RF251 Tx ASIC for CDMA, AMPS, and PCS Applications

Product Description

The RF251 Tx Application-Specific Integrated Circuit (ASIC) is a triple-mode, dual-band transmitter intended to be used in Code Division Multiple Access (CDMA) portable phones in both cellular and Personal Communications System (PCS) bands. As a dual mode IC it can be used in CDMA mode or Advanced Mobile Phone System (AMPS) mode.

The RF251 device includes the following functional blocks:

- In-Phase and Quadrature (I/Q) modulator.
- A VHF Voltage Controlled Oscillator (VCO).
- IF Variable Gain Amplifier (VGA).
- Cellular and PCS upconverters with RF gain control.
- Cellular and PCS Power Amplifier (PA) drivers.

The IF signals come off chip after the IF Automatic Gain Correction (AGC) for noise filtering. The RF signal comes off chip after the upconverter for noise filtering and image rejection.

The device package and pinout are shown in Figure 1. A block diagram of the RF251 is shown in Figure 2.

Features

- Tri-mode operation with high linearity that meets the requirements of IS-95A, IS-98, and J-Std-008 standards.
- 90 dB dynamic range.
- Power saving operation in gated output power mode.
- 14 dB RF gain control to compensate for the gain variation of off-chip components.
- Lower power consumption in all modes.
- Enable line for the entire chip.
- Dual drivers for cellular and PCS bands.
- 48-pin Thin Quad Flat Pack (TQFP) package with downset paddle.

Applications

- Cellular and PCS band phones.
- CDMA and AMPS modes in the cellular band:
  - CDMA-US
  - CDMA-J
- CDMA mode in the PCS band:
  - US-PCS
  - K-PCS

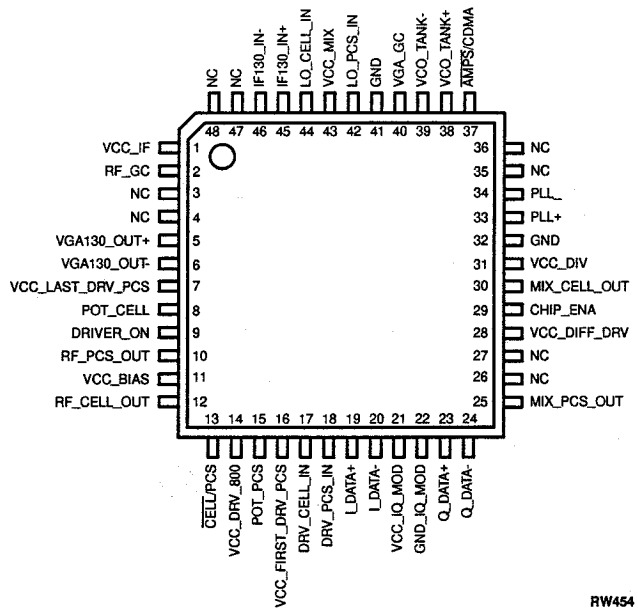


Figure 1. RF251 Tx ASIC Pinout – 48-Pin TQFP-package

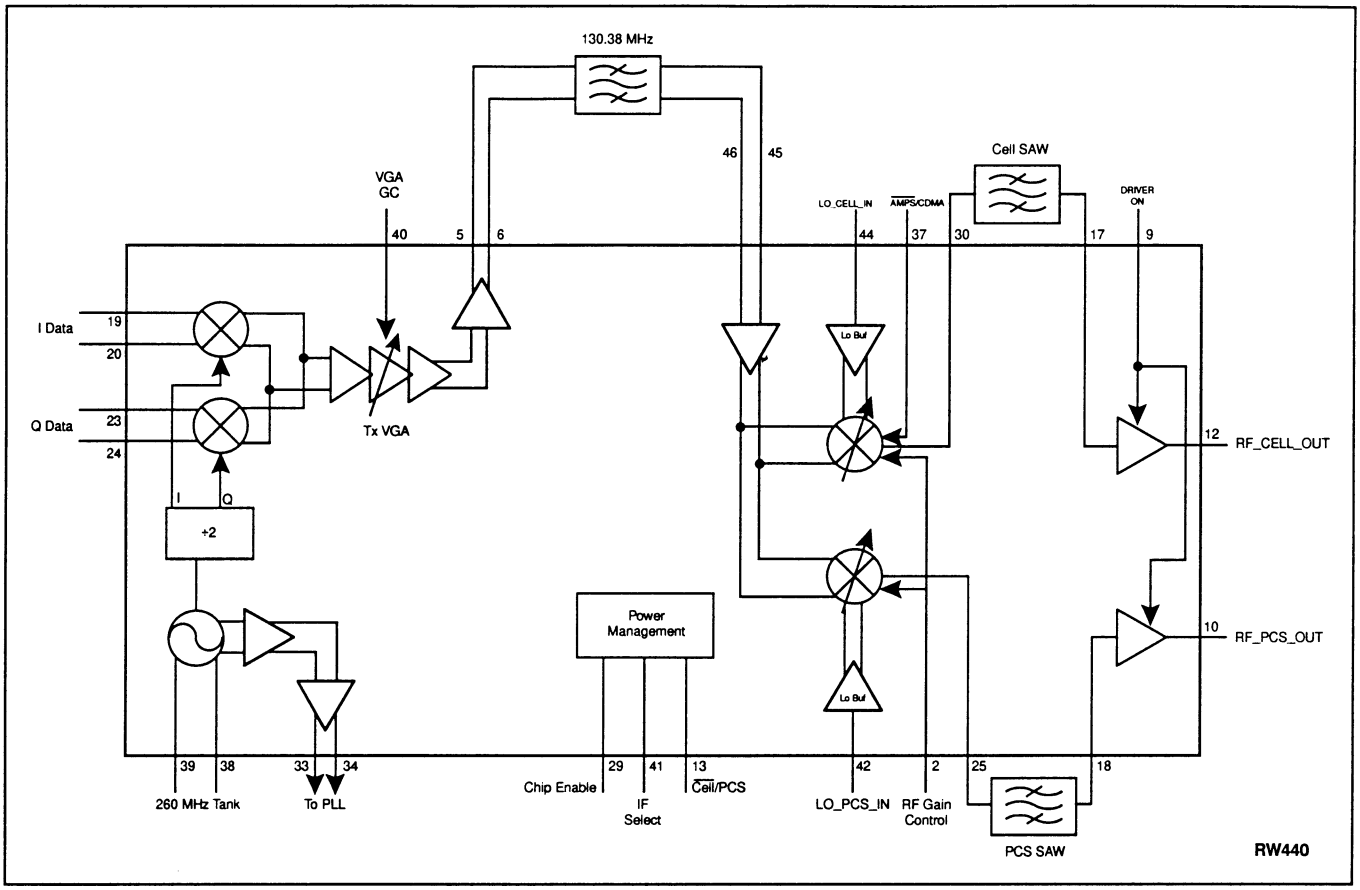


Figure 2. RF251 Tx ASIC Block Diagram

Technical Description

The RF251 is a CDMA transmitter for the cellular and PCS bands. It also can be used as an FM transmitter in AMPS mode. A band select command chooses between the cellular band and the PCS band. A mode select command chooses between CDMA and AMPS mode in the cellular band. The chip consists of an I/Q modulator, a VHF VCO, an IF VGA, two variable gain upconverters for the cellular and PCS bands, and two PA drivers for both bands.

I/Q Modulator. The I/Q modulator converts the incoming analog baseband signals to balanced IF signals using the VHF local oscillator. These signals are fed directly to the VGA.

VHF VCOs. The Local Oscillator (LO) has a frequency range of 100 to 640 MHz. The oscillator has two pins to connect an external tank circuit. The tank circuit can be used to provide the FM modulation in the AMPS mode. It is also connected to a pin that provides an external Phase Locked Loop (PLL).

VGA. The VGA is a differential amplifier that receives its signal from the I/Q modulator, amplifies it, and sends it to the IF output pins (pins 5 and 6). A filter should be attached to the IF output pins for noise reduction. A dynamic range of 90 dB is available on the amplifier. A DC voltage of 0.2 to 2.7 V is needed to control the gain of the amplifier.

Upconverters. The cellular and PCS variable gain upconverters receive the IF signal from the VGA after passing through an external filter. Each upconverter uses an external LO controlled by an external PLL. The conversion gain control in the upconverter can be used to calibrate out any parto-to-part and temperature gain variation in the transmit path. The band select command switches between the cellular and PCS bands. The DRIVER_ON command deactivates the driver during no transmission status. The output RF signal is sent to an output pin to be filtered before driver amplification.

PA Drivers. Two PA drivers are included, the cellular driver and the PCS driver.

Each driver takes its input from the upconverter after passing through an image rejection filter. The driver amplifies the signal and sends it to an external PA.

The DRIVER_ON command is used during gated output power mode to deactivate the drivers in periods of no transmission. A Surface Acoustic Wave (SAW) filter for noise and image rejection should be placed between the driver and the external PA.

The signal pin assignments and functional pin descriptions are found in Table 1. The absolute maximum ratings of the RF251 are provided in Table 2, the recommended operating conditions are specified in Table 3, and electrical specifications are provided in Table 4. Figure 3 provides the package dimensions for the 48-pin TQFP RF251 Tx ASIC.

ESD Sensitivity

The RF251 is a Class 1 device. The following extreme Electrostatic Discharge (ESD) precautions are required according to the Human Body Model (HBM):

- 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.

The HBM ESD withstand threshold value, with respect to ground, is ±1.5 kV. The HBM ESD withstand threshold value, with respect to VDD (the positive power supply terminal) is also ±1.5 kV.

Table 1. RF251 Signal Description (1 of 2)

PIN	NAME	DESCRIPTION
1	VCC_IF	Supply voltage for the VGA, IF mux, and bias circuitry.
2	RF_GC	The gain control pin for both RF upconverters. A DC voltage of 1 to 2.5 V is needed to cover the mixer RF range.
3	NC	No connection.
4	NC	No connection.
5	VGA130_OUT+	The output pin for the 130.38 MHz VGA. This is a balanced output. It should be connected to an external bandpass filter for noise reduction. Requires an inductor choke to VCC IF.
6	VGA130_OUT-	Same as pin 5, except complementary output.
7	VCC_LAST_DRV_PCS	Supply voltage for the PCS driver amplifier. This pin can be used to turn the last driver on and off for a 24 dB gain step.
8	POT_CELL	This pin is connected to an external resistor. The value of the resistor varies the bias current of the cellular driver, which affects gain and Adjacent Channel Power Rejection (ACPR).
9	DRIVER_ON	This is the driver control signal. When the pin is low, the driver is deactivated during no transmission. During transmission the pin should be high to enable the driver. DRIVER_ON = On to DRIVER_ON = Off can be used to provide a 33 dB step in cellular CDMA mode.
10	RF_PCS_OUT	This is the output pin for the PCS RF signal. The pin is connected to the output of the PCS driver amplifier. Impedance matching is required.
11	VCC_BIAS	Supply voltage for the cellular driver bias.
12	RF_CELL_OUT	This is the output pin for the cellular RF signal. The pin is connected to the output of the cellular driver amplifier. Impedance matching is required.
13	$\overline{\text{CELL}}$/PCS	This is a control signal input pin that selects between the cellular band and PCS band. When the input is low, the cellular band is chosen. When the input is high, the PCS band is chosen.
14	VCC_DRV_800	Supply voltage for the driver of the cellular band.
15	POT_PCS	This pin is connected to an external resistor. The value of the resistor varies the bias current of the PCS driver, which affects gain and ACPR.
16	VCC_FIRST_DRV_PCS	Supply voltage for the first amplifier in the PCS driver block.
17	DRV_CELL_IN	The cellular driver input pin connected to the RF input of the cellular band driver. The input signal should pass through a SAW filter before being connected to the driver. Impedance matching is required.
18	DRV_PCS_IN	The PCS driver input pin connected to the RF input of the PCS band driver. The input signal should pass through a SAW filter before being connected to the driver. Impedance matching is required.
19	I_DATA+	The I/Q modulator baseband balanced input for the I channel. A DC bias has to be supplied to the pin.
20	I_DATA-	Same as pin 19, except complementary input.
21	VCC_IQ_MOD	Supply voltage for the I/Q modulator.
22	GND_IQ_MOD	Ground connection for I/Q modulator.
23	Q_DATA+	The I/Q modulator baseband balanced input for the Q channel. A DC bias has to be supplied to the pin.
24	Q_DATA-	Same as pin 23, except complementary input.

Table 1. RF251 Signal Description (2 of 2)

PIN	NAME	DESCRIPTION
25	MIX_PCS_OUT	This pin is connected to the RF output of the PCS upconverter. This pin needs impedance matching. The RF output signal should be routed through an image rejection filter before being connected to the driver input.
26	NC	No connection.
27	NC	No connection.
28	VCC_DIFF_DRV	Supply voltage for a differential amplifier in the upconverter block.
29	CHIP_ENA	This is the IQ modulator, VGA, and upconverter enable signal. When the input is low, the chip is disabled. When the input is high, the chip is enabled.
30	MIX_CELL_OUT	This pin is connected to the RF output of the cellular upconverter. The RF output signal should be routed through an image rejection filter before being connected to the cell driver input.
31	VCC_DIV	Supply voltage for the divider and VCO buffer.
32	GND	Ground pin for the divider and VCO buffer.
33	PLL+	An output pin for the VCO. This is a balanced output. This output goes to an external PLL that locks the VCO frequency.
34	PLL-	Same as pin 33, except complementary input
35	NC	No connection.
36	NC	No connection.
37	$\overline{\text{AMPS}}$/CDMA	This is the cellular mode control signal input. When the input is low, the AMPS mode is selected. If the input is high, CDMA mode is selected.
38	VCO_TANK+	The input pin for external VCO tank connection. This is a balanced input. The tank circuit values estimate the frequency of oscillation (and the Q factor) of the LO. This tank circuit should contain a varacter to directly frequency modulate the IF at the modulator output. The output frequency of the VCO is a divide-by 2 before applying to the I/Q modulator
39	VCO_TANK-	Same as pin 38, except a complementary input.
40	VGA_GC	The VGA gain control signal. A DC control voltage should be applied to this pin to vary the gain of the VGA.
41	GND	Ground connection.
42	LO_PCS_IN	This is the input pin for the local oscillator for the PCS band. It is internally matched.
43	VCC_MIX	Supply voltage for the mixer in the upconverter block and for the LO buffer.
44	LO_CELL_IN	This is the input pin for the local oscillator for the cellular band. It is internally matched.
45	IF130_IN+	A band select command will switch the input IF signal, which is the balanced input to the upconverter, between the cellular upconverter and the PCS upconverter. The DC bias is set internally.
46	IF130_IN-	Same as pin 45, except a complementary input.
47	NC	No connection.
48	NC	No connection.

Table 2. Absolute Maximum Ratings

PARAMETER	MINIMUM	MAXIMUM	UNIT
Supply voltage (VCC)	-0.3	5.0	V
Input voltage range	-0.3	VCC	V
Power dissipation	--	600	mW
Ambient operating temperature	-30	+80	°C
Storage temperature	-40	+125	°C

Table 3. Recommended Operating Conditions

Parameter	Min	Typical	Max	Units
Supply voltage	2.7	3.3	3.6	V
Logic level high	1.9			V
Logic level low			0.6	V
Supply current in 800 MHz CDMA @ 8 dBm	89	102	115	mA
Supply current in 800 MHz AMPS @ 11 dBm	96	110	124	mA
Supply current in 800 MHz (DRIVER_ON = Off)	57	68	79	mA
Supply current in 1900 MHz CDMA @ 9 dBm	89	103	117	mA
Supply current in 1900 MHz CDMA (DRIVER_ON = Off)	56	68	80	mA
Supply current in sleep mode (CHIP_ENA = Off, DRIVER_ON = Off)			10	μA

Table 4. RF251 Tx ASIC Electrical Specifications (1 of 3)

TA = 25° C, VCC = 3.3 V, PLO = -10 dBm, input externally matched

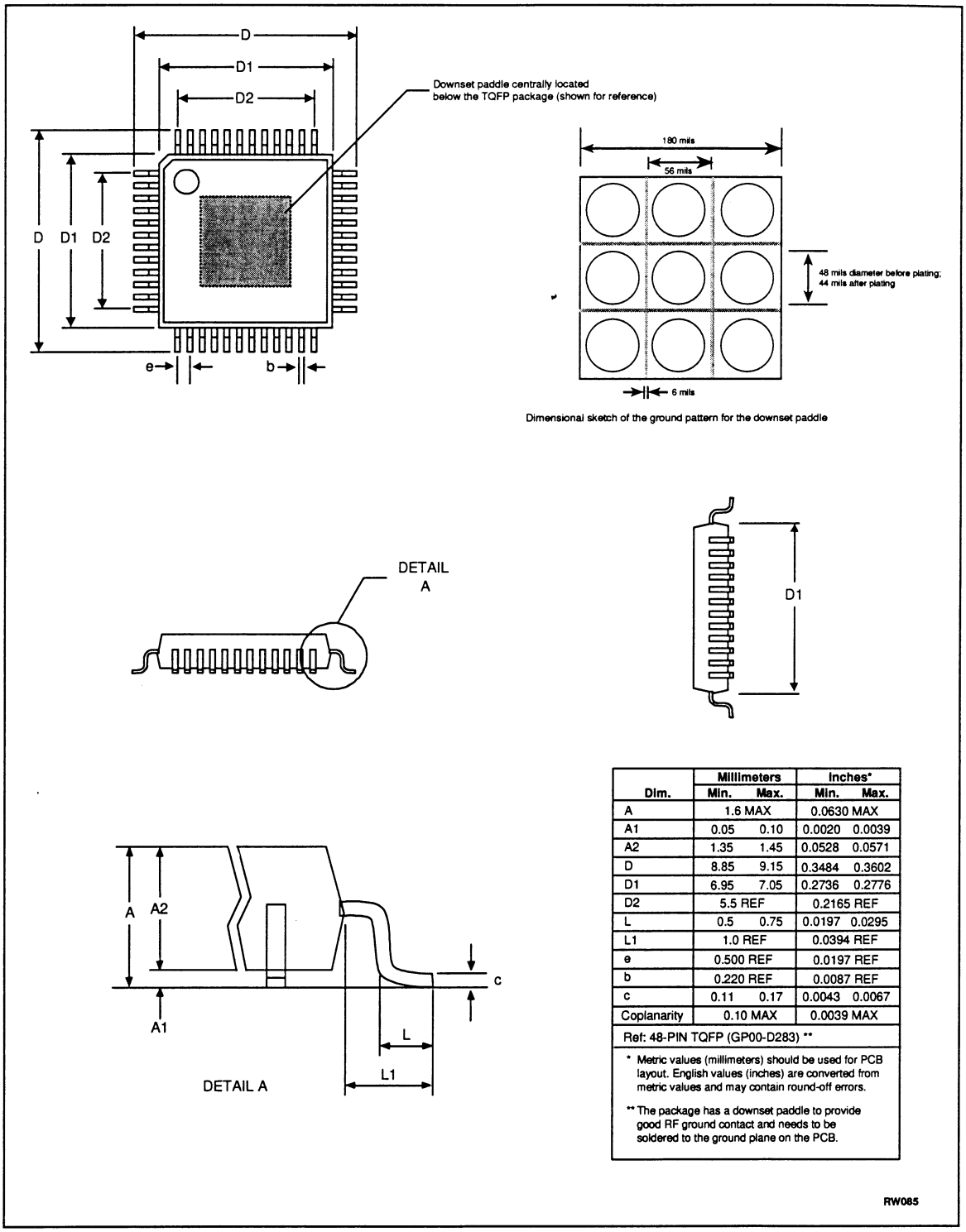
Parameter	Symbol	Test Condition	Min	Typical	Max	Units
VCO (external tank)/Wideband Divide-By-2						
Frequency range for VCOs			100		640	MHz
2nd harmonic (measured @ tank circuit)				-30	-26	dBc
3rd harmonic (measured @ tank circuit)				-20		dBc
Phase noise @100 kHz offset, Fc = 620 MHz, unloaded tank Q = 20				-109		dBc/Hz
Phase noise @100 kHz offset, Fc = 260 MHz, unloaded tank Q = 20				-113		dBc/Hz
Input frequency range to /2 circuit			100		640	MHz
Output impedance of buffer to PLL (differential)				300		Ω
Output signal level to PLL (differential)				300		mVp-p
I/Q Modulator						
Input voltage level, differential				1		Vp-p
Common mode input voltage level			1.6	1.85	2.1	V
Input DC offset					4	mV
Input impedance			100K			Ω
Gain variation over process, temperature, VCC				0.4		dB
I/Q gain mismatch				0.3	0.4	dB
I/Q phase imbalance				2	4	degree
Tx VGA						
VGA frequency range (-1 dB bandwidth)			50		320	MHz
VGA gain (with 510 Ω load resistor): Maximum Minimum			 25 -65	 28 -62	 30 -60	 dB dB
VGA gain variation with VCC 3.0 to 3.6 V @ V_{CTRL} 2 V			-3		3	dB
Gain variation with temperature			-1.5		1.5	dB
Gain control input impedance				40K		Ω
VGA gain slope			40	45	50	dB/V
VGA gain control range			0.2		2.7	V
Gain slope variation over any 6 dB segment			-3		+3	dB/V
Output power level @ 26dB gain Minimum controllable output power (thermal noise:-113dBm)				-13 -107		dBm
ACPR in 30 kHz band at 885 kHz offset, maximum gain				-61	-60	dBc
ACPR in 30 kHz band at 1.25 MHz offset, maximum gain				-63	-62	dBc

Table 4. RF251 Tx ASIC Electrical Specifications (2 of 3)
TA = 25° C, VCC = 3.3 V, PLO = -10 dBm, input externally matched

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Tx VGA (continued)						
ACPR in 30 kHz band at 1.98 MHz offset, maximum gain				-72	-71	dBc
NF at maximum gain				5	6	dB
NF at -52 dB gain				52	53	dB
Cellular Variable Gain Upconverter						
LO frequency range			700		1000	MHz
LO input return loss (reference to 50 Ω)				-10		dB
Terminating resistor across IF inputs			485	510	535	Ω
Output frequency			824		925	MHz
CDMA mode conversion gain, maximum			20	22		dB
CDMA mode conversion gain, mininum				-10		dB
ACPR in 30 kHz at 885 kHz offset @ -2 dBm output				-55	-54	dBc
ACPR in 30 kHz at 1.98 MHz offset @ -2 dBm output					-66	dBc
FM mode conversion gain, maximum			22	25		dB
FM mode conversion gain, minimum				-6		dB
FM mode output P1dB			+5	+6		dBm
Noise figure @ 22 dB gain CDMA/22 dB gain FM				10	11	dB
Noise figure @ 12 dB gain CDMA/14 dB gain FM				16	18	dB
LO to RF leakage @ maximum gain, LO = -10 dBm				-35		dBm
PCS Variable-Gain Upconverter						
LO frequency range			1600		1800	MHz
LO input return loss (reference to 50 Ω)				-10		dB
Terminating resistor across IF inputs			485	510	535	Ω
Output frequency			1700		1910	MHz
Maximum conversion gain			17	18		dB
Minimum conversion gain				-6		dB
Output power @ maximum gain				-3		dBm
ACPR in 30 kHz at 1.25 MHz offset @ -6 dBm output				-56	-54	dBc
ACPR in 1 MHz at 2.75 MHz offset @ -6 dBm output				-56	-54	dBc
Noise figure at 13 dB gain				9	10	dB
Noise figure at minimum gain				13		dB
LO to RF leakage @ maximum gain, LO = -15 dBm				-35		dBm

Table 4. RF251 Tx ASIC Electrical Specifications (3 of 3)
TA = 25° C, VCC = 3.3 V, PLO = -10 dBm, input externally matched

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Cellular PA Driver						
Output frequency			824		925	MHz
Gain (@ POT800 = 100 Ω)			12.5	13.5		dB
Output power level			8	10		dBm
Saturated output power level (FM)			12	14		dBm
ACPR in 30 kHz band at 885 kHz offset @ 8 dBm output				-54	-53	dBc
ACPR in 30 kHz band at 1.98 MHz offset @ 8 dBm output				-67	-66	dBc
Output return loss (reference to 50 Ω)				-15		dB
Noise figure				6	8	dB
PCS PA Driver						
Input return loss (reference to 50 Ω)				-15		dB
Output frequency			1700		1910	MHz
Gain (@ POT1800 = 100 Ω)			18	20		dB
Output power level with 1800 MHz mixer @ maximum gain			+9	+10.5		dBm
ACPR in 30 kHz band at 1.25 MHz offset @ 9 dBm output				-52	-51	dBc
ACPR in 1 MHz band at 2.75 MHz offset @ 9 dBm output				-52	-51	dBc
Noise figure				9	10	dB



Dim.	Millimeters Min.	Millimeters Max.	Inches* Min.	Inches* 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. RF251 Tx ASIC Package Dimensions - 48-pin TQFP Package With Downset Paddle

Headquarters
Rockwell Semiconductor Systems
4311 Jamboree Road,
P.O. Box C
Newport Beach, CA 92658-8902
Phone: (714) 221-4600
Fax: (714 221-6375

European Headquarters
Rockwell Semiconductor Systems
S.A.R.L.
Les Taissounieres B1
Route des Dolines
Sophia Antipolis Cedex
06905 Valbonne
France
Phone: (33) 93 00 33 35
Fax: (33) 93 00 33 03

For more information:
Call 1-800-854-8099
International information:
Call 1-714-833-6996

URL Address:
http://www.nb.rockwell.com
E-Mail Address:
literature@nb.rockwell.com

REGIONAL SALES OFFICES

US Southwest Office
Rockwell Semiconductor Systems
5000 Birch Street
Suite 400
Newport Beach, CA 92660
Phone: (714) 222-9119
Fax: (714) 222-0620

US Southwest Satellite Office
Rockwell Semiconductor Systems
1000 Business Center Circle
Suite 215
Thousand Oaks, CA 91320
Phone: (805) 376-0559
Fax: (805) 376-8180

US South Central Office
Rockwell Semiconductor Systems
2001 North Collins Blvd
Suite 103
Richardson, TX 75080
Phone: (972) 479-9310
Fax: (972) 479-9317

US Southeast Office
Rockwell Semiconductor Systems
3500 Parkway Lane
Suite 415
Norcross, GA 30092
Phone: (770) 246-8283
Fax: (770) 246-0018

US Southeast Satellite Office
Rockwell Semiconductor Systems
One Prestige Place
2600 McCormick Drive
Suite 350
Clearwater, FL 34619
Phone: (813) 799-8406
Fax: (813) 799-8306

US Northwest Office
Rockwell Semiconductor Systems
US Northwest Office
3600 Pruneridge Avenue
Suite 100
Santa Clara, CA 95051
Phone: (408) 249-9696
Fax: (408) 249-7113

US North Central Office
Rockwell Semiconductor Systems
Two Pierce Place
Chancellory Park
Suite 810
Itasca, IL 60143
Phone: (708) 773-3454
Fax: (708) 773-3907

US Northeast Office
Rockwell Semiconductor Systems
239 Littleton Road
Suite 4A
Westford, MA 01886
Phone: (508) 692-7660
Fax: (508) 692-8185

Australia
Rockwell Australia Pty Limited
Rockwell Semiconductor Systems
Suite 603, 51 Rawson Street
Epping, NSW 2121
Australia
Phone: (61-2) 9869 4088
Fax: (61-2) 9869 4077

Europe Mediterranean
Rockwell Semiconductor Systems
c/o Rockwell Automation s.r.l.
Via Di Vittorio, 1
20017 Mazzo Di Rho (MI)
Italy
Phone: (39 2) 9317 9911
Fax (39 2) 9317 9913

Europe North
Rockwell Semiconductor Systems,
Ltd.
Berkshire Court
Western Road
Bracknell
Berkshire RG12 1RE
England
Phone: +44 1344 486 444
Fax: +44 1344 486 555

Europe South
Rockwell Semiconductor Systems
S.A.R.L.
Tour GAN
Cedex 13
92082 Paris La Defense 2
France
Phone: (33-1) 49-06-3980
Fax: (33-1) 49-06-3990

Germany
Rockwell Semiconductor Systems
Rockwell Int'l GmbH Germany
Paul-Gerhardt-Allee 50 a
81245 Munchen
Germany
Phone: (49-89) 829-1320
Fax: (49-89) 834-2734

Hong Kong
Rockwell Int'l (Asia Pacific) Ltd.
13th Floor, Suites 8-10,
Harbour Centre
25 Harbour Road
Wanchai,
Hong Kong
Phone: (852) 2 827-0181
Fax: (852) 2 827-6488

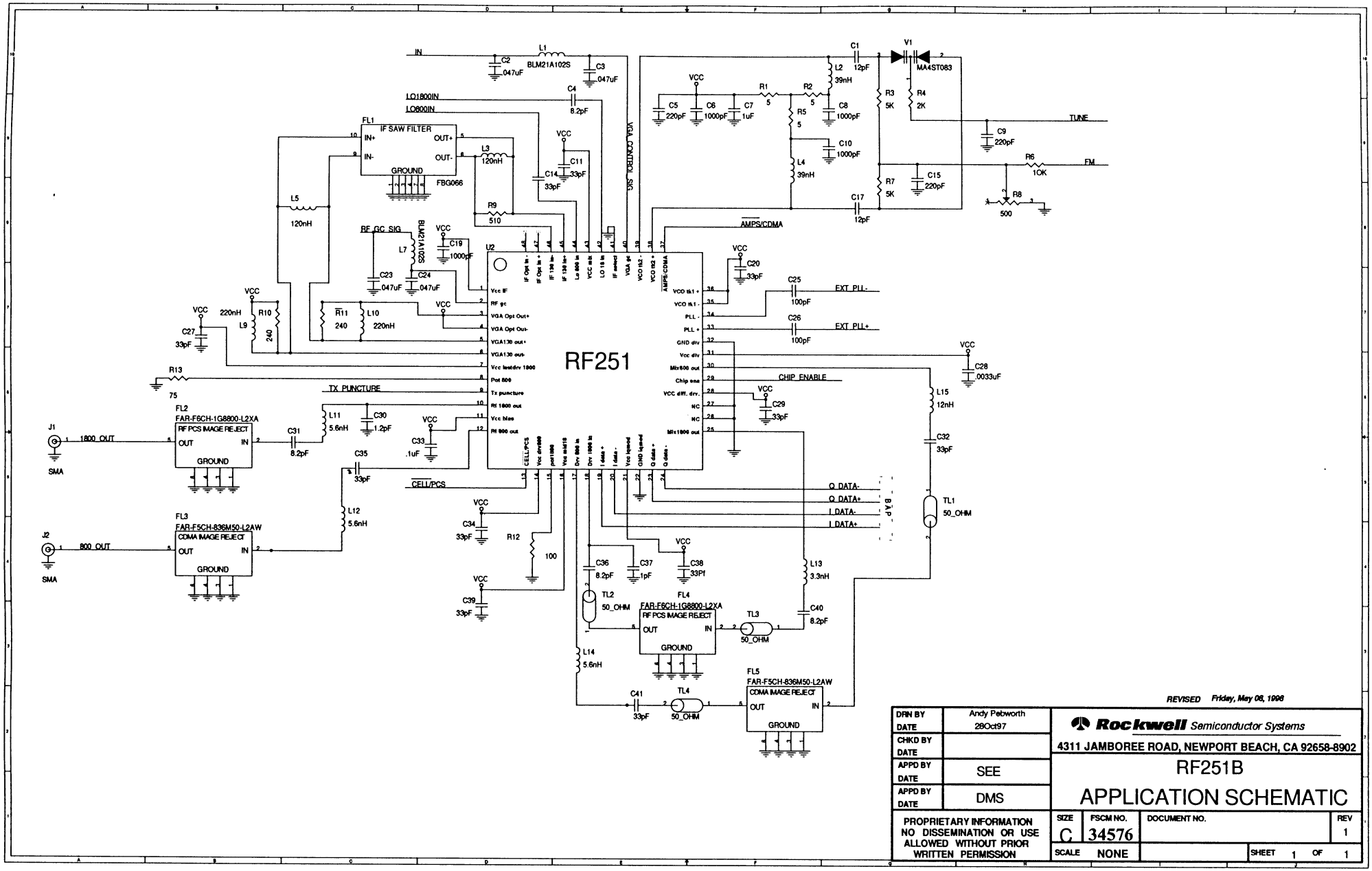
Japan
Rockwell Int'l Japan Co., Ltd.
Shimomoto Bldg
1-46-3 Hatsudai, Shibuya-ku
Tokyo, 151
Japan
Phone: (81-3) 5371 1520
Fax: (81-3) 5371 1501

Korea
Rockwell-Collins Int'l, Inc.
Room No. 1508
Korea Textile Centre Building
944-31, Daechi-3dong
Kangnam P.O. Box 2037
Kangnam-ku
Seoul
Korea
Phone: (82-2) 565-2880
Fax: (82-2) 565-1440

Singapore
Rockwell Semiconductor Systems
1 Kim Seng Promenade
#09-01 East Tower
Great World City
Singapore 237994
Phone: (65) 737-7355
Fax: (65) 737-9077

Taiwan
Rockwell Int'l Taiwan Company, Ltd.
Room 2808 International Trade Bldg.
333, Keelung Road, Section I
Taipei,
Taiwan
10548 ROC
Phone: (886-2) 720-0282
Fax: (886-2) 757-6760

Rockwell
Semiconductor Systems



REVISED Friday, May 08, 1998

DRN BY / DATE	Andy Pebworth 28Oct97	Rockwell Semiconductor Systems
CHKD BY / DATE		4311 JAMBOREE ROAD, NEWPORT BEACH, CA 92658-8902
APPD BY / DATE	SEE	RF251B
APPD BY / DATE	DMS	APPLICATION SCHEMATIC

SIZE	FSCM NO.	DOCUMENT NO.	REV
C	34576		1
SCALE NONE			SHEET 1 OF 1