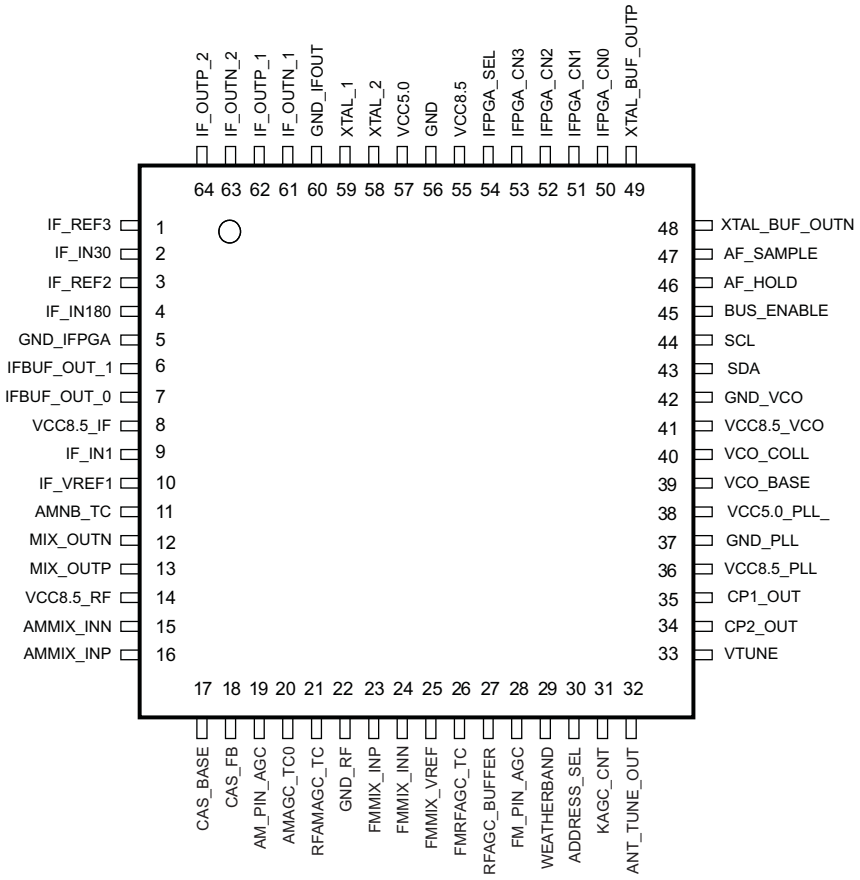
FEATURES

- Radio Frequency (RF) Automatic Gain Control (AGC) With Detection of RF and Intermediate Frequency (IF) Signal
- Image Rejection Mixer
- IF-Programmable Gain Control
- Two IF Programmable Gain Amplifiers (PGA) With Separate Gain Control for Analog/ In Band On Channel (IBOC) Signal Reception
- Programmable IF Tank Center-Frequency Adjustment
- FM Electrical Alignments for RF Preselection Stage
- Fast PLL for RDS System
- Electrical Frequency Adjustments for Crystal (Xtal) Oscillator
- Crystal Oscillator Buffered Output for Diversity Operation

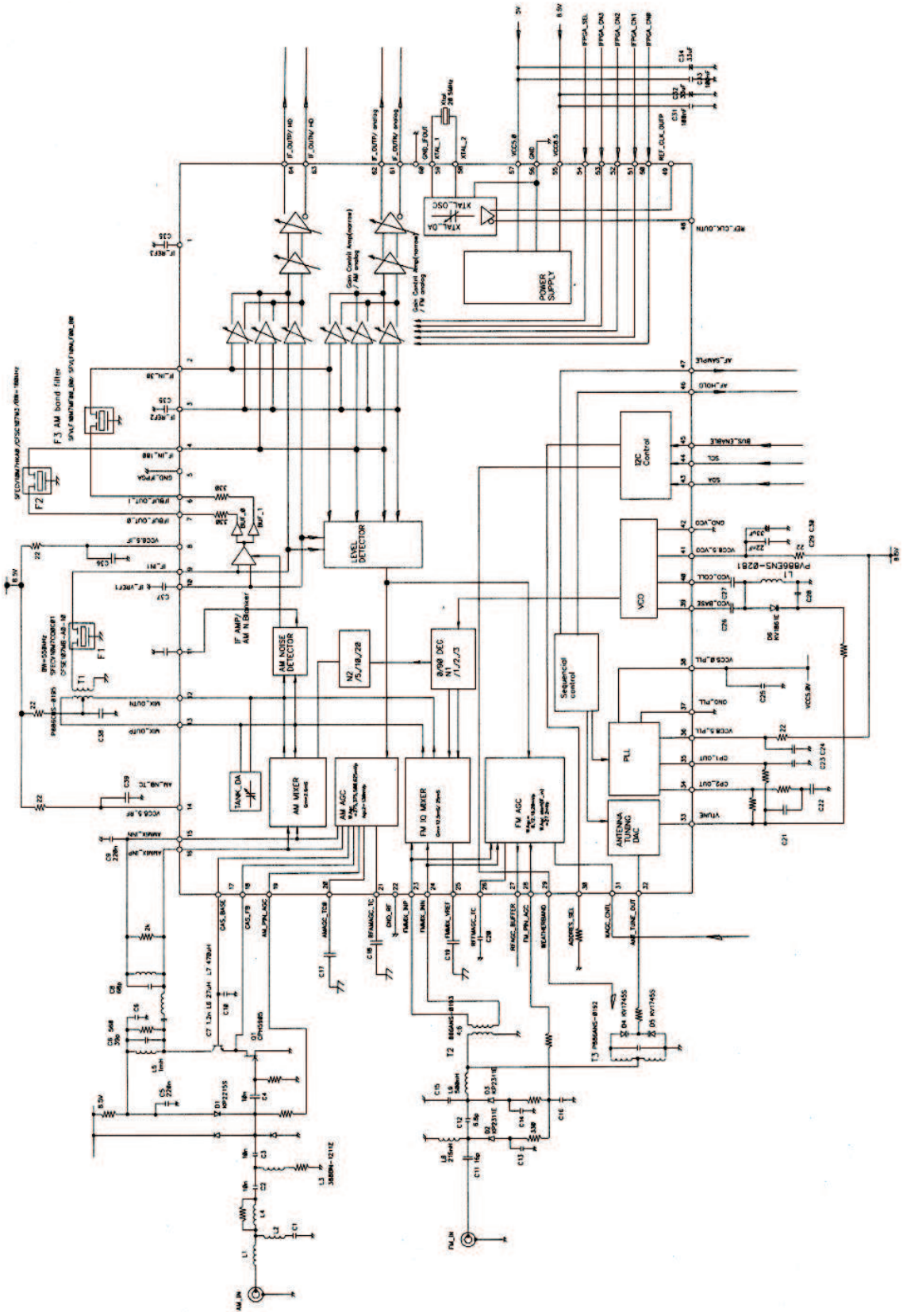
64-PIN HTQFP (PAP)
(TOP VIEW)



PRODUCT PREVIEW

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.

BLOCK DIAGRAM



TERMINAL FUNCTIONS

TERMINAL		DESCRIPTION
NAME	NO.	
IF_REF3	1	30-KHz filter reference input
IF_IN_30	2	30-kHz filter input
IF_REF2	3	180-kHz filter reference input
IF_IN_180	4	180-kHz filter input
GND_IFPGA	5	IF PGA ground
IFBUF_OUT_1	6	IF buffer amplifier output for 30-kHz filter
IFBUF_OUT_0	7	IF buffer amplifier output for 180-kHz filter
VCC8.5_IF	8	IF block 8.5-V power supply
IF_IN1	9	IF wide PGA/buffer amplifier input
IF_VREF1	10	IF wide PGA/buffer amplifier reference input
AMNB_TC	11	AM noise-blanker time constant
MIX_OUTN	12	Mixer output 1
MIX_OUTP	13	Mixer output 2
VCC8.5_RF	14	RF block 8.5-V power supply
AMMIX_INN	15	AM mixer reference input
AMMIX_INP	16	AM mixer input
CAS_BASE	17	Base drive for AM cascade block
CAS_FB	18	VDS sensing for AM cascade block
AM_PIN_AGC	19	Pin diode drive output for AM RF AGC
AMAGC_TC0	20	AM RF AGC time constant 0
RFAMAGC_TC	21	AM RF AGC time constant
GND_RF	22	RF block ground
FMMIX_INP	23	FM mixer input 1
FMMIX_INN	24	FM mixer input 2
FMMIX_VREF	25	FM mixer input bias voltage
FMRFAGC_TC	26	FM RF AGC time constant
RFAGC_BUFFER	27	RF AGC buffer output
FM_PIN_AGC	28	Pin-diode drive output for FM RF AGC
WEATHERBAND	29	Pin-diode drive for weather band
ADDRESS_SEL	30	Address select for I^2C bus
KAGC_CNT	31	FM-keyed AGC input
ANT_TUNE_OUT	32	Output for antenna tank tuning
VTUNE	33	Tuning voltage
CP2_OUT	34	Charge-pump 2 output
CP1_OUT	35	Charge-pump 1 output
VCC8.5_PLL	36	8.5-V power supply for PLL
GND_PLL	37	PLL ground
VCC5.0_PLL	38	Digital 5-V power supply for PLL
VCO_BASE	39	VCO base pin
VCO_COLL	40	VCO collector pin
VCC8.5_VCO	41	8.5-V power supply for crystal (Xtal) oscillator
GND_VCO	42	VCO ground
SDA	43	I^2C bus data line
SCL	44	I^2C bus clock line input
BUS_ENABLE	45	Enable input for I^2C bus

TERMINAL FUNCTIONS (continued)

TERMINAL		DESCRIPTION
NAME	NO.	
AF_HOLD	46	AF-hold flag
AF_SAMPLE	47	Timing out for AF quality test
XTAL_BUF_OUTN	48	20.5-MHz crystal oscillator buffered out negative
XTAL_BUF_OUTP	49	20.5-MHz crystal oscillator buffered out positive
IFPGA_CN0	50	IF PGA gain control 0
IFPGA_CN1	51	IF PGA gain control 1
IFPGA_CN2	52	IF PGA gain control 2
IFPGA_CN3	53	IF PGA gain control 3
IFPGA_SEL	54	IF PGA gain select
VCC8.5	55	8.5-V power supply
GND	56	Regulator block ground
VCC5.0	57	5-V power supply
Xtal_2	58	Crystal oscillator input 2
Xtal_1	59	Crystal oscillator input 1
GND_IFOUT	60	Ground for IF PGA amplifier
IFOUTN_1	61	IF negative output for analog
IFOUTP_1	62	IF positive output for analog
IFOUTN_2	63	IF negative output for HD
IFOUTP_2	64	IF positive output for HD

LIST OF COMPONENTS

SYMBOL	PARAMETER	PART NO./OTHERS	MANUFACTURER
T1	10.7-MHz IF transformer	P886CNS-0559	TOKO
T2	FM input transformer	P886ANS-0558	TOKO
T3	FM image rejection	P886ANS-0557	TOKO
L1	Oscillator coil	PV886ENS-0560	TOKO
L3	AM low-frequency trap	Z388BN-1502	TOKO
D1	AM PIN diode	KP2215S	TOKO
D2	FM PIN diode	KP2311E	TOKO
D3	FM PIN diode	KP2311E	TOKO
D4, D5	FM tracking	KV1735S	TOKO
D6	VCO	KV1861E	TOKO
F1	10.7-MHz ceramic filter_IBOC	CFSE107MB/SFELF10M7CQ0C01	TOKO/MURATA
F2	10.7-MHz ceramic filter_analog	CFSC107M3/SFELF10M7HA00	TOKO/MURATA
F3 (1)	10.7-MHz ceramic filter (option)	SFVLF10M7MF00_B0	MURATA
X1	Crystal 20.5 MHz	AT51	NDK

(1) A 10.7-MHz ceramic filter is an option. When this narrow filter is not needed, it can leave the circuit open with I^2C control.

Absolute Maximum Ratings(1)

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

		MIN	MAX	UNIT
V_{CC}_1	Analog supply voltage range for RF/IF (2)	–0.4	10	V
V_{CC}_2	Analog supply voltage range for PLL/VCO/X'tal OSC(2)	–0.4	10	V
V_{CC}_3	Analog supply voltage range for IF/Lo_divider/ regulator(2)	–0.4	10	V
V_{DD}_1	Digital supply voltage for PLL/I^2C	–0.4	6.5	V
T_{JC}	Storage temperature range	–55	150	°C
T_A	Operating temperature range	–40	85	°C

(1) Derating factor is (8.33 mW/°C) for $T_A \geq 25°C$.
(2) Voltage values are with respect to the GND of the circuit.

Recommended Operating Conditions

PARAMETER		MIN	NOM	MAX	UNIT
V_{CC}_1	Analog supply voltage 1	8	8.5	9	V
V_{CC}_2	Analog supply voltage 2	8	8.5	9	V
V_{CC}_3	Analog supply voltage 3	4.75	5	5.25	V
V_{DD}_1	Digital supply voltage	4.75	5	5.25	V

CAUTION:

It is advised that precautions be taken to avoid damage due to high static voltages or electrostatic fields in handling this device.

PRODUCT PREVIEW

ELECTRICAL CHARACTERISTICS

Supply Current on FM Mode/Single IF PGA Mode

V_{CC} = 8 V to 9 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}_2	Analog/digital supply (5-V) current(1)	FM_Europe/US band		21.2	31.1	mA
		FM_Japan/E. Europe		25.6	40.0	
		FM_Weather		23.9	37.3	
Icc_3	Analog supply (8.5 V) current for RF	FM_mode		20.3	24.8	mA
Icc_4	Analog supply current for IF	FM_mode		30.8	37.6	mA
Icc_5	Analog supply current for VCO/PLL/Xtal	FM mode		14.3	17.4	mA

(1) FM PIN diode bias drive current and PIN bias current for AM input circuit not included

Supply Current on FM Mode/Dual IF Mode

V_{CC} = 8 V to 9 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}_2	Analog/digital supply (5-V) current(1)	FM_Europe/US band		21.2	31.1	mA
		FM_Japan/E. Europe		25.7	40.0	
		FM_Weather		23.9	37.3	
Icc_3	Analog supply (8.5-V) current for RF	FM_mode		20.2	24.6	mA
Icc_4	Analog supply current for IF	FM_mode		50.1	61.1	mA
Icc_5	Analog supply current for VCO/PLL/Xtal	FM mode		14.3	17.4	mA

(1) FM PIN diode bias drive current and PIN bias current for AM input circuit not included

Supply Current on AM Mode/Single IF Mode

V_{CC} = 8 V to 9 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}_2	Analog/digital supply (5-V) current(1)	AM_mode		27.6	34.4	mA
Icc_3	Analog supply current for RF	AM_mode		20.5	25.0	mA
Icc_4	Analog supply current for IF	AM_mode		30.6	37.3	mA
Icc_5	Analog supply current for VCO/PLL/Xtal	AM_mode		12.5	15.4	mA

(1) AM PIN diode bias drive current and PIN bias current for FM input circuit not included

Supply Current on AM Mode/Dual IF Mode

V_{CC} = 8 V to 9 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}_2	Analog/digital supply (5-V) current(1)	AM_mode		27.6	34.4	mA
Icc_3	Analog supply current for RF	AM_mode		20.5	25.0	mA
Icc_4	Analog supply current for IF	AM_mode		49.6	60.5	mA
Icc_5	Analog supply current for VCO/PLL/Xtal	AM_mode		12.6	15.4	mA

(1) AM PIN diode bias drive current and PIN bias current for FM input circuit not included

AC ELECTRICAL CHARACTERISTICS

Voltage-Controlled Oscillator

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Fosc	Oscillator frequency		159.9		248.2	MHz
C/N	Carrier-to-noise ratio	F = 200 MHz at 10 KHz, B = 1 Hz		97		dBc

Crystal Oscillator

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		MIN	TYP	MAX	UNIT
F_xtal	Oscillator frequency		20.5		MHz
Va_xtal	Crystal voltage		190		mV
Rin_Xtal	Real part of input impedance	–250			Ω

PLL Synthesizer

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Np	Programmable divider ratio		1024		32767	
Charge Pump						
Isink	Charge pump_1 sink current	Weather band mode		0.875		µA
Isource	Charge pump_1 source current	Weather band mode		–0.875		µA
Isink	Charge pump_1 sink current	MW/LW		1.01		mA
Isource	Charge pump_1 source current	MW/LW		–1.01		mA
Isink	Charge pump_1 sink current	AM/SW band		0.875		mA
Isource	Charge pump_1 sink current	AM/SW band		–0.875		mA
Isink	Charge pump_2 sink current	FM JPN/STD/EE		0.42		mA
Isource	Charge pump_2 source current	FM JPN/STD/EE		–0.42		mA
Charge Pump/High Current						
Isink	Low charge pump_3 sink current	FM JPN/STD		3.3		mA
Isource	Low charge pump_3 source current	FM JPN/STD		–3.3		mA

PRODUCT PREVIEW

Antenna Tuning Alignment

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I Bias	Input bias current			–10		12	nA
Vin	Input voltage range			0		8.5	V
VO(AM)	Output voltage in AM mode					0.3	V
VO(FM)	Output voltage in FM mode(1)	Vtuning = 0.5 V	Byte2: Data = "10000000 = 0"			0.3	V
		Vtuning = 2.0 V	Byte2: Data = "10101010 = 42"	1.37	1.42	1.45	
			Byte2: Data = "11010101 = 85"	2.33	2.38	2.48	
		Vtuning = 4.0 V	Byte2: Data = "10000000 = 0"		0.94		
			Byte2: Data = "11000000 = 64"	3.74	3.88	4.00	
		Vtuning = 4.7 V	Byte2: Data = "11111111 = 127"	7.5	8.0	8.5	
Vo(n)	Output noise voltage	Vtuning = 4 V B = 400 Hz to 30 KHz	Byte2: Data = “11000000 = 64”		26		uV
Vo(step)	Output step accuracy	N = 0 to 127, Vtuning = 2 V		0.5	1	1.5	LSB
Vo(sink)	Output variation caused by sink current	Vtuning = 4 V, Iout = 50 µA		–1		1	LSB
Vo(source)	Output voltage variation caused by source current	Vtuning = 4 V, Iout = –50 µA		–1		1	LSB
tsettle	Output settling time	Vout 1 V to 7 V, C_L = 270 pF			7.5	20	µS
	Ripple rejection	VADAin = 4 V, Fripple = 100 Hz, V_{CC}_3 = 100 mV(rms)			46		dB
C_L	Output load capacitance					270	pF

(1) Antenna tuning conversion gain formula:
Ant_out = 1.5 × [(n + 20)/128] × VDAAin
Where:
n = 0 to 127

I²C Bus

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		MIN	TYP	MAX	UNIT
R(1st)	Minimum resistor for 1st I²C-bus address	1			MΩ
R(2nd)	Resistor for 2nd I²C-bus address	90	100	110	kΩ
R(3rd)	Resistor for 3rd I²C-bus address	29.7	33	36.3	kΩ
I²C Bus Enable					
V_{IL}	Low-level input voltage	–0.3		1	V
V_{IH}	High-level input voltage	2		V_{dd} + 0.3	V

PRODUCT PREVIEW

AM SIGNAL CHANNEL

AM RF AGC

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Vi(RF)	RF input voltage for wide-band AGC start	m = 0.3, AGC (1:0) = "00"		220		mVpK
		AGC(1:0) = "10"		370		
		AGC(1:0) = "01"		520		
		AGC(1:0) = "11"		650		
AM RF AGC Current Generator for PIN Diode Attenuator						
Isink(max)	Maximum AGC sink current		18	30.4	39	mA
Isink	AM AGC sink current in FM mode		1.0	1.45	1.9	mA
AM RF AGC Cascade Stage						
V_{CAS_BASE}	Cascade voltage (pin CAS_BASE)	At maximum gain I_{CAS_BASE} = 100 µA to 1 µA	4.3	5	5.4	V
V_{CAS_FB}	Cascade voltage (pin CAS_FB)	At minimum gain		0.3		V
I_{CAS_BASE}	Maximum cascade transistor base current		100			µA
I_{CAS_FB}	Cascade feedback sense current	V_{CAS_FB} = 0.2 V			3	µA

AM RF AGC Transconductance Buffer (Pin 27 = RFAGC_BUFFER)

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Gm(buf)	Buffer transconductance, $(\Delta I_{RFAGC\_BUFFER})/(\Delta V_{RFAMAGC\_TC})$	AM mode, $\Delta V_{RFAMAGC\_TC}$ = 50 mV to 0.4 V	0.85	1	1.35	mS
Isink(max)	Maximum sink current	AM mode, $\Delta V_{RFAMAGC\_TC}$ = 0.8 V	400	550	670	µA
Isource(max)	Maximum source current	AM mode, $\Delta V_{RFAMAGC\_TC}$ = < 50 mV			–30	µA

AM Mixer

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Ri	RF input resistance		500	730		kΩ
Ci	RF input capacitance			0.7	5	pF
Vi(max)	Maximum input voltage on pin AMMIX_INP	1-dB compression point of AM mixer out, m = 0	112	117		dBuV
Mixer Output						
Ro	Output resistance		50	70		kΩ
Co	Output capacitance			0.7	5	pF
Vo(max)pp	Maximum output voltage (peak to peak)		8.0			V
Ibias	Mixer bias current	AM mode	4.1	5.5	8.0	mA
Mixer						
gm(conv)	Conversion tranconductance, $(\Delta I_{IFOUT})/(\Delta V_{RFIN})$		1.9	2.6	3.2	mS
gm(convT)	Conversion transconductance variation with temperature, $(\Delta gm)/(\Delta T_{OPE})$			$-0.6e^{-3}$		1/K
IP3	3rd-order intermodulation	R_L = 2.6 kΩ, f1 – f2 = 300 kHz	130	135		dBuV
IP2	2nd-order intermodulation	R_L = 2.6 kΩ		175		dBuV
Vi(n)	Input equivalent noise voltage	Rgen = 600 Ω, Include noise of Rgen, R_L = 2.6 kΩ		7.5		nV/√Hz
NF	Noise figure of AM mixer			7		dB

PRODUCT PREVIEW

AM Noise Blanker

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	UNIT
tsup	Suppression time	Vp = 250 mV, Vlevel < 1.8 V	NB(1:0) = 00		5	µs
			NB(1:0) = 01		10	
			NB(1:0) = 10		14	
			NB(1:0) = 11		18	
$Isink_{AMNB\_TC}$	AM noise blanker sink current			36	47	µA

IF Filter Drive Amplifier AM Mode

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Rin	Input resistance		265	330	420	Ω
Cin	Input capacitance			0.3	7	pF
G	IF amplifier gain	R_L = 330 Ω		0		dB
NF1	Noise figure			14.5		dB
IP3	3rd-order intermodulation			134		dBuV
Vi(max)	Maximum input voltage	1-dB compression point	113	117		dBuV
Vi(n)	Input equivalent noise voltage	Low gain mode		9		nV/rHz

IF_AM_AGC Start Voltage

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
761631	AGC start voltage at IF input	m = 0.3/761631 mode (X721 = 0)	125	155	190	mVpk
X6721		m = 0.3/6721 mode (X721 = 1)	65	78	90	

PRODUCT PREVIEW

AM IF PGA Stage for Wide Filter Path

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
G0	Amplifier gain	X721 = “0”	0000		27		dB
G1			0001		24		
G2			0011		21		
G3			0010		18		
G4			0110		15		
G5			0111		12		
G6			0101		9		
G7			0100		6		
G8			1100		3		
IIP3_0	Amplifier IIP3	X721 = “0”	0000		124		dBuV
IIP3_1			0001		127		
Vi(max)_0	Maximum input voltage 1-dB compression of IF_output	X721 = “0”	0000		180		mVpk
Vi(max)_4			0110		450		
Vi(max)_8			1100		900		
G0	Amplifier gain (6dBgain step)	X721 = “1”	xx00		27		dB
G1			xx01		21		
G2			xx11		15		
G3			xx10		9		
IIP3_0	Amplifier IIP3	X721 = “1”	xx00		124		dBuV
IIP3_1			xx01		130		
Vi(max)_1	Maximum input voltage 1-dB compression of IF_output	X721 = “1”	xx00		350		mVpk
Vi(max)_3			xx10		680		
NF	Noise figure	At maximum gain			13.5		dB
Vi(n)	Equivalent input noise voltage	Rgen = 330 Ω			7.6		nV/rHz
Ri	Input resistance			265	330	420	Ω
Vo(max)(p)	Maximum output voltage swing	Differential			1.8		Vpk

PRODUCT PREVIEW

AM IF PGA Stage for Narrow Filter Path

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
G0	Amplifier gain	X721 = “0”	0000		31		dB
G1			0001		28		
G2			0011		25		
G3			0010		22		
G4			0110		19		
G5			0111		16		
G6			0101		13		
G7			0100		10		
G8			1100		7		
IIP3_0	Amplifier IIP3	X721 = “0”	0000		119		dBuV
IIP3_1			0001		123		
Vi(max)_0	Maximum input voltage 1-dB compression of IF_output	X721 = “0”	0000		126		mVpk
Vi(max)_4			0011		250		
Vi(max)_8			0110		860		
G0	Amplifier gain (6dBgain step)	X721 = “1”	xx00		31		dB
G1			xx01		25		
G2			xx11		19		
G3			xx10		13		
IIP3_0	Amplifier IIP3	X721 = “1”	xx00		120		dBuV
IIP3_1			xx01		127		
Vi(max)_1	Maximum input voltage 1-dB compression of IF_output	X721 = “1”	xx00		235		mVpk
Vi(max)_3			xx10		540		
NF	Noise figure	At maximum gain			11		dB
Vi(n)	Equivalent input noise voltage	Rgen = 330 Ω			5.6		nV/rHz
Ri	Input resistance			265	330	420	Ω
Vo(max)(p)	Maximum output voltage swing	Differential			1.4		Vpk

FM SIGNAL CHANNEL

FM RF AGC

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TYP	UNIT
Vi(RF)	RF input voltage for wide-band FM AGC start	AGC(1:0) = "00"	7	mVrms
		AGC(1:0) = "10"	10	
		AGC(1:0) = "01"	14	
		AGC(1:0) = "11"	20	
FM RF AGC Time Constant Setting: Pin = RFFMAGC_TC				
Vo(ref)	DC output voltage		2.7	V

FM RF AGC

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
FM RF AGC Pin Drive Output: Pin = FM_PIN_AGC						
Isink(max)	Maximum AGC sink current	$V_{FM\_PIN\_AGC}$ = 2.5 V, V_{RFFMAG_TC} = Vo(ref) – 0.5 V	55	10	14.5	mA
Isource(max)	Maximum AGC source current	$V_{FM\_PIN\_AGC}$ = 2.5 V, V_{RFFMAG_TC} = Vo(ref) + 0.5 V	–17	–13	–11	mA
Isource (AGC)	AGC source current	AM mode	–7.5	–5	–3.5	mA
FM Keyed AGC						
Vth_KAGC	Threshold voltage for keyed AGC			1.1		V
FM RF AGC Transconductance Buffer: Pin = RFAGC_BUFFER						
Gm(buf)	Buffer transconductance, $(\Delta I_{RFAGC\_BUFFER})/(\Delta V_{RFFMAGC\_TC})$	FM mode, $V_{RFFMAGC\_TC}$ = 80 mV	4.3	5.5	6.7	ms
Isink(max)	Maximum sink current	FM mode, $V_{RFFMAGC\_TC}$ = Vo(ref) + 0.15 V	350	510	710	µA
Isource(max)	Maximum source current	FM mode, $V_{RFFMAGC\_TC}$ = Vo(ref) – 0.5 V			–30	µA

PRODUCT PREVIEW

FM Mixer

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Ri	RF input resistance	Nominal-gain mode Byte 5: Data = “xxxxxx0x”		2		kΩ
		High-gain mode Byte 5: Data = "xxxxxx1x"		1.2		
Ci	RF input capacitance			4	8	pF
Vi(RF)	RF input voltage	1-dB compression point of FM mixer output Byte 5: Data = "xxxxxx0x"		101		dBuV
		Byte 5: Data = "xxxxxx1x"		95		
Mixer Output						
Ro	Output resistance		100			kΩ
Vo(max)	Maximum output voltage (peak-to-peak)		5			Vpp
Ibias	Mixer bias current per out	FM mode	4	5.2	6.6	mA
gm(conv)	Conversion transconductance, $\Delta I_{MIXEROUT})/(\Delta V_{RFIN})$	1-dB compression point of FM mixer output Byte 5: Data = "xxxxxx0x"		12.5		mS
		Byte 5: Data = "xxxxxx1x"		25		
gm(conv)(T)	Conversion transconductance variation with temperature, $(\Delta gm(conv))/(gm * \Delta T_{OPE})$	Byte 5: Data = "xxxxxx0x"		$-0.8e^{-3}$		1/K
IP3	3rd-order intermodulation	Byte 5: Data = "xxxxxx0x"		113		dBuV
		Byte 5: Data = "xxxxxx1x"		106		
Vi(n)	Input equivalent noise voltage	Rgen = 200 Ω, Byte 5: Data = "xxxxxx0x"		2.9		nV/rHz
		Byte 5: Data = "xxxxxx1x"		2.7		
NF	Noise figure	Rs = 200 Ω Nominal-gain mode Byte 5: Data = "xxxxxx0x'		3.9		dB
		High-gain mode, Rs = 200 Ω Byte 5: Data = "xxxxxx1x"		2.4		
IRR	Image rejection ratio	Fwanred = 87.5 MHz, Fimage = 108.9 MHz	20	23		dB
		Fwanred = 162.475 MHz, Fimage = 183.875 MHz	20	23		

IF Filter Ceramic Driver Amplifier

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Rin	Input resistance		250	330	420	Ω
Cin	Input capacitance				7	pF
G	IF amplifier gain	R_L = 330 Ω		9		dB
NF1	Noise figure			7		dB
IP3	3rd-order intermodulation			121		dBuV
Vi(max)	Maximum input voltage	1-dB compression point	106	108		dBuV
Vi(n)	Input equivalent noise voltage	Low-gain mode		3.6		nV/rHz

FM IF PGA Stage for Wide Filter Path

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
G0	Amplifier gain	X721 = “0”	0000		39		dB
G1			0001		36		
G2			0011		33		
G3			0010		30		
G4			0110		27		
G5			0111		24		
G6			0101		21		
G7			0100		18		
G8			1100		15		
IIP3_0	Amplifier IIP3	X721 = “0”	0000		110		dBuV
IIP3_1			0001		112		
Vi(max)_0	Maximum input voltage 1-dB compression of IF_output	X721 = “0”	0000		70		mVpK
Vi(max)_4			0110		100		
Vi(max)_8			1100		500		
G0	Amplifier gain/18-dB, 6-dB step mode	X721 = “1”	xx00		39		dB
G1			xx01		33		
G2			xx11		27		
G3			xx10		21		
IIP3_0	Amplifier IIP3/18-dB, 6-dB step mode	X721 = “1”	xx00		110		dBuV
IIP3_1			xx01		116		
Vi(max)_1	Maximum input voltage 1-dB compression of IF_output/ 18-dB, 6-dB step mode	X721 = “1”	xx00		100		mVpK
Vi(max)_3			xx10		208		
NF	Noise figure	At maximum gain			6.5		dB
Vi(n)	Equivalent input noise voltage	Rgen = 330 Ω			3.4		nv/rHz
Ri	Input resistance			265	330	420	Ω
Vo(max)(p)	Maximum output voltage swing	Differential			1.8		Vpk

PRODUCT PREVIEW

FM IF PGA Stage for Narrow Filter Path

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
G0	Amplifier gain	X721 = “0”	0000		34		dB
G1			0001		31		
G2			0011		28		
G3			0010		25		
G4			0110		22		
G5			0111		19		
G6			0101		16		
G7			0100		13		
G8			1100		10		
IIP3_0	Amplifier IIP3	X721 = “0”	0000		116		dBuV
IIP3_1			0001		119		
Vi(max)_0	Maximum input voltage 1-dB compression of IF_output	X721 = “0”	0000		109		mVpK
Vi(max)_4			0110		200		
Vi(max)_8			1100		790		
G0	Amplifier gain/18-dB, 6-dB step mode	X721 = “1”	xx00		34		dB
G1			xx01		28		
G2			xx11		22		
G3			xx10		16		
IIP3_0	Amplifier IIP3/18-dB, 6-dB step mode	X721 = “1”	xx00		116		dBuV
IIP3_1			xx10		124		
Vi(max)_1	Maximum input voltage 1-dB compression of IF_output/ 18-dB, 6-dB step mode	X721 = “1”	xx00		180		mVpK
Vi(max)_3			xx10		380		
NF	Noise figure	At maximum gain			8.5		dB
Vi(n)	Equivalent input noise voltage	Rgen = 330 Ω			4.3		nv/rHz
Ri	Input resistance			265	330	420	Ω
Vo(max)(p)	Maximum output voltage swing	Differential			1.8		Vpk

FM IF AGC

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
761631	IF AGC start voltage	761631 mode, X721 = "0"	20	28	42	mVrms
X6721		6721 mode, X721 = "1"	10	14	21	

Crystal-Frequency Digital Adjust

V_{CC} = 8.5 V, T_A = 25°C (unless otherwise noted)

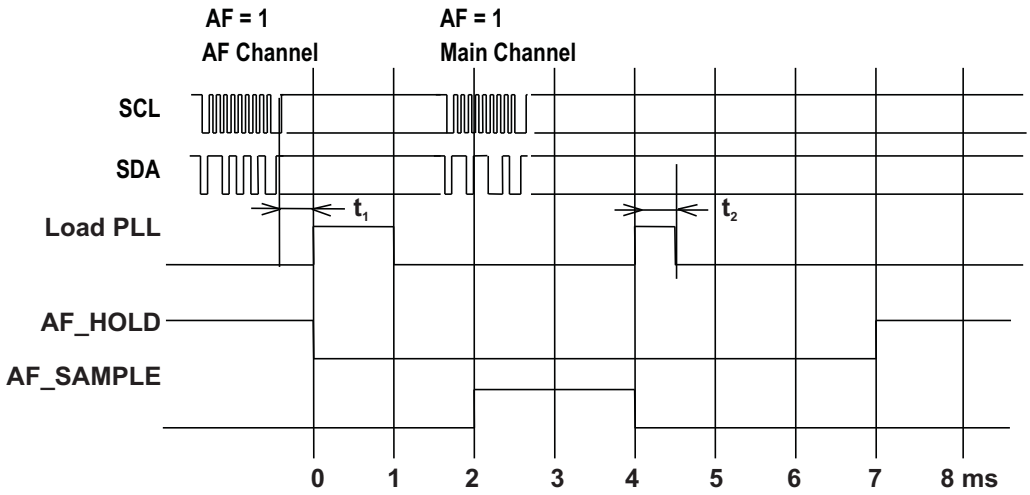
PARAMETER		TEST CONDITIONS	TYP	UNIT
F_adj_down	Frequency change at maximum capacitor from "01101111" capacitor(1)	Byte 7: Data = "11111111"	–1.1	kHz
F_adj_up	Frequency change at minimum capacitor from "01101111" capacitor(1)	Byte 7: Data = "00000000"	2.8	kHz

(1) Data = "01101111" is nominal capacitor position.

IFT (10.7 MHz) Tank Digital Adjust

V_{CC} = 8.5 V, V_{CC} = 5 V, T_A = 25°C (unless otherwise noted)

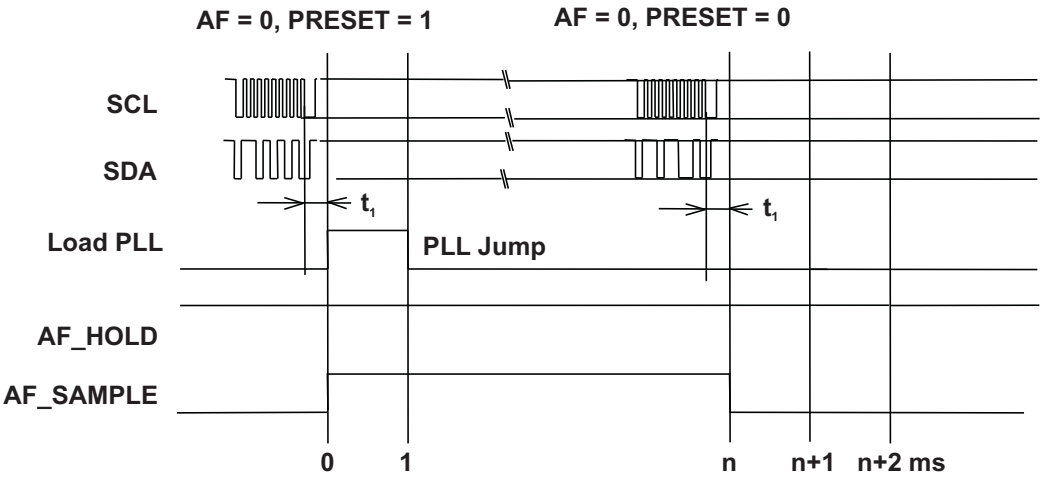
PARAMETER		TEST CONDITIONS	TYP	UNIT
F_cap_max	Center frequency change at maximum capacitor from "0111" capacitor data	Byte 6: Data = "1111xxxx"	–170	kHz
F_cap_min	Center frequency change at minimum capacitor from "0111" capacitor	Byte 6: Data = "0000xxxx"	250	kHz



A. AF_HOLD signal is used to hold the quality information for DSP during the alternative frequency jumps. PLL data are loaded during load_PLL = 1, and frequency jumps at the falling edge of this signal. Quality tests in DSP should be done during AF_SAMPLE = 1.

t_1 is the SN761631 internal delay, 100 µs, t_2 = 0.5 ms.

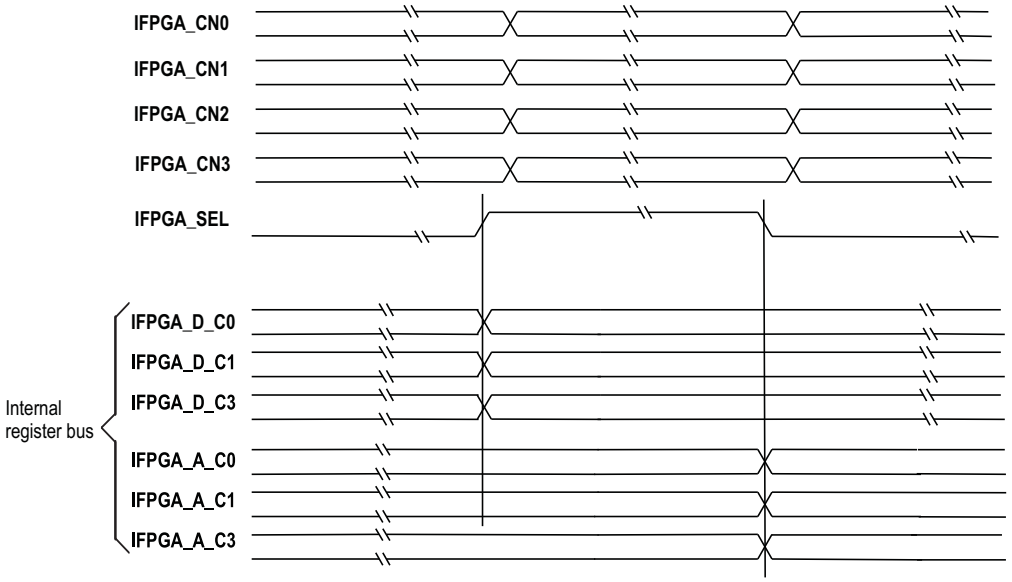
Figure 1. Inaudible Alternate Frequency Update



A. t_1 is the SN761631 internal delay, 100 µs.

Figure 2. Preset Mode

PRODUCT PREVIEW



A. IFPGA gain control data for digital radio IF path is latched at rising edge of IFPGA_SEL, and IFPGA gain control data for analog AM/FM path is latched at falling edge of IFPGA_SEL.

Figure 3. IFPGA Gain Control

FM Keyed AGC

The keyed AGC function shift threshold of the AGC on the case in-band signal is small. The amount of threshold change is 8 dB (typ). The keyed function is activated via the I^2C bus and is controlled by in-band signal level information delivered from the DSP.

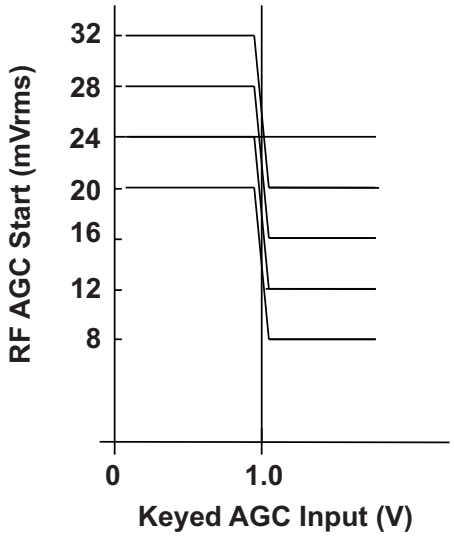


Figure 4. Keyed AGC Input vs RF AGC Set-Points Shift

PRODUCT PREVIEW

FUNCTIONAL DESCRIPTION

I²C Bus Mode

Write Data

Table 1. Write Data Format

	MSB							LSB	
Address byte (ADB)	1	1	0	0	0	A1	A0	R/W = 0	A(1)
Byte_0 (DB0)	AF	PCA6	PCA5	PCA4	PCA3	PCA2	PCA1	PCA0	A(1)
Byte_1 (DB1)	PCB7	PCB6	PCB5	PCB4	PCB3	PCB2	PCB1	PCB0	A(1)
Byte_2 (DB2)	PRESET	AA6	AA5	AA4	AA3	AA2	AA1	AA0	A(1)
Byte_3 (DB3)	0(2)	X721	REF2	REF1	REF0	BAND1	BAND0	AMFM	A(1)
Byte_4 (DB4)	DIV32	1	X	X	IF_FIL1	IF_FIL0	ANALOG	IBOC	A(1)
Byte_5 (DB5)	KAGC	AMNBL	AGC1	AGC0	LOCAL	FMMXINJ	MIXGAIN	AGCSW	A(1)
Byte_6 (DB6)	IFT13	IFT12	IFT11	IFT10	NBS2	NBS1	NB1	NB0	A(1)
Byte_7 (DB7)	XOSC2	XOSC1	XOSC0	XF4	XF3	XF2	XF1	XF0	A(1)
Byte_8 (DB8)	HPLL(7)	HPLL(6)	HPLL(5)	HPLL(4)	HPLL(3)	HPLL(2)	HPLL(1)	HPLL(0)	A(1)
Byte_9 (DB9)	DIO1	DIO0	D_PDF(1)	D_PDF(0)	R_SEL(3)	R_SEL(2)	R_SEL(1)	R_SEL(0)	A(1)

(1) A = Acknowledge
(2) Reserved for TI internal use

Table 2. LKD/Chip ID Read Out

	MSB							LSB	
Address byte (ADB)	1	1	0	0	0	A1	A0	R/W=1	A(1)
Byte_0 (DB0)	0	0	0	LKD	ID3	ID2	ID1	ID0	A(1)

(1) A = Acknowledge

Table 3. Write Data Symbol Description

SYMBOL	DESCRIPTION
A(1:0)	Address set (see Table 4)
R/W	0 = Write to SN761631 1 = Read out from SN761631
PCA(6:0)	Setting programmable counter of PLL synthesizer Upper byte of PLL divider word
AF	Alternative frequency 0 = Normal operation 1 = AF update mode
PCB(7:0)	Setting programmable counter of PLL synthesizer lower byte of PLL divider word
AA(6:0)	Antenna tuning alignment data
PRESET	Preset 0 = Programmable divider and antenna alignment locked 1 = Programmable divider and antenna alignment enabled
IBOC	In-band on-channel mode select 0 = IBOC IF PGA power off 1 = IBOC IF PGA power on
ANALOG	Analog mode select 0 = Analog IF PGA power off 1 = Analog IF PGA power on
AMFM	AM or FM mode selection 0 = FM mode 1 = AM mode

PRODUCT PREVIEW

Table 3. Write Data Symbol Description (continued)

SYMBOL	DESCRIPTION
DIV32	PLL prescaler modulus control 1 = 33/32 0 = 17/16
X721	0 = Normal operation mode 1 = 6721 mode
IF_FIL(1:0)	Ceramic filter driver/IF filter selection (see Table 10)
BAND(1:0)	Band select (see Table 6)
REF(2:0)	PLL reference frequency select (see Table 5)
MIXGAIN	FM mixer gain control 0 = Normal gain 1 = Mixer gain is boosted by 6 dB.
FMMXINJ	FM mixer injection setting 0 = Low injection 1 = High injection
LOCAL	Select local or distance 0 = Distance mode 1 = Local mode
AGC(1:0)	Wideband AGC start voltage setting (see Table 8 and Table 9)
KAGC	Keyed AGC control 0 = Keyed AGC function OFF 1 = Keyed AGC function ON
AMNBL	AM noise blanker control 0 = AM noise blanker OFF 1 = AM noise blanker ON
PINAGCSW	PIN diode attenuator control 0 = AM AGC on FM mode and FM AGC on AM mode is OFF. 1 = AM pin diode drive is active on FM mode, FM pin diode drive is active on AM mode.
XF(4:0)	Crystal frequency control (see Table 12)
XOSC(2:0)	Crystal oscillator center frequency adjust (see Table 14)
DI(1:0)	Diversity mode control (see Table 11)
NB(1:0)	AM noise banking suppression time setting 00: Suppression time = 5 µs 01: Suppression time = 10 µs 10: Suppression time = 14 µs 11: Suppression time = 18 µs
NBS(1:0)	AM noise blanker sense control 00: Noise blanker starts when noise is over 10 dB from average. 01: Noise blanker starts when noise is over 20 dB from average. 10: Noise blanker starts when noise is over 27 dB from average.
IFT1(3:0)	IFT1 (10.7-MHz) center frequency adjust (see Table 13)

Table 4. Address Selection

RESISTOR VALUE	MA0	MA0
Open	0	0
100 kΩ	0	1
33 kΩ	1	0

Table 5. Reference Frequency Setting

REF2	REF1	REF0	F_{REF} (kHz)
0	0	0	100
0	0	1	50
0	1	0	25
0	1	1	20
1	0	0	10
1	0	1	10
1	1	0	10
1	1	1	10

Table 6. Band Control/FM Mode

BAND1	BAND0	BAND	VCO DIVIDER	CHARGE-PUMP CURRENT
0	0	FM standard	2	0.375 mA + 3 mA
0	1	FM Japan	3	0.375 mA + 3 mA
1	0	FM E. Europe	3	0.75 mA
1	1	FM weather	1	0.375 mA

Table 7. Band Control/AM Mode

BAND1	BAND0	BAND	VCO DIVIDER	CHARGE PUMP CURRENT
0	X	AM SW	10	0.75 mA
1	X	AM LW/MW	20	0.875 mA

Table 8. Wideband AGC Setting for FM

AGC1	AGC0	WIDE AGC START VOLTAGE FOR FM MODE
0	0	7 mVrms
0	1	10 mVrms
1	0	14 mVrms
1	1	20 mVrms

Table 9. Wideband AGC Setting for AM

AGC1	AGC0	WIDE AGC START VOLTAGE FOR AM MODE
0	0	220 mVp
0	1	370 mVp
1	0	520 mVp
1	1	650 mVp

Table 10. IF Ceramic Filter Driver/Filter Selection Control

MODE	IF_FIL11	IF_FIL0	FILTER DRIVER_1	FILTER DRIVER_0	FILTER FOR IBOC	FILTER FOR ANALOG
FM	X	X	OFF	ON	F1 (450 kHZ)	F2 (180 kHZ)
AM	0	X	OFF	ON	F2 (180 kHZ)	F2 (180 kHZ)
	1	0	OFF	ON	F2 (180 kHZ)	F3 (30 kHZ)
	1	1	ON	OFF	F3 (30 kHZ)	F3 (30 kHZ)

PRODUCT PREVIEW

Table 11. FM Diversity Mode Control

MODE	DI1	DI0	CRYSTAL OSCILLATOR BUFFER AMPLIFIER	FM AGC OUTPUT CURRENT
Normal	0	0	OFF	Sink + source
Diversity/master	1	0	ON	Sink + source
Diversity/slave	1	1	OFF (receive mode)	Sink + source

Table 12. Crystal Frequency Control (Series Digital Control Capacitor)

XF4	XF3	XF2	XF1	XF0	CAPACITOR (pF)
0	0	0	0	0	2.4
0	0	0	0	1	3.8
0	0	0	1	0	5.2
...	...	...	...	...	...
1	1	1	1	1	46.2

Table 13. IFT (10.7-MHz) Tank Center Frequency Control

IFT13	IFT12	IFT11	IFT10	CAPACITOR (pF)
0	0	0	0	0
0	0	0	1	0.72
0	0	1	0	1.40
...	...	...	...	...
1	1	1	1	7.20

Table 14. Crystal Oscillator (XOSC) Center Frequency Adjustments

XOSC2	XOSC1	XOSC0	CAPACITANCE (pF)
0	0	0	16.2
0	0	1	17.9
0	1	0	19.5
...	...	...	...
1	1	1	27.8

I²C Command Code for AM and FM Setting

Setting for FM address=00
AF= 0
BAND=”00” / US standard, VCO divider=2, charge pump=375uA+3mA
Frequency= 98.0MHz
Reference=100kHz
PLL=2174 :(98.0+10.7)*2/0.1=2174
Preset=1 :preset mode
Antenna tracking= 70
test=0
X721=0
AMFM=0
Diversity=0
DIV32=0
IF Filter=”00”
Analog=1
IBOC=1
AM noise blanker=0 /dummy
KAGC=0
Wide AGC=”01”
Local=0
FM injection=1
FM Mixer Gain=1
AGC switch=0 :no AGC current for AM PIN AGC
IFT f.triming=”7”
Xtal freq. trimming=15
OSC trimming=3
AM N. Blanker sensitivity=00 /dummy
AM N. Blanker suppression Time=00 /dummy
High current PLL active time=2mS
Diversity mode=00
PLL phase detector control=”00”
Readout register=”0000”
I2C_bus transmission= **start C0 08 7E C6 40 03 16 70 6F C8 00 stop** AF=0/Preset=1
then **start C0 08 7E 46 stop** AF=0/Preset=0

Setting for AM
address=00
AF= 0
BAND=”10” / VCO divider=20, charge pump=0.75mA
Frequency= 1.098MHz
Reference= 20kHz
PLL=11798 :(1.098+10.7)*20/0.02=11798
Preset=1 :preset mode
Antenna tracking= 70
test=0
X721=1: IF PGA 6dB step mode
AMFM=1
Diversity=”00”
IF_Filter=”10” : IBOC=180kHzBW/ Analog= 50kHzBW
Analog=1
IBOC=1
AM noise blanker=1
KAGC=0 /dummy
Wide AGC=”01”
Local=0 /dummy
FM injection=0 /dummy
FM Mixer Gain=0 /dummy
AGC switch=0 no AGC current for FM PIN AGC
IFT f.triming=”7”
Xtal freq. trimming=15
OSC trimming=3
AM N. Blanker sensitivity=01 /middle of sensitivity
AM N. Blanker suppression Time=01 / =8uS
High current PLL active time=2mS /dummy
Diversity mode=00
PLL phase detector control=”00”
Readout register =”0000”
I2C_bus transmission= **start C0 2E 16 C6 5D 0B 16 75 6F C8 00 stop** AF=0/Preset=1
then **start C0 2E 16 46 stop** AF=0/Preset=0

PRODUCT PREVIEW

PACKAGING INFORMATION

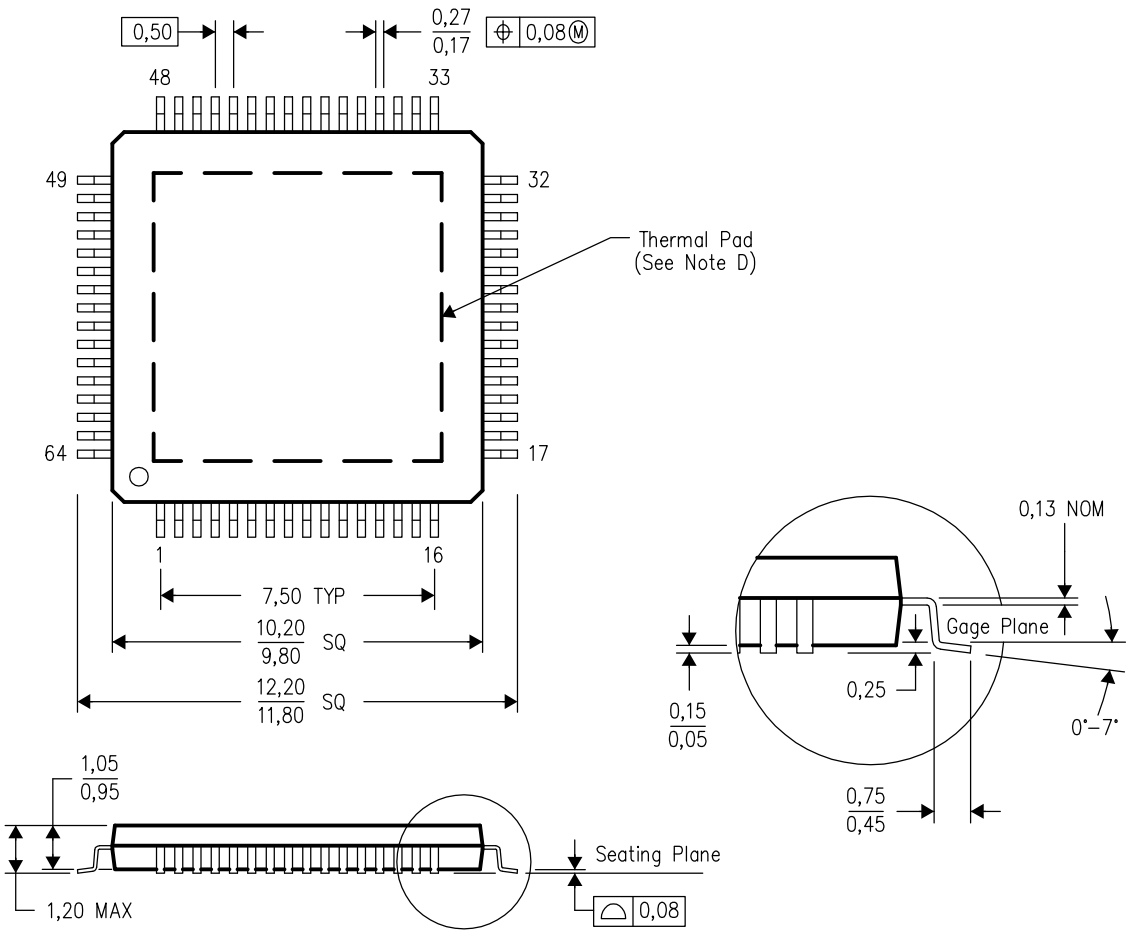
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
SN761631PAPR	PREVIEW	HTQFP	PAP	64		TBD	Call TI	Call TI

(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.

PAP (S–PQFP–G64) PowerPAD™ PLASTIC QUAD FLATPACK



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion
D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <http://www.ti.com>.
E. Falls within JEDEC MS–026

PowerPAD is a trademark of Texas Instruments.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information 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.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
Low Power Wireless	www.ti.com/lpw	Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265