RF2878

3V LOW NOISE AMPLIFIER/ 3V PA DRIVER AMPLIFIER

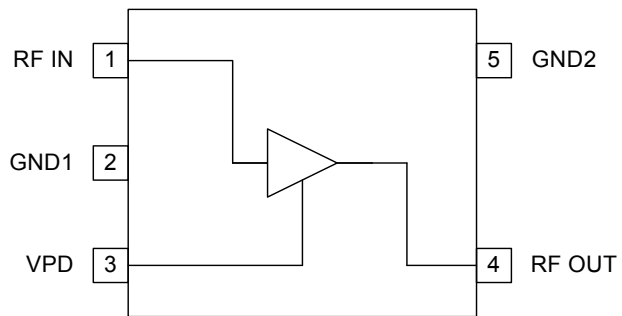**Package Style: SOT 5-Lead**

Features

- Low Noise and High Intercept Point
- Adjustable Bias Current
- Power Down Control
- Single 2.5V to 5.0V Power Supply
- 150MHz to 2500MHz Operation

Applications

- CDMA/FM Cellular PCS LNA
- Low Noise Transmit Driver Amplifier
- General Purpose Amplification
- Commercial and Consumer Systems

Functional Block Diagram

Product Description

The RF2878 is a low noise amplifier with a very high dynamic range designed for digital cellular applications. The device functions as an outstanding front end low noise amplifier or power amplifier driver amplifier in the transmit chain of digital subscriber units where low transmit noise power is a concern. When used as an LNA, the bias current can be set externally. When used as a PA driver, the IC can operate directly from a single cell Li-ion battery and includes a power down feature that can be used to completely turn off the device. The IC is featured in a standard SOT 5-lead plastic package.

Ordering Information

RF2878	Sample bag with 25 pieces
RF2878SR	7" Sample reel with 100 pieces
RF2878TR7	7" Reel with 2500 pieces
RF2878PCK-410	1800MHz to 2170MHz PCBA with 5-piece sample bag

Optimum Technology Matching® Applied

☑ GaAs HBT	☐ SiGe BiCMOS	☐ GaAs pHEMT	☐ GaN HEMT
☐ GaAs MESFET	☐ Si BiCMOS	☐ Si CMOS	☐ RF MEMS
☐ InGaP HBT	☐ SiGe HBT	☐ Si BJT	

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Absolute Maximum Ratings

Parameter	Rating	Unit
Supply Voltage, V_{CC}	≤ 5	V
Power Down Voltage, V_{PD}	≤ 3	V
Input RF Level	+10	dBm
Operating Ambient Temperature	-40 to +85	°C
Storage Temperature	-40 to +150	°C
Operating Junction Temperature	150	°C
I_{CC}	30	mA

Caution! ESD sensitive device.

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.

RoHS status based on EU Directive 2002/95/EC (at time of this document revision).

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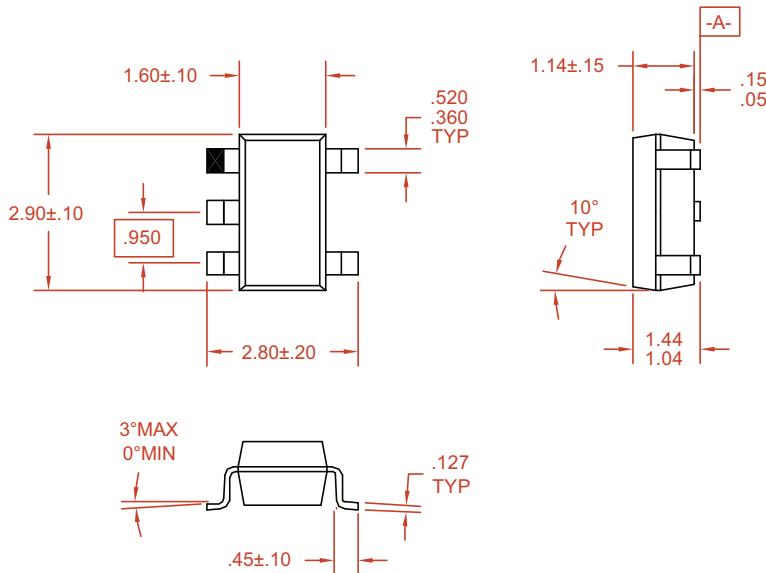
Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Overall					
RF Frequency Range	150		2500	MHz	
Low Noise Amplifier 881 MHz Performance					Schematic per LNA Application; T=25°C, RF=881 MHz, V_{PD}=2.8V, R1=1kΩ
Gain		20		dB	V_{CC}=3.0V, I_{CC}=7.6 mA
		20		dB	V_{CC}=2.7V, I_{CC}=7.5 mA
Noise Figure		1.4	1.6	dB	V_{CC}=3.0V, I_{CC}=7.6 mA
		1.4	1.6	dB	V_{CC}=2.7V, I_{CC}=7.5 mA
Input IP3		+6.0		dBm	V_{CC}=3.0V, I_{CC}=7.6 mA
		+5.5		dBm	V_{CC}=2.7V, I_{CC}=7.5 mA
Low Noise Amplifier 1950 MHz Performance					Schematic per LNA Application; T=25°C, RF=1950 MHz, V_{PD}=2.8V, R1=1kΩ
Gain		13		dB	V_{CC}=3.0V, I_{CC}=6.4 mA
		13		dB	V_{CC}=2.7V, I_{CC}=6.3 mA
Noise Figure		1.3	1.5	dB	V_{CC}=3.0V, I_{CC}=6.4 mA
		1.3	1.5	dB	V_{CC}=2.7V, I_{CC}=6.3 mA
Input IP3		+16.5		dBm	V_{CC}=3.0V, I_{CC}=6.4 mA
		+16.0		dBm	V_{CC}=2.7V, I_{CC}=6.3 mA
Driver Amplifier 836 MHz Performance					Schematic per Driver Amplifier Application; T=25°C, RF=836 MHz, V_{PD}=2.8V
Gain	19.5	20.5	21.5	dB	V_{CC}=3.5V
	19.5	20.5	21.5	dB	V_{CC}=3.0V
	19.5	20.5	21.5	dB	V_{CC}=2.7V
Output IP3	25	+32.0	35	dBm	V_{CC}=3.5V
		+29.0		dBm	V_{CC}=3.0V
		+27.8		dBm	V_{CC}=2.7V
Noise Figure		1.9	2.0	dB	V_{CC}=3.5V
		1.85	2.0	dB	V_{CC}=3.0V
		1.8	2.0	dB	V_{CC}=2.7V
Reverse Isolation		25		dB	V_{CC}=3.5V
		25		dB	V_{CC}=3.0V
		25		dB	V_{CC}=2.7V

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Driver Amplifier **836 MHz Performance, cont.**					
Input VSWR		1.8:1	2.0:1		
Output VSWR		1.25:1	2.0:1		Using External LC network used on evaluation board.
P_{1dB}		14.4		dBm	$V_{CC}=3.5V$
		12.5		dBm	$V_{CC}=3.0V$
		11.5		dBm	$V_{CC}=2.7V$
Power Supply					$T=25\,°C$
Voltage (V_{CC})		3.5		V	
Voltage (V_{PD})		2.8		V	
Current Consumption - Driver Amplifier (see note 1)	14.0	21.5	29.0	mA	$V_{CC}=3.5V$; $V_{PD}=2.8V$
Power Down			10	µA	$V_{CC}=3.5V$; $V_{PD} \leq 0.9\,V$
Driver Amplifier **1880 MHz Performance**					Schematic per Driver Amplifier Application; $T=25°C$, $RF=1880\,MHz$, $V_{PD}=2.8V$
Gain		14.0		dB	$V_{CC}=3.5V$
		14.0		dB	$V_{CC}=3.0V$
		14.0		dB	$V_{CC}=2.7V$
Output IP3		+35.0		dBm	$V_{CC}=3.5V$
		+31.0		dBm	$V_{CC}=3.0V$
		+28.8		dBm	$V_{CC}=2.7V$
Noise Figure		1.85	2.0	dB	$V_{CC}=3.5V$
		1.8	2.0	dB	$V_{CC}=3.0V$
		1.75	2.0	dB	$V_{CC}=2.7V$
Reverse Isolation		19		dB	$V_{CC}=3.5V$
		19		dB	$V_{CC}=3.0V$
		19		dB	$V_{CC}=2.7V$
Input VSWR		1.6:1	2.0:1		
Output VSWR		1.6:1	2.0:1		Using External LC network used on evaluation board.
P_{1dB}	14	15.6		dBm	$V_{CC}=3.5V$
	13	14.1		dBm	$V_{CC}=3.0V$
	12	13.1		dBm	$V_{CC}=2.7V$
Power Supply					$T=25\,°C$
Voltage (V_{CC})		3.5		V	
Voltage (V_{PD})		2.8		V	
Current Consumption - Driver Amplifier (see note 2)	14	21	29	mA	$V_{CC}=3.5V$; $V_{PD}=2.8V$
Power Down			10	µA	$V_{CC}=3.5V$; $V_{PD} \leq 0.9\,V$

Note 1: Current consumption shown for I_{CC} only. I_{PD} typical $=2.0\,mA$ with $V_{PD}=2.8V$

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Pin	Function	Description	Interface Schematic
1	RF IN	RF input pin. This pin is DC coupled and matched to $50\,\Omega$ at 836 MHz.	To Bias Circuit / RF IN / RF OUT
2	GND1	Ground connection. Keep traces physically short and connect immediately to ground plane for best performance.	
3	VPD	For low noise amplifier applications, this pin is used to control the bias current. See plots for bias current settings. An external resistor (R1) can be used to set the bias current for any V_{PD} voltage. For driver amplifier applications, this is the Power Down pin for the IC. V_{PD}=2.8V +/- 0.1V is required for proper operation. V_{PD}< 0.9V turns off the Part. External RF bypassing is required. The trace length between the pin and the bypass capacitors should be minimized. The ground side of the bypass capacitors should connect immediately to ground plane. Nominal current required for V_{PD}=2.8V is 2.0 mA typical and 3.0 mA Max (@ V_{PD}=2.9V).	P D
4	RF OUT	Amplifier Output pin. This pin is an open-collector output. It must be biased to either V_{CC} or pin 4 through a choke or matching inductor. This pin is typically matched to $50\,\Omega$ with a shunt bias/matching inductor and series blocking/matching capacitor. Refer to application schematics.	
5	GND2	Ground connection. Keep traces physically short and connect immediately to ground plane for best performance.	

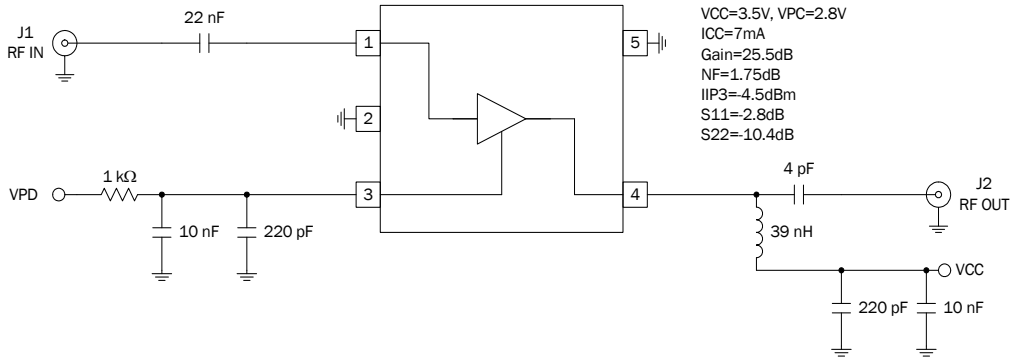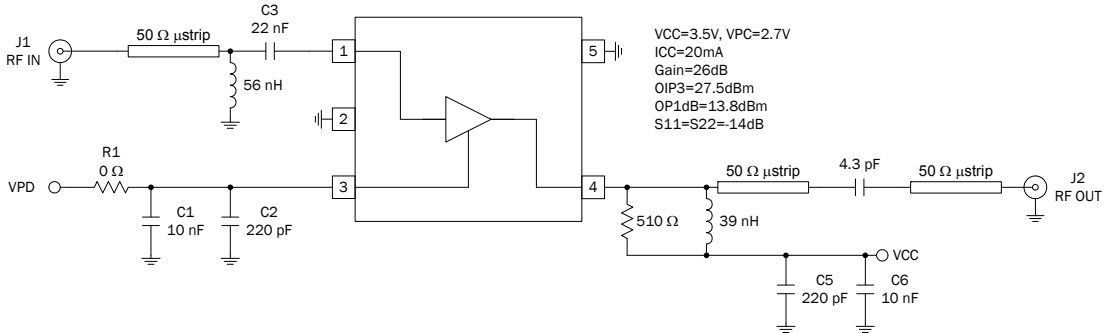## Package Drawing

Notes:
1. Shaded Lead is Pin 1.
2. Dimensions do not influde mold flash, protrusions or burrs.
3. :ead Dimensions include solder plating.
4. Foot Length measured reference to flat foot surface parallel to datum "A".
5. Package is die down configuration.

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Application Schematic:
350 MHz LNA

J1
RF IN

22 nF

1

2

5

VCC=3.5V, VPC=2.8V
ICC=7mA
Gain=25.5dB
NF=1.75dB
IIP3=-4.5dBm
S11=-2.8dB
S22=-10.4dB

VPD

1 kΩ

10 nF

220 pF

3

4

4 pF

J2
RF OUT

39 nH

VCC

220 pF

10 nF

Application Schematic:
350 MHz Linear Driver

J1
RF IN

50 Ω µstrip

C3
22 nF

56 nH

1

2

5

VCC=3.5V, VPC=2.7V
ICC=20mA
Gain=26dB
OIP3=27.5dBm
OP1dB=13.8dBm
S11=S22=-14dB

VPD

R1
0 Ω

C1
10 nF

C2
220 pF

3

4

510 Ω

39 nH

50 Ω µstrip

4.3 pF

50 Ω µstrip

J2
RF OUT

C5
220 pF

C6
10 nF

VCC

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Application Schematic:
1200 MHz to 1600 MHz Driver
(set resistance at V_{PD}=1000Ω for LNA)

22 nF

J1
RF IN

1

2

3

0Ω

10 nF   100 pF

4

5

VCC=3.5V, VPC=2.7V
ICC=21mA
Gain=17dB to 14.2dB from 1200MHz to 1600MHz
S11=-8.7dB to -23dB from 1200MHz to 1600MHz
S22=-14.5dB to -8.1dB from 1200MHz to 1600MHz

1.5 pF

J2
RF OUT

6.8 nH

VCC

100 pF   10 nF

VPD
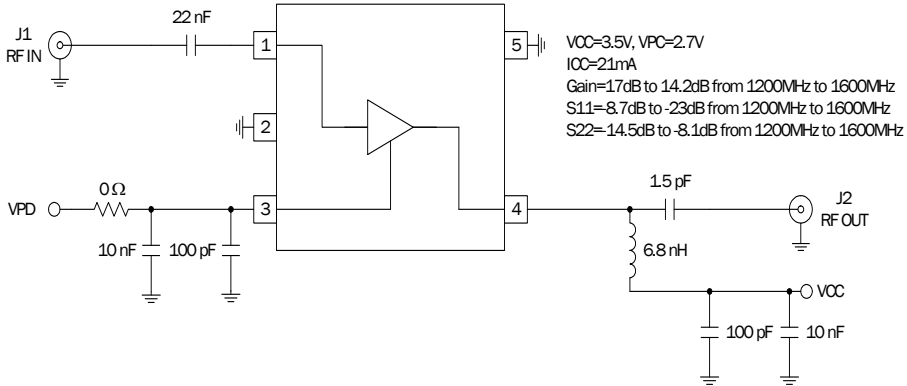
Application Schematic:
1800 MHz to 2170 MHz Linear Driver
(set resistance at V_{PD}=1000Ω for LNA)

22 nF

J1
RF IN

1

2

3

0Ω

10 nF   100 pF

4

5

VCC=4V, VPC=2.7V
ICC=21mA
Gain=13.8dB to 12.3dB from 1800MHz to 2170MHz
S11=-11dB to -20dB from 1800MHz to 2170MHz
S22=-11.5dB to -12.5dB from 1800MHz to 2170MHz
OIP3=36dBm to 34.5dBm from 1800MHz to 2170MHz
OP1dB=16dBm to 17dBm from 1800MHz to 2170MHz

1 pF

J2
RF OUT

2.7 nH

**47Ω

VCC

100 pF   10 nF

VPD

**47Ω dropping R for use with VCC=5V.
5-0.021*47=4V at RF2878 collector
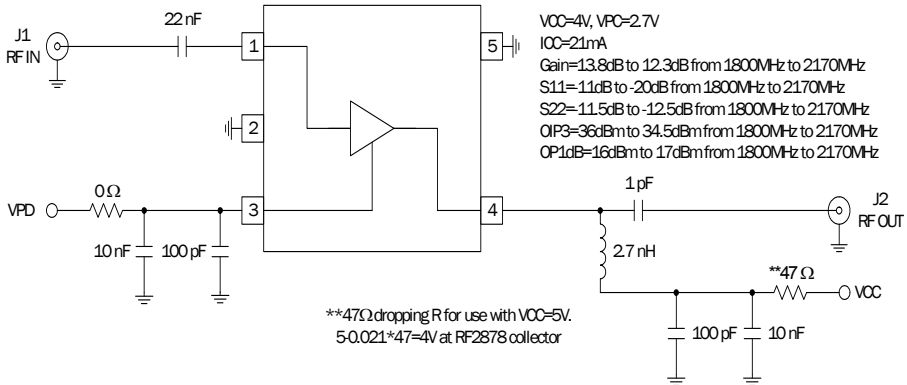
Application Schematic:
Low Noise Amplifier ~1950 MHz Operation

J1
RF IN

22 nF

1

5

2

3

4

VPD

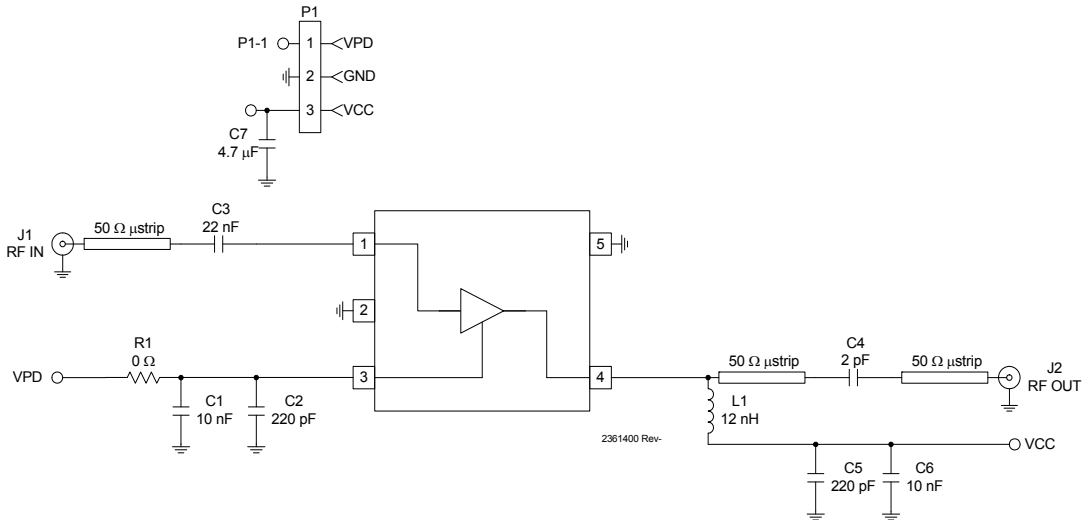1k Ω

10 nF   100 pF

1 pF

3.3 nH

J2
RF OUT

100 pF   10 nF   VCC
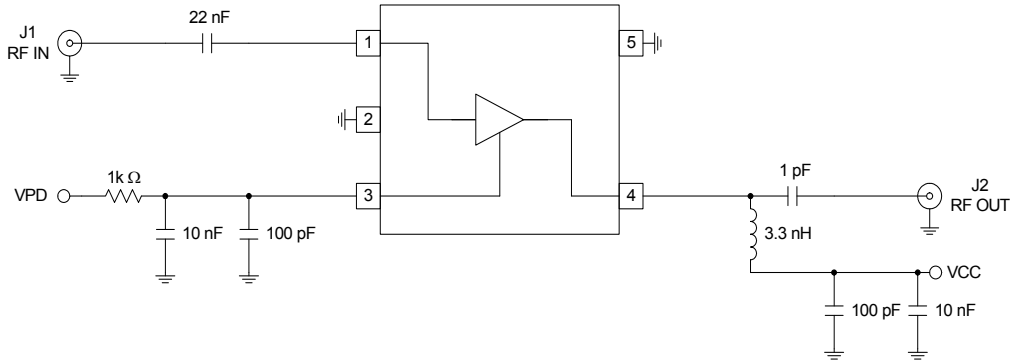
Application Schematic:
Driver Amplifier ~1880 MHz Operation

J1
RF IN

22 nF

1

5

2

3

4

VPD

0 Ω

10 nF   100 pF

1 pF

3.3 nH

J2
RF OUT

100 pF   10 nF   VCC

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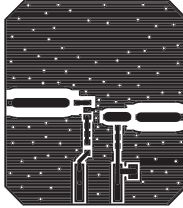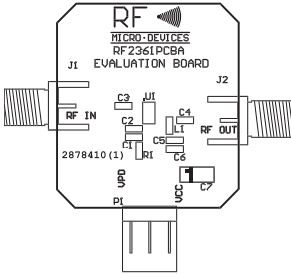support, contact RFMD at **(+1) 336-678-5570** or **sales-support@rfmd.com**.

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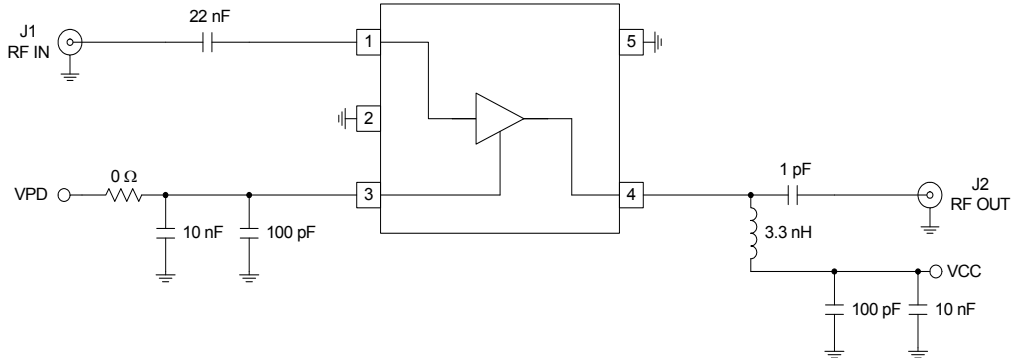
Evaluation Board Schematic:
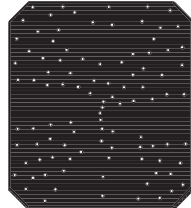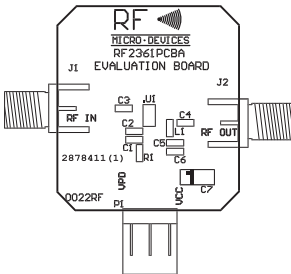## Low Noise Amplifier ~881MHz Operation

P1

P1-1 1 VPD
      2 GND
      3 VCC
C7
4.7 µF

J1
RF IN
50 Ω µstrip   C3
               22 nF   1   5

               2

VPD   R1   3   4   50 Ω µstrip   C4   50 Ω µstrip   J2
       1k Ω   2 pF   RF OUT
              C1   C2   L1   VCC
              10 nF 220 pF   12 nH
                          2361410 Rev-   C5   C6
                                                  220 pF 10 nF
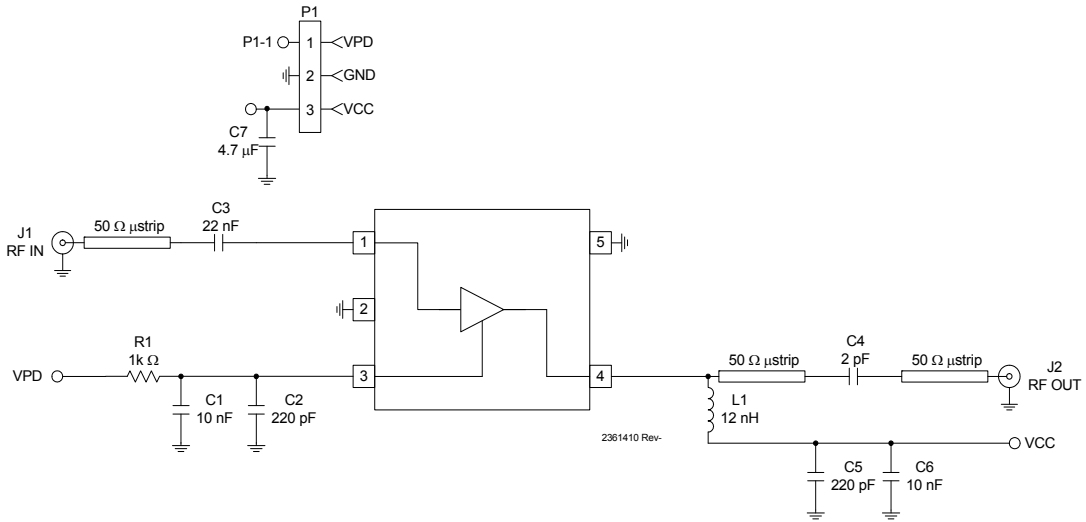
Evaluation Board Schematic:
Driver Amplifier ~836MHz Operation

P1

P1-1 1 VPD
      2 GND
      3 VCC
C7
4.7 µF

J1
RF IN
50 Ω µstrip   C3
               22 nF   1   5

               2

VPD   R1   3   4   50 Ω µstrip   C4   50 Ω µstrip   J2
       0 Ω   2 pF   RF OUT
              C1   C2   L1   VCC
              10 nF 220 pF   12 nH
                          2361400 Rev-   C5   C6
                                                  220 pF 10 nF

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Evaluation Board Layout - 900 MHz Driver
Board Size 0.948" x 1.063"
Board Thickness 0.031"; Board Material FR-4

Evaluation Board Layout - 900 MHz LNA

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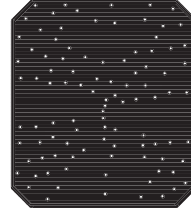
RF2878

Theory of Operation

This section will focus on a variety of applications outside the nominal, for the purpose of demonstrating RF2878 versatility. Application schematics pertaining to topics discussed can be found within the data sheet for reference.

First, an application for linear driver, covering 1800MHz to 2170MHz. Operating condition:

$V_{CC}=4V$

$V_{PD}=2.7V$

$I_{CC}=21mA$

Note 0Ω value for bias resistor at V_{PD} in the application schematic, set for increased current/IP3. Typical specs are listed along with schematic. $V_{CC}=4V$ contributes to enhanced compression point (16dBm to 17dBm). Junction temperature seen for ambient condition=85°C will be a consideration in setting V_{CC}/V_{PD}. The above biasing condition yields $T_J=132°C$. Thus, the conditions chosen allow for highly reliable operation while providing impressive linear performance.

Using a 5V supply rail is often convenient from a design standpoint. In the 1800MHz to 2170MHz driver application already discussed, $V_{CC}=4V$ is recommended in order to maintain highest reliability. An option for using $V_{CC}=5V$ is shown in the application schematic. Use of a simple dropping resistor at V_{CC} provides 4.0V at output collector, resulting in the suggested device operating condition. Power dissipation in the resistor=0.021 Watt, easily handled by standard resistors available to the system designer.
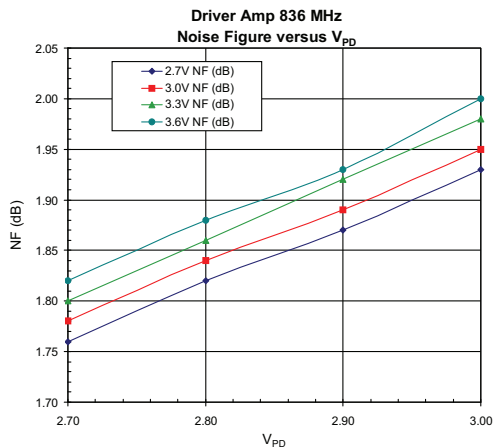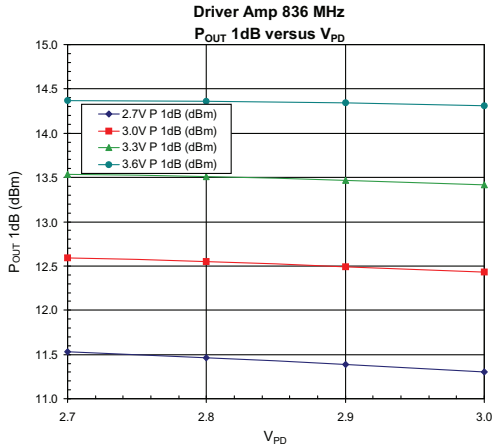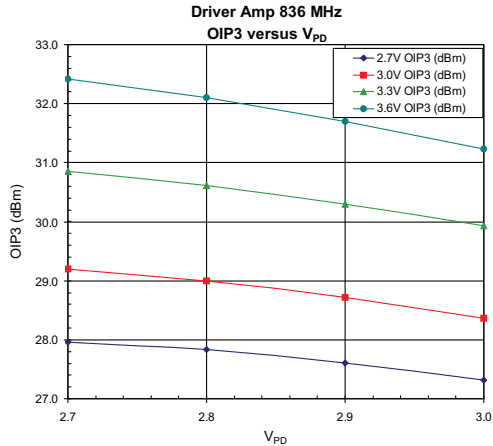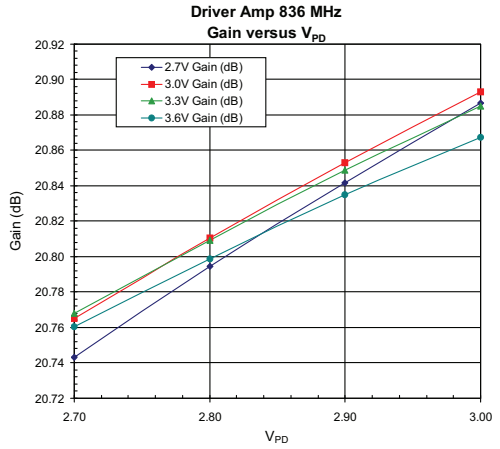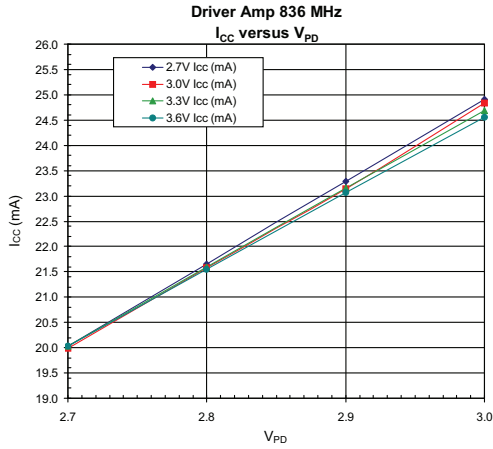
Moving to another application, consider the schematic for 350MHz LNA. Noise figure in this case=1.75dB. In contrast to above linear driver, bias resistor is set at 1000Ω to limit current. In the specifications next to schematic, see that input return loss is somewhat degraded at 2.8dB. The absence of input matching is intentional, as the integrated circuit design was geared for optimum noise figure with input looking back into 50Ω. Note that in the nominal cases, 881MHz and 1950MHz, input return losses are favorable in the absence of input match.

In converting 350MHz LNA to driver, noise figure will no longer be a key specification. As such, RF2878 device s-parameter data can be used to match input for favorable return loss. The resulting driver application schematic is found below that for the LNA. When matching in bands other than those covered here, RF2878 S-parameter data can be obtained through applications/sales contact at RFMD.
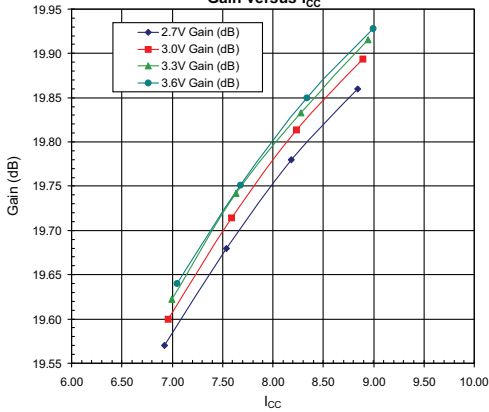
As a final example, refer to driver application schematic covering 1200MHz to 1600MHz. This match provides favorable return losses over the entire band.

In summary, the examples above are intended to aid the system designer in determining suitable matches and device operating points for both LNA and driver applications. Key points to consider:
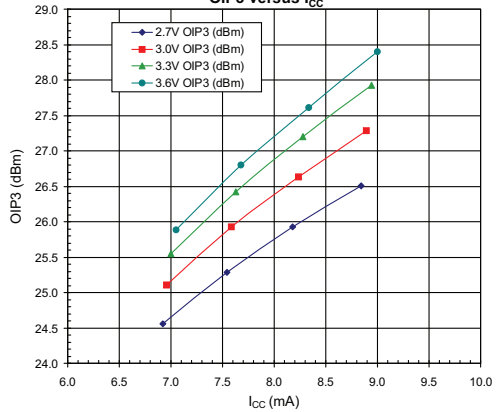
1. In setting bias condition to accommodate both LNA and driver, the first consideration is choice of bias resistance at V_{PC}. Linearity versus power dissipation trade-offs are taken into account in the driver application.
2. Noise figure versus input return loss trade-off must be considered in the specific case of low frequency LNA application. Driver application here allows for flexibility in optimizing input match for return loss.
3. Higher frequency LNA sees favorable return loss in the absence of input match. Thus, optimization at frequency >800MHz involves matching adjust to output L-C only.
4. Small signal S-parameter simulation proves an excellent method for obtaining starting point matches in the design process.
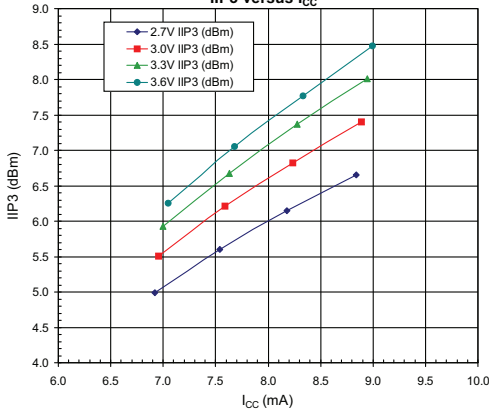
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Driver Amp 836 MHz
I_{CC} versus V_{PD}

- 2.7V Icc (mA)
- 3.0V Icc (mA)
- 3.3V Icc (mA)
- 3.6V Icc (mA)

Driver Amp 836 MHz
Gain versus V_{PD}

- 2.7V Gain (dB)
- 3.0V Gain (dB)
- 3.3V Gain (dB)
- 3.6V Gain (dB)

Driver Amp 836 MHz
OIP3 versus V_{PD}

- 2.7V OIP3 (dBm)
- 3.0V OIP3 (dBm)
- 3.3V OIP3 (dBm)
- 3.6V OIP3 (dBm)

Driver Amp 836 MHz
P_{OUT} 1dB versus V_{PD}

- 2.7V P 1dB (dBm)
- 3.0V P 1dB (dBm)
- 3.3V P 1dB (dBm)
- 3.6V P 1dB (dBm)

Driver Amp 836 MHz
Noise Figure versus V_{PD}

- 2.7V NF (dB)
- 3.0V NF (dB)
- 3.3V NF (dB)
- 3.6V NF (dB)

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Low Noise Amplifier 881 MHz
Gain versus I_{CC}

- 2.7V Gain (dB)
- 3.0V Gain (dB)
- 3.3V Gain (dB)
- 3.6V Gain (dB)

Low Noise Amplifier 881 MHz
OIP3 versus I_{CC}

- 2.7V OIP3 (dBm)
- 3.0V OIP3 (dBm)
- 3.3V OIP3 (dBm)
- 3.6V OIP3 (dBm)

Low Noise Amplifier 881 MHz
IIP3 versus I_{CC}

- 2.7V IIP3 (dBm)
- 3.0V IIP3 (dBm)
- 3.3V IIP3 (dBm)
- 3.6V IIP3 (dBm)

Low Noise Amplifier 881 MHz
P_{OUT} 1dB versus I_{CC}

- 2.7V Pout 1dB (dBm)
- 3.0V Pout 1dB (dBm)
- 3.3V Pout 1dB (dBm)
- 3.6V Pout 1dB (dBm)
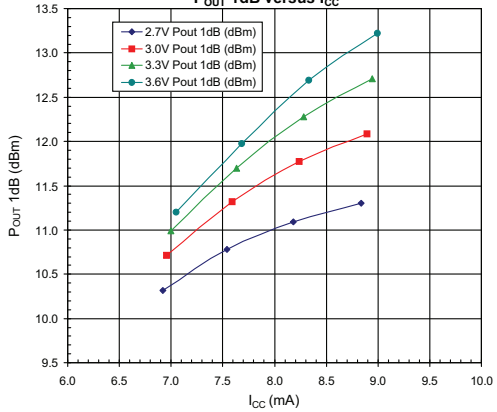
Low Noise Amplifier 881 MHz
Noise Figure versus I_{CC}

- 2.7V NF (dB)
- 3.0V NF (dB)
- 3.3V NF (dB)
- 3.6V NF (dB)

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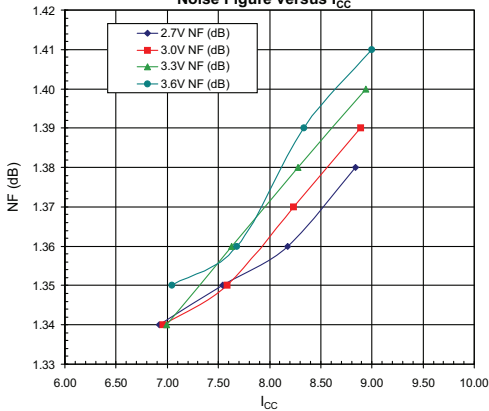
PCB Design Requirements

PCB Surface Finish

The PCB surface finish used for RFMD's qualification process is electroless nickel, immersion gold. Typical thickness is 3μinch to 8μinch gold over 180μinch nickel.

PCB Land Pattern Recommendation

PCB land patterns are based on IPC-SM-782 standards when possible. The pad pattern shown has been developed and tested for optimized assembly at RFMD; however, it may require some modifications to address company specific assembly processes. The PCB land pattern has been developed to accommodate lead and package tolerances.

PCB Metal Land Pattern

A = 0.70 x 1.00 (mm) Typ.

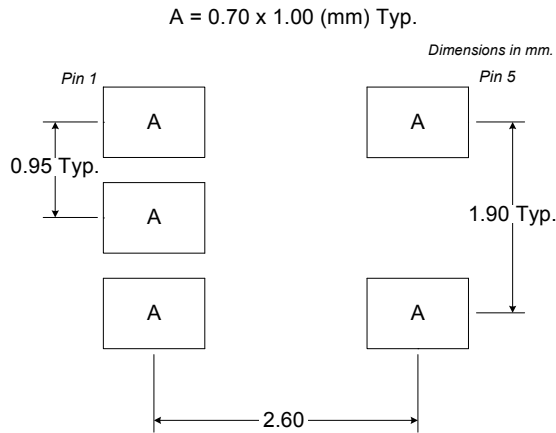*Dimensions in mm.*

Pin 1   *Pin 5*

Figure 1. PCB Metal Land Pattern (Top View)

DS111104

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