

## DIGITAL TV TUNER IC

Check for Samples: [SN761644](#)

### FEATURES

- Integrated Mixer/Oscillator/PLL and IF GCA
- Mirror Pin Package of [SN761640](#)
- VHF-L, VHF-H, UHF 3-Band Local Oscillator
- RF AGC Detector Circuit
- I<sup>2</sup>C Bus Protocol  
Bidirectional Data Transmission
- High-Voltage Tuning Voltage Output
- Four NPN-Type Band Switch Drivers
- One Auxiliary Port/5-Level ADC
- Crystal Oscillator Output
- Programmable Reference Divider Ratio  
(24/28/32/64/80/128)
- IF GCA Enable/Disable Control
- Selectable digital IFOUT and Analog IFOUT
- Standby Mode
- 5-V Power Supply
- 44-Pin Thin Shrink Small-Outline Package  
(TSSOP)

### APPLICATIONS

- Digital TVs
- Digital CATVs
- Set-Top Boxes

### DESCRIPTION

The SN761644 is a low-phase-noise synthesized tuner IC designed for digital TV tuning systems. The circuit consists of a PLL synthesizer, three-band local oscillator and mixer, RF AGC detector circuit, and IF gain-controlled amplifier. The SN761644 is available in a small-outline package.

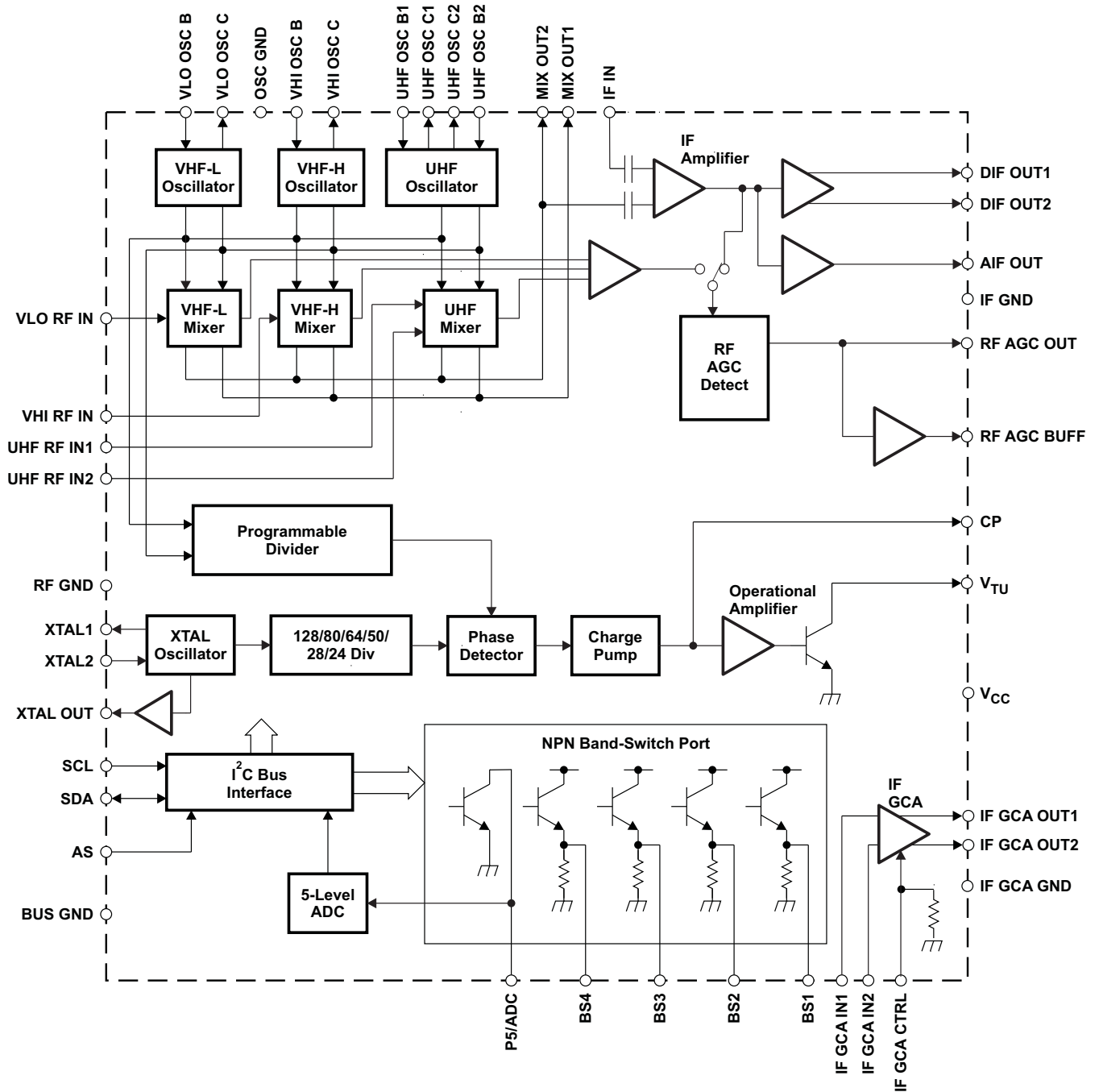
**DBT PACKAGE  
(TOP VIEW)**

BS4	1	44	VLO OSCB
UHF RF IN1	2	43	VLO OSC C
UHF RF IN2	3	42	VHI OSC B
VHI RF IN	4	41	VHI OSC C
VLO RF IN	5	40	UHF OSC B1
RF GND	6	39	UHF OSC C1
MIX OUT2	7	38	UHF OSC C2
MIX OUT1	8	37	UHF OSC B2
IF IN	9	36	OSC GND
RF AGC OUT	10	35	CP
RF AGC BUF	11	34	VTU
BS3	12	33	IF GND
BS2	13	32	AIF OUT
BS1	14	31	DIF OUT1
SDA	15	30	DIF OUT2
SCL	16	29	IF GCA CTRL
AS	17	28	VCC
BUS GND	18	27	IF GCA IN1
P5/ADC	19	26	IF GCA IN2
XTAL OUT	20	25	IF GCA GND
XTAL2	21	24	IF GCA OUT2
XTAL1	22	23	IF GCA OUT1



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

FUNCTIONAL BLOCK DIAGRAM



## TERMINAL FUNCTIONS

**Table 1.**

TERMINAL		DESCRIPTION	SCHEMATIC
NAME	NO.		
AIF OUT	32	IF amplifier output (analog)	<a href="#">Figure 8</a>
AS	17	Address selection input	<a href="#">Figure 1</a>
BS1	14	Band switch 1 output	<a href="#">Figure 2</a>
BS2	13	Band switch 2 output	<a href="#">Figure 2</a>
BS3	12	Band switch 3 output	<a href="#">Figure 2</a>
BS4	1	Band switch 4 output	<a href="#">Figure 2</a>
BUS GND	18	BUS ground	
CP	35	Charge-pump output	<a href="#">Figure 3</a>
DIF OUT1	31	IF amplifier output 1	<a href="#">Figure 9</a>
DIF OUT2	30	IF amplifier output 2	<a href="#">Figure 9</a>
IF GCA CTRL	29	IF GCA CTRL voltage inout	<a href="#">Figure 4</a>
IF GCA GND	25	IF GCA ground	
IF GCA IN1	27	IF GCA input 1	<a href="#">Figure 5</a>
IF GCA IN2	26	IF GCA input 2	<a href="#">Figure 5</a>
IF GCA OUT1	23	IF GCA output 1	<a href="#">Figure 6</a>
IF GCA OUT2	24	IF GCA output 2	<a href="#">Figure 6</a>
IF GND	33	IF ground	
IF IN	9	IF amplifier input	<a href="#">Figure 7</a>
MIXOUT1	8	Mixer output 1	<a href="#">Figure 10</a>
MIXOUT2	7	Mixer output 2	<a href="#">Figure 10</a>
OSC GND	36	Oscillator ground	
P5/ADC	19	Port-5 output/ADC input	<a href="#">Figure 11</a>
RF AGC BUF	11	RF AGC buffer output	<a href="#">Figure 12</a>
RF AGC OUT	10	RF AGC output	<a href="#">Figure 13</a>
RF GND	6	RF ground	
SCL	16	Serial clock input	<a href="#">Figure 14</a>
SDA	15	Serial data input/output	<a href="#">Figure 15</a>
UHF OSC B1	40	UHF oscillator base 1	<a href="#">Figure 16</a>
UHF OSC B2	37	UHF oscillator base 2	<a href="#">Figure 16</a>
UHF OSC C1	39	UHF oscillator collector 1	<a href="#">Figure 16</a>
UHF OSC C2	38	UHF oscillator collector 2	<a href="#">Figure 16</a>
UHF RF IN1	2	UHF RF input 1	<a href="#">Figure 17</a>
UHF RF IN2	3	UHF RF input 2	<a href="#">Figure 17</a>
V <sub>CC</sub>	28	Supply voltage	
VHI OSC B	42	VHF-H oscillator base	<a href="#">Figure 18</a>
VHI OSC C	41	VHF-H oscillator collector	<a href="#">Figure 18</a>
VHI RF IN	4	VHF-H RF input	<a href="#">Figure 19</a>
VLO OSC B	44	VHF-L oscillator base	<a href="#">Figure 20</a>
VLO OSC C	43	VHF-L oscillator collector	<a href="#">Figure 20</a>
VLO RF IN	5	VHF-L RF input	<a href="#">Figure 21</a>
VTU	34	Tuning voltage amplifier output	<a href="#">Figure 3</a>
XTAL1	22	4-MHz crystal oscillator	<a href="#">Figure 22</a>
XTAL2	21	4-MHz crystal oscillator	<a href="#">Figure 22</a>
XTALOUT	20	4-MHz crystal oscillator buffer output	<a href="#">Figure 23</a>

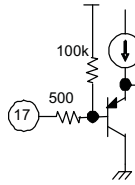


Figure 1. AS

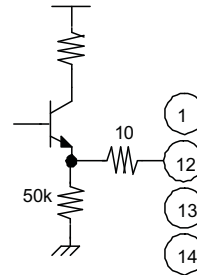


Figure 2. BS1, BS2, BS3, and BS4

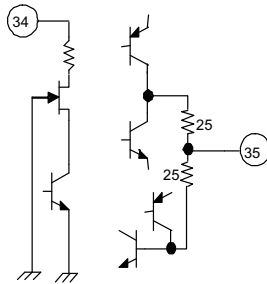


Figure 3. CP and VTU

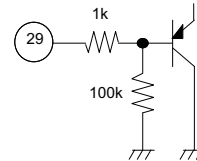


Figure 4. IF GCA CTRL

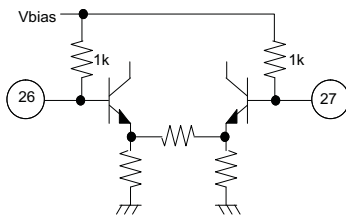


Figure 5. IF GCA IN1 and IF GCA IN2

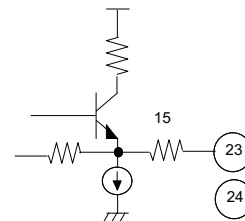


Figure 6. IF GCA OUT1 and IF GCA OUT2

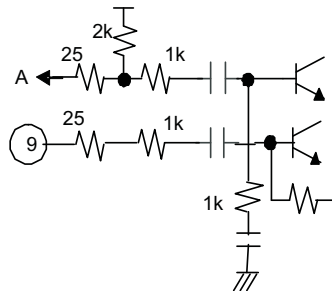


Figure 7. IF IN

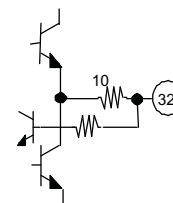


Figure 8. AIF OUT

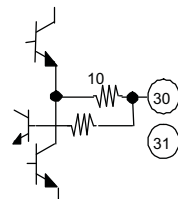


Figure 9. DIF OUT1 and DIF OUT2

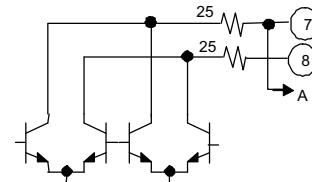


Figure 10. MIXOUT1 and MIXOUT2

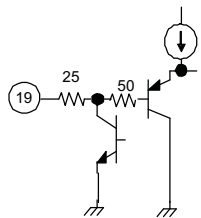


Figure 11. P5/ADC

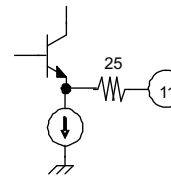


Figure 12. RF AGC BUF

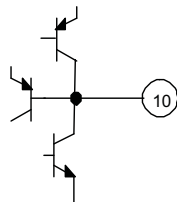


Figure 13. RF AGC OUT

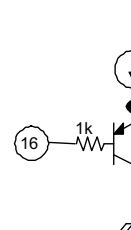


Figure 14. SCL

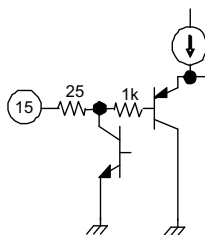


Figure 15. SDA

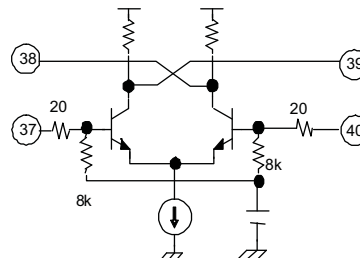


Figure 16. UHF OSC B1, UHF OSC B2, UHF OSC C1, and UHF OSC C2

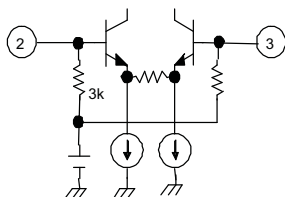


Figure 17. UHF RF IN1 and UHF RF IN2

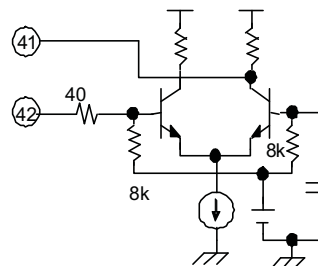


Figure 18. VHI OSC B and VHI OSC C

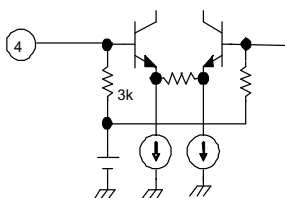


Figure 19. VHI RF IN

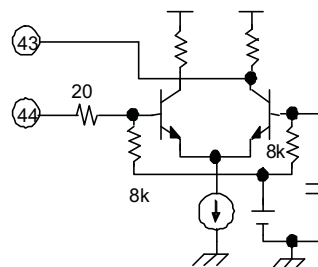


Figure 20. VLO OSC B and VLO OSC C

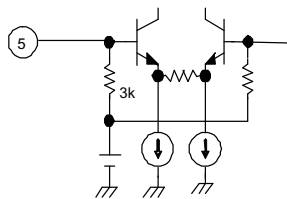


Figure 21. VLO RF IN

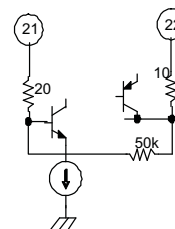


Figure 22. XTAL1 and XTAL2

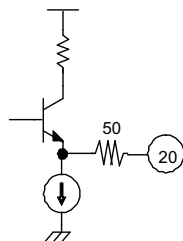


Figure 23. XTALOUT

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

over recommended operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage range <sup>(2)</sup>	V <sub>CC</sub>	-0.4	6.5	V
V <sub>GND</sub>	Input voltage range 1 <sup>(2)</sup>	RF GND, OSC GND	-0.4	0.4	V
V <sub>VTU</sub>	Input voltage range 2 <sup>(2)</sup>	VTU	-0.4	35	V
V <sub>IN</sub>	Input voltage range 3 <sup>(2)</sup>	Other pins	-0.4	6.5	V
P <sub>D</sub>	Continuous total dissipation <sup>(3)</sup>	T <sub>A</sub> ≤ 25°C		1438	mW
T <sub>A</sub>	Operating free-air temperature range		-20	85	°C
T <sub>stg</sub>	Storage temperature range		-65	150	°C
T <sub>J</sub>	Maximum junction temperature			150	°C
t <sub>SC(max)</sub>	Maximum short-circuit time	Each pin to V <sub>CC</sub> or to GND		10	s

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Voltage values are with respect to the IF GND of the circuit.
- (3) Derating factor is 11.5 mW/°C for T<sub>A</sub> ≥ 25°C.

## RECOMMENDED OPERATING CONDITIONS

			MIN	NOM	MAX	UNIT
V <sub>CC</sub>	Supply voltage	V <sub>CC</sub>	4.5	5	5.5	V
V <sub>VTU</sub>	Tuning supply voltage	VTU		30	33	V
I <sub>BS</sub>	Output current of band switch	BS1 – BS4, one band switch on			10	mA
I <sub>P5</sub>	Output current of port 5	P5/ADC			-5	mA
T <sub>A</sub>	Operating free-air temperature		-20		85	°C



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

IF IN1, MIXOUT1, and MIXOUT2 (pins 7–9) withstand 1.5 kV, and all other pins withstand 2 kV, according to the Human-Body Model (1.5 kΩ, 100 pF).

## ELECTRICAL CHARACTERISTICS

### Total Device and Serial Interface

$V_{CC} = 4.5\text{ V to }5.5\text{ V}$ ,  $T_A = -20^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{CC1}$	Supply current 1	BS[1:4] = 0100, IFGCA disabled		90	120	mA
$I_{CC2}$	Supply current 2	BS[1:4] = 0100, IFGCA enabled		115	145	mA
$I_{CC3}$	Supply current 3	BS[1:4] = 0100, IFGCA enabled, $I_{BS} = 10\text{ mA}$		125	155	mA
$I_{CC-STBY}$	Standby supply current	BS[1:4] = 1100		9		mA
$V_{IH}$	High-level input voltage (SCL, SDA)		2.3			V
$V_{IL}$	Low-level input voltage (SCL, SDA)				1.05	V
$I_{IH}$	High-level input current (SCL, SDA)				10	$\mu\text{A}$
$I_{IL}$	Low-level input current (SCL, SDA)		-10			$\mu\text{A}$
$V_{POR}$	Power-on-reset supply voltage (threshold of supply voltage between reset and operation mode)		2.1	2.8	3.5	V
<b>I<sup>2</sup>C Interface</b>						
$V_{ASH}$	Address-select high-input voltage (AS)	$V_{CC} = 5\text{ V}$	4.5		5	V
$V_{ASM1}$	Address-select mid-input 1 voltage (AS)	$V_{CC} = 5\text{ V}$	2		3	V
$V_{ASM2}$	Address-select mid-input 2 voltage (AS)	$V_{CC} = 5\text{ V}$	1		1.5	V
$V_{ASL}$	Address-select low-input voltage (AS)	$V_{CC} = 5\text{ V}$			0.5	V
$I_{ASH}$	Address-select high-input current (AS)				50	$\mu\text{A}$
$I_{ASL}$	Address-select low-input current (AS)		-10			$\mu\text{A}$
$V_{ADC}$	ADC input voltage	See <a href="#">Table 11</a>	0		$V_{CC}$	V
$I_{ADH}$	ADC high-level input current	$V_{ADC} = V_{CC}$			10	$\mu\text{A}$
$I_{ADL}$	ADC low-level input current	$V_{ADC} = 0\text{ V}$	-10			$\mu\text{A}$
$V_{OL}$	Low-level output voltage (SDA)	$V_{CC} = 5\text{ V}$ , $I_{OL} = 3\text{ mA}$			0.4	V
$I_{SDAH}$	High-level output leakage current (SDA)	$V_{SDA} = 5.5\text{ V}$			10	$\mu\text{A}$
$f_{SCL}$	Clock frequency (SCL)			100	400	kHz
$t_{HD-DAT}$	Data hold time	See <a href="#">Figure 24</a>	0		0.9	$\mu\text{s}$
$t_{BUF}$	Bus free time		1.3			$\mu\text{s}$
$t_{HD-STA}$	Start hold time		0.6			$\mu\text{s}$
$t_{LOW}$	SCL-low hold time		1.3			$\mu\text{s}$
$t_{HIGH}$	SCL-high hold time		0.6			$\mu\text{s}$
$t_{SU-STA}$	Start setup time		0.6			$\mu\text{s}$
$t_{SU-DAT}$	Data setup time		0.1			$\mu\text{s}$
$t_r$	Rise time (SCL, SDA)				0.3	$\mu\text{s}$
$t_f$	Fall time (SCL, SDA)				0.3	$\mu\text{s}$
$t_{SU-STO}$	Stop setup time		0.6			$\mu\text{s}$



## PLL and Band Switch

 $V_{CC} = 4.5\text{ V to }5.5\text{ V}$ ,  $T_A = -20^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
N	Divider ratio	15-bit frequency word	512		32767	
$f_{XTAL}$	Crystal oscillator frequency	$R_{XTAL} = 25\ \Omega$ to $300\ \Omega$		4		MHz
$Z_{XTAL}$	Crystal oscillator input impedance		1.6	2.4		k $\Omega$
$V_{XLO}$	XTALOUT output voltage	Load = $10\text{ pF}/5.1\text{ k}\Omega$ , $V_{CC} = 5\text{ V}$ , $T_A = 25^\circ\text{C}$		0.48		V <sub>p-p</sub>
$V_{VTUL}$	Tuning amplifier low-level output voltage	$R_L = 20\text{ k}\Omega$ , $VTU = 30\text{ V}$	0.2	0.3	0.46	V
$I_{VTUOFF}$	Tuning amplifier leakage current	Tuning amplifier = off, $VTU = 30\text{ V}$			10	$\mu\text{A}$
$I_{CP11}$	Charge-pump current	CP[2:0] = 011		600		$\mu\text{A}$
$I_{CP10}$		CP[2:0] = 010		350		
$I_{CP01}$		CP[2:0] = 001		140		
$I_{CP00}$		CP[2:0] = 000		70		
$I_{CP100}$		CP[2:0] = 100, Mode = 1		900		
$V_{CP}$	Charge-pump output voltage	PLL locked		1.95		V
$I_{CPOFF}$	Charge-pump leakage current	$V_{CP} = 2\text{ V}$ , $T_A = 25^\circ\text{C}$	-15		15	nA
$I_{BS}$	Band switch driver output current (BS1–BS4)				10	mA
$V_{BS1}$	Band switch driver output voltage (BS1–BS4)	$I_{BS} = 10\text{ mA}$		3		V
$V_{BS2}$		$I_{BS} = 10\text{ mA}$ , $V_{CC} = 5\text{ V}$ , $T_A = 25^\circ\text{C}$		3.5	3.7	
$I_{BSOFF}$	Band switch driver leakage current (BS1–BS4)	$V_{BS} = 0\text{ V}$			8	$\mu\text{A}$
$I_{P5}$	Band switch port sink current (P5/ADC)				-5	mA
$V_{P5ON}$	Band switch port output voltage (P5/ADC)	$I_{P5} = -2\text{ mA}$ , $V_{CC} = 5\text{ V}$ , $T_A = 25^\circ\text{C}$			0.6	V

## RF AGC<sup>(1)</sup>

 $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , measured in [Figure 25](#) reference measurement circuit at 50- $\Omega$  system, IF = 44 MHz, IF filter characteristics:  $f_{peak} = 44\text{ MHz}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{OAGC0}$	RF AGCOUT output source current	ATC = 0		300		nA
$I_{OAGC1}$		ATC = 1		9		$\mu\text{A}$
$I_{OAGCSINK}$	RF AGCOUT peak output sink current	ATC = 0		100		$\mu\text{A}$
$V_{OAGCH}$	RFAGCOUT output high voltage (max level)	ATC = 1	3.5	4	4.5	V
$V_{OAGCL}$	RFAGCOUT output low voltage (min level)	ATC = 1		0.3		V
$I_{AGCBUF}$	RFAGCBUF output current	ATC = 0		1.5		mA
$V_{OAGCBFH}$	RFAGCBUF output high voltage (max level)	ATC = 1	3.5	4	4.5	V
$V_{OAGCBFL}$	RFAGCBUF output low voltage (min level)	ATC = 1		0.3		V
$V_{AGCSP00}$	Start-point IF output level	ATP[2:0] = 000		114		dB $\mu\text{V}$
$V_{AGCSP01}$		ATP[2:0] = 001		112		
$V_{AGCSP02}$		ATP[2:0] = 010		110		
$V_{AGCSP03}$		ATP[2:0] = 011		108		
$V_{AGCSP04}$		ATP[2:0] = 100		106		
$V_{AGCSP05}$		ATP[2:0] = 101		104		
$V_{AGCSP06}$		ATP[2:0] = 110		102		

(1) When AISL=1, RF AGC function is not available at VHF-L band (output level is undefined).

## Mixer, Oscillator, IF Amplifier (DIF OUT)

$V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , measured in [Figure 25](#) reference measurement circuit at 50- $\Omega$  system, IF = 44 MHz, IF filter characteristics:  $f_{\text{peak}} = 44\text{ MHz}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TYP	UNIT
$G_{C1D}$	Conversion gain (mixer-IF amplifier), VHF-LOW	$f_{\text{in}} = 57\text{ MHz}^{(1)}$	35	dB
$G_{C3D}$		$f_{\text{in}} = 171\text{ MHz}^{(1)}$	35	
$G_{C4D}$	Conversion gain (mixer-IF amplifier), VHF-HIGH	$f_{\text{in}} = 177\text{ MHz}^{(1)}$	35	dB
$G_{C6D}$		$f_{\text{in}} = 467\text{ MHz}^{(1)}$	35	
$G_{C7D}$	Conversion gain (mixer-IF amplifier), UHF	$f_{\text{in}} = 473\text{ MHz}^{(1)}$	35	dB
$G_{C9D}$		$f_{\text{in}} = 864\text{ MHz}^{(1)}$	35	
$NF_{1D}$	Noise figure, VHF-LOW	$f_{\text{in}} = 57\text{ MHz}$	9	dB
$NF_{3D}$		$f_{\text{in}} = 171\text{ MHz}$	9	
$NF_{4D}$	Noise figure, VHF-HIGH	$f_{\text{in}} = 177\text{ MHz}$	9	dB
$NF_{6D}$		$f_{\text{in}} = 467\text{ MHz}$	10	
$NF_{7D}$	Noise figure, UHF	$f_{\text{in}} = 473\text{ MHz}$	10	dB
$NF_{9D}$		$f_{\text{in}} = 864\text{ MHz}$	12	
$CM_{1D}$	Input voltage causing 1% cross-modulation distortion, VHF-LOW	$f_{\text{in}} = 57\text{ MHz}^{(2)}$	79	dB $\mu$ V
$CM_{3D}$		$f_{\text{in}} = 171\text{ MHz}^{(2)}$	79	
$CM_{4D}$	Input voltage causing 1% cross-modulation distortion, VHF-HIGH	$f_{\text{in}} = 177\text{ MHz}^{(2)}$	79	dB $\mu$ V
$CM_{6D}$		$f_{\text{in}} = 467\text{ MHz}^{(2)}$	79	
$CM_{7D}$	Input voltage causing 1% cross-modulation distortion, UHF	$f_{\text{in}} = 473\text{ MHz}^{(2)}$	77	dB $\mu$ V
$CM_{9D}$		$f_{\text{in}} = 864\text{ MHz}^{(2)}$	77	
$V_{\text{IFO1D}}$	IF output voltage, VHF-LOW	$f_{\text{in}} = 57\text{ MHz}$	117	dB $\mu$ V
$V_{\text{IFO3D}}$		$f_{\text{in}} = 171\text{ MHz}$	117	
$V_{\text{IFO4D}}$	IF output voltage, VHF-HIGH	$f_{\text{in}} = 177\text{ MHz}$	117	dB $\mu$ V
$V_{\text{IFO6D}}$		$f_{\text{in}} = 467\text{ MHz}$	117	
$V_{\text{IFO7D}}$	IF output voltage, UHF	$f_{\text{in}} = 473\text{ MHz}$	117	dB $\mu$ V
$V_{\text{IFO9D}}$		$f_{\text{in}} = 864\text{ MHz}$	117	
$\Phi_{\text{PLVL1D}}$	Phase noise, VHF-LOW	$f_{\text{in}} = 57\text{ MHz}^{(3)}$	-90	dBc/Hz
$\Phi_{\text{PLVL3D}}$		$f_{\text{in}} = 171\text{ MHz}^{(4)}$	-85	
$\Phi_{\text{PLVL4D}}$	Phase noise, VHF-HIGH	$f_{\text{in}} = 177\text{ MHz}^{(3)}$	-85	dBc/Hz
$\Phi_{\text{PLVL6D}}$		$f_{\text{in}} = 467\text{ MHz}^{(4)}$	-77	
$\Phi_{\text{PLVL7D}}$	Phase noise, UHF	$f_{\text{in}} = 473\text{ MHz}^{(3)}$	-80	dBc/Hz
$\Phi_{\text{PLVL9D}}$		$f_{\text{in}} = 864\text{ MHz}^{(4)}$	-77	

- (1) IF = 44 MHz, RF input level = 70 dB $\mu$ V, differential output  
(2)  $f_{\text{undes}} = f_{\text{des}} \pm 6\text{ MHz}$ ,  $P_{\text{in}} = 70\text{ dB}\mu\text{V}$ , AM 1 kHz, 30%, DES/CM = S/I = 46 dB  
(3) Offset = 1 kHz, CP current = 350  $\mu$ A, reference divider = 64  
(4) Offset = 1 kHz, CP current = 900  $\mu$ A, reference divider = 64

## Mixer, Oscillator, IF Amplifier (AIF OUT)

$V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , measured in [Figure 25](#) reference measurement circuit at 50- $\Omega$  system, IF = 45.75 MHz,  
IF filter characteristics:  $f_{\text{peak}} = 44\text{ MHz}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TYP	UNIT
$G_{C1A}$	Conversion gain (mixer-IF amplifier), VHF-LOW	$f_{\text{in}} = 55.25\text{ MHz}^{(1)}$	29	dB
$G_{C3A}$		$f_{\text{in}} = 169.25\text{ MHz}^{(1)}$	29	
$G_{C4A}$	Conversion gain (mixer-IF amplifier), VHF-HIGH	$f_{\text{in}} = 175.25\text{ MHz}^{(1)}$	29	dB
$G_{C6A}$		$f_{\text{in}} = 465.25\text{ MHz}^{(1)}$	29	
$G_{C7A}$	Conversion gain (mixer-IF amplifier), UHF	$f_{\text{in}} = 471.25\text{ MHz}^{(1)}$	29	dB
$G_{C9A}$		$f_{\text{in}} = 862.25\text{ MHz}^{(1)}$	29	
$NF_{1A}$	Noise figure, VHF-LOW	$f_{\text{in}} = 55.25\text{ MHz}$	9	dB
$NF_{3A}$		$f_{\text{in}} = 169.25\text{ MHz}$	9	
$NF_{4A}$	Noise figure, VHF-HIGH	$f_{\text{in}} = 175.25\text{ MHz}$	9	dB
$NF_{6A}$		$f_{\text{in}} = 465.25\text{ MHz}$	10	
$NF_{7A}$	Noise figure, UHF	$f_{\text{in}} = 471.25\text{ MHz}$	10	dB
$NF_{9A}$		$f_{\text{in}} = 862.25\text{ MHz}$	12	
$CM_{1A}$	Input voltage causing 1% cross-modulation distortion, VHF-LOW	$f_{\text{in}} = 55.25\text{ MHz}^{(2)}$	79	dB $\mu$ V
$CM_{3A}$		$f_{\text{in}} = 169.25\text{ MHz}^{(2)}$	79	
$CM_{4A}$	Input voltage causing 1% cross-modulation distortion, VHF-HIGH	$f_{\text{in}} = 175.25\text{ MHz}^{(2)}$	79	dB $\mu$ V
$CM_{6A}$		$f_{\text{in}} = 465.25\text{ MHz}^{(2)}$	79	
$CM_{7A}$	Input voltage causing 1% cross-modulation distortion, UHF	$f_{\text{in}} = 471.25\text{ MHz}^{(2)}$	79	dB $\mu$ V
$CM_{9A}$		$f_{\text{in}} = 862.25\text{ MHz}^{(2)}$	77	
$V_{\text{IFO1A}}$	IF output voltage, VHF-LOW	$f_{\text{in}} = 55.25\text{ MHz}$	117	dB $\mu$ V
$V_{\text{IFO3A}}$		$f_{\text{in}} = 169.25\text{ MHz}$	117	
$V_{\text{IFO4A}}$	IF output voltage, VHF-HIGH	$f_{\text{in}} = 175.25\text{ MHz}$	117	dB $\mu$ V
$V_{\text{IFO6A}}$		$f_{\text{in}} = 465.25\text{ MHz}$	117	
$V_{\text{IFO7A}}$	IF output voltage, UHF	$f_{\text{in}} = 471.25\text{ MHz}$	117	dB $\mu$ V
$V_{\text{IFO9A}}$		$f_{\text{in}} = 862.25\text{ MHz}$	117	
$\Phi_{\text{PLVL1A}}$	Phase noise, VHF-LOW	$f_{\text{in}} = 55.25\text{ MHz}^{(3)}$	-95	dBc/Hz
$\Phi_{\text{PLVL3A}}$		$f_{\text{in}} = 169.25\text{ MHz}^{(3)}$	-95	
$\Phi_{\text{PLVL4A}}$	Phase noise, VHF-HIGH	$f_{\text{in}} = 175.25\text{ MHz}^{(3)}$	-90	dBc/Hz
$\Phi_{\text{PLVL6A}}$		$f_{\text{in}} = 465.25\text{ MHz}^{(3)}$	-90	
$\Phi_{\text{PLVL7A}}$	Phase noise, UHF	$f_{\text{in}} = 471.25\text{ MHz}^{(3)}$	-85	dBc/Hz
$\Phi_{\text{PLVL9A}}$		$f_{\text{in}} = 862.25\text{ MHz}^{(3)}$	-90	

(1) IF = 44 MHz, RF input level = 70 dB $\mu$ V

(2)  $f_{\text{undes}} = f_{\text{des}} \pm 6\text{ MHz}$ ,  $P_{\text{in}} = 70\text{ dB}\mu\text{V}$ , AM 1 kHz, 30%, DES/CM = S/I = 46 dB

(3) Offset = 10 kHz, CP current = 70  $\mu$ A, reference divider = 128

## IF Gain Controlled Amplifier

$V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , measured in [Figure 25](#) reference measurement circuit at 50- $\Omega$  system,  $f_{IF} = 44\text{ MHz}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{IFGCA}$	Input current (IF GCA CTRL)	$V_{IFGCA} = 3\text{ V}$		30	60	$\mu\text{A}$
$V_{IFGCAMAX}$	Maximum gain control voltage	Gain maximum	3		$V_{CC}$	V
$V_{IFGCAMIN}$	Minimum gain control voltage	Gain minimum	0		0.2	V
$G_{IFGCAMAX}$	Maximum gain	$V_{IFGCA} = 3\text{ V}$		65		dB
$G_{IFGCAMIN}$	Minimum gain	$V_{IFGCA} = 0\text{ V}$		-1		dB
$GCR_{IFGCA}$	Gain control range	$V_{IFGCA} = 0\text{ V to }3\text{ V}$		66		dB
$V_{IFGCAOUT}$	Output voltage	Single-ended output, $V_{IFGCA} = 3\text{ V}$		2.1		Vp-p
$NF_{IFGCA}$	Noise figure	$V_{IFGCA} = 3\text{ V}$		11		dB
$IM3_{IFGCA}$	Third order intermodulation distortion	$f_{IFGCAIN1} = 43\text{ MHz}$ , $f_{IFGCAIN2} = 44\text{ MHz}$ , $V_{IFGCAOUT} = -2\text{ dBm}$ , $V_{IFGCA} = 3\text{ V}$		-50		dBc
$IIP3_{IFGCA}$	Input intercept point	$V_{IFGCA} = 0\text{ V}$		11		dBm
$R_{IFGCAIN}$	Input resistance (IF GCA IN1, IF GCA IN2)			1		k $\Omega$
$R_{IFGCAOUT}$	Output resistance (IF GCA OUT1, IF GCA OUT2)			25		$\Omega$

## FUNCTIONAL DESCRIPTION

### I<sup>2</sup>C Bus Mode

#### I<sup>2</sup>C Write Mode (R/W = 0)

**Table 2. Write Data Format**

	MSB						LSB			
Address byte (ADB)	1	1	0	0	0	MA1	MA0	R/W = 0	A <sup>(1)</sup>	
Divider byte 1 (DB1)	0	N14	N13	N12	N11	N10	N9	N8	A <sup>(1)</sup>	
Divider byte 2 (DB2)	N7	N6	N5	N4	N3	N2	N1	N0	A <sup>(1)</sup>	
Control byte 1 (CB1)	1	0	ATP2	ATP1	ATP0	RS2	RS1	RS0	A <sup>(1)</sup>	
Band switch byte (BB)	CP1	CP0	AISL	P5	BS4	BS3	BS2	BS1	A <sup>(1)</sup>	
Control byte 2 (CB2)	1	1	ATC	MODE	T3/DISGCA	T2/IFDA	T1/CP2	T0/XLO	A <sup>(1)</sup>	

(1) A : acknowledge

**Table 3. Write Data Symbol Description**

SYMBOL	DESCRIPTION	DEFAULT													
MA[1:0]	Address-set bits (see <a href="#">Table 4</a> )														
N[14:0]	Programmable counter set bits $N = N14 \times 2^{14} + N13 \times 2^{13} + \dots + N1 \times 2 + N0$	N14 = N13 = N12 = ... = N0 = 0													
ATP[2:0]	RF AGC start-point control bits (see <a href="#">Table 5</a> )	ATP[2:0] = 000													
RS[2:0]	Reference divider ratio-selection bits (see <a href="#">Table 6</a> )	RS[2:0] = 000													
CP[1:0]	Charge-pump current-set bit (see <a href="#">Table 7</a> )	CP[1:0] = 00													
AISL <sup>(1)</sup>	RF AGC detector input selection bit AISL = 0: IF amplifier AISL = 1: Mixer output	AISL = 0													
P5	Port output/ADC input control bit P5 = 0: ADC INPUT P5 = 1: Tr = ON	P5 = 0													
BS[4:1]	Band switch control bits BSn = 0: Tr = OFF BSn = 1: Tr = ON	BSn = 0													
	Band selection by BS[1:2] <table style="margin-left: 20px;"> <thead> <tr> <th>BS1</th> <th>BS2</th> <th></th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>VHF-LO</td> </tr> <tr> <td>0</td> <td>1</td> <td>VHF-HI</td> </tr> <tr> <td>0</td> <td>0</td> <td>UHF</td> </tr> <tr> <td>1</td> <td>1</td> <td>Standby mode/stop MOP function (XTALOUT is available in standby mode)</td> </tr> </tbody> </table>		BS1	BS2		1	0	VHF-LO	0	1	VHF-HI	0	0	UHF	1
BS1	BS2														
1	0	VHF-LO													
0	1	VHF-HI													
0	0	UHF													
1	1	Standby mode/stop MOP function (XTALOUT is available in standby mode)													
ATC	RF AGC current-set bit ATC = 0: Current = 300 nA ATC = 1: Current = 9 μA	ATC = 0													
Mode T3/DISGCA T2/IFDA T1/CP2 T0/XLO	Mode = 0 : IFGCA enabled, DIFOUT1, 2 selected T3/DISGCA, T2/IFDA, T1/CP2, T0/XLO are Test bits and XTALOUT control bit (see <a href="#">Table 8</a> )	MODE = 0 T[3:0] = 0000													
	Mode = 1 : T3/DISGCA = 0 : IF GCA enabled T3/DISGCA = 1 : IF GCA disabled T2/IFDA = 0 : DIFOUT1, 2 selected T2/IFDA = 1 : AIFOUT selected T1/CP2 : lcp control bit, See <a href="#">Table 7</a> T0/XLO = 0 : XTALOUT enabled T0/XLO = 1 : XTALOUT disabled														

(1) When AISL = 1, RF AGC function is not available at VHF-L band (Output level is undefined.)

**Table 4. Address Selection**

MA1	MA0	VOLTAGE APPLIED ON AS INPUT
0	0	0 V to 0.1 V <sub>CC</sub> (Low)
0	1	OPEN, or 0.2 V <sub>CC</sub> to 0.3 V <sub>CC</sub> (Mid2)
1	0	0.4 V <sub>CC</sub> to 0.6 V <sub>CC</sub> (Mid1)
1	1	0.9 V <sub>CC</sub> to V <sub>CC</sub> (High)

**Table 5. RF AGC Start Point<sup>(1)</sup>**

ATP2	ATP1	ATP0	IFOUT LEVEL (dBμV)
0	0	0	114
0	0	1	112
0	1	0	110
0	1	1	108
1	0	0	106
1	0	1	104
1	1	0	102
1	1	1	Disabled

(1) When AISL=1, RF AGC function is not available at VHF-L band (output level is undefined).

**Table 6. Reference Divider Ratio**

RS2	RS1	RS0	REFERENCE DIVIDER RATIO
0	0	0	24
0	0	1	28
0	1	0	32
0	1	1	64
1	0	0	128
1	X	1	80

**Table 7. Charge-Pump Current**

MODE	CP2	CP1	CP0	CHARGE PUMP CURRENT (μA)
X	0	0	0	70
X	0	0	1	140
X	0	1	0	350
X	0	1	1	600
1	1	0	0	900

**Table 8. Test Bits/XTALOUT Control <sup>(1)</sup>**

MODE	T3/DISGCA	T2/IFDA	T1/CP2	T0/XLO	DEVICE OPERATION	XTALOUT 4-MHz OUTPUT
0	0	0	0	0	Normal operation	Enabled
0	0	0	0	1	Normal operation	Disabled
1	X	X	X	0	Normal operation	Enabled
1	X	X	X	1	Normal operation	Disabled
0	X	1	X	X	Test mode	Not available
0	1	X	X	X	Test mode	Not available

(1) RFAGC and XTALOUT are not available in test mode.

**I<sup>2</sup>C Read Mode (R $\bar{W}$  = 1)**
**Table 9. Read Data Format**

	MSB							LSB	
Address byte (ADB)	1	1	0	0	0	MA1	MA0	R $\bar{W}$ = 1	A <sup>(1)</sup>
Status byte (SB)	POR	FL	1	1	X	A2	A1	A0	–

(1) A : acknowledge

**Table 10. Read Data Symbol Description**

SYMBOL	DESCRIPTION	DEFAULT
MA[1:0]	Address-set bits (see <a href="#">Table 4</a> )	
POR	Power-on reset flag POR set: power on POR reset: end-of-data transmission procedure	POR = 1
FL <sup>(1)</sup>	In-lock flag PLL locked (FL=1), Unlocked (FL=0)	
A[2:0]	Digital data of ADC (see <a href="#">Table 11</a> ) Bit P5 must be set to 0.	

(1) Lock detector works by using phase error pulse at the phase detector. Lock flag (FL) is set or reset according to this pulse width discriminator. Hence unstableness of PLL may cause the lock detect circuit to malfunction. In order to stable PLL, it is required to evaluate application circuit in various condition of loop-gain (loop filter, CP current), and to verify with whole conditions of actual application.

**Table 11. Address Selection<sup>(1)</sup>**

A2	A1	A0	VOLTAGE APPLIED ON ADC INPUT
1	0	0	0.6 V <sub>CC</sub> to V <sub>CC</sub>
0	1	1	0.45 V <sub>CC</sub> to 0.6 V <sub>CC</sub>
0	1	0	0.3 V <sub>CC</sub> to 0.45 V <sub>CC</sub>
0	0	1	0.15 V <sub>CC</sub> to 0.3 V <sub>CC</sub>
0	0	0	0 to 0.15 V <sub>CC</sub>

(1) Accuracy is 0.03 x V<sub>CC</sub>.

## Example I<sup>2</sup>C Data Write Sequences

Telegram examples:

Start-ADB-DB1-DB2-CB1-BB-CB2-Stop

Start-ADB-DB1-DB2-Stop

Start-ADB-CB1-BB-CB2-Stop

Start-ADB-CB1-BB-Stop

Start-ADB-CB2-Stop

Abbreviations:

ADB: Address byte

BB: Band switch byte

CB1: Control byte 1

CB2: Control byte 2

DB1: Divider byte 1

DB2: Divider byte 2

Start: Start condition

Stop: Stop condition

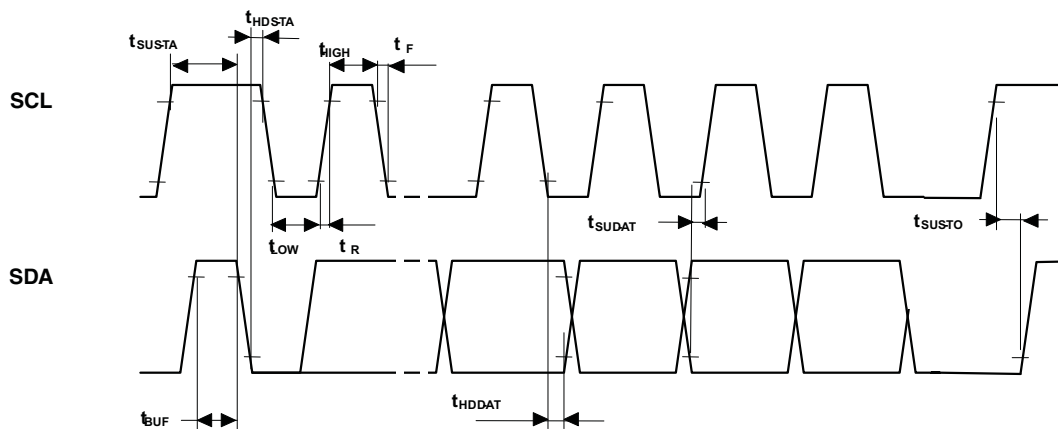
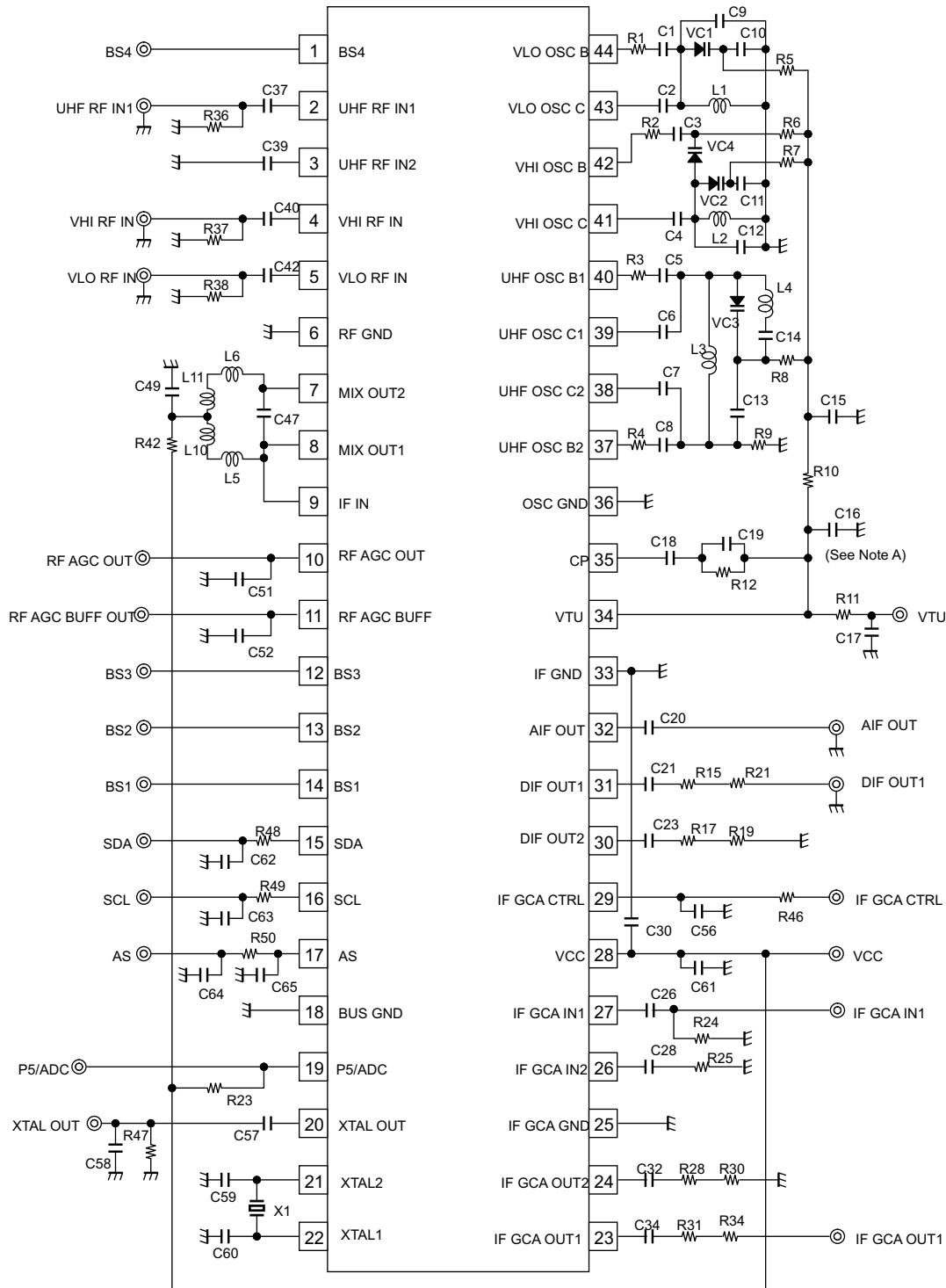


Figure 24. I<sup>2</sup>C Timing Chart



APPLICATION INFORMATION



- A. To prevent abnormal oscillation, connect C16, which does not affect a PLL.
- B. This application information is advisory and performance-check is required at actual application circuits. TI assumes no responsibility for the consequences of use of this circuit, such as an infringement of intellectual property rights or other rights, including patents, of third parties.

Figure 25. Reference Measurement Circuit

**Table 12. Component Values for Measurement Circuit<sup>(1)</sup>**

PARTS NAME	VALUE	PARTS NAME	VALUE
C1 (VLO OSC B)	1 pF	L1 (VLO OSC)	3.0 mm, 7T, wire 0.32 mm
C2 (VLO OSC C)	2 pF	L2 (VHI OSC)	2.0 mm, 3T, wire 0.4 mm
C3 (VHI OSC B)	7 pF	L3 (UHF OSC)	1.8 mm, 3T, wire 0.4 mm
C4 (VHI OSC C)	5 pF	L4 (UHF OSC)	1.8 mm, 3T, wire 0.4 mm
C5 (UHF OSCB1)	1.5 pF	L5 (MIX OUT)	680 nH (LK1608R68K-T)
C6 (UHF OSC1)	1 pF	L6 (MIX OUT)	680 nH (LK1608R68K-T)
C7 (UHF OSC2)	1 pF	L10 (MIX OUT)	Short
C8 (UHF OSCB2)	1.5 pF	L11 (MIX OUT)	Short
C9 (VLO OSC)	OPEN	R1(VLO OSC B)	0
C10(VLO OSC)	43 pF	R2 (VHI OSC B)	4.7 Ω
C11 (VHI OSC)	51 pF	R3 (UHF OSC B1)	4.7 Ω
C12 (VHI OSC)	0.5 pF	R4 (UHF OSC B2)	0
C13 (UHF OSC)	10 pF	R5 (VLO OSC)	3.3 kΩ
C14 (UHF OSC)	100 pF	R6 (VHI OSC)	3.3 kΩ
C15 (VTU)	2.2 nF/50 V	R7 (VHI OSC)	3.3 kΩ
C16 (CP)	150 pF/50 V	R8 (UHF OSC)	1 kΩ
C17 (VTU)	2.2 nF/50 V	R9 (UHF OSC)	2.2 k
C18(CP)	0.01 u/50 V	R10 (VTU)	3 kΩ
C19(CP)	22 pF/50 V	R11 (VTU)	20 kΩ
C20 (AIF OUT)	2.2 nF	R12 (CP)	47 kΩ
C21 (DIF OUT1)	2.2 nF	R15 (DIF OUT1)	200 Ω
C23 (DIF OUT2)	2.2 nF	R17 (DIF OUT2)	200 Ω
C26 (IF GCA IN1)	2.2 nF	R19 (DIF OUT2)	50 Ω
C28 (IF GCA IN2)	2.2 nF	R21 (DIF OUT1)	0
C30 (VCC)	0.1 uF	R23 (P5/ADC)	Open
C32 (IF GCA OUT1)	2.2 nF	R24 (IF GCA IN1)	(50 Ω)
C34 (IF GCA OUT2)	2.2 nF	R25 (IF GCA IN2)	0
C37 (UHF RF IN1)	2.2 nF	R28 (IF GCA OUT1)	200 Ω
C39 (UHF RFIN2)	2.2 nF	R30 (IF GCA OUT1)	50 Ω
C40 (VHI RF IN)	2.2 nF	R31 (IF GCA OUT2)	200 Ω
C42 (VLO RF IN)	2.2 nF	R34 (IF GCA OUT2)	0
C47 (MIX OUT)	6 pF	R36 (UHF RF IN1)	(50 Ω)
C49 (MIX OUT)	2.2 nF	R37 (VHI RF IN)	(50 Ω)
C51 (RF AGC OUT)	0.15 uF	R38 (VLO RF IN)	(50 Ω)
C52 (RF AGC BUF)	Open	R42 (MIX OUT)	0
C56 (IFGCA CTRL)	0.1 μF	R46 (IFGCA CTRL)	0
C57 (XTAL OUT)	0.01 uF	R47 (XTAL OUT)	5.1 kΩ
C58 (XTAL OUT)	10 pF	R48 (SDA)	330 Ω
C59(XTAL)	27 pF	R49 (SCL)	330 Ω
C60 (XTAL)	27 pF	R50 (AS)	Open
C61 (VCC)	2.2 nF	VC1 (VLO OSC)	MA2S374
C62 (SDA)	Open	VC2 (VHI OSC)	MA2S374
C63 (SCL)	Open	VC3 (UHF OSC)	MA2S372
C64 (AS)	Open	VC4 (VHI OSC)	MA2S372
C65 (AS)	22 pF	X1	4-MHz crystal

(1) IF frequency = 44 MHz Local frequency range : VHF-LOW=101~215 MHz, VHF-HIGH: 221~511 MHz, UHF: 517~908 MHz

APPLICATION INFORMATION (CONTINUED)

Test Circuits

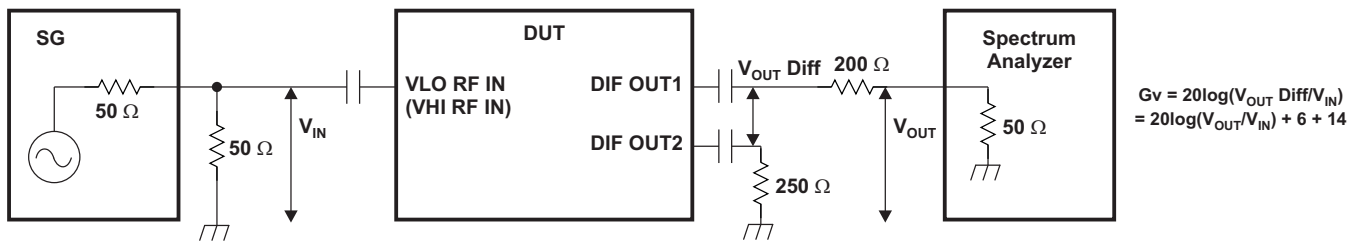


Figure 26. VHF-Conversion Gain-Measurement Circuit (at DIFOUT)

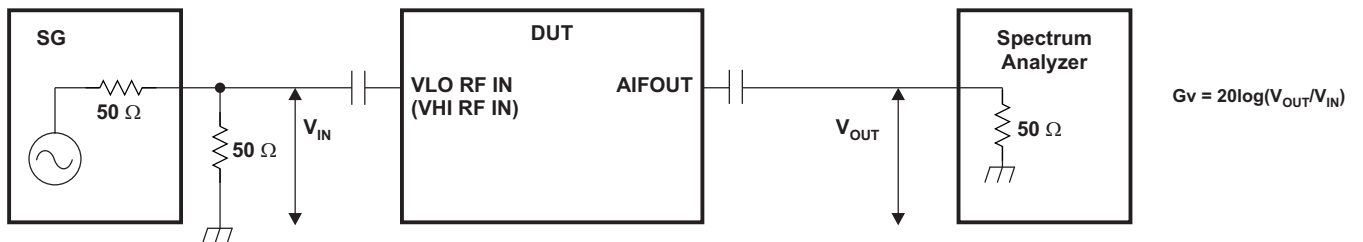


Figure 27. VHF-Conversion Gain Measurement Circuit (at AIFOUT)

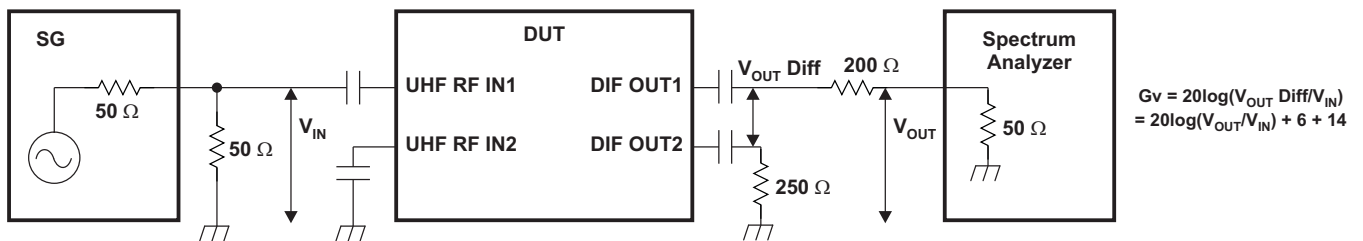


Figure 28. UHF-Conversion Gain-Measurement Circuit (at DIFOUT)

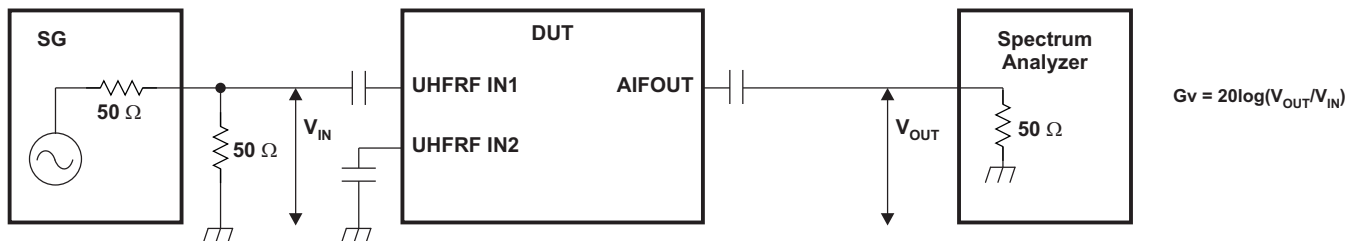


Figure 29. UHF-Conversion Gain Measurement Circuit (at AIFOUT)

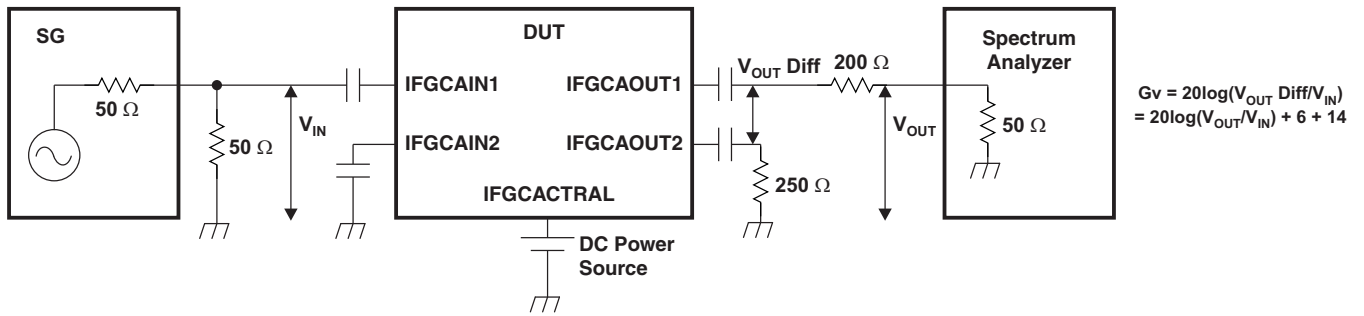


Figure 30. IF GCA Gain Measurement Circuit

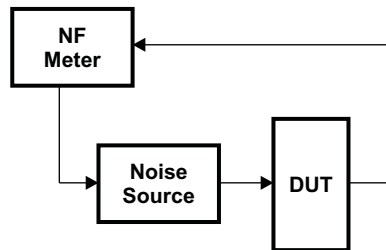


Figure 31. Noise-Figure Measurement Circuit

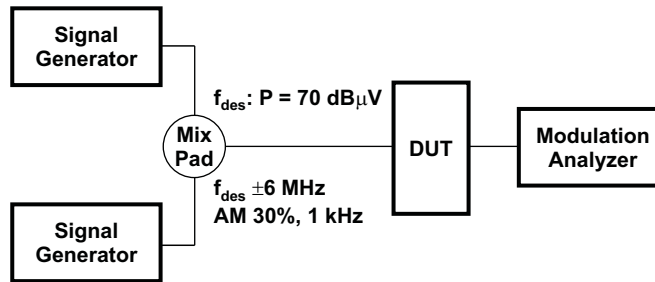


Figure 32. 1% Cross-Modulation Distortion Measurement Circuit

### TYPICAL CHARACTERISTICS

#### Band Switch Driver Output Voltage (BS1–BS4)

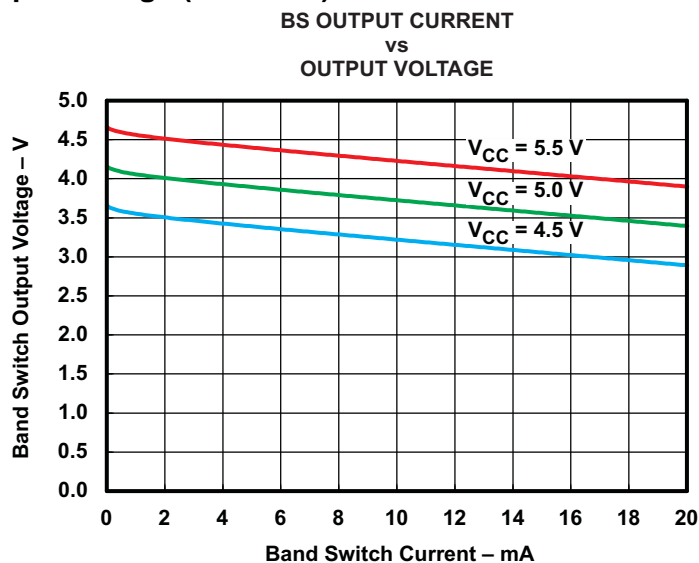


Figure 33. Band Switch Driver Output Voltage

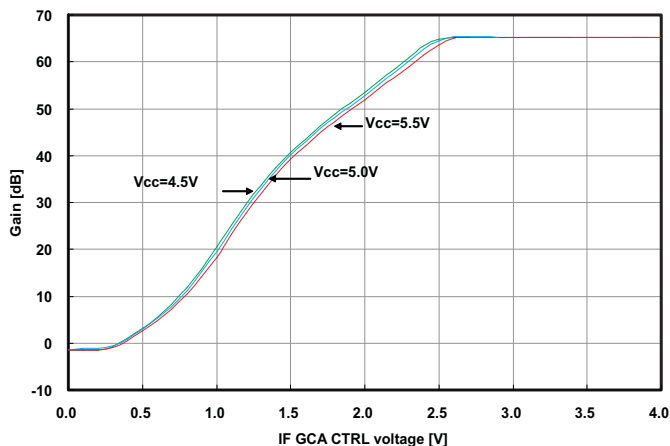


Figure 34. IF GCA Gain vs Control Voltage-1

TYPICAL CHARACTERISTICS (continued)

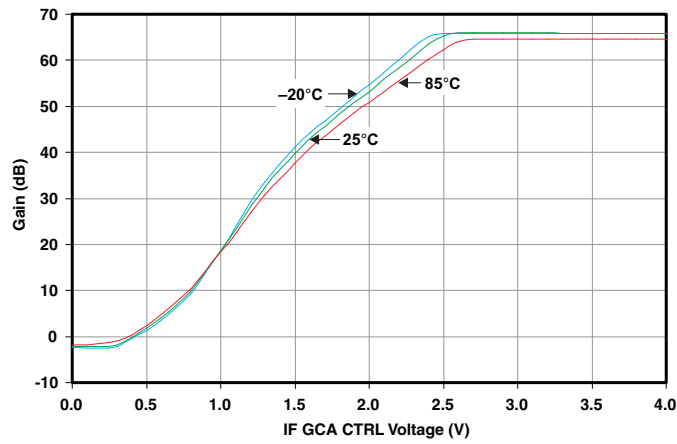


Figure 35. IF GCA Gain vs Control Voltage-2

S-Parameter

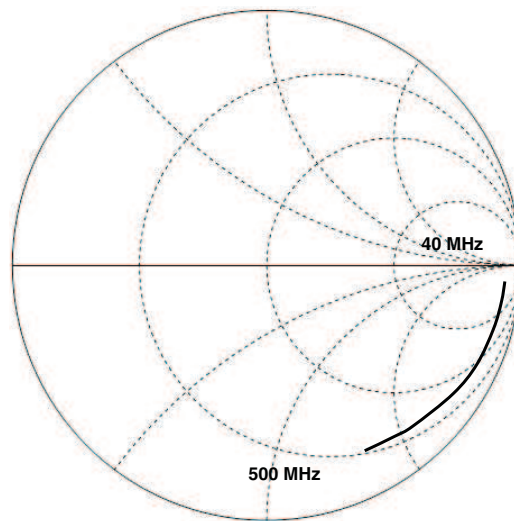
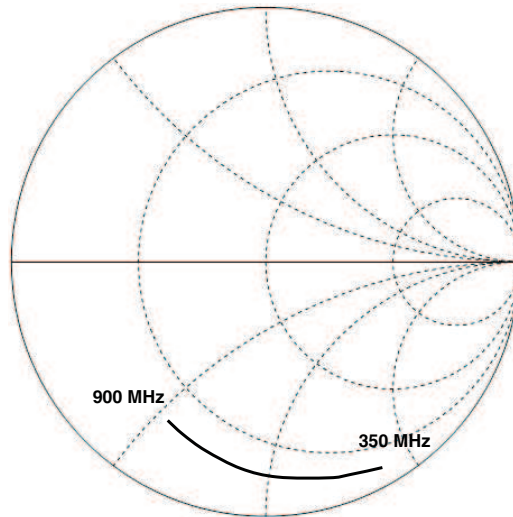
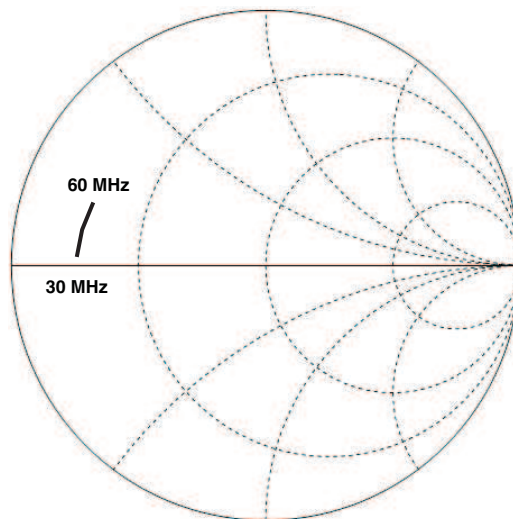


Figure 36. VLO RFIN, VHI RFIN

**TYPICAL CHARACTERISTICS (continued)**



**Figure 37. UHF RFIN**



**Figure 38. DIFOUT**

TYPICAL CHARACTERISTICS (continued)

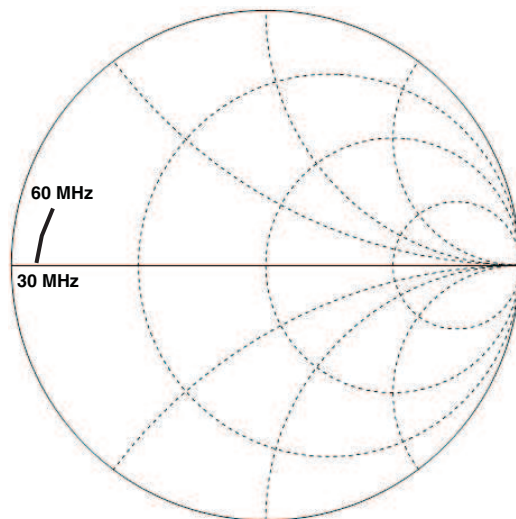


Figure 39. AIFOUT

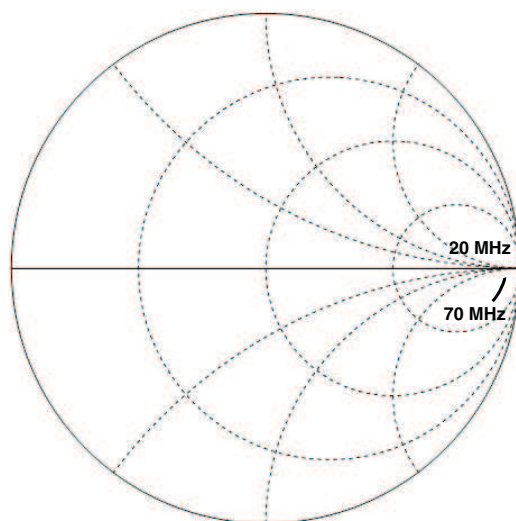


Figure 40. IF GCA IN



TYPICAL CHARACTERISTICS (continued)

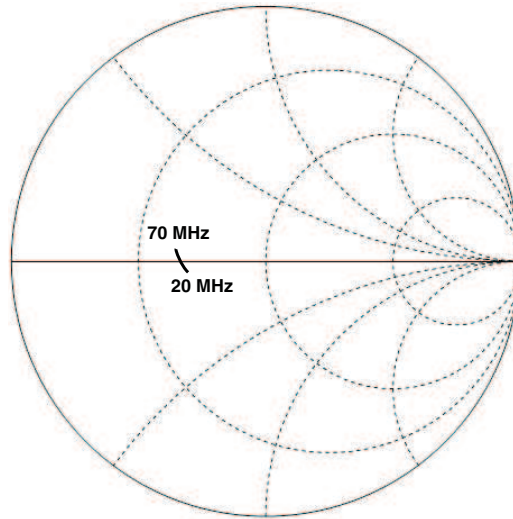


Figure 41. IF GCAOUT

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN761644DBTR	OBSOLETE	TSSOP	DBT	44		TBD	Call TI	Call TI	-20 to 85	SN761644	

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

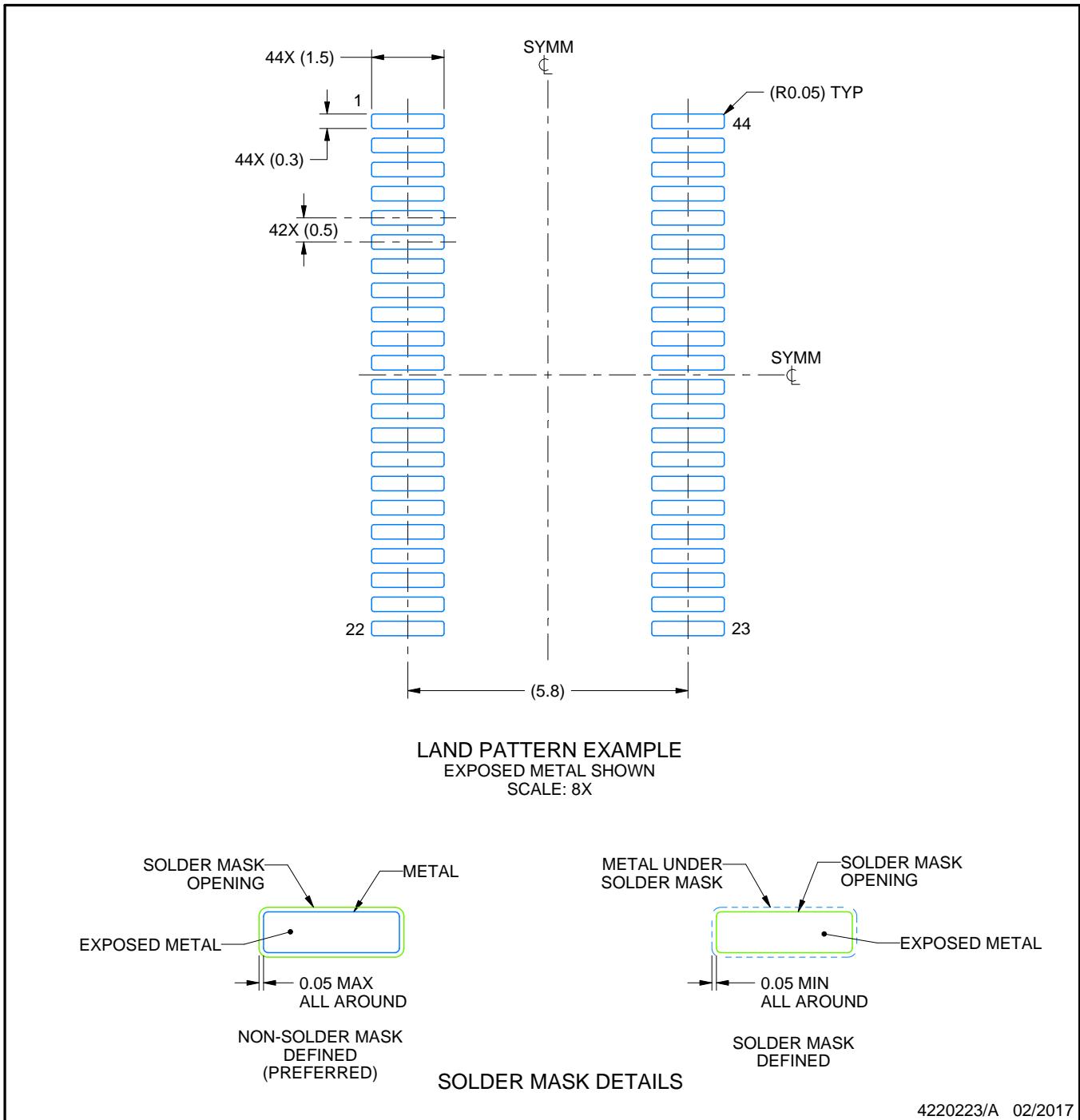


# EXAMPLE BOARD LAYOUT

DBT0044A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES: (continued)

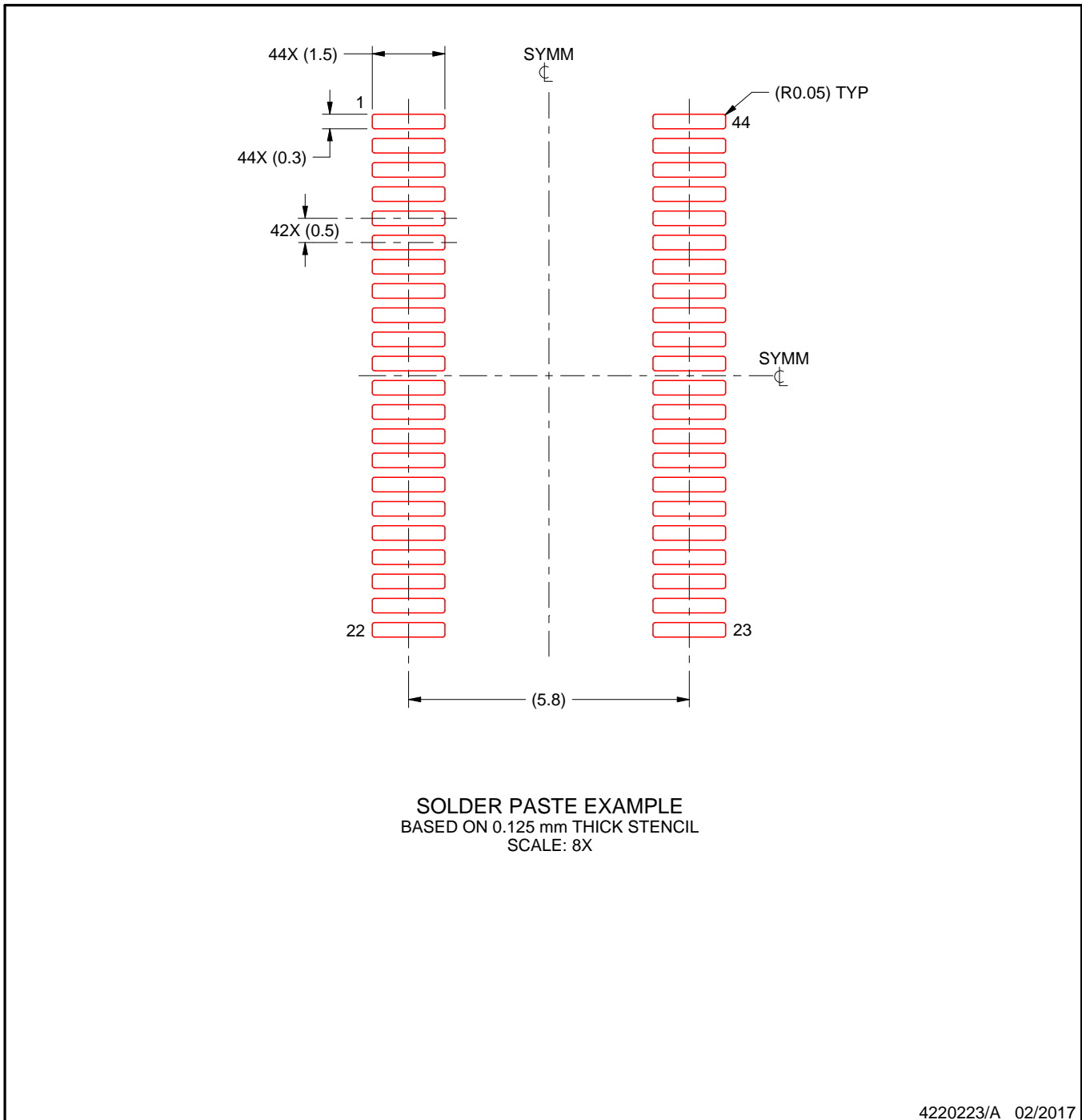
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DBT0044A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

## IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2017, Texas Instruments Incorporated