Low-voltage digital IF receiver | SA637

DESCRIPTION

The SA637 is a low-voltage high performance monolithic digital system with high-speed RSSI incorporating a mixer, oscillator with buffered output, two limiting intermediate frequency amplifiers, fast logarithmic received signal strength indicator (RSSI), voltage regulator, RSSI op amp and power down pin. The SA637 is available in SSOP (shrink small outline package).

The SA637 was designed for portable digital communication applications and will function down to 2.7V. The limiter amplifier has differential outputs with 2MHz small signal bandwidth. The RSSI output has access to the feedback pin. This enables the designer to level adjust the outputs or add filtering.

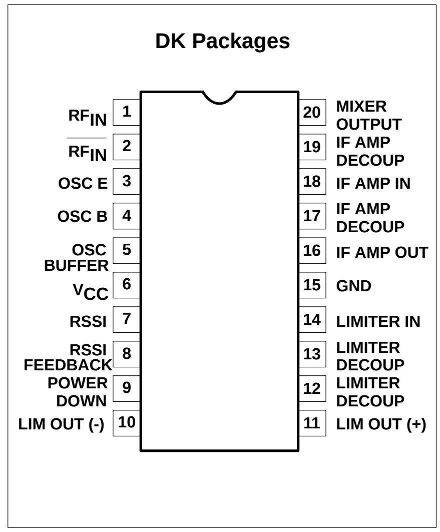
FEATURES

- V_{CC} = 2.7 to 5.5V
- Low power receiver (3.8mA @ 3V)
- Power down mode (I_{CC} = 110µA)
- Fast RSSI rise and fall times
- Extended RSSI range with temperature compensation
- RSSI op amp
- 2MHz limiter small signal bandwidth
- 455kHz filter matching (1.5kΩ)
- Differential limiter output
- Oscillator buffer
- SSOP-20 package

APPLICATIONS

- ADC (American Digital Cellular)
- Digital receiver systems
- Cellular radio

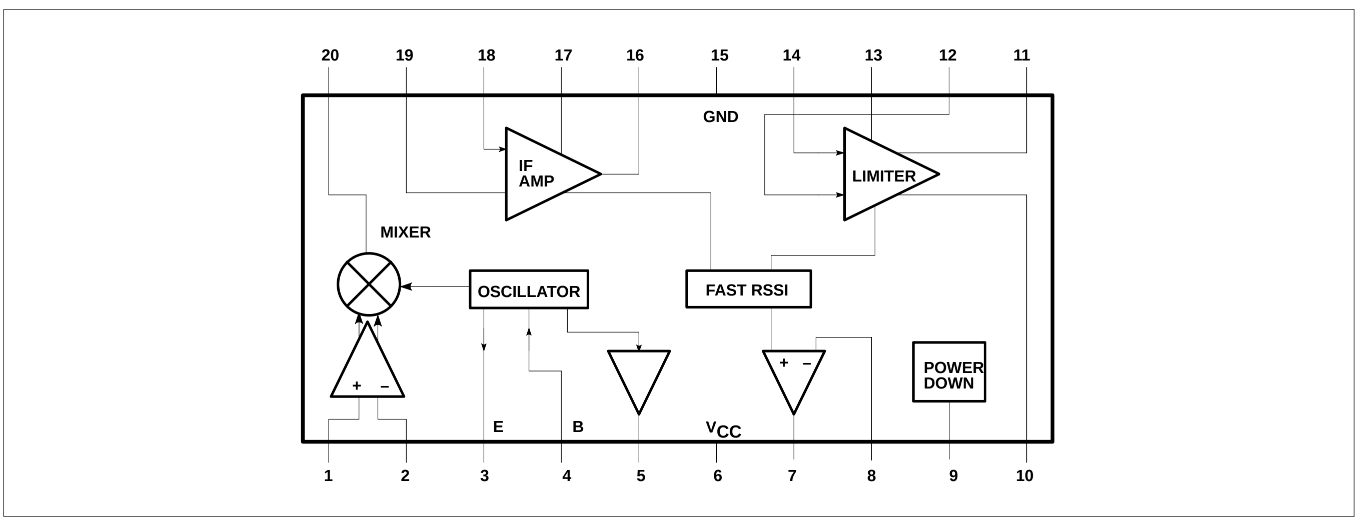
PIN CONFIGURATION



ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
20-Pin Plastic Shrink Small Outline Package (Surface-mount)	-40 to +85°C	SA637DK	1563

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNITS
V_{CC}	Supply voltage	-0.3 to +6.0	V
V_{IN}	Voltage applied to any other pin	-0.3 to (V_{CC} + 0.3)	V
T_{STG}	Storage temperature range	-65 to +150	°C
T_A	Operating ambient temperature range	-40 to +85	°C

NOTE: Thermal impedance (θ_{JA}) = 117°C/W

DC ELECTRICAL CHARACTERISTICS

V_{CC} = +3V, T_A = 25°C; unless otherwise stated.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
V_{CC}	Power supply voltage range		2.7		5.5	V
I_{CC}	DC current drain	Pin 9 = HIGH or OPEN		3.8	4.5	mA
		V_{CC} = 4.7V		4.4	5.5	mA
	Standby	Pin 9 = LOW		0.11	0.5	mA
	Input current	Pin 9 = LOW	-10		10	µA
		Pin 9 = HIGH	-10		10	µA
	Input level	Pin 9 = LOW	0		$0.3V_{CC}$	µA
		Pin 9 = HIGH	$0.7V_{CC}$		V_{CC}	µA
t_{ON}	Power up time	RSSI valid (10% to 90%)		10		µs
t_{OFF}	Power down time	RSSI invalid (90% to 10%)		5		µs

AC ELECTRICAL CHARACTERISTICS

T_A = 25°C; V_{CC} = +3V, unless otherwise stated. RF frequency = 90MHz; RF input step-up = +14.5dBV; IF frequency = 455kHz; RF level = -68dBm. Test circuit Figure 1. The parameters listed below are tested using automatic test equipment to assure consistent electrical characteristics. The limits do not represent the ultimate performance limits of the device. Use of an optimized RF layout will improve many of the listed parameters.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
Mixer/Osc section						
f_{IN}	Input signal frequency			200		MHz
f_{OSC}	Crystal oscillator frequency			200		MHz
NF	Noise figure at 90MHz	Matched input and output		6.2		dB
TOI	Third-order input intercept point	Input matched to 50Ω source		-17		dBm
P1dB	Input 1dB compression point			-27		dBm
	Conversion power gain	Matched 50Ω		7		dB
R_{IN}	Mixer input resistance			2.5		kΩ
C_{IN}	Mixer input capacitance			2.2		pF
R_{OUT}	Mixer output resistance			1.87		kΩ
	Buffered LO output level	LO = 447mV_{P-P}, 1kΩ AC load	100	300	500	mV_{P-P}
IF section						
	IF amp power gain	50Ω source		36		dB
	Limiter power gain	50Ω source		60		dB
IF_{BW}	IF amp bandwidth			2.5		MHz

AC ELECTRICAL CHARACTERISTICS (Continued)

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
	RF RSSI output	RF level = -118dBm	.01	0.2	.65	V
		RF level = -68dBm	.4	0.9	1.7	V
		RF level = -28dBm	1.0	1.7	2.3	V
	RSSI range			90		dB
	RSSI accuracy			±1.5		dB
	RSSI ripple			30		mV_{P-P}
	RSSI speed Rise time	No interstage filter		2.5		µs
		With interstage filter		22		µs
	RSSI speed Fall time	No interstage filter		10		µs
		With interstage filter		50		µs
	IF input impedance			1.5		kΩ
	IF output impedance			1.5		kΩ
	Limiter input impedance			1.5		kΩ
	Limiter output impedance	(Pin 10, Pin 11)		200		Ω
	Limiter output signal level	(Pin 10, Pin 11) 1.5kΩ AC load		280		mV_{P-P}
	Limiter output DC level			1.27		V
	Differential output matching			±6		mV
	Differential output offset			±30		mV

CIRCUIT DESCRIPTION

Mixer

The mixer has a balanced input and is capable of being driven single-ended. The input impedance is 2.5kΩ in parallel with a 2.2pF cap at 90MHz RF. The mixer output can drive a 1500Ω ceramic filter at 455kHz or 600kHz directly without any matching required. The mixer conversion power gain is 7dB when both input and output are matched and optimum LO level is used to drive the internal mixer core.

Oscillator and Buffer

The on-board oscillator supplies the signal for the mixer down-conversion. The internally biased transistor can be configured as a Colpitts or Butler overtone crystal oscillator. The transistor’s bias current can be increased if desired by adding a shunt resistor from Pin 3 to ground. The oscillator’s buffered output (Pin 5) can be used as a feedback signal to lock the oscillator to an appropriate reference.

IF Amplifier and IF Limiter

The IF strip provides more than 95dB of power gain for the down converted signal. Its overall bandwidth is limited to 2MHz. The input and output impedance of the IF amplifier and the input impedance of the IF limiter are set to 1500Ω (match to 455kHz filter). A second filter is connected between the IF amplifier and the limiter for improved channel selectivity and reduced instability. This ceramic filter provides 3dB interstage insertion loss which results in optimal RSSI linearity. The overall gain can be reduced if desired by adding an external attenuator after the IF amplifier. The differential limiter outputs (Pins 10 and 11) are available for demodulator circuits.

RSSI

The received signal strength indicator provides a linear voltage indication of the received signal strength in dB for a range in excess of 90dB. The response time to a change in input signal is less than a few microseconds and the delay is kept to a minimum because of the use of a minimum phase shift circuit. Because of the speed of the RSSI circuit, the RSSI rise and fall time may, in practice, be dominated by the bandwidth of the external bandpass filter that is placed between the mixer and the IF, and the external filter placed between the IF amplifier and limiter. Since the RSSI function requires the signal to propagate through the whole IF strip, and the rise and fall time of the filters are inversely proportional to their bandwidth, there is a trade-off between channel selectivity and RSSI response. A possible solution is to use a second SA637 with wider band external filters for faster RSSI response.

The RSSI curve is temperature compensated and in addition is designed for improved consistency from unit to unit.

The RSSI circuit drives an on-chip low power op amp with rail-to-rail output which can be connected as a unity gain RSSI buffer or a gain stage or even a comparator.

DC Power Supply

The IC is designed for operation between 2.7 and 5.5V. A power supply dependent biasing scheme is used in the mixers to benefit from the large headroom available at higher V_{CC}s.

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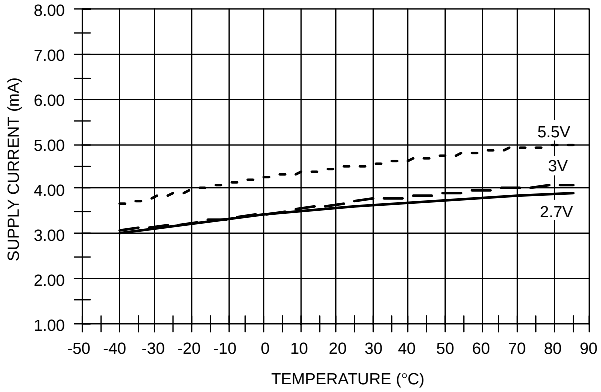
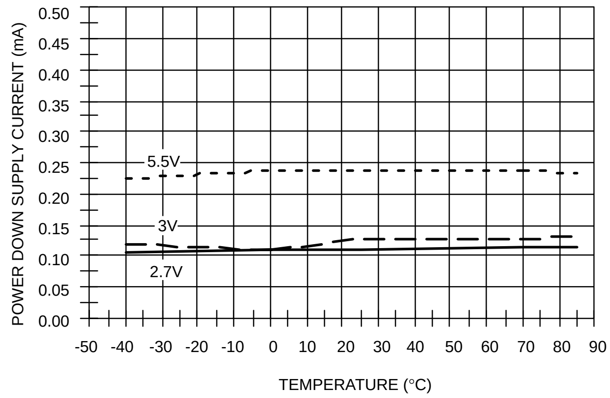
PERFORMANCE CHARACTERISTICS

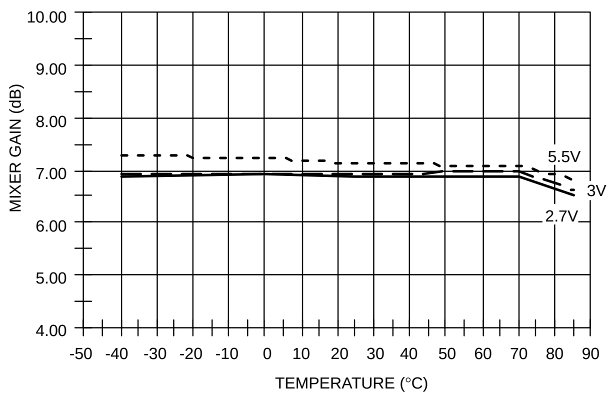
Supply Current vs Temperature and Supply Voltage



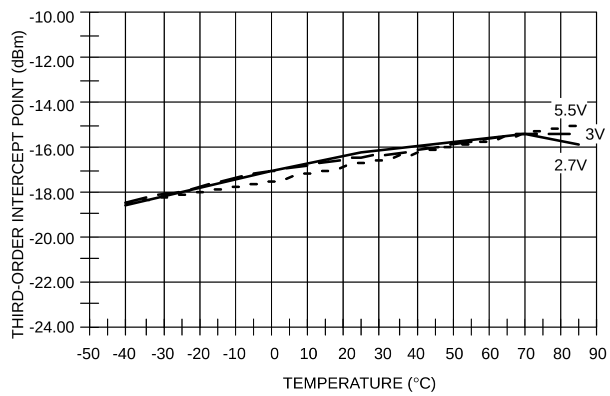
Power Down Supply Current vs Temperature and Supply Voltage



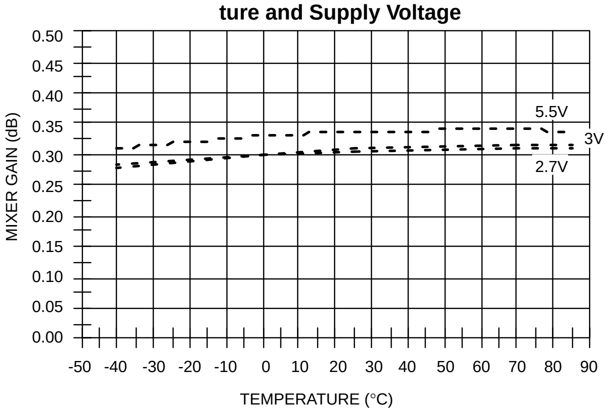
Mixer Power Gain vs Temperature and Supply Voltage



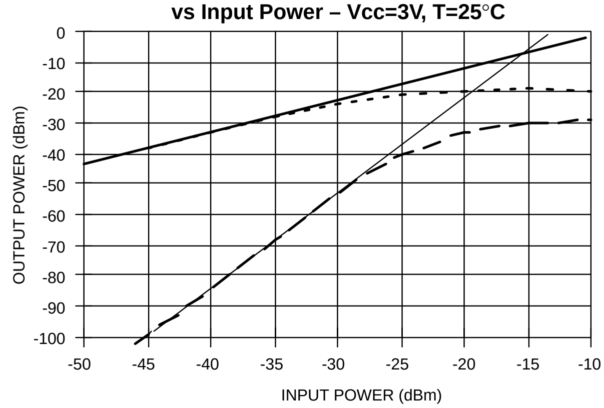
Mixer Third Order Input Intercept Point vs Temperature and Supply Voltage



Oscillator Buffer Output Level vs Temperature and Supply Voltage



Mixer Third Order Intercept and Compression vs Input Power – Vcc=3V, T=25°C



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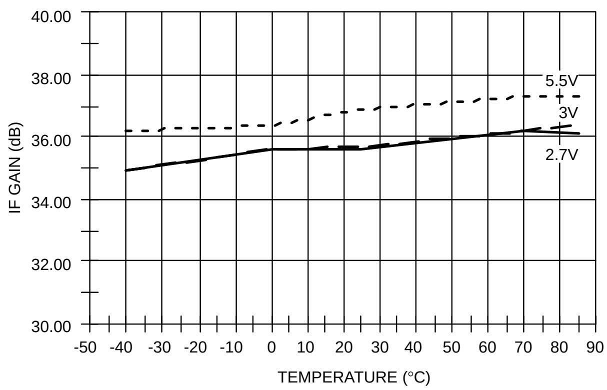
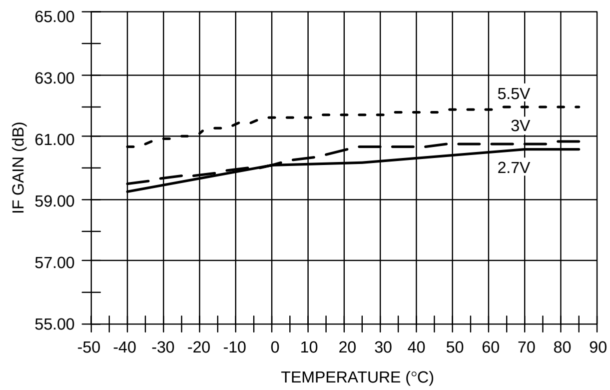
PERFORMANCE CHARACTERISTICS (cont.)

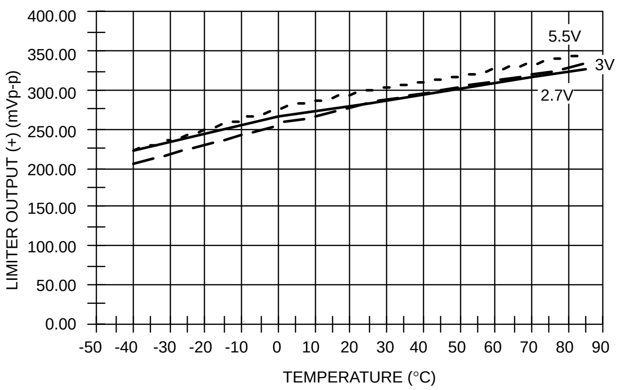
IF Power Gain vs Temperature and Supply Voltage



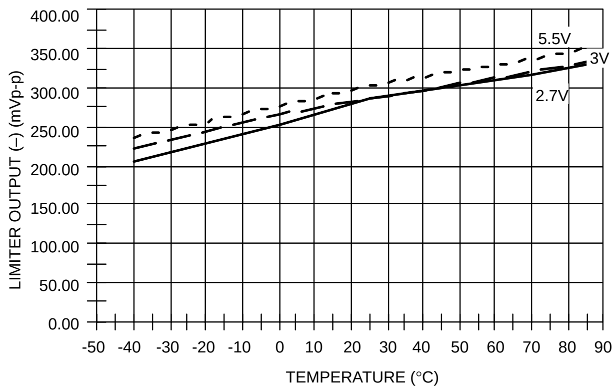
Limiter Power Gain vs Temperature and Supply Voltage



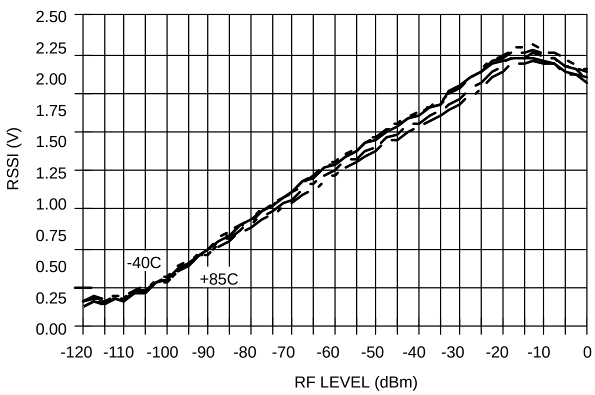
Limiter Output (+) Level vs Temperature and Supply Voltage



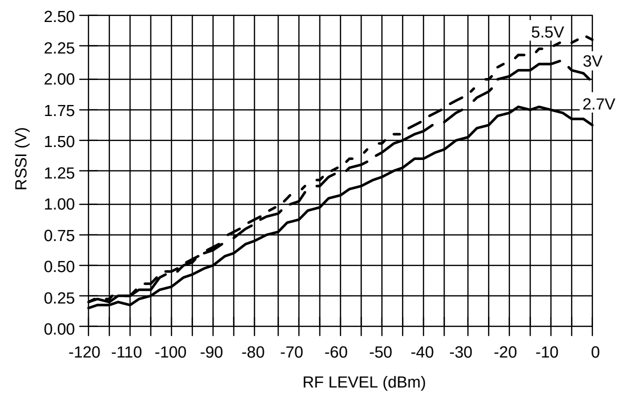
Limiter Output (–) Level vs Temperature and Supply Voltage



RSSI vs RF Level and Temperature – V_{CC} = 3V



RSSI vs RF Level and Supply Voltage – Temperature = 25°C



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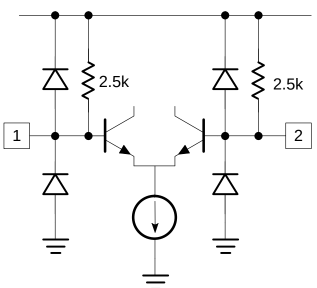
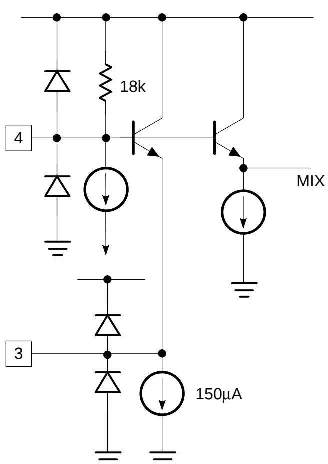
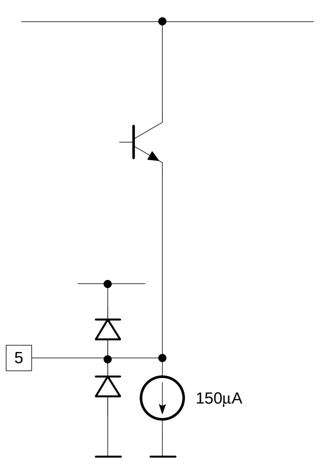
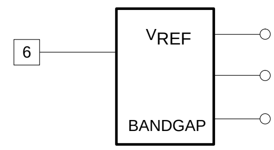
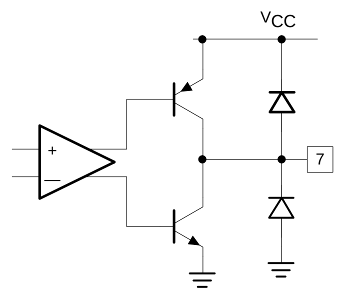
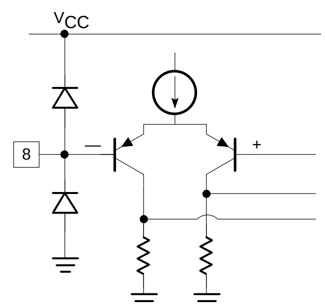
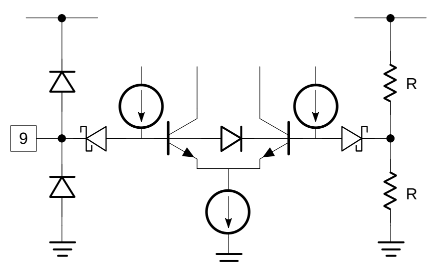
PIN FUNCTIONS

PIN No.	PIN MNEMONIC	DC V	EQUIVALENT CIRCUIT
1	RF IN	+1.40	
2	RF BYPASS	+1.40	
3	OSC E	+1.79	
4	OSC B	+2.56	
5	OSC BUFFER	+1.79	
6	V_{CC}	+3.00	
7	RSSI OUT	+0.20	
8	RSSI FEEDBACK	+0.20	
9	POWER DOWN	+2.00	

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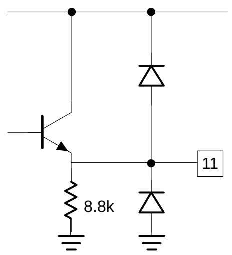
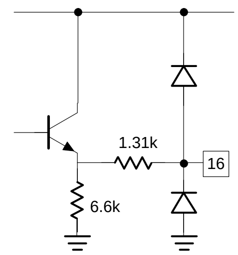
PIN FUNCTIONS (continued)

<table>
<tr><th>PIN No.</th><th>PIN MNEMONIC</th><th>DC V</th><th>EQUIVALENT CIRCUIT</th><th>PIN No.</th><th>PIN MNEMONIC</th><th>DC V</th><th>EQUIVALENT CIRCUIT</th></tr>
<tr><td>10
11</td><td>LIMITER OUT</td><td>+1.25</td><td>
</td><td>16</td><td>IF AMP OUT</td><td>+1.28</td><td>
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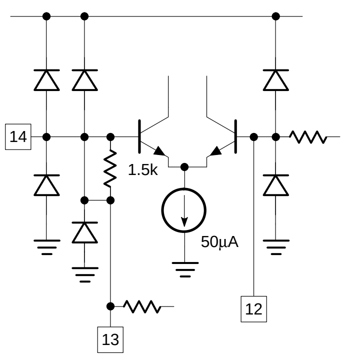
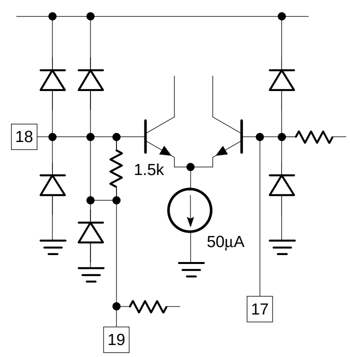
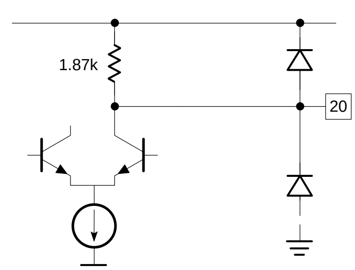
<tr><td>12</td><td>LIMITER DECOUP</td><td>+1.28</td><td rowspan="3">
</td><td>17</td><td>IF AMP DECOUP</td><td>+1.28</td><td rowspan="3">
</td></tr>
<tr><td>13</td><td>LIMITER COUPLING</td><td>+1.28</td><td>18</td><td>IF AMP IN</td><td>+1.28</td></tr>
<tr><td>14</td><td>LIMITER IN</td><td>+1.28</td><td>19</td><td>IF AMP DECOUP</td><td>+1.28</td></tr>
<tr><td>15</td><td>GND</td><td>0</td><td></td><td>20</td><td>MIXER OUT</td><td>+2.03</td><td>
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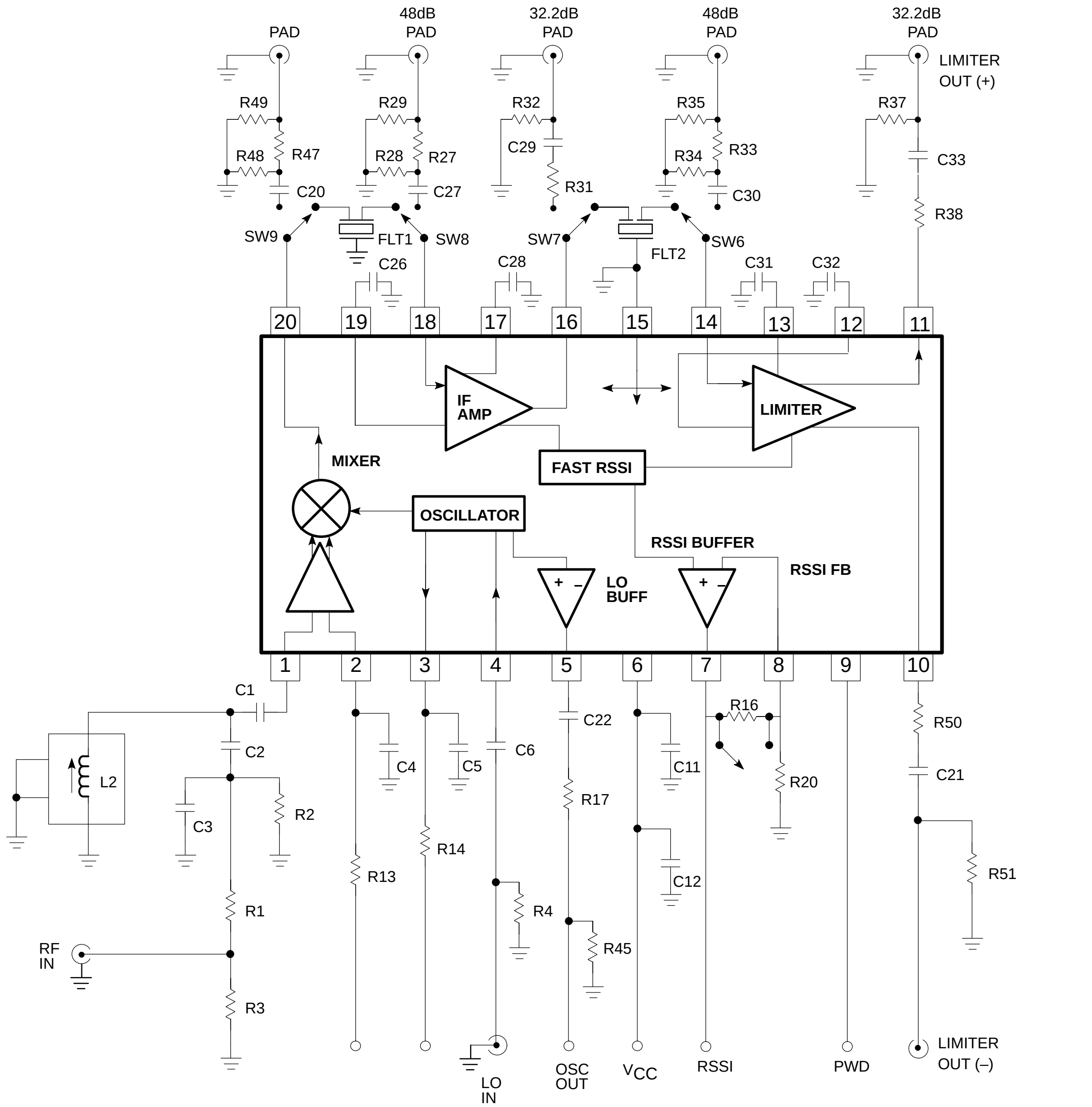


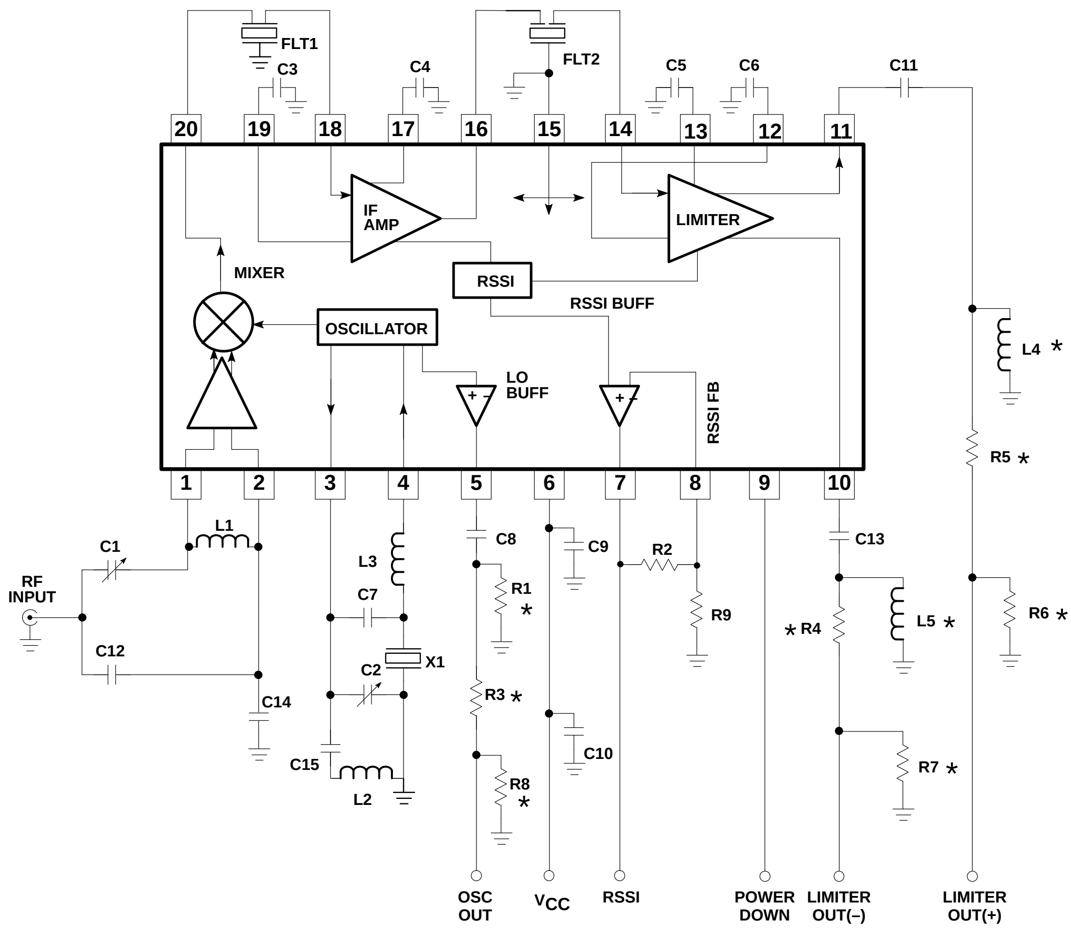
Automatic Test Circuit Component List

C1	10nF	C27	100nF	R4	49.9Ω	R32	49.9Ω	R32	49.9Ω
C2	91pF	C28	100nF	R13	10kΩ	R33	13.7kΩ	R50	1kΩ
C3	620pF	C29	100nF	R14	10kΩ	R34	1.68kΩ	R51	49.9Ω
C4	100nF	C30	100nF	R16	10kΩ	R35	49.9Ω	L2	62nH
C5	100nF	C31	100nF	R17	1kΩ	R38	1kΩ		
C6	10nF	C32	100nF	R20	10kΩ	R39	49.9Ω		
C11	100nF	C33	100nF	R27	13.7kΩ	R45	49.9Ω		
C20	100nF	R1	249Ω	R28	1.68kΩ	R47	2.43kΩ		
C21	100nF	R2	60.4Ω	R29	49.9Ω	R48	39.2kΩ		
C26	100nF	R3	60.4Ω	R31	1kΩ	R49	49.9Ω		

Figure 1. SA637 Automatic Test Circuit

Low-voltage digital IF receiver

SA637



Component List

C1	**5-30pF**	**C9**	**0.1µF**	**R1**	**OPEN**	**L1**	**0.15µH PM20-R15M**
C2	**5-30pF**	**C10**	**1.0µF**	**R2**	**0Ω** (short)	**L2**	**0.15µH PM20-R15M**
C3	**0.1µF**	**C11**	**0.1µF**	**R3**	**1kΩ**	**L3**	**0.47µH PM20-R47M**
C4	**0.1µF**	**C12**	**68pF**	**R4**	**1.0kΩ**	**L4**	**OPEN**
C5	**0.1µF**	**C13**	**0.1µF**	**R5**	**2.0kΩ**	**L5**	**OPEN**
C6	**0.1µF**	**C14**	**0.1µF**	**R6**	**51Ω**	**FLT1**	**455kHz SFGCC 455BX-TC**
C7	**10pF**	**C15**	**1000pF**	**R7**	**100Ω**	**FLT2**	**455kHz SFGCC 455BX-TC**
C8	**0.1µF**			**R8**	**100Ω**	**X1**	**82.705MHz CTS XTAL 020-3249-042**
				R9	**OPEN**		

* NOTE: These components are optional and depend on user matching requirements.
Pads are provided on the demo board.
R2 and R9 set the RSSI buffer gain. For unity gain short R2 (Pin 7 to Pin 8) and leave R9 open.

Figure 2. SA637 Application Circuit

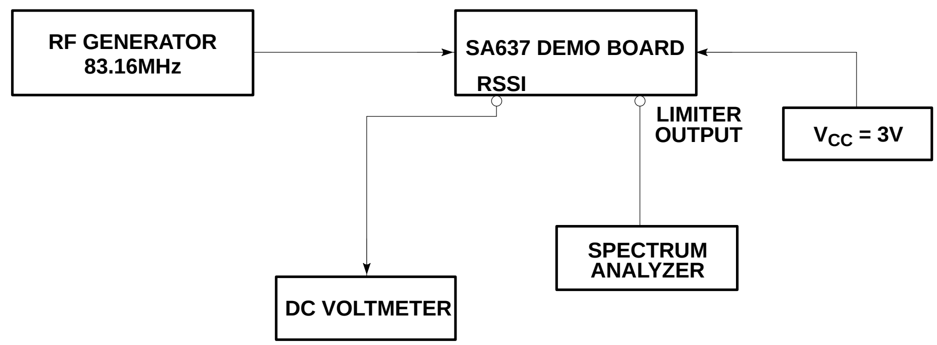
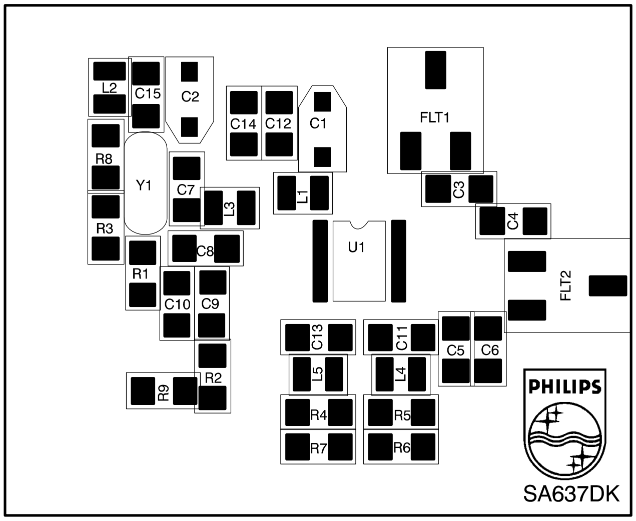


Figure 3. SA637 Application Circuit Test Set Up

NOTES:
1. Carrier-to-Noise (C/N): Connect a spectrum analyzer to Pin 10 or 11; set your RF generator to 83.16MHz or 455kHz above your LO frequency, modulation off; set the spectrum analyzer resolution bandwidth to 300Hz; and adjust your RF input level until the C/N = 26dB. Use video averaging. Assure that LIMOUT(+) and LIMOUT(–) are matched symetrically.
2. Ceramic filters: The ceramic filter can be SFGCC455BX-TC made by Murata which has 30kHz IF bandwidth.
3. Sensitivity: The measured typical sensitivity for 12dB SINAD should be 0.45µV or -114dBm at the RF input.
4. Layout: The layout is very critical in the performance of the receiver. We highly recommend our demo board layout.
5. RSSI: The smallest RSSI voltage (i.e., when no RF input is present and the input is terminated) is a measure of the quality of the layout and design. If the lowest RSSI voltage is 500mV or higher, it means the receiver is in regenerative mode. In that case, the receiver sensitivity will be worse than expected.
6. Supply bypass and shielding: All of the inductors, the quad tank, and their shield must be grounded. A 0.1µF bypass capacitor on the supply pin improves sensitivity.


L2
C15
C2
C14
C12
C1
FLT1
R8
Y1
C7
L3
L1
C3
C4
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U1
C8
R1
FLT2
C10
C9
C13
C11
C5
C6
L5
L4
R2
R9
R4
R5
R7
R6
PHILIPS
SA637DK