RF250 Rx ASIC for CDMA, AMPS, and PCS Applications

Product Description

The RF250 Rx Application-Specific Integrated Circuit (ASIC) is an integrated receiver intended for use in "tri-mode" cellular phones operating in the Advanced Mobile Phone System (AMPS), Code Division Multiple Access (CDMA) cellular, and CDMA Personal Communications System (PCS) modes.

The device incorporates all the components required to implement the receiver front end and the Intermediate Frequency (IF) stages except the filter blocks. It has two Low Noise Amplifiers (LNAs), one for 800 MHz (AMPS and CDMA800) and one for the 1900 MHz PCS band.

There are separate mixers for AMPS, CDMA 800 MHz, and PCS bands. The provision exists for two image reject filters for the 800 MHz and 1900 MHz bands. The AMPS mixer has a single-ended output for the AMPS IF Surface Acoustic Wave (SAW) filter. The CDMA 800 MHz and 1900 MHz (PCS) mixers have balanced outputs for the CDMA IF SAW filters. The mixers are followed by a single IF Variable Gain Amplifier (VGA) and an In-Phase and Quadrature (I/Q) demodulator.

The outputs from the filters are combined through separate buffers at the input of the VGA. The buffers are enabled depending on the selected mode. The VGA has a gain control range of over 90 dB. There are two VHF oscillators which operate with external tank circuits. They provide the Local Oscillator (LO) with signals for the I/Q demodulator in the cellular and PCS bands.

The noise figure, gain, and IP3 of each stage in the receiver chip are optimized to meet the system requirements for AMPS and CDMA modes as per IS-98 and ANSI J-STD-018 (PCS). Employing silicon bipolar technology, the ASIC is designed for high performance and a high level of integration.

The device package and pinout are shown in Figure 1. A block diagram of the RF250 is shown in Figure 2.

Features

- Supports CDMA/AMPS/PCS1900 modes.
- Three battery cell operation (2.7 V < VCC < 3.6 V).
- Dual Low Noise Amplifiers.
- Three low noise and high IP3 mixers.
- I/Q demodulator.
- 100 to 450 MHz oscillator.
- Low power operation: <60 mA.
- 48-pin Thin Quad Flat Pack (TQFP) package with downset paddle.

Applications

- Dual mode cellular CDMA/AMPS.
- Dual band PCS/cellular CDMA.
- Triple mode/dual band.

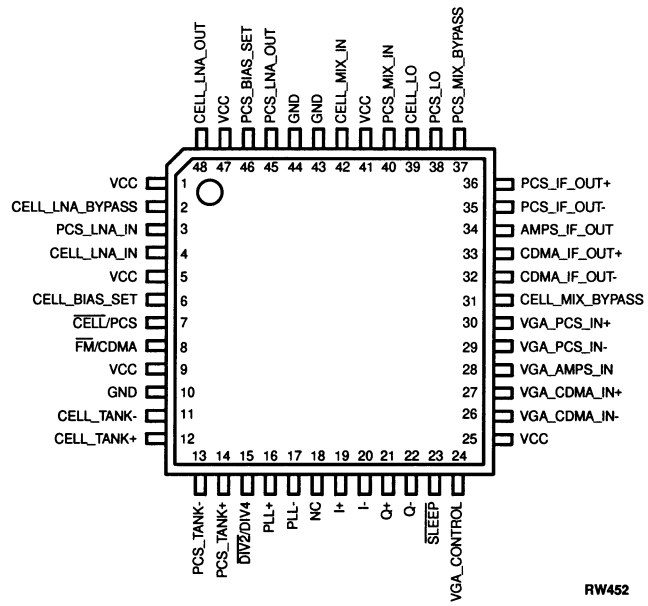


Figure 1. RF250 Rx ASIC Pinout – 48-Pin TQFP-package With Downset Paddle

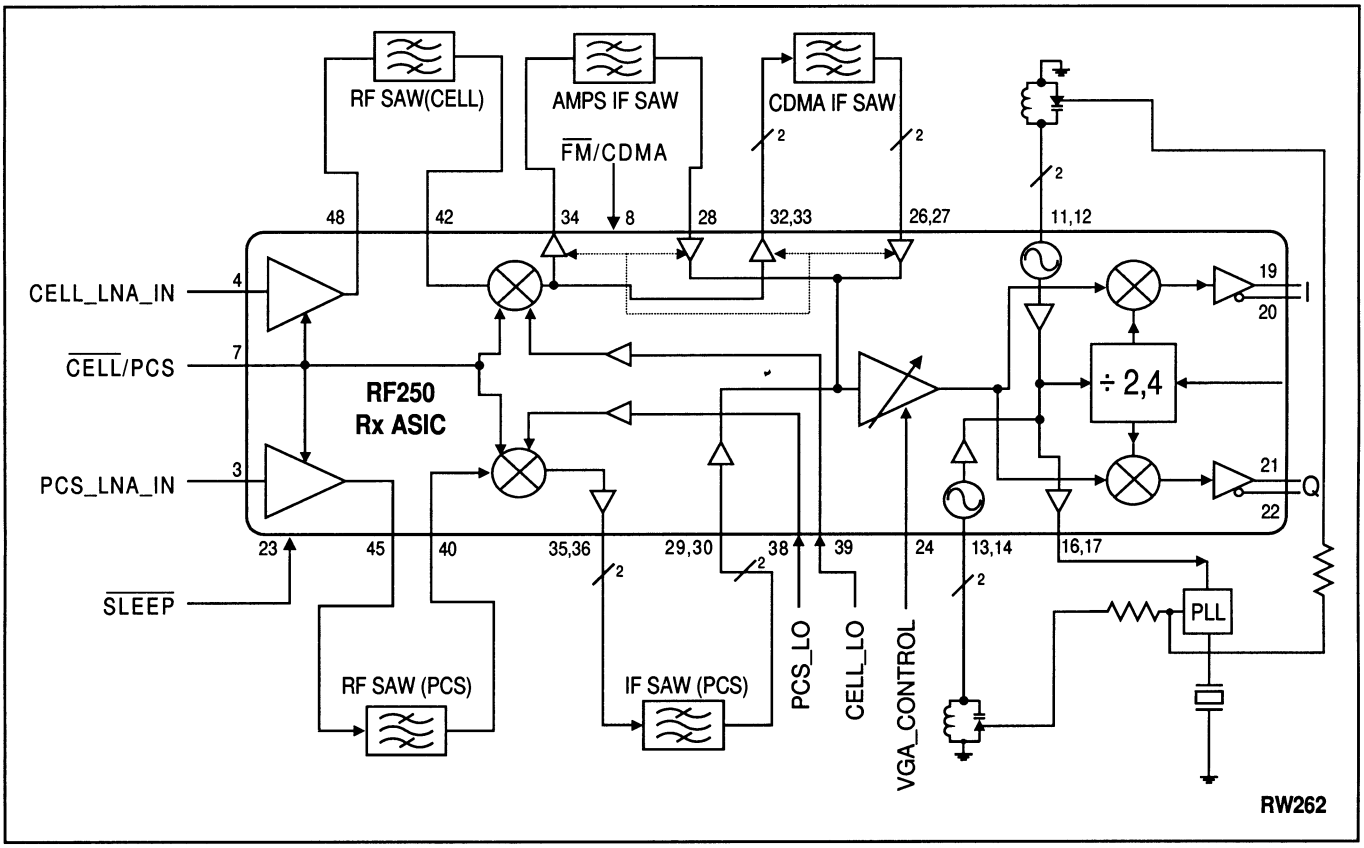


Figure 2. RF250 Rx ASIC Block Diagram

Technical Description

Low Noise Amplifiers (LNAs). The RF250 Rx ASIC has two independent LNAs for the cellular and PCS bands.

The cellular band LNA is designed to provide low noise figure and high linearity to achieve maximum dynamic range. Pin 2, the 800 LNA bypass pin, is required to be grounded through an RF bypass capacitor with minimum trace length. The input and output match are external to the chip.

The PCS band LNA output is matched internal to the chip. The input match is external. The LNA has a low noise figure and high gain to achieve a good cascaded noise figure for the receiver.

Mixers. The RF250 Rx ASIC has three independent mixers, one optimized for the PCS band and two for the cellular band (AMPS and CDMA).

The mixers are designed to operate with very low LO powers of -10 dBm. The LO ports are matched internal to the chip.

The cellular band mixers have a high gain and a low noise figure which allows it to meet the system noise figure with a low gain LNA. The cellular CDMA and PCS mixers have balanced output to drive the IF filters. The AMPS mixer has a single-ended output to match the standard SAW filters.

Variable Gain Amplifier (VGA). The high dynamic range required by CDMA standards is achieved by the VGA, which is common to all the modes. It has three different inputs. The appropriate signal path is switched internal to the device. This eliminates off-chip switching needed to operate this common VGA in cellular AMPS and CDMA modes, as well as PCS CDMA mode.

The VGA has a dynamic range of 90 dB with a control voltage of 0.1 to 2.7 volts. It has a low noise figure at high gain which allows it to meet the system noise figure requirements. The balanced output is common for all the modes.

I/Q Demodulator. The I/Q demodulator is internally connected to the VGA output. The local oscillator signals are generated on-chip. It is designed to have very low amplitude and phase offsets. The I and Q outputs are differential. The DC offsets between the differential outputs and between I and Q channels are designed to be extremely low to facilitate compatibility with baseband Interfaces.

VHF Oscillators. There are two on-chip oscillators, one each for the cellular and PCS bands. These Voltage Controlled Oscillators (VCOs) work with external tank circuits with varactor diodes. The outputs of the differential oscillators are buffered and the output is used to drive the prescaler of an external Phase Locked Loop (PLL). The VCOs can operate at twice (or four times) the IF frequency.

The local oscillators for the I/Q demodulators are derived by an on-chip frequency divider. The logic signal to select the divider ratio (2 or 4) is available on Pin 15 (DIV2/DIV4).

The operation of the chip is controlled by signals at Pin 7 ($\overline{\text{CELL}}$/PCS), Pin 8 ($\overline{\text{FM}}$/CDMA), Pin 23 ($\overline{\text{SLEEP}}$), and the DIV2/DIV4 select commands at Pin 15. All the switching is done internally. The supply voltage should be present at all the VCC pins for normal operation.

The signal pin assignments and functional pin descriptions are found in Table 1. The absolute maximum ratings of the RF250 are provided in Table 2, the recommended operating conditions are specified in Table 3, and electrical specifications are provided in Table 6. Figure 3 provides the package dimensions for the 48-pin TQFP with downset paddle RF250 Rx ASIC.

ESD Sensitivity

The RF250 is a Class 1 device. The following extreme Electrostatic Discharge (ESD) precautions are required according to the ***** TBD Human Body Model (HBM) or Charged Device Model (CDM) ***:**

- Complete ESD training program required.
- Protective outer garments.
- Handle device in ESD safeguarded work area.
- Transport device in ESD shielded containers.
- Monitor and test all ESD protection equipment.

Treat the RF250 Rx ASIC as extremely sensitive to ESD since ESD sensitivity has not yet been determined for this device.

Table 1. RF250 Signal Description (1 of 2)

PIN	NAME	DESCRIPTION
1	VCC	Supply voltage to the LNA. An RF bypass capacitor needs to be connected with very short traces.
2	CELL_LNA_BYPASS	An RF bypass capacitor with very short trace should be connected to this pin.
3	PCS_LNA_IN	The input to LNA needs external matching. The matching network should be placed as close to this pin as possible. High Q components are recommended to minimize the effect on the noise figure.
4	CELL_LNA_IN	The input to LNA needs external matching. The matching network should be placed as close to this pin as possible. High Q components are recommended to minimize the effect on the noise figure.
5	VCC	Supply voltage to the RF bias. An RF bypass capacitor should be connected from the pin to ground with short traces..
6	CELL_BIAS_SET	A 180 Ω resistor must be connected from the pin to ground. This sets the cellular RF bias current.
7	$\overline{\text{CELL}}$/PCS	Band select: 0 = cellular (800 MHz); 1 = PCS (1900 MHz).
8	$\overline{\text{FM}}$/CDMA	Cellular band mode select: 0 = AMPS; 1 = CDMA.
9	VCC	Voltage supply pin to the VCO buffer. An RF bypass capacitor should be placed close to the pin.
10	GND	Ground return from the VCO buffer. A bypass capacitor should be placed close to the device from pin 9 to pin 10. The trace should be short and connected immediately to the ground plane for best performance.
11	CELL_TANK-	Differential tank connection for the cellular band VCO. Care should be taken during the layout of the external tank circuit to prevent parasitic oscillations.
12	CELL_TANK+	Differential tank connection for the cellular band VCO. Care should be taken during the layout of the external tank circuit to prevent parasitic oscillations.
13	PCS_TANK-	Differential tank connection for the PCS band VCO. Care should be taken during the layout of the external tank circuit to prevent parasitic oscillations.
14	PCS_TANK+	Differential tank connection for the PCS band VCO. Care should be taken during the layout of the external tank circuit to prevent parasitic oscillations.
15	$\overline{\text{DIV2}}$/DIV4	Selects the divide ratio of the VCO to the LO port of the I/Q demodulator: 0 = divide by 2; 1 = divide by 4.
16	PLL+	Differential buffered VCO output.
17	PLL-	Differential buffered VCO output.
18	NC	No connection.
19	I+	I channel differential output.
20	I-	I channel differential output.
21	Q+	Q channel differential output.
22	Q-	Q channel differential output.
23	$\overline{\text{SLEEP}}$	Activates sleep mode: 0 = sleep; 1 = enable
24	VGA_CONTROL	Automatic Gain Control (AGC) voltage input. Input impedance is greater than 50K Ω.
25	VCC	Voltage supply to VGA and I/Q demodulator stages. Supply should be well regulated and bypassed to prevent modulation of the signal by the supply ripple.
26	VGA_CDMA_IN-	CDMA differential VGA input
27	VGA_CDMA_IN+	CDMA differential VGA input
28	VGA_AMPS_IN	AMPS VGA input.

Table 1. RF250 Signal Description (2 of 2)

PIN	NAME	DESCRIPTION
29	VGA_PCS_IN-	PCS differential VGA input.
30	VGA_PCS_IN+	PCS differential VGA input.
31	CELL_MIX_BYPASS	Low frequency bypass for the cellular mixer.
32	CDMA_IF_OUT-	CDMA differential mixer output. Requires an external inductor to VCC. An on-chip resistor sets the output impedance.
33	CDMA_IF_OUT+	CDMA differential mixer output. Requires an external inductor to VCC. An on-chip resistor sets the output impedance.
34	AMPS_IF_OUT	AMPS mixer output. Requires an external inductor to VCC. An on-chip resistor sets the output impedance.
35	PCS_IF_OUT-	PCS differential mixer output. Requires an external inductor to VCC. An on-chip resistor sets the output impedance.
36	PCS_IF_OUT+	PCS differential mixer output. Requires an external inductor to VCC. An on-chip resistor sets the output impedance.
37	PCS_MIX_BYPASS	Low frequency bypass for the PCS mixer.
38	PCS_LO	The local oscillator input for the PCS band.
39	CELL_LO	The local oscillator input for the cellular band.
40	PCS_MIX_IN	PCS mixer input.
41	VCC	Voltage supply pin for the mixers. An RF bypass capacitor should be connected from this pin to ground. It should be connected as close to the device as possible with very short trace lengths.
42	CELL_MIX_IN	Cellular mixer input.
43	GND	The trace should be short and connected immediately to the ground plane for best performance.
44	GND	The trace should be short and connected immediately to the ground plane for best performance. Excess inductance will lower mixer gain.
45	PCS_LNA_OUT	PCS LNA output.
46	PCS_BIAS_SET	A 180 Ω resistor must be connected from the pin to ground. This sets the PCS RF bias current.
47	VCC	Supply voltage to LNA stage. An RF bypass capacitor should be connected from the pin to ground. It should be placed as close to the device as possible.
48	CELL_LNA_OUT	Cellular band LNA output. This is an open collector output. An inductor must be connected to VCC. The matching is done externally to the chip.

Table 2. Absolute Maximum Ratings

PARAMETER	MINIMUM	MAXIMUM	UNIT
Supply voltage (VCC)	-0.3	5.5	V
Input voltage range	-0.3	VCC	V
LNA input power	--	+5	dBm
Power dissipation	--	600	mW
Ambient operating temperature	-30	+80	°C
Storage temperature	-40	+125	°C

Table 3. Recommended Operating Conditions

PARAMETER	MINIMUM	TYPICAL	MAXIMUM	UNIT
Supply voltage (VCC)	2.7	3.3	3.6	V
Operating temperature	-30	+25	+80	°C
Junction temperature				°C
Impedance of logic inputs		50		KΩ
Logic 0	0.0		0.5	V
Logic 1	VCC - 0.5		VCC	V

Table 4. RF250 Rx ASIC Electrical Specifications (1 of 3)
TA = 25° C, VCC = 3.3 V, PLO = -10 dBm

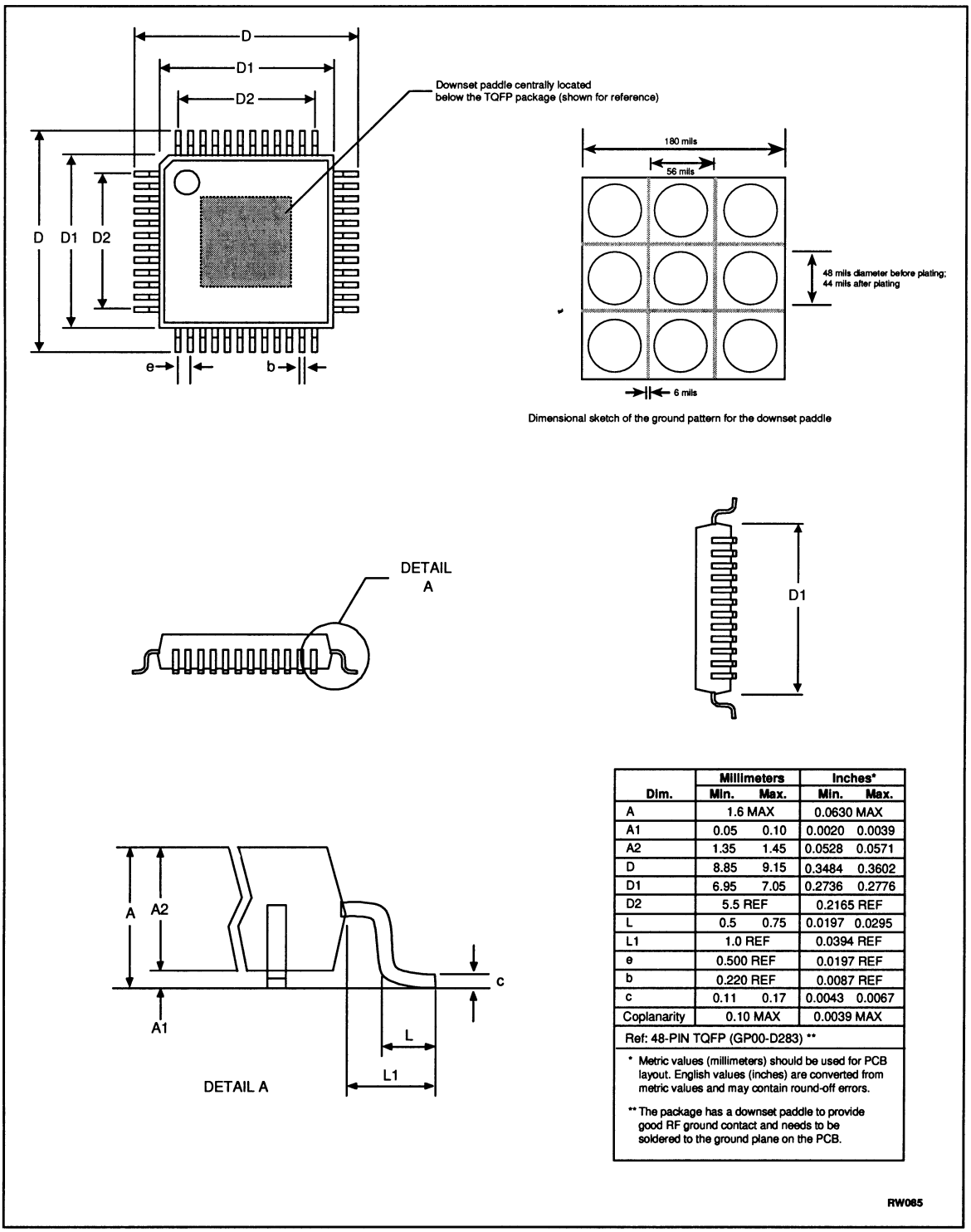
SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS
	Cellular LNA				
	Gain @ 881 MHz		13		dB
	Gain variation over band (869-894 MHz)			0.5	dB
	Gain variation over temperature			1.5	dB
	Noise figure @ 881 MHz		2.0		dB
	Reverse isolation		20		dB
	P1dB @ input		-6		dBm
	IP3 @ input		6		dBm
	Input return loss (869-894 MHz)			-12	dB
	Output return loss (869-894 MHz)		-15		dB
	Total supply current (adjustable)		10		mA
	Cellular Mixer				
	Conversion gain (power): CDMA mode AMPS mode	 14 11			 dB dB
	Single-sideband noise figure: CDMA mode AMPS mode		 8 8.5		 dB dB
	P1dB @ input: CDMA mode AMPS mode		 -6 -9		 dBm dBm
	IP3 @ input: CDMA mode AMPS mode		 +5 +3		 dBm dBm
	Mixer RF input return loss, RF port 1 (869-894 MHz)		-15		dB
	LO input power level	-10	-5	0	dBm
	LO input return loss (524-1149 MHz)		-15		dB
	IF output resistance: CDMA mode (differential) AMPS mode (single-ended)		 3000 1000		 Ω Ω
	IF frequency range			300	MHz
	LO/LNA input isolation	35			dB
	LO/RF input isolation		20		dB
	Total supply current		15		mA

Table 4. RF250 Rx ASIC Electrical Specifications (2 of 3)
TA = 25° C, VCC = 3.3 V, PLO = -10 dBm

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS
	PCS Mixer				
	Conversion gain (power)		10		dB
	Single-sideband noise figure		12		dB
	P1dB @ input	-5			dBm
	IP3 @ input	+5			dBm
	RF input return loss (1930-1990 MHz)		-15		dB
	LO input power level	-10	-5	0	dBm
	LO input return loss (1600-2300 MHz)		-10		dB
	IF output resistance (differential)		1000		Ω
	IF frequency range			300	MHz
	LO/LNA input isolation	25			dB
	LO/RF input isolation		20		dB
	Total supply current (adjustable)		24		mA
	Rx VGA				
	Frequency range	50		300	MHz
	Input impedance: CDMA input (differential) PCS input (differential) AMPS input (single-ended)		 1000 1000 1000		 Ω Ω Ω
	Output impedance		1000		Ω
	Gain: Maximum Maximum (AMPS) Minimum	 +45 +53		 -45	 dB dB dB
	Gain slope		45		dB/V
	Gain slope linearity (over any 6 dB segment)	-3		+3	dB
	Gain variation over frequency (Fo ± 650 KHz)			0.25	dB
	Gain variation over temperature		3		dB
	IF amplifier IIP3: @ Maximum gain (CDMA mode) Minimum gain	 0	 -48 	 	 dBm dBm

Table 4. RF250 Rx ASIC Electrical Specifications (3 of 3)
TA = 25° C, VCC = 3.3 V, PLO = -10 dBm

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS
	Rx VGA (continued)				
	IF amplifier noise figure: @ Maximum gain Minimum gain		 5 50		 dB dB
	Total supply current		10		mA
	I/Q Demodulator				
	Frequency range (-1 dB)	50		300	MHz
	Output level: CDMA AMPS		 3.5 7		 mVrms mVrms
	Maximum output level	1.5			Vp-p
	Gain variation over frequency: CDMA (1-630 KHz) AMPS (0.1-12.2 KHz)		 0.1 0.1	 0.3 0.3	 dB dB
	Gain variation over temperature and supply			±0.6	dB
	Output impedance (differential)			1000	Ω
	Input referred noise: CDMA (1-630 KHz) AMPS (0.1-15 KHz)		 65 35	 105 45	 µVrms µVrms
	I+, I-, and Q+, Q- DC offset			8	mV
	Total supply current (includes I/Q mixers, LO buffers, and dividers)		5		mA
CDMA-Specific					
	I/Q gain mismatch		0.2	0.3	dB
	I/Q phase mismatch		2	4	deg
	I to Q DC offset			30	mV
	Oscillator				
	Frequency range	100		450	MHz
	Phase noise (fc = 200 MHz, unloaded Q = 20) @ 100 KHz offset		-117		dBc/Hz
	Second harmonic distortion (application dependent)		-30		dBc
	Pulling		TBD		KHz
	Pushing		TBD		KHz
	Total supply current		5		mA
	Buffered VCO Output				
	Frequency range	100		450	MHz
	Output level (peak differential)		150		mV
	Output impedance (differential)		300		Ω
	Reverse isolation	-30		-40	dB



Dim.	Millimeters Min.	Max.	Inches* Min.	Max.
A	1.6 MAX		0.0630 MAX	
A1	0.05	0.10	0.0020	0.0039
A2	1.35	1.45	0.0528	0.0571
D	8.85	9.15	0.3484	0.3602
D1	6.95	7.05	0.2736	0.2776
D2	5.5 REF		0.2165 REF	
L	0.5	0.75	0.0197	0.0295
L1	1.0 REF		0.0394 REF	
e	0.500 REF		0.0197 REF	
b	0.220 REF		0.0087 REF	
c	0.11	0.17	0.0043	0.0067
Coplanarity	0.10 MAX		0.0039 MAX	
Ref: 48-PIN TQFP (GP00-D283) **				

* Metric values (millimeters) should be used for PCB layout. English values (inches) are converted from metric values and may contain round-off errors.

** The package has a downset paddle to provide good RF ground contact and needs to be soldered to the ground plane on the PCB.

Figure 3. RF250 Rx ASIC Package Dimensions - 48-pin TQFP Package With Downset Paddle

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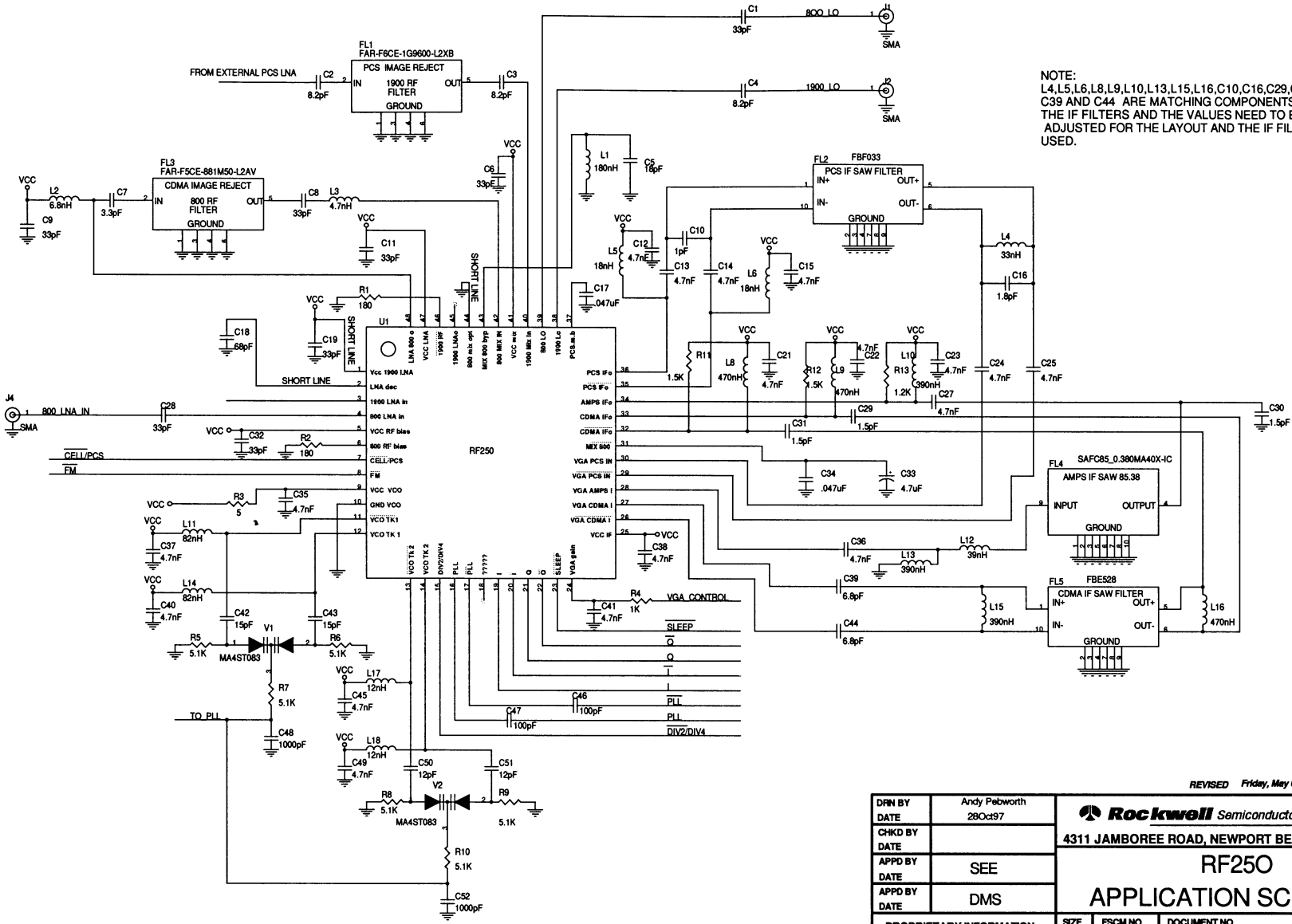

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