SA58646

UHF 900 MHz transceiver IC

Rev. 01 — 8 February 2007 Product data sheet

1. General description

The SA58646 is a BiCMOS integrated circuit that performs all functions from the antenna to the microcontroller for reception and transmission for both the base station and the handset in a 902 MHz to 928 MHz full-duplex radio. The SA58646 may be used in a UHF push-to-talk walkie-talkie or in a UHF to 900 MHz data transceiver. The SA58646 is a pin-compatible derivative of the UAA3515 with advanced features.

This IC integrates most of the functions required for a half-duplex or full-duplex radio in a single integrated circuit. Additionally, the programmability implemented reduces significantly external components count, board space requirements and external adjustments.

2. Features

- RF RX (single frequency conversion FM receiver):
  - Integrated LNA
  - Image reject mixer
  - FM detector at 10.7 MHz including an IF limiter, a wide band PLL demodulator, an output amplifier and a RSSI output
  - Carrier detection with programmable threshold
  - Programmable data amplifier (slicer) phase
- Synthesizer:
  - Crystal reference oscillator with integrated tuning capacitor
  - Reference frequency divider
  - Narrow band RX PLL including RX VCO with integrated varicaps
  - Narrow band TX PLL including TX VCO with integrated varicaps
  - VCO external inductors can be done with printed transmission lines on the PCB which offers substantial savings
  - Programmable clock divider with output buffer to drive a microcontroller
- Baseband RX section:
  - Programmable RX gain (enable phone volume control)
  - Expander with output noise level control
  - Earpiece amplifier with volume control feature
  - Data amplifier
- Baseband TX section:
  - Microphone amplifier
  - Compressor with automatic level control and hard limiter
  - Programmable TX gain

- Microcontroller interface:
  - 3-wire serial interface
- Other features:
  - Voltage regulator to supply internal PLLs
  - Selectable voltage doubler
  - Programmable low battery detection time multiplexed with RSSI carrier detection

3. Applications

- 902 MHz to 928 MHz full-duplex radio
- UHF to 900 MHz data transceiver
- UHF push-to-talk walkie-talkie

4. Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
SA58646BD	LQFP64	plastic low profile quad flat package; 64 leads; body 10 × 10 × 1.4 mm	SOT314-2

5. Block diagram

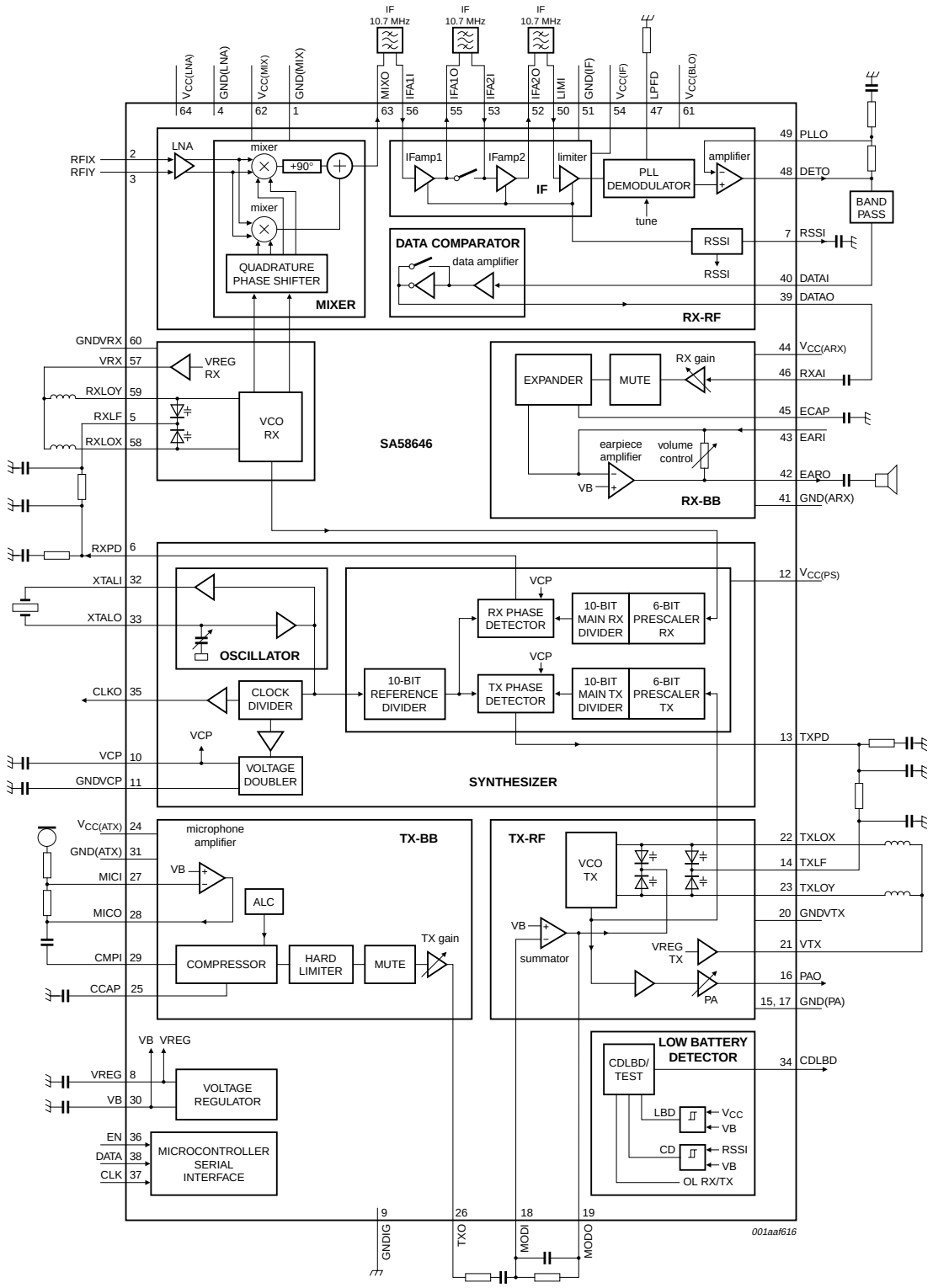


Fig 1. Block diagram of SA58646

6. Pinning information

6.1 Pinning

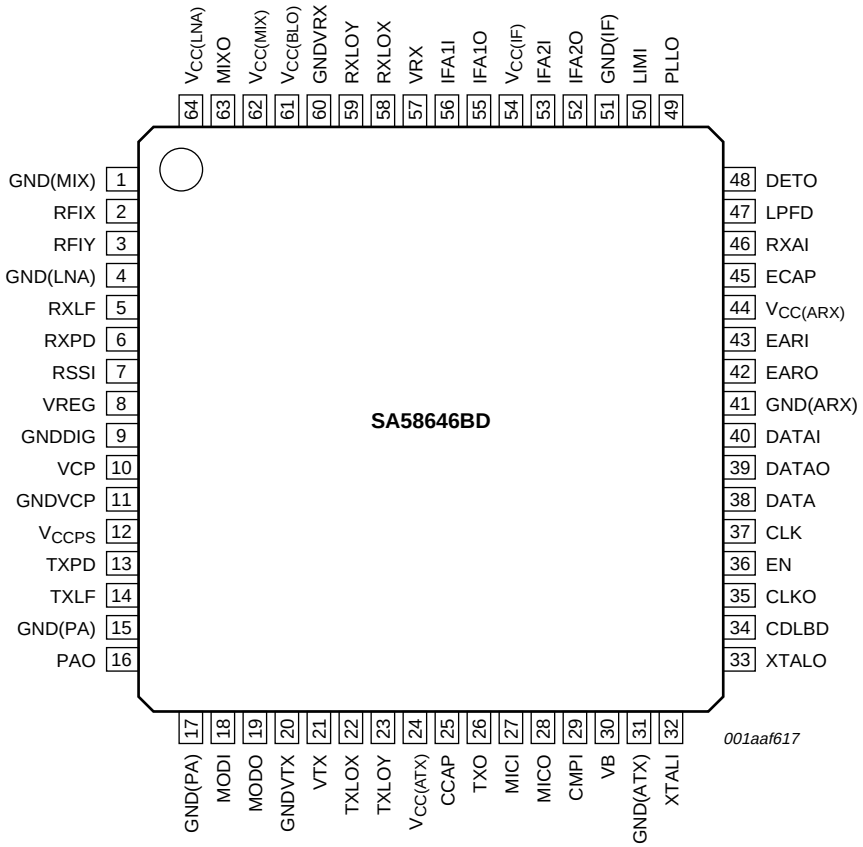


Fig 2. Pin configuration

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
GND(MIX)	1	mixer ground
RFIX	2	LNA input x
RFIY	3	LNA input y
GND(LNA)	4	LNA ground
RXLF	5	RX loop filter output
RXPD	6	RX phase detector output
RSSI	7	RSSI output
VREG	8	internal voltage regulator capacitor connection
GNDDIG	9	digital parts ground
VCP	10	charge pump voltage output
GNDVCP	11	charge pump ground

Table 2. Pin description *…continued*

Symbol	Pin	Description
$V_{CC(PS)}$	12	prescaler supply
TXPD	13	TX phase detector output
TXLF	14	TX loop filter output
GND(PA)	15	PA ground
PAO	16	PA output
GND(PA)	17	PA ground
MODI	18	summator amplifier input
MODO	19	summator amplifier output
GNDVTX	20	VCO TX ground
VTX	21	VCO TX voltage output
TXLOX	22	VCO TX coil connection x
TXLOY	23	VCO TX coil connection y
$V_{CC(ATX)}$	24	audio TX supply
CCAP	25	external capacitor connection for compressor
TXO	26	audio TX output
MICI	27	microphone amplifier input
MICO	28	microphone amplifier output
CMPI	29	compressor input
VB	30	voltage reference capacitor connection
GND(ATX)	31	audio TX ground
XTALI	32	crystal input
XTALO	33	crystal output
CDLBD	34	carrier detector or low battery detector output (out-of-lock synthesizer RX and/or TX in Test mode)
CLKO	35	clock output
EN	36	serial interface enable input
CLK	37	serial interface clock input
DATA	38	serial interface data input
DATAO	39	data amplifier output
DATAI	40	data amplifier input
GND(ARX)	41	audio RX ground
EARO	42	earpiece amplifier output
EARI	43	earpiece amplifier input
$V_{CC(ARX)}$	44	audio RX supply
ECAP	45	external capacitor connection for expander
RXAI	46	audio RX input
LPFD	47	demodulator loop filter
DETO	48	inverting demodulator amplifier output
PLLO	49	demodulator amplifier negative input
LIMI	50	limiter input
GND(IF)	51	IF ground

Table 2. Pin description *…continued*

Symbol	Pin	Description
IFA2O	52	IF second amplifier output
IFA2I	53	IF second amplifier input
$V_{CC(IF)}$	54	IF supply
IFA1O	55	IF first amplifier output
IFA1I	56	IF first amplifier input
VRX	57	VCO RX voltage output
RXLOX	58	VCO RX coil connection x
RXLOY	59	VCO RX coil connection y
GNDVRX	60	VCO RX ground
$V_{CC(BLO)}$	61	RX LO buffer supply
$V_{CC(MIX)}$	62	mixer supply
MIXO	63	mixer output
$V_{CC(LNA)}$	64	LNA supply

7. Functional description

Refer to Figure 1 “Block diagram of SA58646”.

7.1 Power supply and power management

7.1.1 Power supply voltage

This circuit is used in a full-duplex radio handset and base unit. The handset unit is battery powered and can operate on three NiCad cells. The minimum supply voltage of the IC is V_{CC} = 2.9 V.

7.1.2 Power-saving operation modes

When the circuit is used in a handset, it is important to reduce the current consumption. There are 3 main modes of operation:

- Active mode (talk): all blocks are powered
- RX mode: all circuitry in the RF receiver part is active
- Inactive mode: all circuitry is powered down except the serial interface. In this latter mode the crystal reference oscillator, output clock buffer, voltage regulator and voltage doubler can be disabled separately.

A low current consumption mode on the crystal oscillator and clock output can be programmed. Latch memory is maintained in all modes. Table 3 shows which blocks are powered in each mode.

Table 3. Powered blocks

Circuit block	Mode		
	Active	RX	Inactive
VB reference	X	X	-
RX-RF	X	X	-
RX PLL	X	X	-
RX and TX audio	X	-	-
TX-RF (and PA if enabled)	X	-	-

Some blocks can be activated separately: crystal oscillator, voltage regulator (adjustment is always disabled), power amplifier, voltage doubler, hard limiter, automatic level control, output clock buffer and earpiece amplifier. Table 4 shows which block can be activated in each mode.

Table 4. Activated blocks

Circuit block	Mode		
	Active	RX	Inactive
Crystal active[1]	X	X	X
Clock output not disabled	X	X	X
Voltage regulator active[2]	X	X	X
Power amplifier active	X	-	-
Doubler enabled[3]	X	X	X
Hard limiter or automatic level control not disabled	X	-	-
Earpiece amplifier enabled	X	X	-[4]

[1] In RX and TX mode, the crystal oscillator is automatically activated. An external frequency can be forced to pins XTALI and XTALO.

[2] In RX and TX mode, the voltage regulator with adjustment is automatically enabled; bit REG can be either logic 1 or logic 0.

[3] If the voltage doubler is enabled, the crystal oscillator is automatically activated.

[4] In Inactive mode, the earpiece amplifier is automatically disabled.

7.1.3 Control bits in power saving modes

Table 5 shows the control bit values for selection of each mode and the typical current consumption for those modes.

Table 5. Control bit values

V_{CC} = 3.3 V; T_{amb} = 25 °C; f_{xtal} = 10.24 MHz.

Power saving mode	MODE[1:0]		Conditions				Typical current consumption
	Bit 1	Bit 0	Voltage doubler	Crystal oscillator	Voltage regulator	Clock output	
Active mode	1	1	-	-	-	-	76 mA
RX mode	1	0	-	-	-	-	58 mA
Inactive mode	0	X	inactive	disabled	disabled	disabled	< 10 µA
				XTAL_H = 0			210 µA
				XTAL_H = 1			300 µA
			inactive	XTAL_H = 1	enabled	disabled	550 µA
			active				690 µA

When the clock output is activated, an extra power consumption is applied which is proportional to the programmed bit CLKO. If bit XTAL_H = 0, then the crystal loss is less than 50 Ω to ensure reliable start-up.

Table 6. Extra power consumption

Divider ratio	Extra current consumption	
Bits CLK_DIV[2:0]	Bit CLKO = 0	Bit CLKO = 1
XXX (1, 2, 2.5, 4, 128)	520 µA	350 µA
000 (off)	0 µA	0 µA

7.2 FM receiver part

The FM receiver has a single frequency conversion architecture. The image reject mixer enables the user to save an RF filter. The side band select feature (bit SBS) enables the user to choose its frequency plan with RX LO in or out of ISM band and have the same IC for both base and handset. An IF channel filtering compromise between price and performance can be achieved using two or three 10.7 MHz external filters. The integrated FM PLL demodulator with limiter enables consistent saving on external components and pins.

The data comparator is an inverting hysteresis comparator. The open-collector output is current limited to control the output signal slew rate. An external band-pass filter is connected between pins DETO and DATAI (AC coupled). The external resistor should be 180 kΩ at maximum V_{CC}. An external capacitor can be added to further reduce the slew rate.

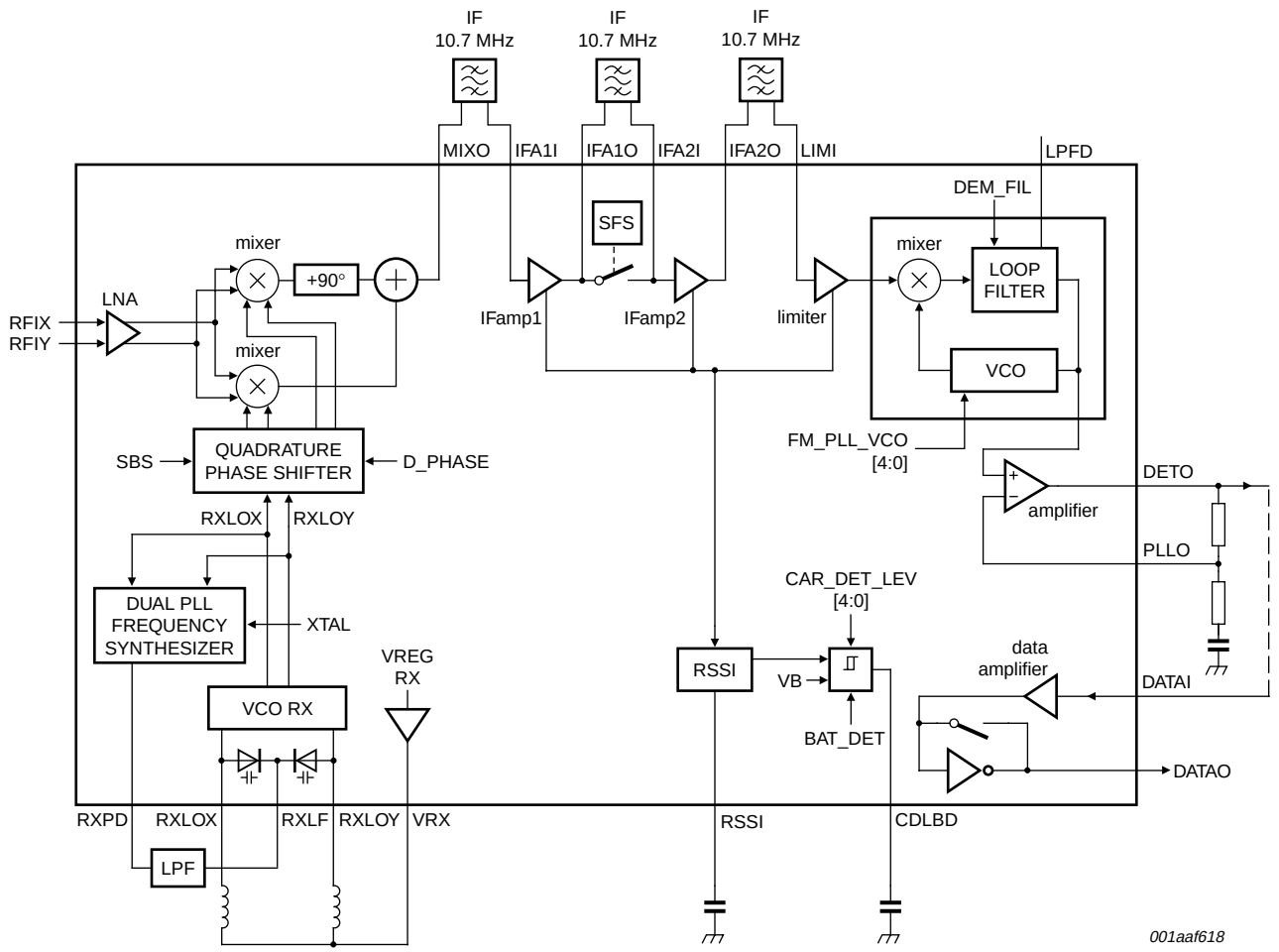


Fig 3. FM receiver part

7.3 Transmitter part

The transmitter architecture is of the direct modulation type. The transmit VCO will be frequency modulated by either speech or data (see Figure 4).

Before the VCO, an amplifier sums the modulating signal and the data TX signal. VCO varicaps are integrated. External inductors that are in series with bonding wires and lead frame are needed to obtain the right frequency. The power amplifier is capable of driving 50 Ω. The output level is programmed through the serial bus interface.

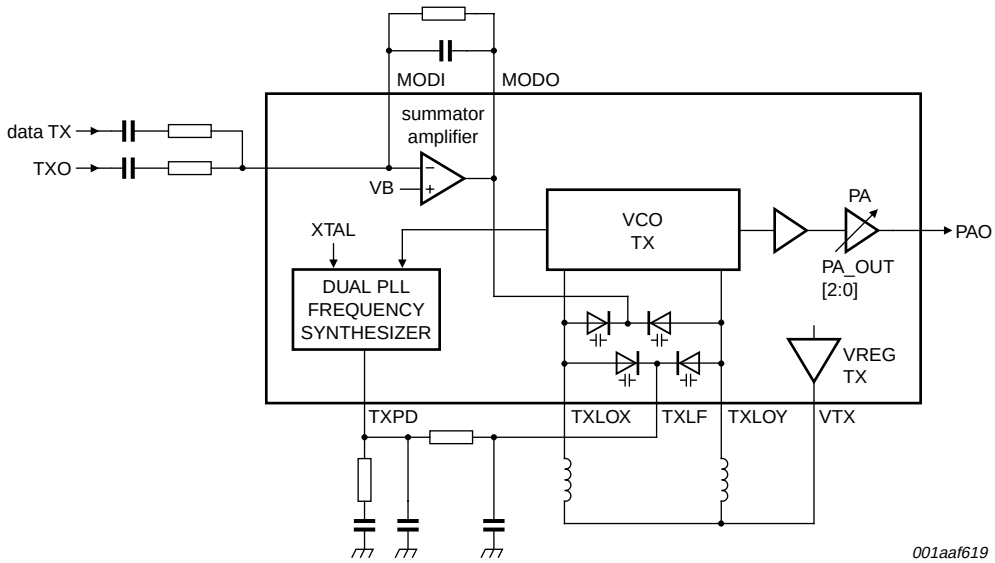


Fig 4. Transmit part

7.4 Synthesizer

The crystal local oscillator and reference divider provide the reference frequency for the RX and TX PLLs. The 10-bit programmed divider value for the reference divider is selected based on the crystal frequency, the desired RX and TX reference frequency values. The crystal frequency of 16.348 MHz is chosen to provide to the microcontroller the standard 4.096 MHz frequency when programming the clock divider value to 4. Then the 16.384 MHz crystal frequency is proposed. The clock divider value will be programmed to 1, 2, 2.5, 4 and 128. The clock divider value of 128 is chosen to place the SA58646 in Sleep mode which enables current saving in the microcontroller. The clock output is an emitter follower type.

The 16-bit TX counter is programmed for the desired transmit channel frequency. The 16-bit RX counter is programmed for the desired local oscillator frequency. The counters are built with a 6-bit prescaler (divider value R from 64 to 127) and a 10-bit divider (divider value C from 8 to 1023). The full counter then provides a divider value from 512 to 65535. To calculate the settings of the two counters, the following procedure is used:

$C = \text{int}(M / 64)$

$R = M - C \times 64$

where M being the division ratio between the VCO frequency and the reference frequency.

Example: RF RX f = 903 MHz, VCO RX f = 892.3 MHz, IF f = 10.7 MHz, VCO TX f = 925.6 MHz and the internal comparison frequency f = 20 kHz (f_{xtal} = 10.24 MHz):

REF_DIV[9:0] = 512 (10 0000 0000),

For RX: M = $892.3 \times 10^6 / 20 \times 10^3$ = 44615, C = 697 (10 1011 1001), R = 7 (00 0111),

For TX: M = $925.6 \times 10^6 / 20 \times 10^3$ = 46280, C = 723 (10 1101 0011), R = 8 (00 1000).

VCOs and varicaps are integrated. The total equivalent inductance is comprised of the bonding wires, lead frame of the package and external inductors. External inductors can be done with printed transmission lines on the PCB, which allows substantial savings.

An on-chip selectable voltage doubler is provided to enable a larger tuning range of the VCOs.

The phase detectors have current drive type outputs. Current can be chosen between 400 µA and 800 µA.

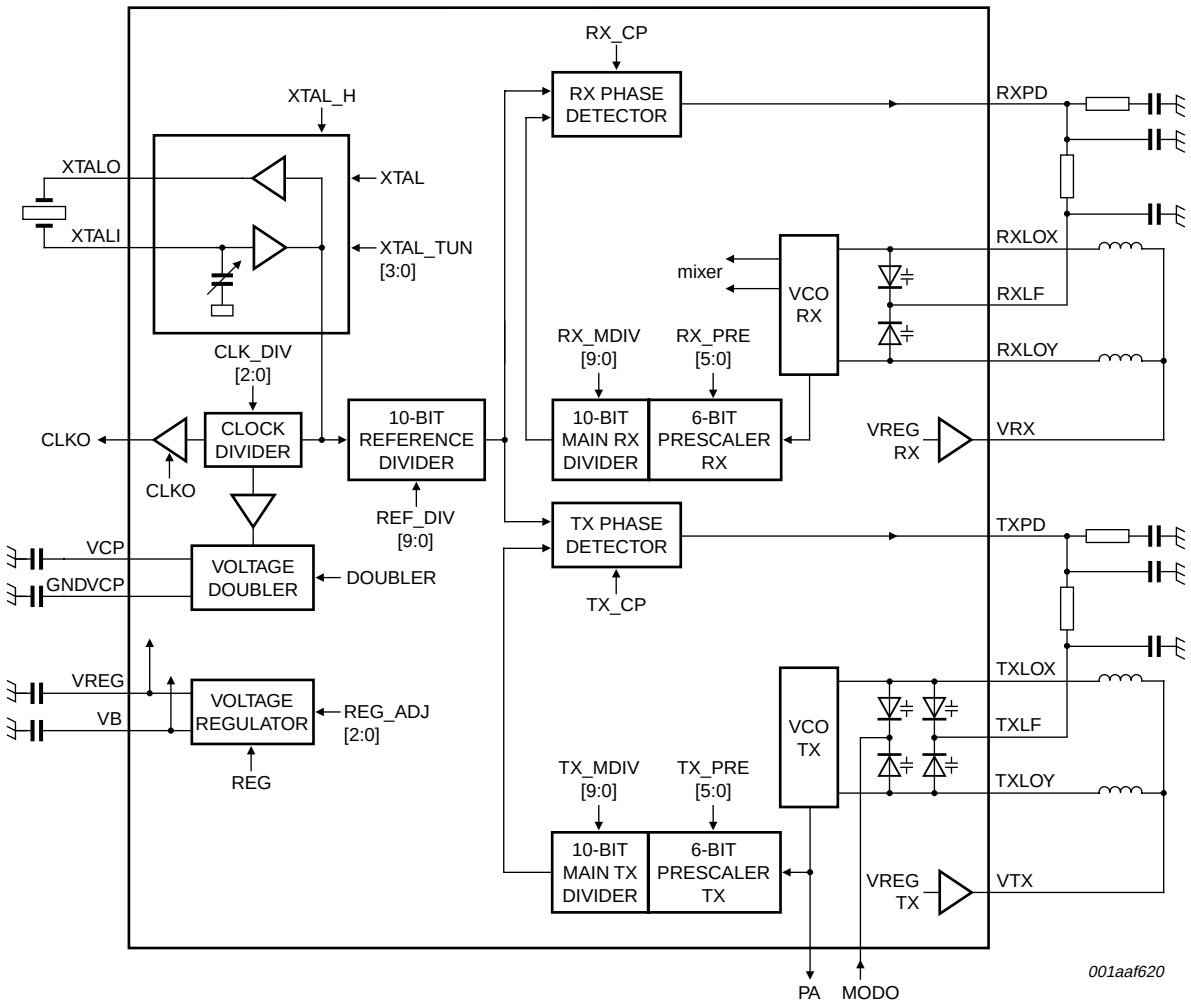


Fig 5. Synthesizer part

7.5 RX baseband

This section covers the RX audio path from pins RXAI to EARO. The RXAI input signal is AC-coupled. The microcontroller sets the value of the RX gain with 32 linear steps of 0.5 dB. The RX baseband has a mute and an expander with the characteristics shown in Figure 7. The audio level is programmable over a dynamic range of 31 dB by the RX gain control. The expander slope multiplies the RX gain step by 2 to achieve 1 dB steps on the earpiece output. Noise coming from, and within, the RX baseband can be shaped thanks to a 'noise control' programmability. It provides the possibility to attenuate the expander gain at low input level. Figure 7 provides some information about the noise shaper function. The earpiece amplifier is an inverting rail-to-rail operational amplifier. The non-inverting input is connected to the internal VB reference voltage. Software volume control on the earpiece amplifier is done by integrated switched feedback resistances. Volume control tuning range is 14 dB. Hardware volume control is done by externally switching the earpiece feedback resistance.

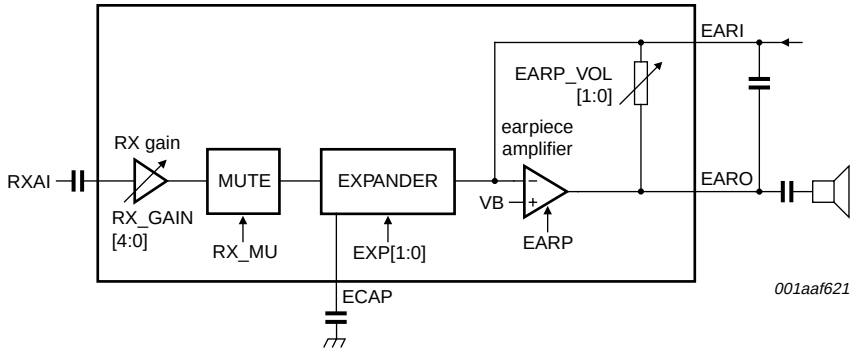
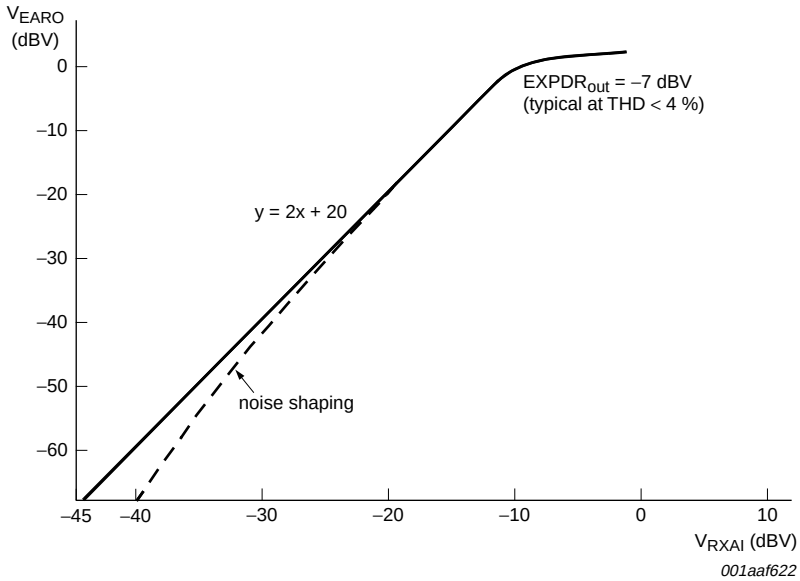


Fig 6. RX baseband part



RX gain adjustment at 0 dB; volume earpiece at 0 dB; no external resistance.

Fig 7. Expander characteristic

7.6 TX baseband

This section covers the TX audio path from pins MICI to TXO. The input signal at pin MICI is AC-coupled. The microphone amplifier output is also AC-coupled.

The microphone amplifier is an inverting operational amplifier whose gain can be set by external resistors. The non-inverting input is connected to the internal VB reference voltage. External resistors are used to set the gain and frequency response.

The TX baseband has a compressor with the characteristic shown in Figure 9. The Automatic Level Control (ALC) provides a 'soft' limit to the output signal swing as the input voltage increases slowly (that is, a sine wave is maintained at the output). A hard limiter clamps the compressor output voltage at 1.26 V (p-p). The ALC and hard limiter can be disabled via the microcontroller interface. The hard limiter is followed by a mute. The TX gain is digitally programmable with 32 steps of 0.5 dB.

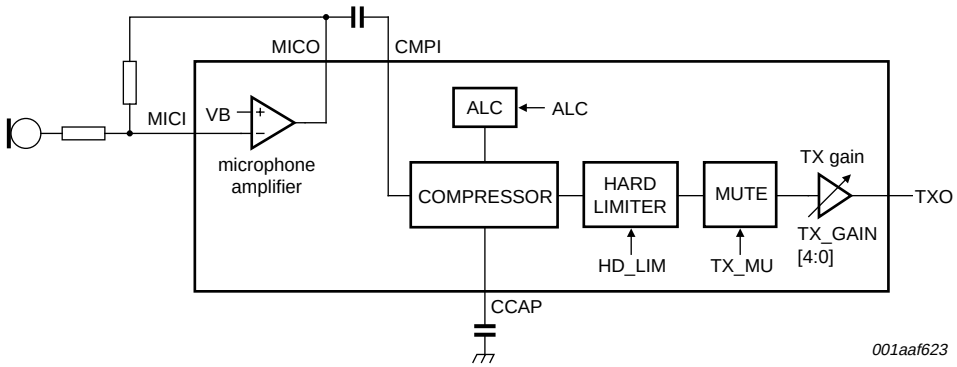


Fig 8. TX baseband part

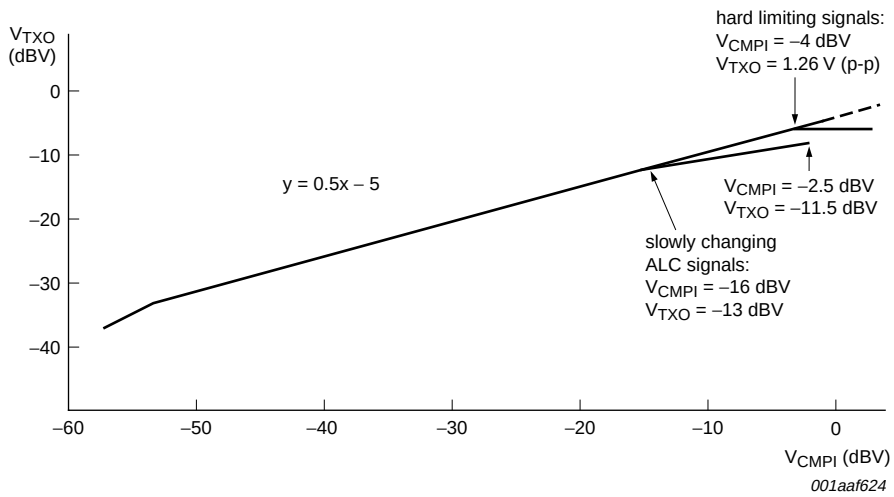


Fig 9. Compressor characteristic

7.7 Other features

7.7.1 Voltage regulator

Regulator voltage VREG is the internal supply for the RX and TX PLLs. It is regulated at 2.7 V nominal voltage. Two capacitors with 4.7 µF and 100 nF values must be connected to pin VREG to filter and stabilize this regulated voltage. The tolerance of the regulated voltage is initially ±8 % but is improved to ±2 % after the internal band gap voltage reference is adjusted via the microcontroller interface. In Inactive mode, the regulator voltage adjustment is automatically disabled.

7.7.2 Low battery detector

The low battery detector measures the supply voltage V_{CC} with a resistor divider and a comparator. One input of the comparator is connected to reference voltage VB and the other is connected to the middle point of the resistor divider. To prevent spurious switching the comparator has a built-in hysteresis. The precision of the detection depends on the divider accuracy, the comparator offset and the accuracy of the reference voltage. The output is multiplexed at pin CDLBD. When the battery voltage level is under the threshold voltage, the CDLBD output is set at LOW level.

7.8 Microcontroller serial interface

The serial interface is used for programming the IC. To program the IC, 19 bits are used: 16 bits for data and 3 bits for register addresses. The serial interface requires 3 pins: DATA, CLK, EN (see Figure 10).

The serial interface pins are supplied by regulator voltage VREG. The ESD protection diodes on these pins are connected to the supply voltage V_{CC}. Digital outputs (CDLBD and DATAO) have open-collector or open-drain; CLKO is an emitter-follower output.

The DATA, CLK and EN pins provide a 3-wire unidirectional serial interface for programming the reference counters, the transmit and receive channel divider counters, and the control functions.

The interface consists of 19-bit shift registers connected to a matrix of registers organized as 7 words of 16 bits (all control registers). The data is entered with the most significant bit first. The leading 16 bits include the data (D15 to D0), while the trailing 3 bits set up the address (AD2 to AD0). The first bit entered is D15, the last bit AD0.

The DATA and CLK pins are used to load data into the shift registers. Data is clocked into the shift registers on negative clock transitions.

A new clock divider ratio is enabled thanks to an extra EN rising edge. Minimum hold time is 50 ns. During that time, no clock cycle is allowed. These extra EN edges can be applied to all the data programmed, but will have no effect on the serial interface programming.

8. Data registers and addresses

D15 is the most significant bit, and is written first. Table 7 shows the data latches and addresses which are used to select each of the registers.

Table 7. Data registers including preset values at power-on

Addr	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
000	SBS	EARP_VOL[1:0]		EARP	RX_GAIN[4:0]					SFS	D_PHASE	FM_PLL_VCO[4:0]				
	0	11		0	0 1111					1	0	0 1111				
001	RX_PRE[5:0]						RX_MDIV[9:0]									
	XX XXXX						XX XXXX XXXX									
010	[1]						REF_DIV[9:0]									
	00 0000						XX XXXX XXXX									
011	TX_PRE[5:0]						TX_MDIV[9:0]									
	XX XXXX						XX XXXX XXXX									
100	TM2	CLKO	TM1	DOUBLER	TX_GAIN[4:0]					TX_MU	HD_LIM	ALC	XTAL	RX_MU	DEM_FIL	[1]
	0	0	0	0	01111					1	0	0	1	1	0	0
101	REG	MODE[1:0]		XTAL_H	CAR_DET_LEV[4:0]					L_BAT_DET[2:0]			BAT_DET	CLK_DIV[2:0]		
	1	00		1	0 0000					000			1	100		
110	PA_OUT[2:0]			TX_CP	RX_CP	REG_ADJ[2:0]			EXP[1:0]		TM0	[1]	XTAL_TUN[3:0]			
	010			0	0	011			00		0	0	0111			

[1] Undefined zone should always be programmed with logic 0.

8.1 Data register 0

Table 8. Data register 0 (address 000h) bit description

*Legend: * reset value.*

Bit	Symbol	Value	Description
15	SBS		**Side band select**. The image reject mixer can be programmed to either reject the image frequency at the LO upper frequency or at the LO lower frequency. It enables the user to have the RX LO in or out of ISM band and to use the same IC in both handset and base.
		0*	frequency LO – IF is rejected
		1	frequency LO + IF is rejected
14 to 13	EARP_VOL[1:0]		**Earpiece volume control.** Software gain control on the earpiece amplifier is done with integrated switch feedback resistances.
		00	R_{fbck} = 14 kΩ, G_{ctrl} = 0 dB
		01	R_{fbck} = 24 kΩ, G_{ctrl} = 4.7 dB
		10	R_{fbck} = 41 kΩ, G_{ctrl} = 9.3 dB
		11*	R_{fbck} = 70.2 kΩ, G_{ctrl} = 14 dB
12	EARP		**Earpiece**
		0*	earpiece disable
		1	earpiece enable; can be used in RX mode for specific feature
11 to 7	RX_GAIN[4:0]		**RX gain setting**
		0 1111*	for values, see Table 9
6	SFS		**Second filter select.** Depending on the features of the IF filters used, the user might not need to use the second IF filter. IF filters having 4.5 dB insertion loss are recommended.
		0	second IF filter not selected
		1*	second IF filter selected
5	D_PHASE		**Data phase shifter.** The SBS bit is used to invert the phase of the data. Depending on the SBS bit value and the protocol chosen, the data can be inverted between the base and handset data transmission. To correct the data polarity, bit D_PHASE is set.
		0*	inverter is bypassed
		1	inverter is used
4 to 0	FM_PLL_VCO[4:0]		**PLL center frequency calibration**. This programming allows calibration of the center frequency of the VCO within the FM PLL to align the frequency as close as possible to the nominal 10.7 MHz frequency.
		0 1111*	For values, see Table 10

Table 9. TX and RX gain

Select	RX_GAIN[4:0] and TX_GAIN[4:0]					RX and TX gain (dB)	Earpiece output (dB)
	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0		
0	0	0	0	0	0	−7.5	−15.0
1	0	0	0	0	1	−7.0	−14.0
2	0	0	0	1	0	−6.5	−13.0
3	0	0	0	1	1	−6.0	−12.0
4	0	0	1	0	0	−5.5	−11.0
5	0	0	1	0	1	−5.0	−10.0
6	0	0	1	1	0	−4.5	−9.0
7	0	0	1	1	1	−4.0	−8.0
8	0	1	0	0	0	−3.5	−7.0
9	0	1	0	0	1	−3.0	−6.0
10	0	1	0	1	0	−2.5	−5.0
11	0	1	0	1	1	−2.0	−4.0
12	0	1	1	0	0	−1.5	−3.0
13	0	1	1	0	1	−1.0	−2.0
14	0	1	1	1	0	−0.5	−1.0
15	0	1	1	1	1	0	0
16	1	0	0	0	0	+0.5	+1.0
17	1	0	0	0	1	+1.0	+2.0
18	1	0	0	1	0	+1.5	+3.0
19	1	0	0	1	1	+2.0	+4.0
20	1	0	1	0	0	+2.5	+5.0
21	1	0	1	0	1	+3.0	+6.0
22	1	0	1	1	0	+3.5	+7.0
23	1	0	1	1	1	+4.0	+8.0
24	1	1	0	0	0	+4.5	+9.0
25	1	1	0	0	1	+5.0	+10.0
26	1	1	0	1	0	+5.5	+11.0
27	1	1	0	1	1	+6.0	+12.0
28	1	1	1	0	0	+6.5	+13.0
29	1	1	1	0	1	+7.0	+14.0
30	1	1	1	1	0	+7.5	+15.0
31	1	1	1	1	1	+8.0	+16.0

The TX and RX audio signal paths each have a programmable gain block. If a TX or RX voltage gain other than the nominal power-up default is desired, it can be programmed via the microcontroller interface. The gain blocks can be used during final test of the radio to electronically adjust for gain tolerances in the radio system. The RX and TX gain have steps of 0.5 dB covering a dynamic range from −7.5 dB to +8 dB. At the earpiece output, the RX gain steps are multiplied by 2 due to the expander slope. The volume control feature for the earpiece amplifier allows for compensation of gain tolerances from −15 dB to +16 dB. Volume control is preferably done on the earpiece amplifier (bits EARP_VOL[1:0]).

Table 10. PLL center frequency calibration

Select	FM_PLL_VCO[4:0]					Center frequency shift (MHz)
	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
0	0	0	0	0	0	+3.0
1	0	0	0	0	1	+2.8
2	0	0	0	1	0	+2.6
3	0	0	0	1	1	+2.4
4	0	0	1	0	0	+2.2
5	0	0	1	0	1	+2.0
6	0	0	1	1	0	+1.8
7	0	0	1	1	1	+1.6
8	0	1	0	0	0	+1.4
9	0	1	0	0	1	+1.2
10	0	1	0	1	0	+1.0
11	0	1	0	1	1	+0.8
12	0	1	1	0	0	+0.6
13	0	1	1	0	1	+0.4
14	0	1	1	1	0	+0.2
15	0	1	1	1	1	0
16	1	0	0	0	0	−0.2
17	1	0	0	0	1	−0.4
18	1	0	0	1	0	−0.6
19	1	0	0	1	1	−0.8
20	1	0	1	0	0	−1.0
21	1	0	1	0	1	−1.2
22	1	0	1	1	0	−1.4
23	1	0	1	1	1	−1.6
24	1	1	0	0	0	−1.8
25	1	1	0	0	1	−2.0
26	1	1	0	1	0	−2.2
27	1	1	0	1	1	−2.4
28	1	1	1	0	0	−2.6
29	1	1	1	0	1	−2.8
30	1	1	1	1	0	−3.0
31	1	1	1	1	1	−3.2

This programming allows calibration of the center frequency of the VCO within the FM PLL to align the frequency as close as possible to the nominal 10.7 MHz frequency.

8.2 Data register 1

Table 11. Data register 1 (address 001h) bit description

*Legend: * reset value.*

Bit	Symbol	Value	Description
15 to 10	RX_PRE[5:0]	-	**RX prescaler**
9 to 0	RX_MDIV[9:0]	-	**RX main divider**

8.3 Data register 2

Table 12. Data register 2 (address 010h) bit description

*Legend: * reset value.*

Bit	Symbol	Value	Description
15 to 10	reserved	00 0000*	undefined; must always be set logic 0
9 to 0	REF_DIV[9:0]	-	**Reference divider**

8.4 Data register 3

Table 13. Data register 3 (address 011h) bit description

*Legend: * reset value.*

Bit	Symbol	Value	Description
15 to 10	TX_PRE[5:0]	-	**TX prescaler**
9 to 0	TX_MDIV[9:0]	-	**TX main divider**

8.5 Data register 4

Table 14. Data register 4 (address 100h) bit description

*Legend: * reset value.*

Bit	Symbol	Value	Description
15	TM2	0*	**Test mode selection.** Test mode bits are only used for test in production and application tuning. Those bits have to be set to logic 0 for normal operation. See Table 22.
14	CLKO	0*	**Clock output drive**. Depending on the microcontroller clock frequency and clock capacitive load, the output CLKO can be programmed to optimize current consumption. The clock output level is 1.5 V (p-p). Output CLKO is AC-coupled with pin XTALI of the microcontroller. The external resonator from the microcontroller is then removed.
		0*	10 MHz at 10 pF
		1	10 MHz at 5 pF (or 5 MHz at 10 pF)
13	TM1	0*	**Test mode selection.** Test mode bits are only used for test in production and application tuning. Those bits have to be set to logic 0 for normal operation. See Table 22.

Table 14. Data register 4 (address 100h) bit description *...continued*

*Legend: * reset value.*

Bit	Symbol	Value	Description
12	DOUBLER		**Voltage doubler.** The minimum supply voltage for the IC is 2.9 V which limits the voltage swing on both charge pumps to approximately 2.3 V. Using the voltage doubler or an external high supply voltage on pin VCP, allows the increased voltage range to enhance the tuning range of the VCO varicaps. To save current in Inactive mode, the voltage doubler clock frequency is the same as the CLKO clock (can be programmed to XTAL / 128); in Active mode, the voltage doubler clock is XTALI / 2.
		0*	doubler inactive
		1	doubler active
11 to 7	TX_GAIN[4:0]		**TX gain setting**
		01 1111*	for values, see Table 9
6	TX_MU		**TX channel mute**
		0	not muted (normal operation)
		1*	muted
5	HD_LIM		**Hard limiter**
		0*	disable
		1	enable
5	ALC		**Automatic level control**
		0*	enable (normal operation)
		1	disable
3	XTAL		**Crystal oscillator**
		0	on
		1*	off
2	RX_MU		**RX channel mute**
		0	not muted (normal operation)
		1*	muted
1	DEM_FIL		**Demodulator filter.** An internal programmable filter limits the demodulator bandwidth. The –3 dB cut-off frequency is selected with this bit. The wider bandwidth provides a solution for audio and sub-audio digital applications.
		0*	7 kHz
		1	100 kHz
0	reserved	0*	undefined, must always be set to logic 0

8.6 Data register 5

Table 15. Data register 5 (address 101h) bit description

*Legend: * reset value.*

Bit	Symbol	Value	Description
15	REG		**Internal voltage regulator**
		0	disable and tied to supply voltage V_{CC} (in Inactive mode)
		1*	enable
14	MODE[1:0]		**Active mode selection.** See details in Table 4 “Activated blocks”.
		00*	Inactive mode
		01	Inactive mode
		10	RX mode
		11	Active mode
13	XTAL_H		**Crystal high current.** In Inactive mode, the crystal oscillator is a major contributor to the full current consumption.
		0	save current operation yields a full current consumption in Inactive mode at 230 μA; see details in Section 7.1.3 “Control bits in power saving modes”
		1*	crystal oscillator current is increased by 100 μA
11 to 7	CAR_DET_LEV[4:0]		**Carrier detection threshold programming**. When bit BAT_DET = 0, the carrier detector is enabled and the signal *Carrier detection* is routed to the output pin CDLBD. If RSSI is above the programmed RSSI level, pin CDLBD = LOW; if not then pin CDLBD = HIGH. The carrier detector gives an indication if a carrier signal is present on the selected channel. The nominal value and tolerance of the carrier detection threshold is given in the carrier detector specification. If a different carrier detection threshold value is desired, it can be programmed through the microcontroller interface. To scale the carrier detection range, connect an external resistor from pin RSSI to ground. The value 1 0011 corresponds to RSSI = 0.86 V (typical DC value).
		0 0000*	For values, see Table 16
6 to 4	L_BAT_DET[2:0]		**Low battery detector voltage**. When bit BAT_DET = 1, the low battery detector is enabled and the signal *BDout* is routed to the output pin CDLBD. If the supply voltage is below the programmed level, pin CDLBD = LOW and if not, pin CDLBD = V_{CC}.
		000*	3.5 V
		001	3.4 V
		010	3.3 V
		011	3.2 V
		100	3.1 V
		101	3.0 V
		110*	2.9 V
		111	2.8 V

Table 15. Data register 5 (address 101h) bit description *...continued*

*Legend: * reset value.*

Bit	Symbol	Value	Description
3	BAT_DET		**Battery detection**
		0	disable
		1*	enable
2 to 0	CLK_DIV[2:0]		**Clock output divider.** The *Clockout* signal is derived from the crystal oscillator and is used to drive a microcontroller (bit CLKO). The crystal signal is divided down with a programmable divider value. To supply the clock to the microcontroller and save current in the handset, an external low power resonator may be used and with the clock output disable (bits CLK_DIV[2:0] = 000) as well as the crystal oscillator not active (bit XTAL = 1). In Power-saving mode, the divider ratio is programmed down to 128 to reduce the microcontroller power consumption.
		100*	for values, see Table 17

Table 16. Carrier detection

Select	CAR_DET_LEV[4:0]					RSSI threshold detection voltage (V)
	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
0	0	0	0	0	0	0.1
1	0	0	0	0	1	0.14
2	0	0	0	1	0	0.18
3	0	0	0	1	1	0.22
4	0	0	1	0	0	0.26
5	0	0	1	0	1	0.3
6	0	0	1	1	0	0.34
7	0	0	1	1	1	0.38
8	0	1	0	0	0	0.42
9	0	1	0	0	1	0.46
10	0	1	0	1	0	0.5
11	0	1	0	1	1	0.54
12	0	1	1	0	0	0.58
13	0	1	1	0	1	0.62
14	0	1	1	1	0	0.66
15	0	1	1	1	1	0.7
16	1	0	0	0	0	0.74
17	1	0	0	0	1	0.78
18	1	0	0	1	0	0.82
19	1	0	0	1	1	0.86
20	1	0	1	0	0	0.9
21	1	0	1	0	1	0.94
22	1	0	1	1	0	0.98
23	1	0	1	1	1	1.02

Table 16. Carrier detection *…continued*

Select	CAR_DET_LEV[4:0]					RSSI threshold detection voltage (V)
	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
24	1	1	0	0	0	1.06
25	1	1	0	0	1	1.1
26	1	1	0	1	0	1.14
27	1	1	0	1	1	1.18
28	1	1	1	0	0	1.22
29	1	1	1	0	1	1.26
30	1	1	1	1	0	1.3
31	1	1	1	1	1	1.34

Table 17. Clock output divider

Select	CLK_DIV[2:0]			Clock divider ratio
	Bit 2	Bit 1	Bit 0	
1	0	0	0	output disable
2	0	0	1	2
3	0	1	0	2.5
4	0	1	1	4
5	1	0	0	1
6	1	1	1	128

8.7 Data register 6

Table 18. Data register 6 (address 110h) bit description

*Legend: * reset value.*

Bit	Symbol	Value	Description
15 to 13	PA_OUT[2:0]		**Power amplifier output level.** The power amplifier uses 2 bits to modify the output power. The PA is disabled for value 000. Duplexer matching from 300 Ω to 50 Ω is implemented with a parallel inductor and series C network. To get the power at the antenna, the duplexer insertion loss should be subtracted. At maximum power, the DC current consumption is increased by 3 mA over the minimum power current consumption.
		010*	The output power for a 50 Ω termination is specified in Table 20.
12	TX_CP		**TX charge pump current**. The performance of the PLL can be improved by increasing charge pump current.
		0*	400 µA
		1	800 µA
11	RX_CP		**RX charge pump current**. The performance of the PLL can be improved by increasing charge pump current.
		0*	400 µA
		1	800 µA

Table 18. Data register 6 (address 110h) bit description *...continued*

*Legend: * reset value.*

Bit	Symbol	Value	Description
10 to 8	REG_ADJ[2:0]		**Voltage regulator adjustment.** An internal 1.5 V band gap voltage reference provides the voltage reference for the low battery detector circuits, the VREG regulator voltage, the VB reference voltage and all internal analog references. In Inactive mode, the adjustment is disabled.
		011*	for values, see Table 21
7 to 6	EXP[1:0]		**Expander noise level control.** Depending on the application noise floor specification, a noise level control can be applied.
		00*	expander disabled
		11	expander maximum value
5	TM0	0*	**Test mode selection.** Test mode bits are only used for test in production and application tuning. Those bits have to be set to logic 0 for normal operation. See Table 22.
4	reserved	0*	undefined; must always be set to logic 0
3 to 0	XTAL_TUN[3:0]		**Crystal tuning capacitors.** An on-chip crystal reference tuning is provided to compensate for frequency spread over process and temperature. The value of the external capacitor on pin XTALI is chosen to be around 3 pF lower than on pin XTALO. Internally, a programmable capacitance is in parallel with pin XTALI. Tuning capacitance values are in the range of 0 pF to 4.5 pF.
		0111*	for values, see Table 19

Table 19. Crystal tuning capacitance

Select	XTAL_TUN[3:0]				Capacitance (pF)
	Bit 3	Bit 2	Bit 1	Bit 0	
0	0	0	0	0	0.2
1	0	0	0	1	0.5
2	0	0	1	0	0.8
3	0	0	1	1	1.1
4	0	1	0	0	1.4
5	0	1	0	1	1.7
6	0	1	1	0	2.0
7	0	1	1	1	2.3
8	1	0	0	0	2.6
9	1	0	0	1	2.9
10	1	0	1	0	3.2
11	1	0	1	1	3.5
12	1	1	0	0	3.8
13	1	1	0	1	4.1
14	1	1	1	0	4.4
15	1	1	1	1	4.7

Table 20. Power amplifier output

Select	PA_OUT[2:0]			Power amplifier			
	Bit 2	Bit 1	Bit 0	Output power (dBm)	Second harmonic (dBm)	Third harmonic (dBm)	Fourth harmonic (dBm)
-	0	X	X	PA inactive	-	-	-
0	1	0	0	1.0	–17	–27	–34
1	1	0	1	1.9	–19	–29	–34
2	1	1	0	2.5	–23	–33	–36
3	1	1	1	3.0	–26	–36	–40

Table 21. Voltage reference adjust

Select	REG_ADJ[2:0]			Nominal voltage reference
	Bit 2	Bit 1	Bit 0	
0	0	0	0	–7 %
1	0	0	1	–5 %
2	0	1	0	–3 %
3	0	1	1	–1 %
4	1	0	0	+1 %
5	1	0	1	+3 %
6	1	1	0	+5 %
7	1	1	1	+7 %

Table 22. Test mode

TM2	TM1	TM0	Select
0	0	0	normal operation
0	0	1	up or down RX
0	1	0	up or down TX
0	1	1	up or down RX or TX
1	0	0	reference divider output divided by 2
1	0	1	prescaler and main divider RX divided by 2
1	1	0	prescaler and main divider TX divided by 2
1	1	1	double synthesizers charge pump are in 3-state

Out-of-lock of synthesizers RX or TX can be indirectly monitored on pin CDLBD: the width of the ‘glitch’ gives a direct measure of the phase error on the PLL RX and/or PLL TX.

To tune the external RX and TX VCO inductors, a defined divider ratio has to be programmed on the dividers, and then the image of the VCO frequency can be read on pin CDLBD.

It can also be used to check the divider ratio: force a frequency on VCO or crystal pins and read the programmed frequency on pin CDLBD.

Before pin CDLBD, there is a divide-by-2, then all frequencies are divided by 2. When charge pumps are in 3-state, the VCOs can be measured in stand-alone.

9. Limiting values

Table 23. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage		–0.3	+6.0	V
T_{stg}	storage temperature		–55	+125	°C

10. Thermal characteristics

Table 24. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	68	K/W

11. Characteristics

Table 25. Supplies

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage		2.9	3.3	5.5	V
T_{amb}	ambient temperature		–40	+25	+85	°C

Table 26. Receiver part

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Low noise amplifier and image reject mixer (f_o = 903 MHz)							
Input: pins RFIX and RFIY							
$R_{i(RF)}$	RF input resistance	real part of the parallel input impedance; balanced; indicative value		-	110	-	Ω
$C_{i(RF)}$	RF input capacitance	imaginary part of the parallel input impedance; balanced; indicative value		-	0.7	-	pF
$f_{i(RF)}$	RF input frequency			902	903	928	MHz
LNA							
$\lvert s_{11(RF)}\rvert^2$	RF input return loss		[1]	10	-	-	dB
$G_{p(conv)}$	conversion power gain	from balun input to pin MIXO matched to 330 Ω		-	22	-	dB
ICP_{1dB}	1 dB input compression point		[1]	-	–23	-	dBm
IP3	third-order intercept point			-	–13	-	dBm
NF	noise figure	overall RF front-end (does not include the IF section)		-	4	5	dB
$\alpha_{f(image)}$	image frequency rejection	in band of interest		26	45	-	dB

Table 26. Receiver part *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Output: pin MIXO							
R_L	load resistance	indicative value of IF resistive output load		-	330	-	Ω
C_L	load capacitance	indicative value of IF capacitive output load		-	-	3	pF
IF amplifier section (f_o = 10.7 MHz)							
G	gain	SFS = 0	[2]	-	43	-	dB
		SFS = 1; measured at amplifier output	[2]				
		first IF amplifier		-	22.5	-	dB
		second IF amplifier		-	25	-	dB
NF	noise figure	IF amplifier		-	7.5	-	dB
		first IF amplifier	[2]	-	7	-	dB
		second IF amplifier	[2]	-	14	-	dB
PLL demodulator (f_o = 10.7 MHz; Δf = ±25 kHz; f_{mod} = 1 kHz)							
$B_{-3dB(demod)}$	demodulator −3 dB bandwidth	DEM_FIL = 0; loop filter: 4.7 kΩ, 1.8 nF and 150 pF		-	7	-	kHz
		DEM_FIL =1; loop filter: 15 kΩ, 150 pF and 12 pF		-	100	-	kHz
VCO							
f_{VCO}	VCO frequency	VCO center frequency (free running); open loop; all conditions		7.0	10.7	15.0	MHz
Δf	frequency deviation			-	-	±75	kHz
$\Delta f_{VCO}/\Delta V_{VCO}$	VCO frequency change to VCO voltage change ratio	after calibration		-	760	-	kHz/V
$f_{VCO(step)}$	VCO frequency step			-	200	-	kHz
$N_{step(f\_VCO)}$	number of VCO frequency steps			-	32	-	
Output: pin DETO							
R_L	load resistance			5	-	-	kΩ
$V_{o(RMS)}$	RMS output voltage	TX mode; R_L = 10 kΩ; amplifier gain G = 10	[3]	-	100	350	mV
V_O	output voltage	adjust with microcontroller		1.2	1.4	1.6	V

Table 26. Receiver part *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
FM receiver system characteristics						
Conditions: f_o = 903 MHz; Δf = ±25 kHz; f_{mod} = 1 kHz; DEM_F = 0; pin EARO: R_L = 150 Ω in series with 10 µF (all with ITU-T filter)						
S_{RX}	receiver sensitivity	measured at antenna with 3 dB duplexer insertion loss; B = 100 kHz				
		RX mode; input level for 9 dB SINAD	-	–115	-	dBm
		TX mode; PA = 10; V_{EARO} = 200 mV (RMS); minimum TX-to-RX duplexer isolation = 35 dB	-	–113.5	-	dBm
S/N	signal-to-noise ratio	$V_{i(RF)}$ = –80 dBm and –40 dBm; TX mode; PA_OUT[2:0] = 10; CLKO off; V_{EARO} = 200 mV (RMS)	25	38	-	dB
THD	total harmonic distortion	at Δf = ±60 kHz (without ITU-T filter); $V_{i(RF)}$ = –80 dBm and –40 dBm; TX mode; PA_OUT[2:0] = 10; CLKO off; V_{EARO} = 500 mV (RMS)	-	0.6	2	%
RSSI or carrier detection: V_{VB} = 1.5 V						
$I_{o(dyn)}$	dynamic output current	on pin RSSI	-	68	-	dB
$N_{step(th)(cd)}$	number of carrier detect threshold steps	programmable through microcontroller	-	32	-	
V_{det}	detection voltage		0.05	-	1.6	V
V_{hys}	hysteresis voltage		-	45	-	mV
$V_{det(step)}$	detection voltage step		-	40	-	mV
Output: pin RSSI						
R_{int}	internal resistance	measured between pin RSSI and V_{CC}	-	175	-	kΩ
Output: pin CDLBD						
V_{OH}	HIGH-level output voltage	$V_{i(limiter)}$ = 0 mV (RMS); RSSI threshold level = 0.86 V	$0.9V_{CC}$	-	-	V
V_{OL}	LOW-level output voltage	$V_{i(limiter)}$ = 100 mV (RMS); RSSI threshold level = 0.86 V	-	-	$0.1V_{CC}$	V
Data comparator						
Input: pin DATAI						
$V_{i(p-p)}$	peak-to-peak input voltage		100	-	-	mV
$V_{hys(i)}$	input hysteresis voltage		25	40	75	mV
V_{th}	threshold voltage		-	V_{CC} – 0.9	-	V
Z_i	input impedance		150	240	-	kΩ
Output: pin DATAO						
V_{OH}	HIGH-level output voltage	$V_{DATAI} = V_{CC} – 1.4$ V	$0.9V_{CC}$	-	-	V

Table 26. Receiver part *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{OL}	LOW-level output voltage	$V_{DATAI} = V_{CC} - 0.4$ V		-	-	$0.1V_{CC}$	V
$I_{O(sink)}$	output sink current	$V_{DATAI} = V_{CC} - 0.4$ V; $V_{DATAO} = 0.1V_{CC}$		-	50	-	µA
RX voltage controlled oscillator							
f_{VCO}	VCO frequency	free running	[1]	-	910	-	MHz
$\Delta f_{VCO}/\Delta V_{VCO}$	VCO frequency change to VCO voltage change ratio	L_{ext} = 4.7 nH at 890 MHz; L_{ext} = 3.9 nH at 935 MHz; control voltage					
		V_{RXLF} = 0.5 V		-	50	-	MHz/V
		V_{RXLF} = 1.5 V		-	30	-	MHz/V
φ_n	phase noise	indicative value (cannot be directly measured	[4]				
		f_{offset} = 1 kHz		-	–58	-	dBc/Hz
		f_{offset} = 10 kHz		-	–82	-	dBc/Hz
		f_{offset} = 100 kHz		-	–102	-	dBc/Hz
Q_{min}	minimum quality factor	external inductor quality factor at 920 MHz; L_{ext} = 3.9 nH		30	-	-	

[1] This specification will be measured and guaranteed only on the NXP Semiconductors SA58646 board.

[2] 330 Ω matched input and output.

[3] The level on pin RXAI will be higher in RX mode than in TX mode.

[4] Conditions: carrier = 892.3 MHz; L_{ext} = 4.7 nH (3.9 nH for 935 MHz operation); loop filter: C1 = 3.9 nF; R2 = 6.8 kΩ; C2 = 47 nF (see application note).

Table 27. Transmitter part

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Summator amplifier							
Input: pin MODI							
V_{bias}	bias voltage			-	2.2	-	V
Output: pin MODO							
$V_{o(p-p)}$	peak-to-peak output voltage			-	94	240	mV
R_{fbck}	feedback resistance	between pins MODI and MODO		10	-	-	kΩ
TX voltage controlled oscillator							
f_{VCO}	VCO frequency	free running	[1]	-	910	-	MHz
$\Delta f_{VCO}/\Delta V_{VCO}$	VCO frequency change to VCO voltage change ratio	control voltage					
		V_{TXLF} = 0.5 V		-	50	-	MHz/V
		V_{TXLF} = 1.5 V		-	25	-	MHz/V
		modulation voltage					
		V_{MODO} = 2.2 V		-	530	-	kHz/V

Table 27. Transmitter part *…continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
φ_n	phase noise	VCO TX plus PA; output power at 0 dB	[2]				
		f_{offset} = 20 MHz		–139	–150	-	dBc/Hz
		f_{offset} = 10 kHz		-	–85	-	dBc/Hz
		f_{offset} = 1 kHz		-	–60	-	dBc/Hz
Q_{min}	minimum quality factor	external inductor quality factor at 902 MHz to 928 MHz; L_{ext} = 3.9 nH		30	-	-	
Power amplifier							
P_o	output power	subtract duplexer insertion loss to get power on antenna; see Table 20	[3]	-	3	-	dBm
ΔP_o	output power variation	see Table 20	[3]	-	2	-	dB
$N_{step(G\_adj)}$	number of gain adjustment steps	software control		-	4	-	
Transmit system							
THD	total harmonic distortion	measured after demodulation; V_{MODO} for demodulated Δf = ±60 kHz; measured with ITU-T filter		-	1	2	%
P_{sp}	spurious output power	RX VCO spurious emission on PA output versus output power	[1]	-	–45	-	dBc

[1] This specification will be measured and guaranteed only on the NXP Semiconductors SA58646 board.

[2] TX-to-RX duplexer isolation = 35 dB; carrier = 925.6 MHz; L_{ext} = 3.9 nH (for both base and handset); loop filter: C1 = 470 nF, R2 = 1.8 kΩ and C2 = 4.7 µF (see application note).

[3] Load: R = 50 Ω; L_p = 22 nH; C_s = 1.6 pF.

Table 28. Synthesizer

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Crystal oscillator; external capacitors on pins XTALO = 8.2 pF and XTALI = 5.6 pF (indicative)						
f_{xtal}	crystal frequency	reference input frequency	4	10.24	20	MHz
$C_{i(XTALI)}$	input capacitance on pin XTALI	indicative; XTAL_TUN[3:0] = 8	-	4	-	pF
$C_{i(XTALO)}$	input capacitance on pin XTALO	indicative	-	1.5	-	pF
$C_{tune(xtal)}$	crystal tuning capacitance	on pin XTALI	-	4.5	-	pF
$N_{step(C\_tune)}$	number of tuning capacitance steps	XTAL_TUN[3:0]	-	16	-	
Clock divider						
D/D_{clk}	clock divider ratio	CLK_DIV[2:0]	1	-	128	
t_{sw}	switching time	from one frequency f1 to frequency f2	-	2 / f2	-	s
Output: pin CLKO						
C_L	load capacitance	external load	-	-	20	pF

Table 28. Synthesizer *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{o(p-p)}$	peak-to-peak output voltage	CLKO = 1; 10 MHz at 5 pF (or 5 MHz at 10 pF)	-	1.5	-	V
		CLKO = 0; 10 MHz at 10 pF	-	1.5	-	V
10-bit reference divider						
D/D_{ref}	reference divider ratio	REF_DIV[9:0]	8	-	1023	
TX and RX prescaler and main dividers						
$f_{i(RF)}$	RF input frequency		902	903	928	MHz
D/D_{main}	main divider ratio	RX_MDIV[9:0]; TX_MDIV[9:0]	8	-	1023	
D/D_{ps}	prescaler divider ratio	RX_PRE[5:0]; TX_PRE[5:0]	64	-	127	
RX and TX charge pump: pins RXPD and TXPD						
$I_{o(cp)}$	charge pump output current	RX_CP = 0; TX_CP = 0	-	±400	-	µA
		RX_CP = 1; TX_CP = 1	-	±800	-	µA
C_o	output capacitance		-	-	8	pF
Voltage doubler						
$V_{O(VCP)}$	output voltage on pin VCP	DOUBLER = 1; V_{CC} = 3 V	-	5.2	-	V

Table 29. RX baseband

V_{CC} = 3.3 V; T_{amb} = 25 °C; see Figure 6.

V_{VB} = 1.5 V; f_i = 1 kHz; RX gain set for 0 dB gain at −20 dBV on pin RXAI; earpiece volume at +4.7 dB; 560 pF between pins EARI and EARO; 150 Ω in series with 10 µF on pin EARO; all measured with a ITU-T filter except THD; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
RX audio path: RX gain adjust, mute and expander							
THD	total harmonic distortion	V_{RXAI} = −20 dBV		-	0.2	2	%
NF_M	peak noise figure	B = 300 Hz to 3.4 kHz		-	−83	-	dBV
Input: pin RXAI							
$V_{i(max)}$	maximum input voltage	THD < 4 %		-	13	-	dBV
Z_i	input impedance	in TX mode	[1]	-	15	-	kΩ
		in RX mode	[1]	100	-	-	kΩ
RX audio gain adjust							
ΔG_{adj}	gain adjustment range	RX_GAIN[4:0]					
		on RX gain amplifier		−7.5	-	+8	dB
		on pin EARO		−15	-	+16	dB
$N_{step(G\_adj)}$	number of gain adjustment steps			-	32	-	
α_{mute}	mute attenuation	V_{RXAI} = −20 dBV		-	−70	−60	dB
Expander							
G_{expdr}	expander gain	V_{RXAI} = −20 dBV		−1	0	+1	dB

Table 29. RX baseband *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; see Figure 6.
V_{VB} = 1.5 V; f_i = 1 kHz; RX gain set for 0 dB gain at −20 dBV on pin RXAI; earpiece volume at +4.7 dB; 560 pF between pins EARI and EARO; 150 Ω in series with 10 µF on pin EARO; all measured with a ITU-T filter except THD; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ΔG_{expdr}	expander gain change	referenced to V_{RXAI} = −20 dBV with RX baseband audio noise tuning [2]				
		V_{RXAI} = −30 dBV	−24	−20	−18	dB
		V_{RXAI} = −35 dBV	−37	−30	−26	dB
		V_{RXAI} = −45 dBV	-	−47	−45	dB
$t_{att(expdr)}$	expander attack time	C_{ECAP} = 0.47 µF	-	2.0	-	ms
$t_{rel(expdr)}$	expander release time	C_{ECAP} = 0.47 µF	-	5.0	-	ms
$\alpha_{ct(compr-expdr)}$	compressor to expander crosstalk attenuation	from pins CMPI to EARO; V_{CMPI} = −20 dBV; V_{RXAI} = 0 V (RMS)	-	80	-	dB
$V_{o(max)}$	maximum output voltage	indicative value; THD < 4 %	-	−7	-	dBV
Earpiece amplifier						
$G_{ctrl(dyn)}$	dynamic gain control		13	14	15	dB
G_{ctrl}	gain control	no external resistor or capacitor used				
		EARP_VOL[1:0] = 00	−1	0	+1	dB
		EARP_VOL[1:0] = 01	3.7	4.7	5.7	dB
		EARP_VOL[1:0] = 10	8.3	9.3	10.3	dB
		EARP_VOL[1:0] = 11	13	14	15	dB
Output: pin EARO						
$V_{o(p-p)}$	peak-to-peak output voltage	THD < 4 %	-	2.2	-	V
R_L	load resistance	to keep amplifier stability; R_L in series with 10 µF	-	150	100000	Ω

[1] Pin RXAI level will be higher in RX mode than in TX mode.

[2] With expander output noise level control tuned for −65 dBV (max) and maximum gain tolerance of −4 dB at −35 dBV. With a larger gain tolerance at −35 dBV, the typical output noise can be reduced by 10 dB. See application note.

Table 30. TX baseband

V_{CC} = 3.3 V; T_{amb} = 25 °C; see Figure 8.
V_{VB} = 1.5 V; f_i = 1 kHz; TX gain set for +10 dB gain at −30 dBV on pin CMPI; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Microphone amplifier						
G	gain		0	-	34	dB
Output: pin MICO						
$V_{o(max)}$	maximum output voltage	R_L = 10 kΩ; THD < 0.2 %	−12	-	-	dBV
Input: pin CMPI						
Z_i	input impedance		-	15	-	kΩ
Compressor						
G	gain	V_{CMPI} = −30 dBV; ALC off; hard limiter enabled	9	10	11	dB

Table 30. TX baseband *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; see Figure 8.
V_{VB} = 1.5 V; f_i = 1 kHz; TX gain set for +10 dB gain at –30 dBV on pin CMPI; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ΔG	gain deviation	referenced to V_{CMPI} = –30 dBV				
		V_{CMPI} = –10 dBV	8	10	12	dB
		V_{CMPI} = –50 dBV	–14	–10	–8	dB
G_{max}	maximum gain	V_{CMPI} = –70 dBV	-	23	-	dB
THD	total harmonic distortion	V_{CMPI} = –10 dBV; ALC off	-	0.5	2	%
$t_{att(compr)}$	compressor attack time	C_{CCAP} = 0.47 µF	-	4.0	-	ms
$t_{rel(compr)}$	compressor release time	C_{CCAP} = 0.47 µF	-	8.0	-	ms
Hard limiter						
$V_{o(p-p)}$	peak-to-peak output voltage	V_{CMPI} = –4 dBV; ALC off; hard limiter enabled	-	1.26	-	V
TX mute						
α_{mute}	mute attenuation	V_{CMPI} = –10 dBV; ALC off	-	–70	–60	dB
TX gain adjust						
ΔG_{adj}	gain adjustment range	RX_GAIN[4:0]	–7.5	-	+8	dB
$N_{step(G\_adj)}$	number of gain adjustment steps		-	32	-	
Output: pin TXO						
$\alpha_{ct(expdr-compr)}$	expander to compressor crosstalk attenuation	from pins RXAI to TXO; V_{RXAI} = –10 dBV; V_{CMPI} = 0 V (RMS)	-	65	-	dB
Z_o	output impedance		-	500	-	Ω
$V_{o(max)}$	maximum output voltage	ALC on				
		V_{CMPI} = –12 dBV	-	–12.5	-	dBV
		V_{CMPI} = –10 dBV	-	–12.3	-	dBV
		V_{CMPI} = –2.5 dBV	-	–11.5	-	dBV

Table 31. Other features

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
PLL voltage regulator: pin VREG							
V_O	output voltage	voltage regulator disabled		-	V_{CC}	-	V
		voltage regulator enabled					
		before V_{ref} adjustment or in Inactive mode		2.5	2.7	2.9	V
		after V_{ref} adjustment		2.65	2.7	2.75	V
I_O	output current	C_{VREG} = 1 µF		-	-	3	mA
Low battery detector: battery detection enabled							
V_{det}	detection voltage	L_BAT_DET[2:0]		2.8	-	3.5	V
V_{hys}	hysteresis voltage		[1]	-	18	-	mV
$N_{step(V\_det)}$	number of detection voltage steps			-	8	-	

Table 31. Other features *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{CC}/V_{CC}$	supply voltage variation to supply voltage ratio	battery voltage detection accuracy after V_{ref} adjust; L_BAT_DET[2:0] = 010 (V_{CC} = 3 V)	-	0.5	5	%
Output: pin CDLBD						
I_{OL}	LOW-level output current		20	-	-	mA
V_{OL}	LOW-level output voltage	R_L = 470 kΩ	-	-	$0.1V_{CC}$	V
V_{OH}	HIGH-level output voltage	R_L = 470 kΩ	$0.9V_{CC}$	-	-	V

[1] $V_{hys} = (V_{high} - V_{low}) \times \frac{V_{VB}}{V_{th}}$

Table 32. Microcontroller serial interface

V_{CC} = 3.3 V; T_{amb} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input and output: pins DATA, CLK and EN						
V_{IL}	LOW-level input voltage		-	-	0.5	V
V_{IH}	HIGH-level input voltage		V_{VREG} / 1.5	-	V_{CC}	V
I_{IL}	LOW-level input current	V_{IL} = 0.3 V	–5	-	-	mA
I_{IH}	HIGH-level input current	$V_{IH} = V_{VREG} - 0.3$ V	-	-	5	mA
C_i	input capacitance		-	-	8	pF
Timing (see Figure 10)						
$t_{su(CLK-EN)}$	CLK to EN set-up time	50 % of signals	50	-	-	ns
$t_{su(DATA-CLK)}$	DATA to CLK set-up time	50 % of signals	50	-	-	ns
$t_{h(EN-CLK)}$	EN to CLK hold time	50 % of signals	50	-	-	ns
f_{clk}	clock frequency		-	-	3	MHz
$t_{r(i)}$	input rise time	at 10 % to 90 % on pins DATA, CLK and EN;	-	-	50	ns
$t_{f(i)}$	input fall time	at 10 % to 90 % on pins DATA, CLK and EN;	-	-	50	ns
$t_{h(CLK-EN)}$	CLK to EN hold time	at end of word	100	-	-	ns
$t_{w(EN)}$	pulse width on pin EN	[1]	1 / f_{comp}	-	-	ns
$t_{startup(MCU)}$	MCU start-up time	90 % of V_{VREG} to pins DATA, CLK and EN	-	-	200	µs

[1] The minimum pulse width $t_{w(EN)}$ should be equal to the period time of the comparison frequency. The synthesizer ensures that the internal EN signal does not occur during a comparison phase to avoid any phase error jump. This time can be reduced to 100 ns for:

a) Clock divider programming

b) Synthesizer programming: only for words which do not influence the synthesizer (word 1, 2, 3)

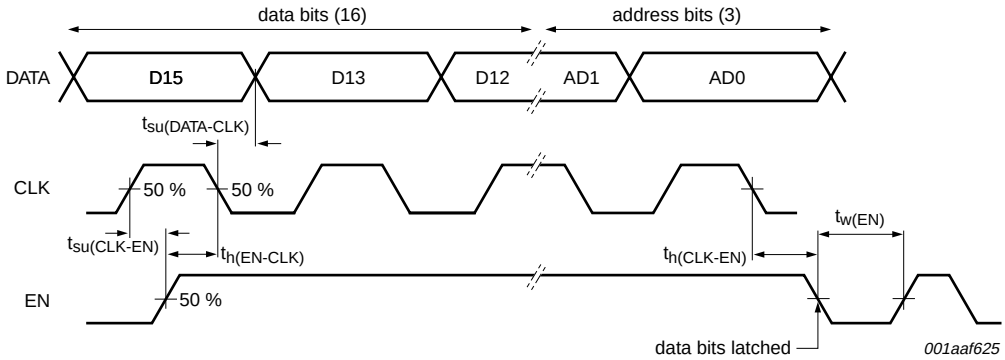


Fig 10. Digital signal timing

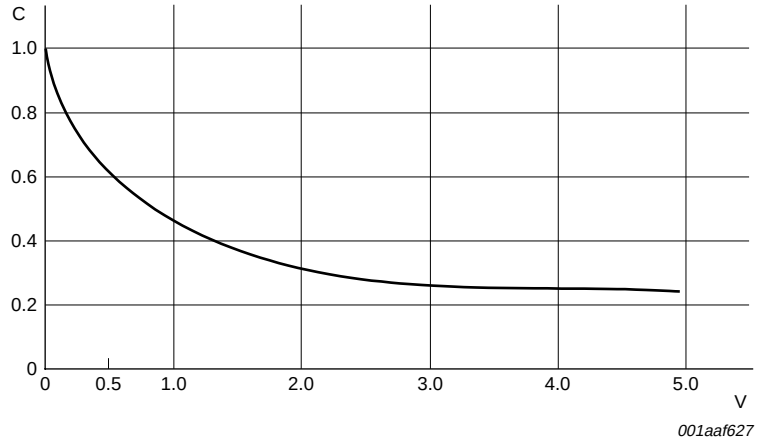
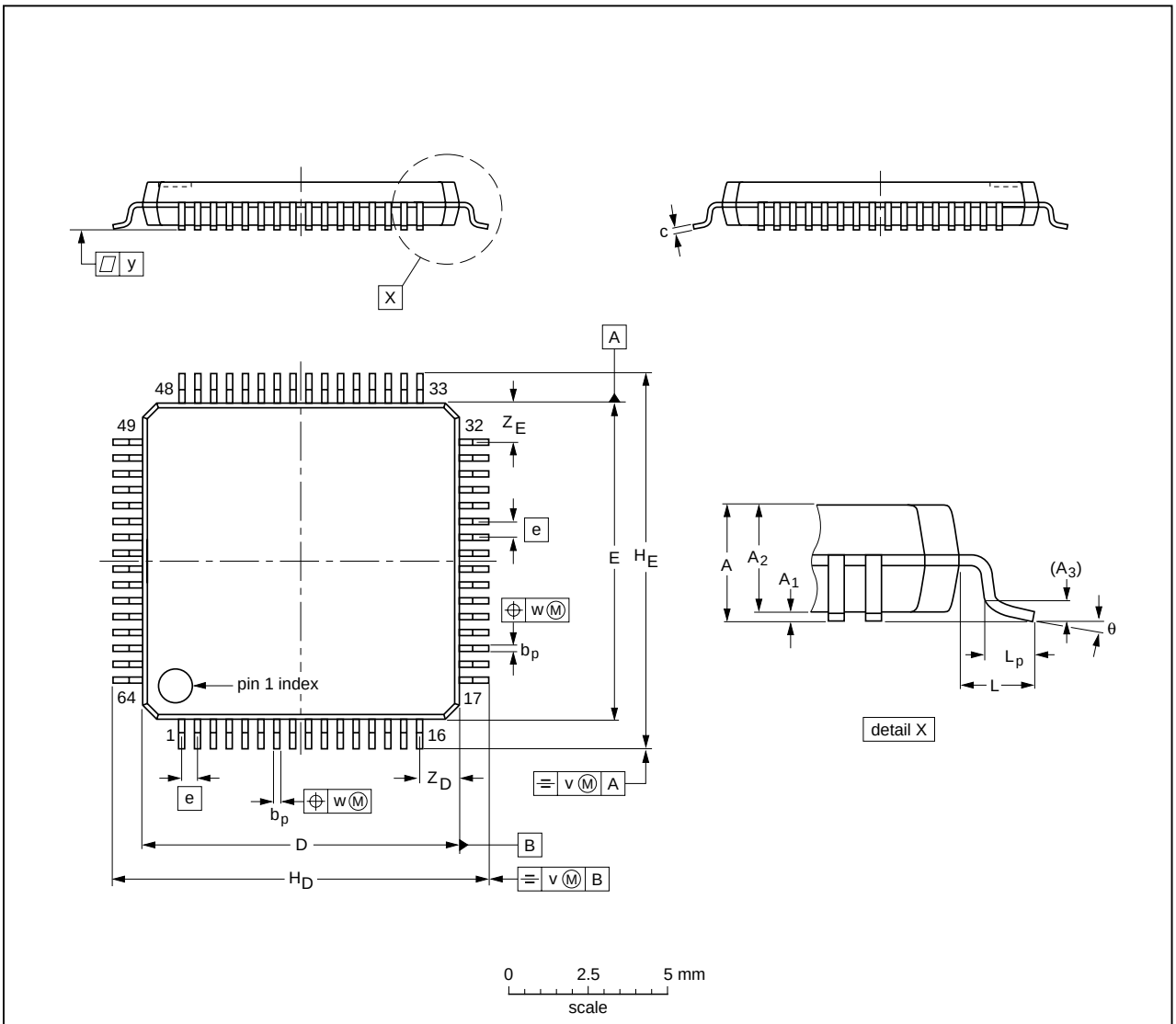


Fig 11. Varicap behavior

12. Package outline

LQFP64: plastic low profile quad flat package; 64 leads; body 10 x 10 x 1.4 mm **SOT314-2**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_D	H_E	L	L_p	v	w	y	$Z_D^{(1)}$	$Z_E^{(1)}$	θ
mm	1.6	0.20 0.05	1.45 1.35	0.25	0.27 0.17	0.18 0.12	10.1 9.9	10.1 9.9	0.5	12.15 11.85	12.15 11.85	1	0.75 0.45	0.2	0.12	0.1	1.45 1.05	1.45 1.05	7^o 0^o

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT314-2	136E10	MS-026				~~00-01-19~~ 03-02-25

Fig 12. Package outline SOT314-2 (LQFP64))

13. Handling information

Inputs and outputs are protected against electrostatic discharge in normal handling. However, to be completely safe you must take normal precautions appropriate to handling integrated circuits.

14. Soldering

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

14.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

14.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus PbSn soldering

14.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

14.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see Figure 13) than a PbSn process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with Table 33 and 34

Table 33. SnPb eutectic process (from J-STD-020C)

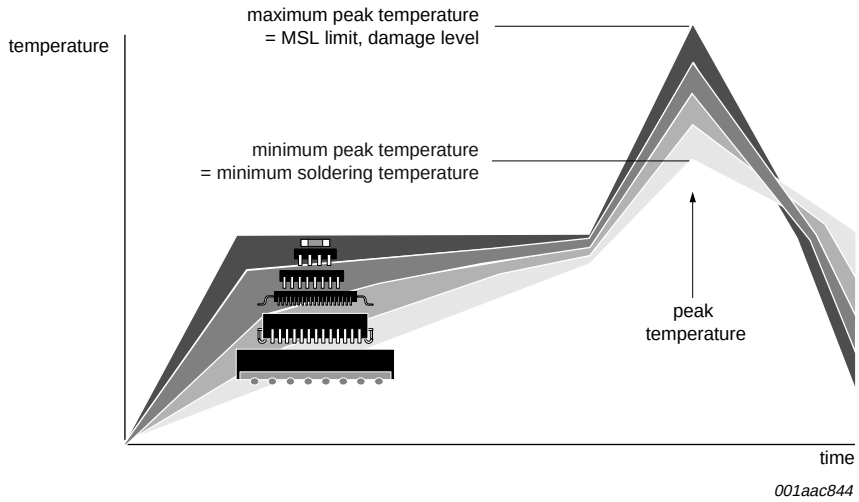
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm^3)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 34. Lead-free process (from J-STD-020C)

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm^3)		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see Figure 13.



MSL: Moisture Sensitivity Level

Fig 13. Temperature profiles for large and small components

For further information on temperature profiles, refer to Application Note *AN10365 "Surface mount reflow soldering description"*.

15. Abbreviations

Table 35. Abbreviations

Acronym	Description
ALC	Automatic Level Control
BiCMOS	Bipolar Complementary Metal Oxide Semiconductor
CMOS	Complementary Metal Oxide Semiconductor
ESD	ElectroStatic Discharge
FM	Frequency Modulation
IF	Intermediate Frequency
ISM	Industrial, Medical and Scientific
LNA	Low Noise Amplifier
LO	Local Oscillator
LPF	Low-Pass Filter
PA	Power Amplifier
PCB	Printed-Circuit Board
PLL	Phase-Locked Loop
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
SINAD	Signal-plus-Noise-And-Distortion to noise-plus-distortion ratio
VCO	Voltage Controlled Oscillator

16. Revision history

Table 36. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
SA58646_1	20070208	Product data sheet	-	-

17. Legal information

17.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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