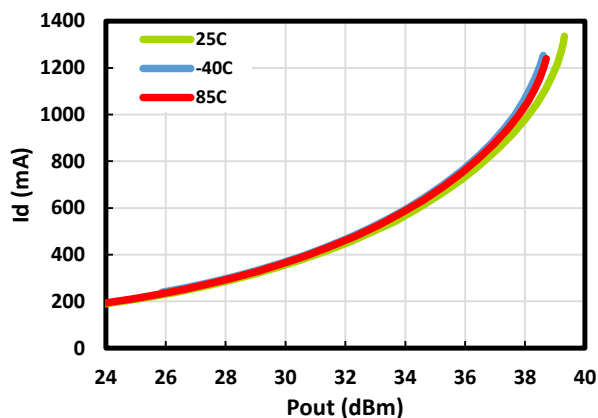


Figure 1-30. P_{out} vs. P_{in} , Freq=21.7GHz

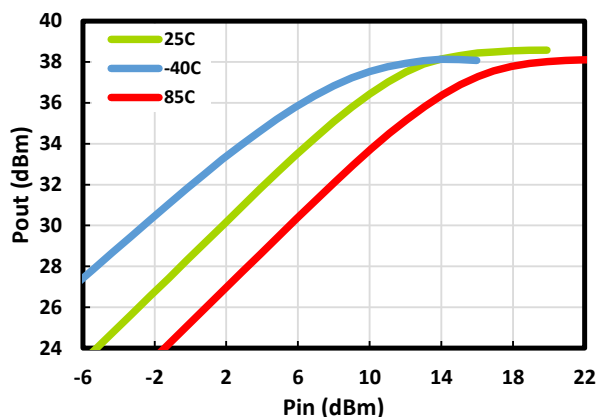


Figure 1-31. Gain vs. P_{out} , Freq=21.7GHz

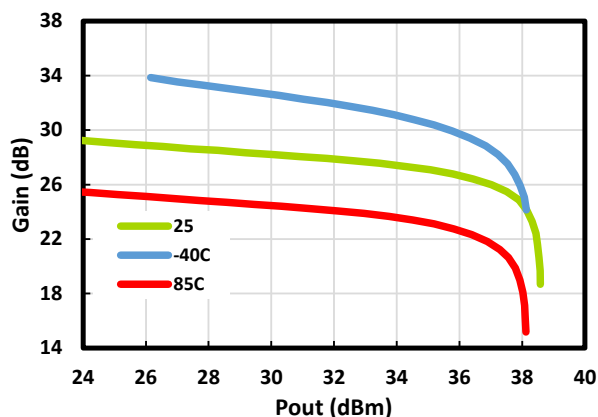


Figure 1-32. PAE vs. P_{out} , Freq=21.7GHz

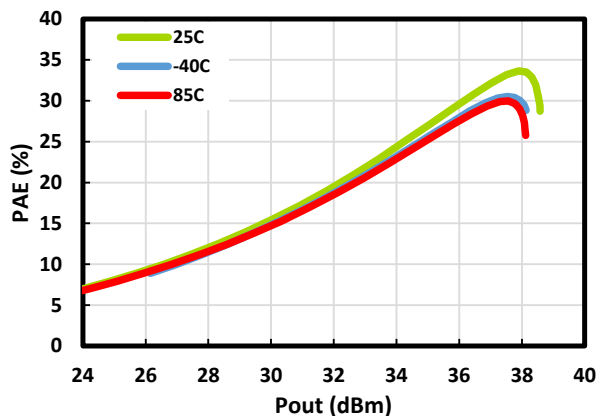
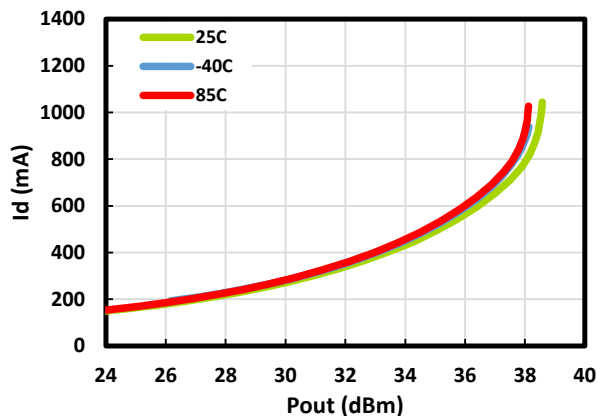
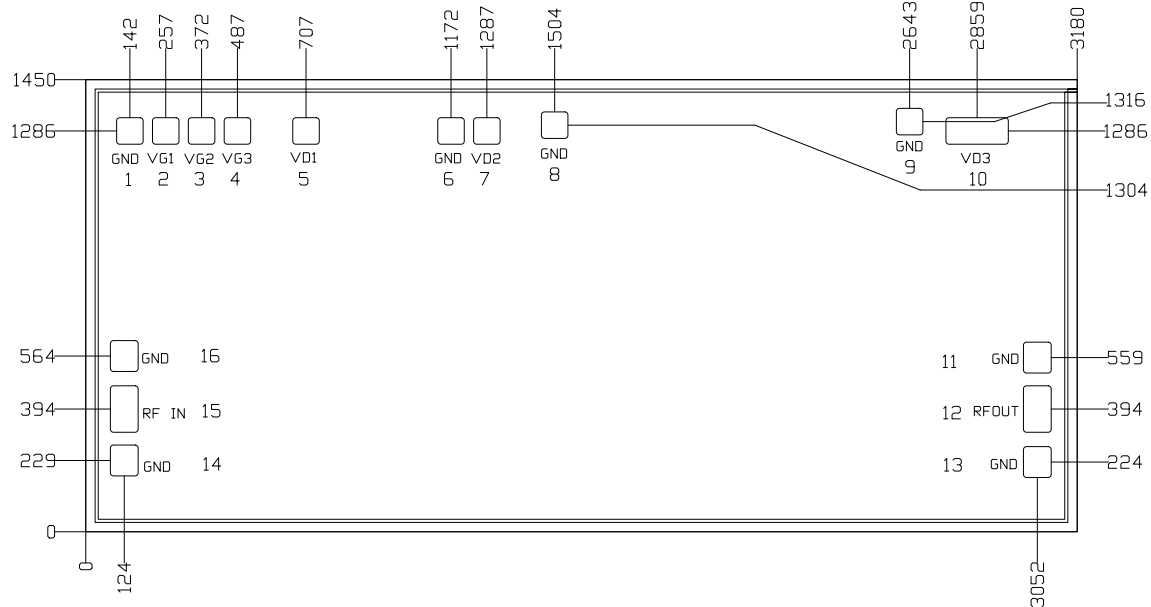


Figure 1-33. I_D vs. P_{out} , Freq=21.7GHz



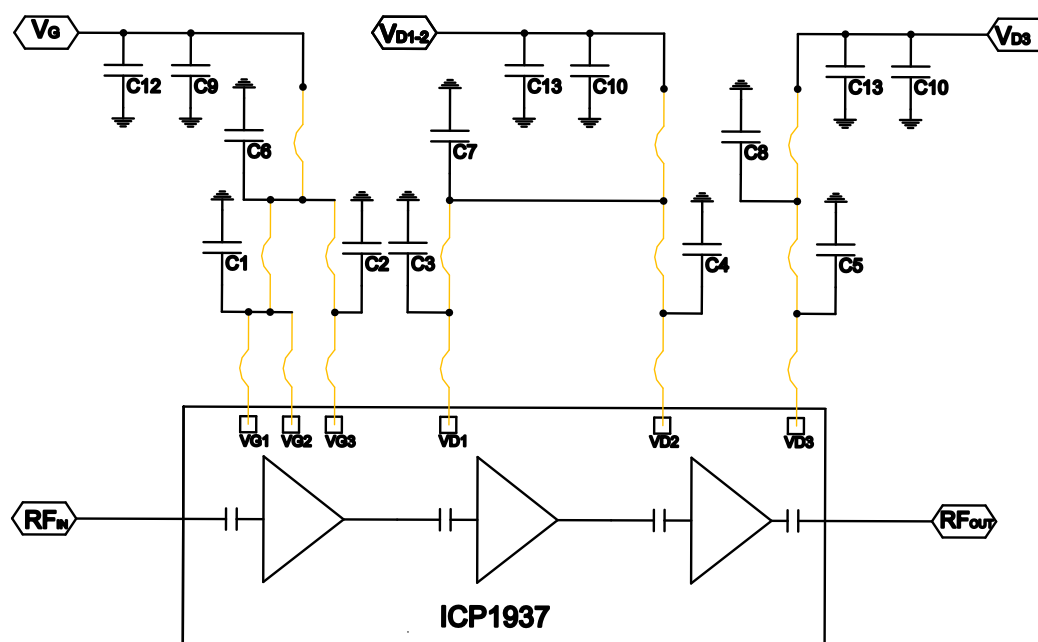
2. Mechanical Drawing



Units: μm | Thickness: $100\mu\text{m}$ | Backside of Die is RF and DC ground

Pad No	Pad size (μm)	Function	Description
1	89x150	GND	Ground
2	85x85	V _{G1}	First stage gate bias, decoupling and bypass caps required
3	85x85	V _{G2}	Second stage gate bias, decoupling and bypass caps required
4	85x85	V _{G3}	Third stage gate bias, decoupling and bypass caps required
5	85x85	V _{D1}	First stage drain voltage, decoupling and bypass caps required
6,8,9	89x150	GND	Ground
7	85x85	V _{D2}	Second stage drain voltage, decoupling and bypass caps required
10	200x85	V _{D3}	Third stage drain voltage, decoupling and bypass caps required
11, 13, 14, 16	89x100	GND	Ground
12	89x150	RF _{OUT}	50 ohm RF output, DC blocked, pad is DC grounded
15	89x150	RF _{IN}	50 ohm RF input, DC blocked

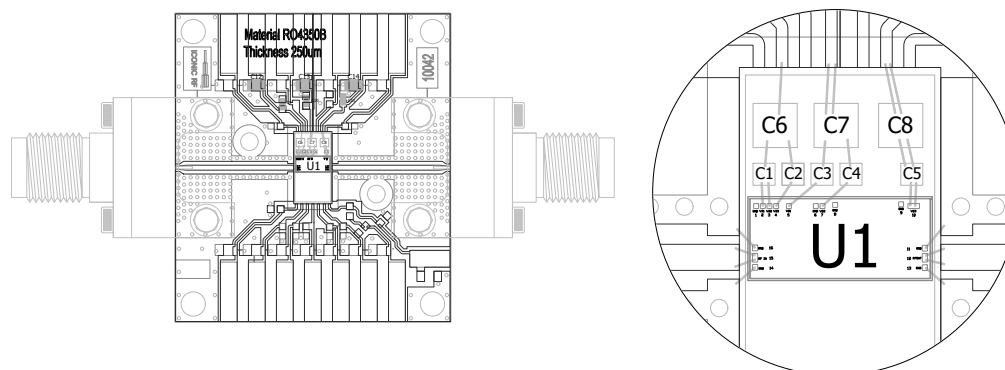
3. Application Circuit



Bill of materials

Component ID	Value	Details	Qty	Manufacturer Part No.
C1 - C5	100pF	SLC Capacitor	10	Johanson 500U01A101MT4W
C6 - C8	10nF	SLC Capacitor	8	Knowles V30BZ103M1SX
C9	100nF	0402 size Capacitor	4	Various
C10, C11	10nF	0402 size Capacitors	6	Various
C12 - C14	10μF	0603 size Capacitors	10	Various

4. Evaluation Board



Evaluation board construction

- Board Size: 25mm X 28mm
- 2 layer PCB: RO4350B thickness 10mil
 - Via size 0.15mm plated to >15um thickness
 - Recommended Copper Weight of 0.5oz
 - Top finish: ENIG in accordance with IPC-4556
- Baseplate: Solid copper 25mm X 28mm X 5mm, Au plated

Component ID	Value	Details	Qty	Manufacturer Part No.
U1		ICP1937 MMIC	2	ICP1937
C1 - C5	100pF	SLC Capacitor	10	Johanson 500U01A101MT4W
C6 - C8	10nF	SLC Capacitor	8	Knowles V30BZ103M1SX
C9	100nF	0402 size Capacitor	4	Various
C10, C11	10nF	0402 size Capacitors	6	Various
C12 - C14	10μF	0603 size Capacitors	10	Various

Note:

Optimum RF power performance achieved by minimizing output RF bond wire length.

5. Other considerations

Assembly Guidance

Interconnect assembly Notes

- Ball Bonding is preferred technique.
- Force, time and ultrasonic parameters are critical.
- Aluminum wire bonding is not recommended.
- Bond Wire diameter of 1mil is recommended.

Die attach of component using adhesive

- Vacuum collets are preferred method of pickup.
- Pickup method must consider the avoidance of die air bridges.
- Die suitable for Eutectic and Epoxy die attach.
- Where Epoxy is used, high thermal conductivity,
- Silver Sintered Epoxy is recommended:
 - Namics H9889-1
 - Kyocera CT2700R7S

Die attach using Eutectic

- Flux-less gold-tin (AuSn) (80% Au, 20% Sn with a melting point of 280°C) preform is preferred between the die and attached surface.
- Recommended preform should be approximately 0.0012" thick.
- Die bonder using heated collet with a temperature of 310°C and die scrubbing should be used to ensure wetting and prevent formation of voids.
- Exposure to extreme temperature should be kept to a minimum.
- The optimum die attach environment is nitrogen atmosphere.

Reflow Process

- Maximum temperature 320°C for 30 seconds.
- Material matching for coefficient of thermal expansion is crucial for long-term reliability.

For optimum RF and thermal performance IconicRF recommends the die assembly base plate is adequately bolted to an forced air heat sink using a thermal graphite interface pad (Graphite Interface Material GCSP-017-G 170µm thick) for optimal heat transfer. There are many variables of the second level assembly between the die base plate and heat sink that IconicRF are unable to control and the following guidance is provided as information only. Fixing bolts should be provided as close to the die as possible to ensure an optimum pressure between the base plate and the heat sink. The bolting screws used to attach the PCB assembly to the heat sink must include washers and be tightened with a suitable tightening pattern to ensure a uniform pressure. It is advised all surfaces be cleaned and be free of grease and dust prior to fully aligning the assembly with all screws located and tightened to finger tight. Further torquing of the screws must be achieved in multiple phases using a star shaped pattern to a recommended torque of 2.5N/m.

Bias-up procedure

1. Set V_G to -5V
2. Set V_D to 20V - 24V
3. Adjust V_G positive until I_D quiescent is 85mA
4. Limit I_D to 1.5A
5. Apply RF signal

Bias-down procedure

1. Turn off RF
2. Turn off V_D , allow drain capacitors to discharge
3. Turn off V_G

6. Ordering, Shipping, and Handling

Handling Recommendations

Integrated circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. It is recommended to follow all procedures and guidelines outlined in the Microsemi application note AN01: GaAs MMIC Handling and Die Attach Recommendations.

Ordering Information

For additional ordering information, contact your Microchip sales representative.

Part Number	Standard Packing Format
ICP1937-1-110I	17-21GHz 5W Bare Die GaN Power Amplifier in Gelpak Format
EV90U69A	Dev Tool for ICP1937-1-110I, Fully Assembled Evaluation Board with RF Test Data

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