SA58640

Low-voltage mixer FM IF system

Rev. 3 — 12 April 2011 **Product data sheet**

1. Introduction

The SA58640 was designed for cordless telephone applications in which efficient and economic integrated solutions are required and yet high performance is desirable. Although the product is not targeted to meet the stringent specifications of high performance cellular equipment, it will exceed the needs for analog cordless phones. The minimal amount of external components and absence of any external adjustments makes for a very economical solution.

2. General description

The SA58640 is a low-voltage monolithic FM IF system incorporating a mixer/oscillator, two limiting intermediate frequency amplifiers, quadrature detector, logarithmic RSSI, voltage regulator and audio and RSSI operational amplifiers. The SA58640 is available in a 20-pin SSOP package.

3. Features and benefits

- Low power consumption: 5.0 mA typical at 5 V
- Mixer input to >100 MHz
- Mixer conversion power gain of 17 dB at 45 MHz
- Crystal oscillator effective to 100 MHz (LC oscillator or external oscillator can be used at higher frequencies)
- 102 dB of IF amplifier/limiter gain
- 2 MHz IF amplifier/limiter small signal bandwidth
- Temperature compensated logarithmic RSSI with a 70 dB dynamic range
- Low external component count; suitable for crystal/ceramic/LC filters
- Audio output internal op amp
- RSSI output internal op amp
- Internal op amps with rail-to-rail outputs
- ESD protection: Human body model 2 kV; robot model 200 V

4. Applications

- Cordless telephones

5. Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
SA58640DK	SSOP20	plastic shrink small outline package; 20 leads; body width 4.4 mm	SOT266-1

6. Block diagram

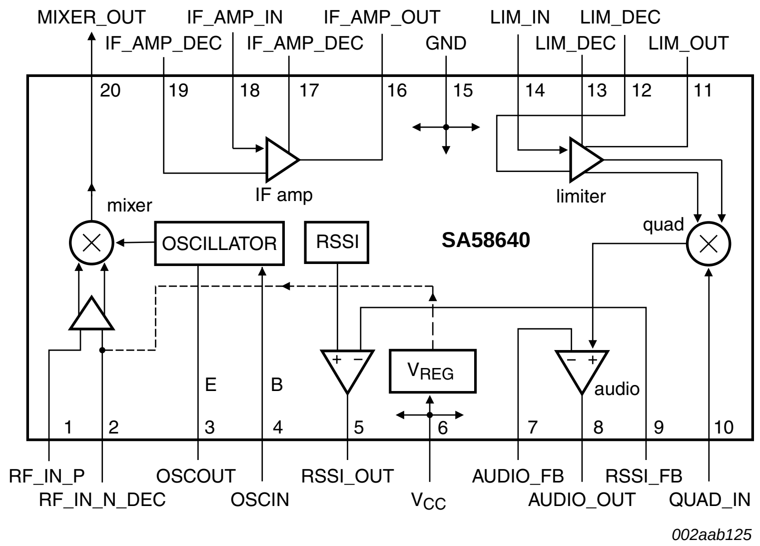


Fig 1. Block diagram of SA58640

7. Pinning information

7.1 Pinning

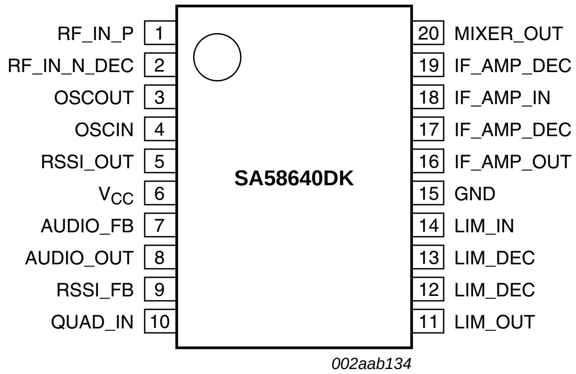


Fig 2. Pin configuration for SSOP20

7.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
RF_IN_P	1	positive RF mixer input
RF_IN_N_DEC	2	negative RF mixer input, decoupling
OSCOUT	3	oscillator output (emitter)
OSCIN	4	oscillator input (base)
RSSI_OUT	5	RSSI amplifier output
V_{CC}	6	positive supply
AUDIO_FB	7	audio amplifier negative input, feedback
AUDIO_OUT	8	audio amplifier output
RSSI_FB	9	RSSI amplifier negative input, feedback
QUAD_IN	10	quadrature detector input
LIM_OUT	11	limiter amplifier output
LIM_DEC	12	limiter decoupling
LIM_DEC	13	limiter decoupling
LIM_IN	14	limiter amplifier input
GND	15	ground
IF_AMP_OUT	16	IF amplifier output
IF_AMP_DEC	17	IF amplifier decoupling
IF_AMP_IN	18	IF amplifier input
IF_AMP_DEC	19	IF amplifier decoupling
MIXER_OUT	20	mixer output

8. Functional description

The SA58640 is an IF signal processing system suitable for second IF systems with input frequency as high as 100 MHz. The bandwidth of the IF amplifier and limiter is at least 2 MHz with 90 dB of gain. The gain/bandwidth distribution is optimized for 455 kHz, 1.5 kΩ source applications. The overall system is well-suited to battery operation as well as and high quality products of all types.

The input stage is a Gilbert cell mixer with oscillator. Typical mixer characteristics include a noise figure of 7.0 dB, conversion gain of 17 dB, and input third-order intercept of −10 dBm. The oscillator will operate in excess of 100 MHz in LC tank configurations. Hartley or Colpitts circuits can be used up to 100 MHz for crystal configurations.

The output impedance of the mixer is a 1.5 kΩ resistor permitting direct connection to a 455 kHz ceramic filter. The input resistance of the limiting IF amplifiers is also 1.5 kΩ. With most 455 kHz ceramic filters and many crystal filters, no impedance matching network is necessary. The IF amplifier has 44 dB of gain and 5.5 MHz bandwidth. The IF limiter has 58 dB of gain and 4.5 MHz bandwidth. To achieve optimum linearity of the log signal strength indicator, there must be a 12 dBV[1] insertion loss between the first and second IF stages. If the IF filter or interstage network does not cause 12 dBV insertion loss, a fixed or variable resistor or an L pad for simultaneous loss and impedance matching can be added between the first IF output (pin 16) and the interstage network. The overall gain will then be 90 dB with 2 MHz bandwidth.

The signal from the second limiting amplifier goes to a Gilbert cell quadrature detector. One port of the Gilbert cell is internally driven by the IF. The other output of the IF is AC-coupled to a tuned quadrature network. This signal, which now has a 90° phase relationship to the internal signal, drives the other port of the multiplier cell.

The demodulated output of the quadrature drives an internal op amp. This op amp can be configured as a unity gain buffer, or for simultaneous gain, filtering, and second-order temperature compensation if needed. It can drive an AC load as low as 10 kΩ with a rail-to-rail output.

A log signal strength indicator completes the circuitry. The output range is greater than 70 dB and is temperature compensated. This signal drives an internal op amp. The op amp is capable of rail-to-rail output. It can be used for gain, filtering, or second-order temperature compensation of the RSSI, if needed.

1. dBV = 20 log V_o / V_i.

9. Limiting values

Table 3. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage		-	7	V
T_{stg}	storage temperature		–65	+150	°C
T_{amb}	ambient temperature	operating	–40	+85	°C
Z_{th}	transient thermal impedance		-	117	K/W

10. Static characteristics

Table 4. Static characteristics

T_{amb} = 25 °C; V_{CC} = +5 V; unless otherwise specified.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage		4.5	-	6.0	V
I_{CC}	supply current		-	5.0	6.0	mA

[1] RF frequency = 45 MHz; +14.5 dBV RF input step-up; IF frequency = 455 kHz; R17 = 2.4 kΩ and R18 = 3.3 kΩ; RF level = –45 dBm; FM modulation = 1 kHz with ± 5 kHz peak deviation. Audio output with de-emphasis filter and C-message weighted filter. See Figure 8 "45 MHz application circuit". The parameters listed above are tested using automatic test equipment to assure consistent electrical characteristics. The limits do not represent the ultimate performance limits of the device. Use of an optimized RF layout will improve many of the listed parameters.

11. Dynamic characteristics

Table 5. Dynamic characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Mixer/oscillator section (external LO = 220 mV RMS value)							
f_i	input frequency			-	100	-	MHz
f_{osc}	oscillator frequency			-	100	-	MHz
NF	noise figure	at 45 MHz		-	7.0	-	dB
$IP3_I$	input third-order intercept point	50 Ω source; f1 = 45.0 MHz; f2 = 45.06 MHz; input RF level = −52 dBm		-	−10	-	dBm
$G_{p(conv)}$	conversion power gain	matched 14.5 dBV step-up		10	17	-	dB
		50 Ω source		-	2.5	-	dB
$R_{i(RF)}$	RF input resistance	single-ended input		-	8	-	kΩ
$C_{i(RF)}$	RF input capacitance			-	3.0	4.0	pF
$R_{o(mix)}$	mixer output resistance	MIXER_OUT pin		1.25	1.5	-	kΩ
IF section							
$G_{amp(IF)}$	IF amplifier gain	50 Ω source		-	44	-	dB
G_{lim}	limiter gain	50 Ω source		-	58	-	dB
α_{AM}	AM rejection	30 % AM 1 kHz		-	50	-	dB
$V_{o(aud)}$	audio output voltage	gain of two		60	120	-	mV
SINAD	signal-to-noise-and-distortion ratio	IF level = −110 dBm		-	17	-	dB
THD	total harmonic distortion			-	−55	-	dB
S/N	signal-to-noise ratio	no modulation for noise		-	60	-	dB
$V_{o(RSSI)}$	RSSI output voltage	IF; R9 = 2 kΩ	[1]				
		IF level = −110 dBm		-	0.5	1.0	V
		IF level = −50 dBm		-	1.7	2.4	V
$\alpha_{RSSI(range)}$	RSSI range			-	60	-	dB
$Z_{i(IF)}$	IF input impedance	measured on IF_AMP_IN pin		1.3	1.5	-	kΩ
$Z_{o(IF)}$	IF output impedance	measured on IF_AMP_OUT pin		-	0.3	-	kΩ
$Z_{i(lim)}$	limiter input impedance	measured on LIM_IN pin		1.3	1.5	-	kΩ
$Z_{o(lim)}$	limiter output impedance	measured on LIM_OUT pin		-	0.3	-	kΩ
$V_{o(RMS)}$	RMS output voltage	measured on LIM_OUT pin		-	130	-	mV
RF/IF section (internal LO)							
SINAD	signal-to-noise-and-distortion ratio	system; RF level = −110 dBm		-	12	-	dB

[1] The generator source impedance is 50 Ω, but the SA58640 input impedance at pin 18 (IF_AMP_IN) is 1500 Ω. As a result, IF level refers to the actual signal that enters the SA58640 IF amplifier input (pin 18), which is about 21 dB less than the ‘available power’ at the generator.

12. Performance curves

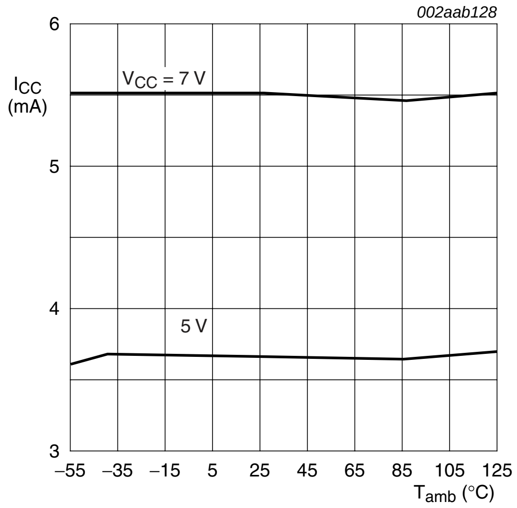
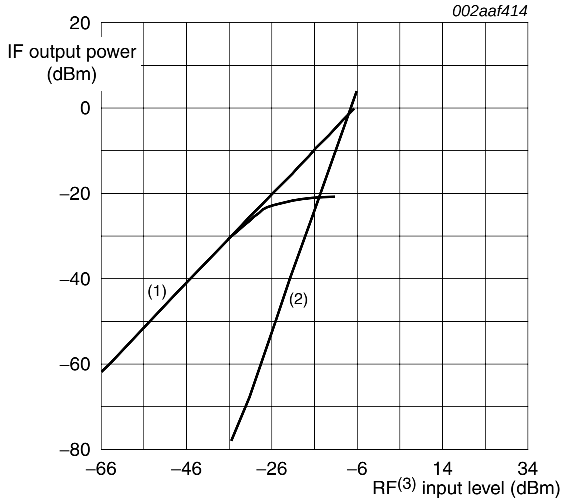


Fig 3. Supply current versus ambient temperature



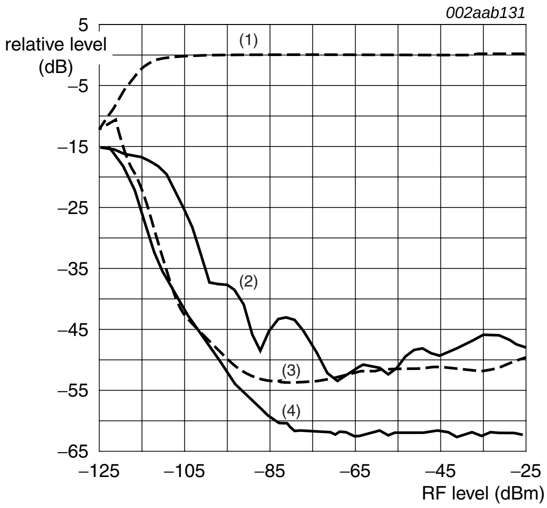
RF = 45 MHz; IF = 455 kHz.

(1) Fund product.

(2) Third-order product.

(3) 50 Ω input.

Fig 4. Mixer third-order intercept and compression



V_{CC} = 5 V; RF = 45 MHz; deviation = ±5 kHz; $V_{o(aud)RMS}$ = 117.6 mV.

(1) Audio.

(2) AM rejection.

(3) THD+N.

(4) Noise.

Fig 5. Relative level of audio, AM rejection, THD+N and noise versus RF level (T_{amb} = +25 °C)

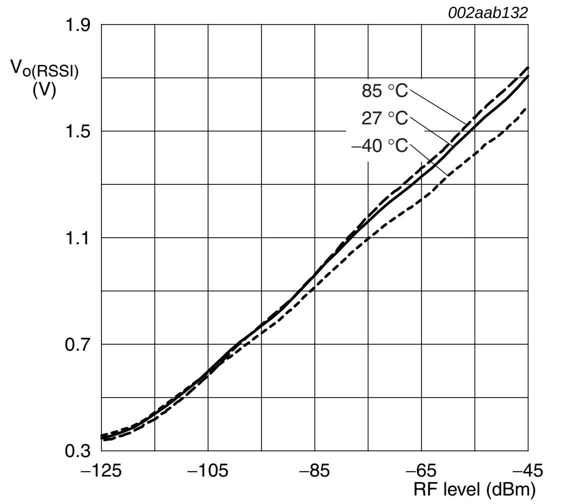


Fig 6. RSSI output voltage versus RF level (V_{CC} = 5 V)

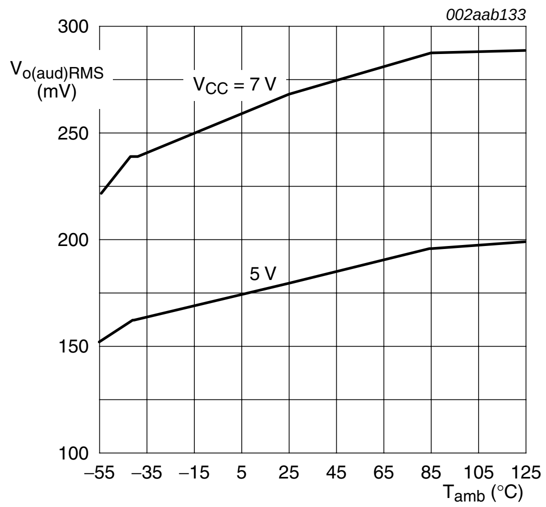
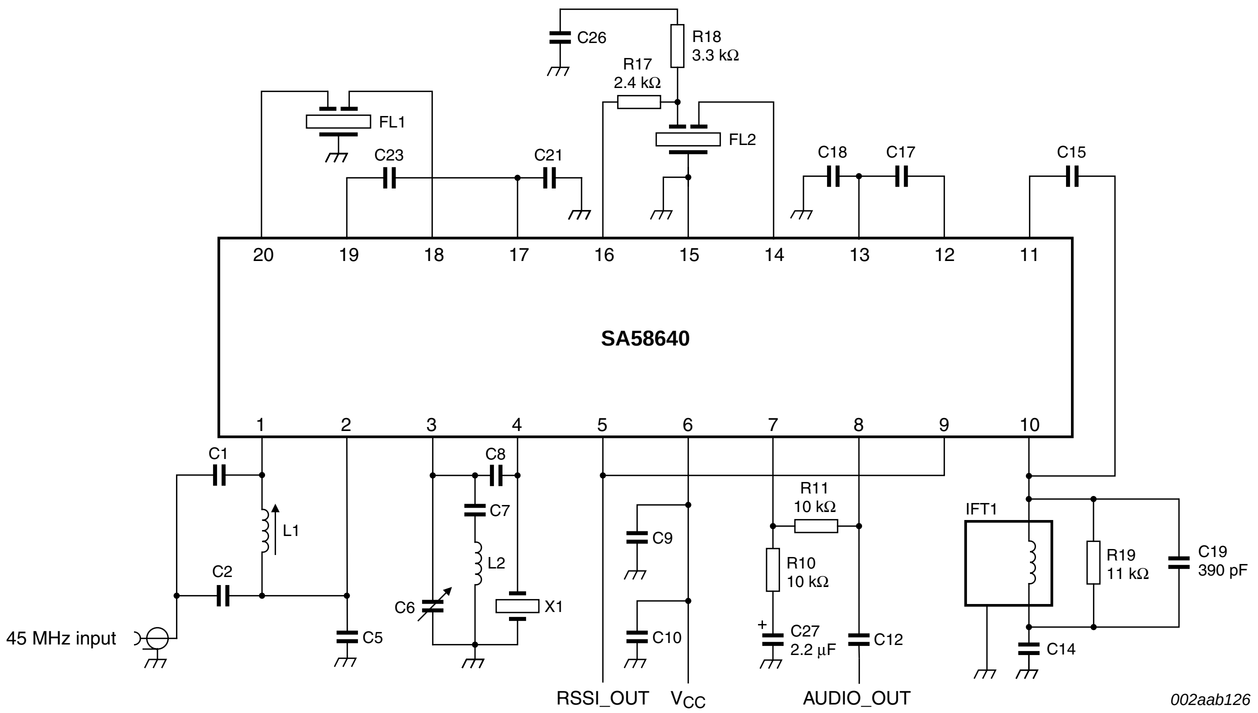


Fig 7. RMS audio output voltage versus ambient temperature

13. Application information



The layout is very critical in the performance of the receiver. We highly recommend our demo board layout.

All of the inductors, the quad tank, and their shield must be grounded. A 10 µF to 15 µF or higher value tantalum capacitor on the supply line is essential. A low frequency ESR screening test on this capacitor will ensure consistent good sensitivity in production. A 0.1 µF bypass capacitor on the supply pin V_{CC}, and grounded near the 44.545 MHz oscillator improves sensitivity by 2 dB to 3 dB.

Fig 8. 45 MHz application circuit

Table 6. Demo board application component list

Component	Value	Type
C1	51 pF	NPO ceramic
C2	220 pF	NPO ceramic
C5	100 nF ± 10 %	monolithic ceramic
C6	5 pF to 30 pF	trim cap
C7	1 nF	ceramic
C8	10.0 pF	NPO ceramic
C9	100 nF ± 10 %	monolithic ceramic
C10	10 μF[1]	tantalum (minimum)
C12	2.2 μF ± 10 %	tantalum
C14	100 nF ± 10 %	monolithic ceramic
C15	10 pF	NPO ceramic
C17	100 nF ± 10 %	monolithic ceramic
C18	100 nF ± 10 %	monolithic ceramic
C19	390 pF ± 10 %	monolithic ceramic
C21	100 nF ± 10 %	monolithic ceramic
C23	100 nF ± 10 %	monolithic ceramic
C26	100 nF ± 10 %	monolithic ceramic
C27	2.2 μF	tantalum
FL1[2]	-	ceramic filter Murata CFUCF455KB4X-R0
FL2[2]	-	ceramic filter Murata CFUCF455KB4X-R0
IFT1	330 μH	Toko 836AN-0129Z
L1	330 nH	Toko A638AN-0158Z
L2	1.2 μH nominal	FSLM2520-12K
X1	44.545 MHz	crystal ICM4712701
R5[3]	-	not used in application board
R10	8.2 kΩ ± 5 %	$^1\!/_4$ W carbon composition
R11	10 kΩ ± 5 %	$^1\!/_4$ W carbon composition
R17	2.4 kΩ ± 5 %	$^1\!/_4$ W carbon composition
R18	3.3 kΩ ± 5 %	$^1\!/_4$ W carbon composition
R19	11 kΩ ± 5 %	$^1\!/_4$ W carbon composition

[1] This value can be reduced when a battery is the power source.

[2] This is a 30 kHz bandwidth 455 kHz ceramic filter. All the characterization and testing are done with this wideband filter. A more narrowband 15 kHz bandwidth 455 kHz ceramic filter that may be used as an alternative selection is Murata CFUKG455KE4A-R0.

[3] R5 can be used to bias the oscillator transistor at a higher current for operation above 45 MHz. Recommended value is 22 kΩ, but should not be below 10 kΩ.

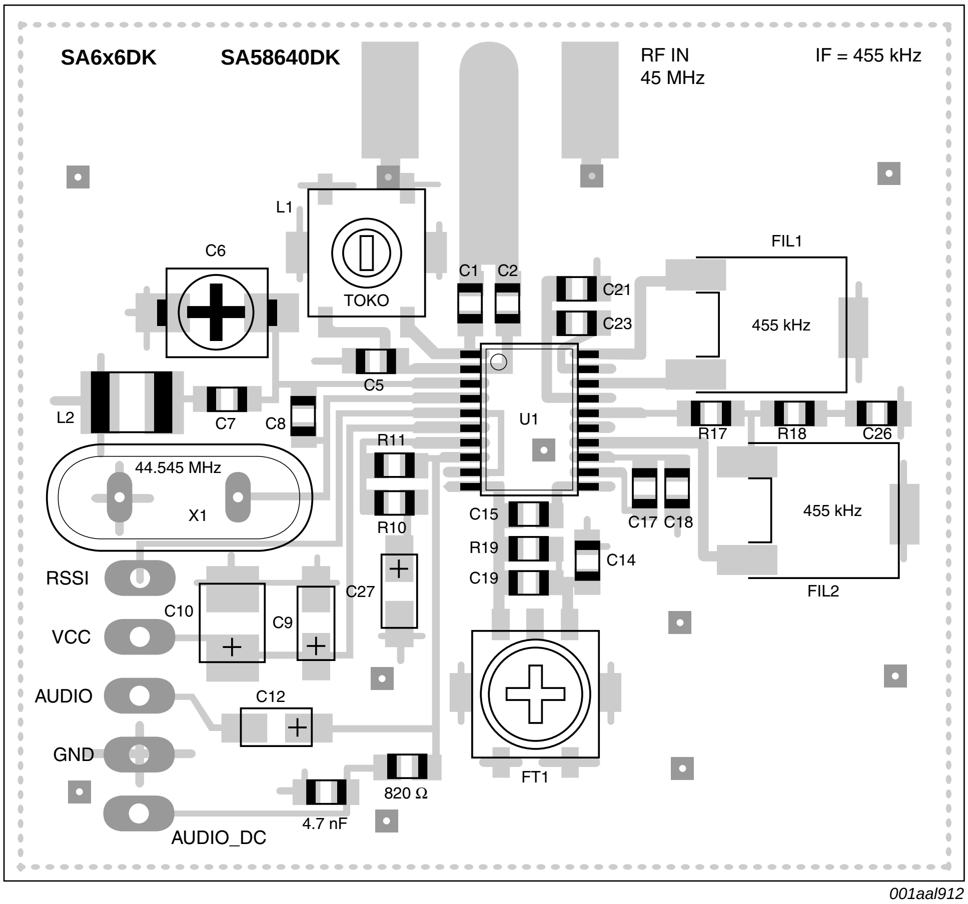


Fig 9. SA6x6DK/SA58640DK top view with components

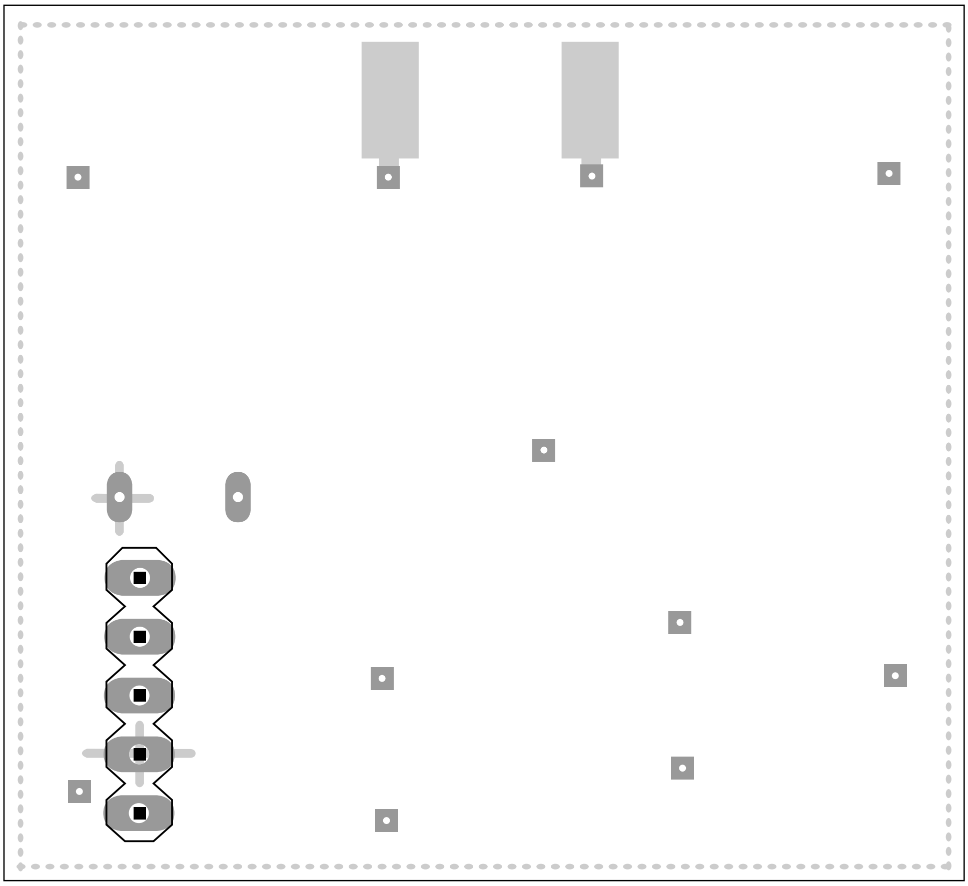
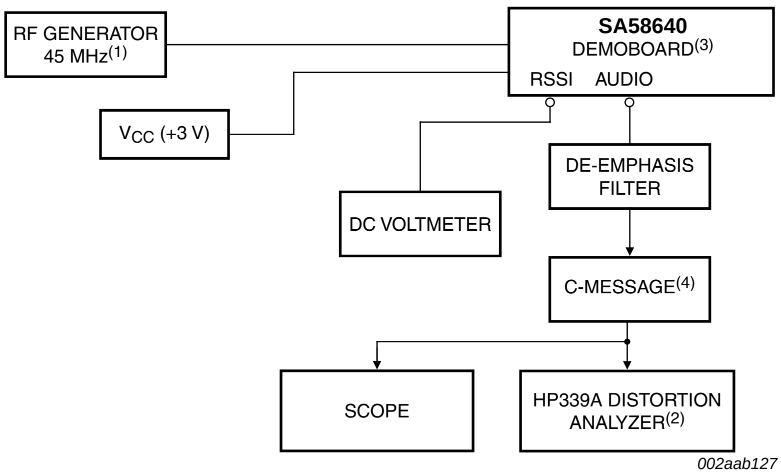


Fig 10. SA6x6DK/SA58640DK bottom view (viewed from top)

14. Test information



(1) Set your RF generator at 45.000 MHz, use a 1 kHz modulation frequency and a 6 kHz deviation if you use 16 kHz filters, or 8 kHz if you use 30 kHz filters.

(2) The measured typical sensitivity for 12 dB SINAD should be 0.45 μV or −114 dBm at the RF input.

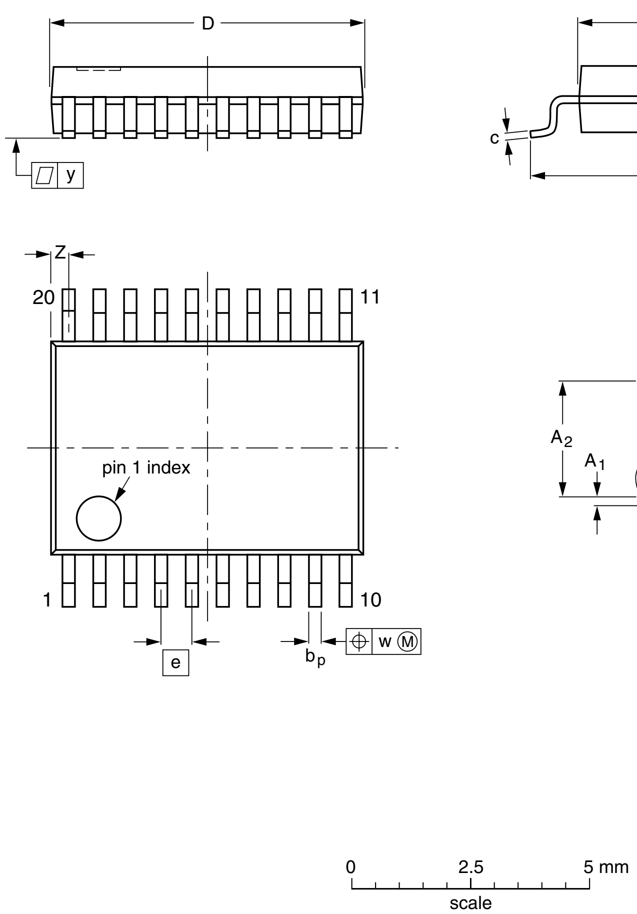
(3) The smallest RSSI voltage (i.e., when no RF input is present and the input is terminated) is a measure of the quality of the layout and design. If the lowest RSSI voltage is 500 mV or higher, it means the receiver is in regenerative mode. In that case, the receiver sensitivity will be worse than expected.

(4) The C-message and de-emphasis filter combination has a peak gain of 10 dB for accurate measurements. Without the gain, the measurements may be affected by the noise of the scope and HP339A analyzer. The de-emphasis filter has a fixed −6 dB/octave slope between 300 Hz and 3 kHz.

Fig 11. Application circuit test setup

15. Package outline

SSOP20: plastic shrink small outline package; 20 leads; body width 4.4 mm **SOT266-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.5	0.15 0	1.4 1.2	0.25	0.32 0.20	0.20 0.13	6.6 6.4	4.5 4.3	0.65	6.6 6.2	1	0.75 0.45	0.65 0.45	0.2	0.13	0.1	0.48 0.18	10° 0°

Note

1. Plastic or metal protrusions of 0.20 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT266-1		MO-152				~~99-12-27~~ 03-02-19

Fig 12. Package outline SOT266-1 (SSOP20)

16. Soldering of SMD packages

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"*.

16.1 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.

16.2 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 SnPb soldering

16.3 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

16.4 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 SnPb 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 7 and 8

Table 7. SnPb eutectic process (from J-STD-020C)

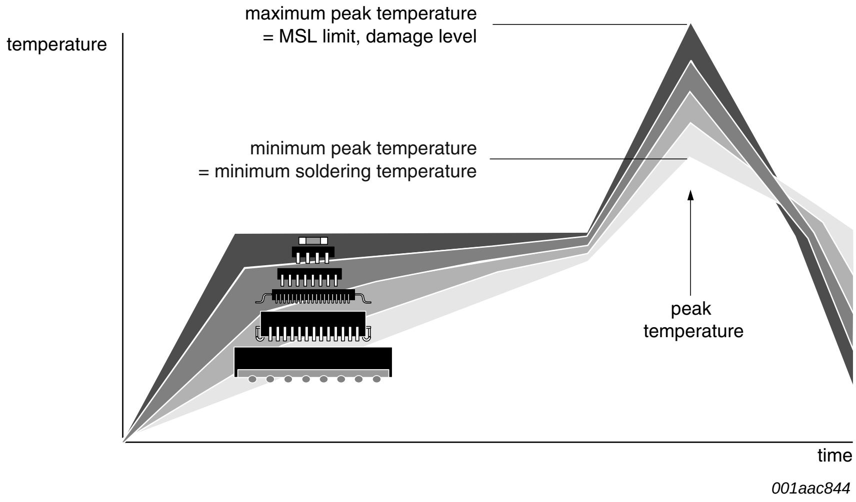
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm^3)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 8. 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"*.

17. Abbreviations

Table 9. Abbreviations

Acronym	Description
AC	Alternating Current
AM	Amplitude Modulation
ESD	ElectroStatic Discharge
ESR	Equivalent Series Resistance
FM	Frequency Modulation
IF	Intermediate Frequency
LC	inductor-capacitor filter
LO	Local Oscillator
NPO	Negative Positive Zero
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
SINAD	Signal-to-Noise And Distortion ratio
THD	Total Harmonic Distortion

18. Revision history

Table 10. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
SA58540 v.3	20110412	Product data sheet	-	SA58640 v.2
Modifications:	• Table 6 “Demo board application component list”: Table note [2] is re-written.			
SA58540 v.2	20110211	Product data sheet	-	SA58640 v.1
SA58640 v.1	20050406	Product data sheet	-	-

19. Legal information

19.1 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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