SENSORY®

SC-601
Speech And Music Processor

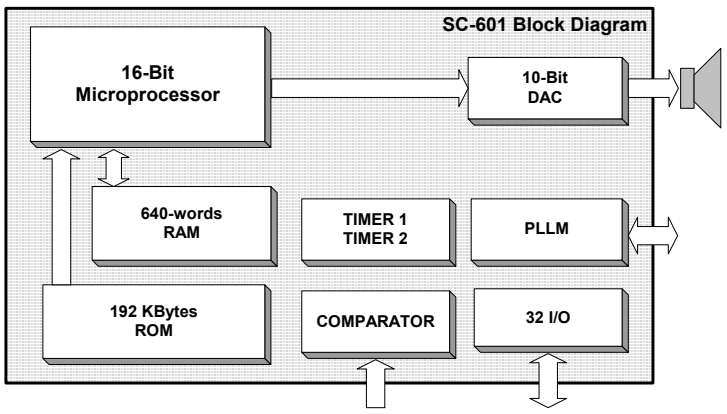
Data sheet

Features

- Advanced, integrated speech synthesizer for high-quality sound.
- Operates up to 12.32 MHz (Performs up to 12 MIPS)
- Single chip solution for up to 24 Minutes of speech (using 1.57 Mb of onboard program + data ROM)
- Supports high-quality synthesis algorithms Such as MX, CX, Simple CX, LX, ADPCM, and Polyphonic Music
- Simultaneous speech plus music capabilities
- Very low-power operation, ideal for handheld devices
- Low-voltage operation, sustainable by three batteries
- Reduced power stand-by modes, less than 10 µA in deep-sleep mode
- 640-Word RAM
- 32 I/O Pins consisting of: 24 general purpose bit configurable I/O, 8 inputs with programmable pullup resistor and a dedicated interrupt (Key-Scan)
- Direct Speaker Driver, 32Ω (PDM)
- One-bit comparator with edge-detection interrupt service
- Resistor-trimmed oscillator or 32.768kHz crystal reference oscillator
- Serial scan port for in-circuit emulation and diagnostics
- The SC-601 is sold in die form or 100-pin LQFP package.
- An emulator device is available in a ceramic package for development (SC-614-P).

Description

The SC-601 is a low-cost, mixed-signal processor that combines a speech synthesizer, general-I/O, onboard ROM, and direct speaker drive in a single package. The computational unit utilizes a powerful DSP which gives the SC-601 unprecedented speed and computational flexibility compared with previous devices of its type. The SC-601 supports a variety of speech and audio coding algorithms, providing range of options for speech duration and sound quality.



The device consists of a micro-DSP core, embedded program, and data memory, and a self-contained generation system. General-purpose periphery is comprised of 32 bits of partially configurable I/O.

The core processor is a general-purpose 16-bit microcontroller with DSP capability. The basic core includes computational unit (CU), data address unit, program address unit, two timers, eight level interrupt processor, and several system and control registers. The core processor gives the SC-601 break-capability in emulation.

The processor is Harvard type for efficient DSP algorithm execution. It requires separate program and memory blocks to permit simultaneous access. The ROM has a protection scheme to prevent third-party pirating. It is configured in 32K 17-bit words.

The total ROM space is divided into three areas:

1. The lower 2K words are reserved by Sensory a built-in self-test
2. The upper 30K words are for user program/data
3. An additional 1 Mb data ROM provides for up to 24 minutes of speech.

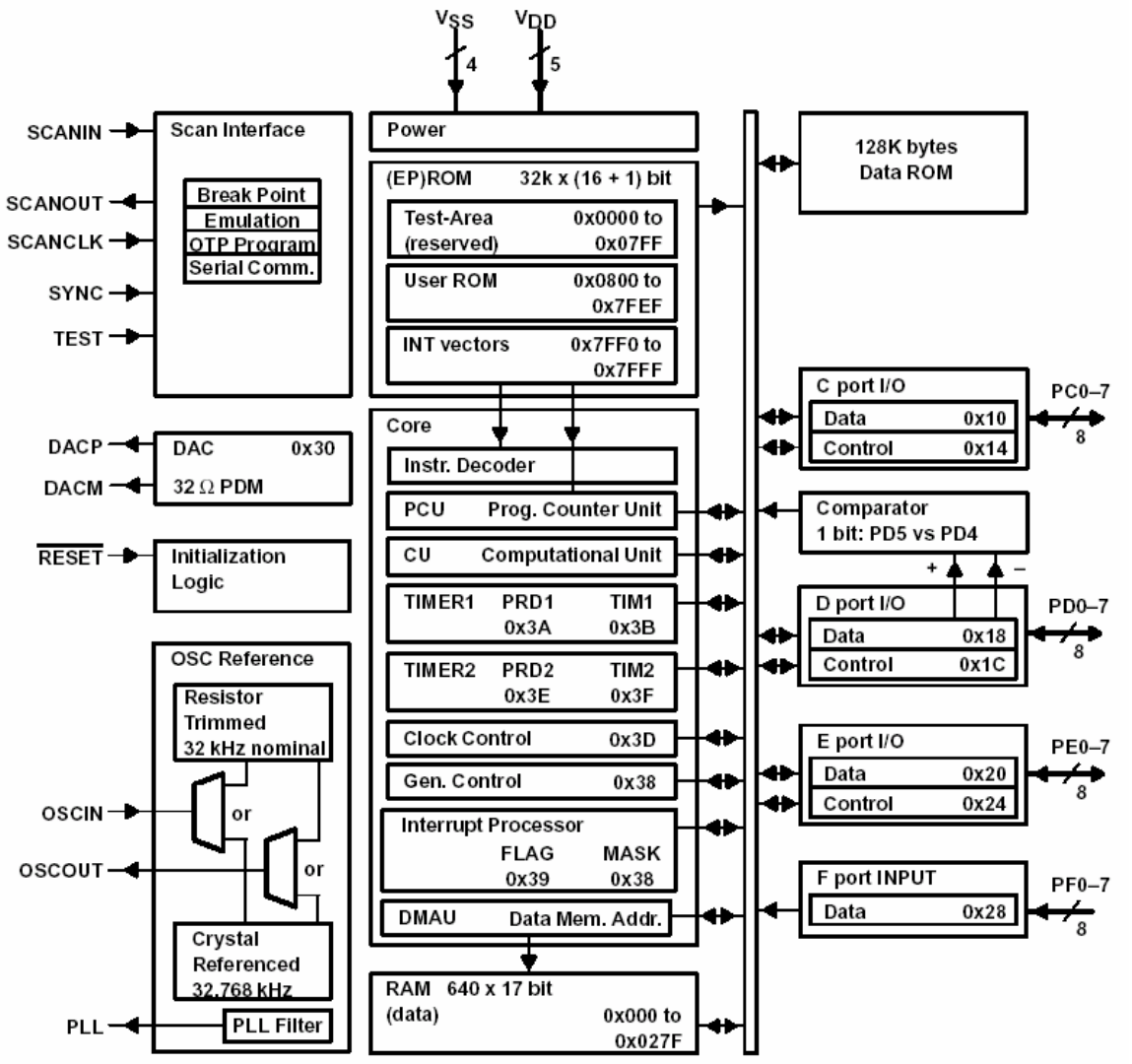
The data memory is internal static RAM. The RAM is configured in 640 17-bit words. All memories are designed to consume minimum power at a given system clock and algorithm acquisition frequency.

A flexible clock generation system enables the software to control the clock over a wide frequency range. The implementation uses a phase-locked loop (PLL) circuit that drives the processor clock at a selectable frequency between the minimum and maximum achievable. Selectable frequencies for the processor clock are spaced apart in 65.536 kHz steps. The PLL clock-reference is also selectable; either a resistor-trimmed oscillator or a crystal-referenced oscillator may be used. Internal and external clock sources are controlled separately to provide different levels of power management.

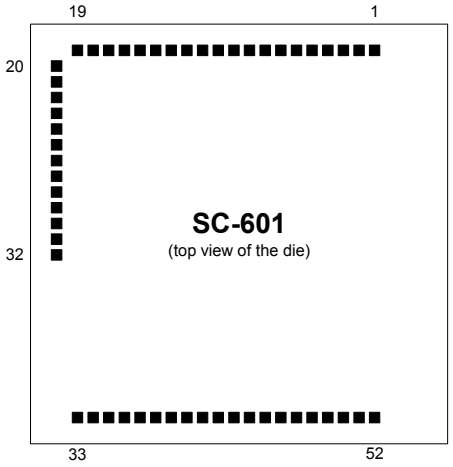
The periphery consists of three 8-bit wide general-purpose I/O ports and one 8-bit wide dedicated input port. The bidirectional I/O can be configured under software control as either high-impedance inputs or as totem-pole outputs. They are controlled via addressable I/O registers. The input-only port has a programmable pullup option (70-kΩ minimum resistance) and a dedicated service interrupt. These features make the input port especially useful as a key-scan interface.

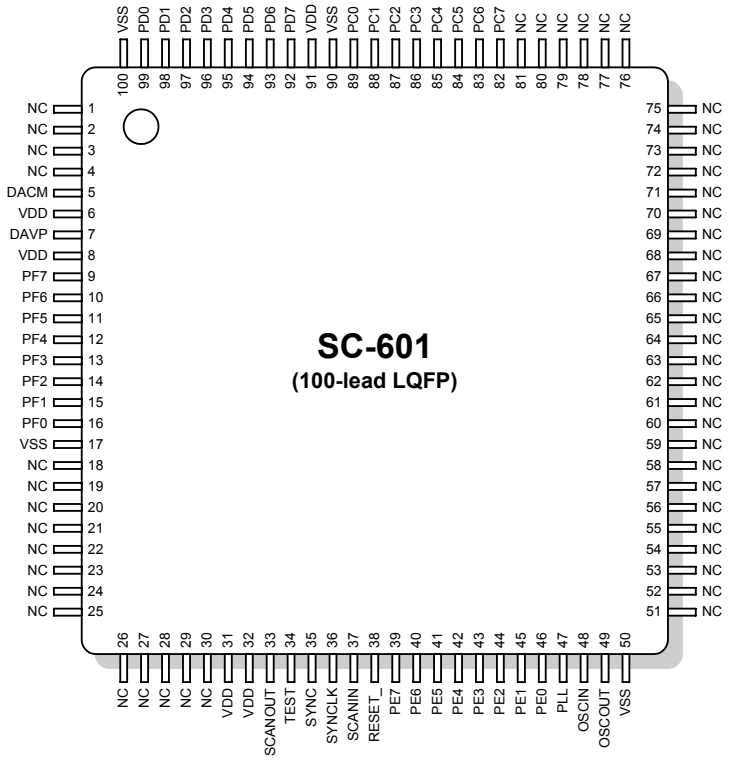
A simple one-bit comparator is also included in the periphery. The comparator is enabled by a control register, and its pin access is shared with two pins in one of the general-purpose I/O ports. Rounding out the SC-601 periphery is a built-in pulse-density-modulated DAC (digital-to-analog converter) with direct speaker-drive capability. The functional block diagram gives an overview of the SC-601 functionality.

Functional Block Diagram



Pin/Pad Assignment





NAME	PIN NO.	PAD NO.	I/O	DESCRIPTION
PC0 – PC7	89 → 82	8 → 1	I/O	Port C general-purpose I/O (1 Byte)
PD0 – PD7	99 → 92	18 → 11	I/O	Port D general-purpose I/O (1 Byte)
PE0 – PE7	46 → 39	48 → 41	I/O	Port E general-purpose I/O (1 Byte)
PF0 – PF7	16 → 9	31 → 24	I/O	Port F general-purpose I/O (1 Byte)
Pins PD4 and PD4 may be dedicated to the comparator function, if the comparator enable bit is set.				
Scan Port Control Signals				
SCANIN	37	39	I	Scan port data input
SCANOUT	33	35	O	Scan port data output
SCANCLK	36	38	I	Scan port clock
SYNC	35	37	I	Scan port synchronization
TEST	34	36	I	SC-601: test modes
The scan port pins must be bonded out on any SC-601 production board.				
Reference Oscillator Signals				
OSCOUT	49	51	O	Resistor/crystal reference out
OSCIN	48	50	I	Resistor/crystal reference in
PLL	47	49	O	Phase-lock-loop filter
Digital-to-Analog Sound Output (DAC)				
DACP	7	22	O	Digital-to-analog plus output (+)
DACM	5	20	O	Digital-to-analog minus output (–)
Initialization				
RESET_	38	40	I	Initialization
Power Signals				
V_{SS}	17, 50, 90, 100†	32, 52, 9, 19†	-	Ground
V_{DD}	6†, 8, 31, 32, 91	21†, 23, 33, 34, 10	-	Processor power (+)

† The V_{SS} and V_{DD} connections service the DAC circuitry. Their pins tend to sustain a higher current draw. A dedicated decoupling capacitor across these pins is therefore required.

Absolute Maximum Ratings

Absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{DD} (see Note 1)	–0.3 to 7 V
Supply current, I_{DD} (see Note 2)	35 mA
Input voltage range, V_I (see Note 1)	–0.3 to VDD + 0.3 V
Output voltage range, V_O (see Note 1)	–0.3 to VDD + 0.3 V
Storage temperature range, T_A	–30ºC to 125ºC

***WARNING**:*
Stressing the SC-601 beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.

NOTES: 1. Unless otherwise noted, all voltages are measured with respect to V_{SS}.
2. The total supply current includes the current out of all the I/O pins as well as the operating current of the device.

Recommended Operating Conditions

		MIN	MAX	UNIT
Supply voltage (with respect to V_{SS}), V_{DD}		3	5.2	V
CPU clock rate (as programmed), $f_{(CPU)}$		64	12,320	kHz
Load resistance between DAC_P and DAC_M, $R_{(DAC)}$		32		Ω
Operating free-air temperature, T_A	Device functionality	0	70	°C

Timing Requirements

		MIN	MAX	UNIT
$t_{(RESET)}$	Reset low pulse width, while V_{DD} is within specified limits	100		ns
$t1_{(WIDTH)}$	Pulse width required prior to a negative transition at pin PD3, PD5, or PF0 → PF7‡	2		$1/F_{CPU}$
$t2_{(WIDTH)}$	Pulse width required prior to a positive transition at pin PD2 or PD4†	2		$1/F_{CPU}$

‡ While these pins are being used as interrupt inputs.

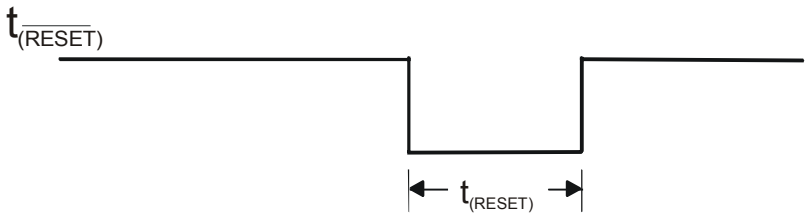


Figure 1: **Initialization Timing Diagram**

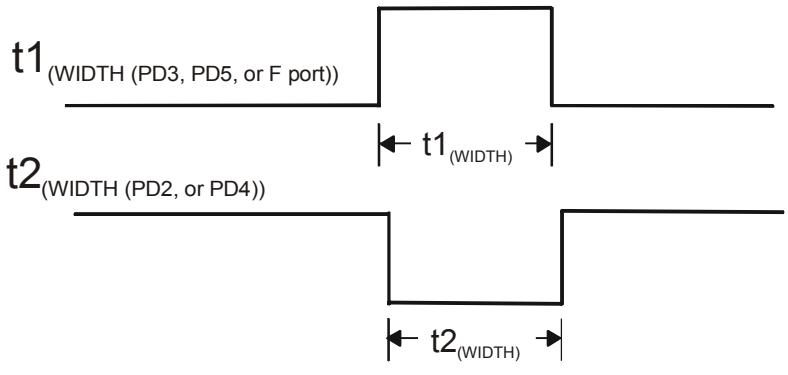


Figure 2: **External Interrupt Pin Pulse Width Requirements t1WIDTH and t2WIDTH**

DC Electrical Characteristics, TA = 0 to 70°C

PARAMETER		TEST CONDITIONS		MIN	TYP§	MAX	UNIT
RESET_	Threshold changes	V_{DD} = 3 V	Positive going threshold		2.4		V
			Negative going threshold		1.8		
			Hysteresis		0.6		
		V_{DD} = 5.2 V	Positive going threshold		3.3		V
			Negative going threshold		2.9		
			Hysteresis		0.4		
V_{IH}	High-level input voltage	V_{DD} = 3 V		2		3	V
		V_{DD} = 4.5 V		3		4.5	
		V_{DD} = 5.2 V		3.5		5.2	
V_{IL}	Low-level input voltage	V_{DD} = 3 V		0		1	V
		V_{DD} = 4.5 V		0		1.5	
		V_{DD} = 5.2 V		0		1.7	
I_{OH}¶	High-level output current per pin of I/O port	V_{DD} = 4.5 V	V_{OH} = 4 V			–2	mA
I_{OL}¶	Low-level output current per pin of I/O port		V_{OL} = 0.5 V			5	mA
$I_{OH\ (DAC)}$	High-level output DAC current		V_{OH} = 4 V			–10	mA
$I_{OL\ (DAC)}$	Low-level output DAC current		V_{OL} = 0.5 V			20	mA
I_{lkg}	Input leakage current	Excludes OSC_{IN}				1	µA
$I_{(STANDBY)}$	Standby current	RESET is low			0.05	10	µA
I_{DD}†	Operating current	V_{DD} = 4.5 V, F_{CLOCK} = 12.32 MHz			15		mA
$I_{(SLEEP\text{-}deep)}$	Supply current	V_{DD} = 4.5 V, DAC off, ARM set, OSC disabled			0.05	10	µA
$I_{(SLEEP\text{-}mid)}$		V_{DD} = 4.5 V, DAC off, ARM set, OSC enabled			40	60	
$I_{(SLEEP\text{-}light)}$		V_{DD} = 4.5 V, DAC off, ARM clear, OSC enabled			60	100	
V_{IO}	Input offset voltage	V_{DD} = 4.5 V, V_{ref} = 1 to 4.25 V			25	50	mV
$R_{(PULLUP)}$	F port pullup resistance	V_{DD} = 5 V		70	150		KΩ
$\Delta f_{(RTO\text{-}trim)}$	Trim deviation	R_{RTO} = 470 KΩ, V_{DD} = 4.5 V, T_A = 25°C, f_{RTO} = 8.192 MHz (PLL setting = 7 Ch)‡			±1%	±3%	
$\Delta f_{(RTO\text{-}volt)}$	Voltage deviation	R_{RTO} = 470 KΩ, V_{DD} = 3.5 to 5.2 V, T_A = 25°C, f_{RTO} = 8.192 MHz (PLL setting = 7 Ch)‡				±1.5%	
$\Delta f_{(RTO\text{-}temp)}$	Temperature deviation	R_{RTO} = 470 KΩ, V_{DD} = 4.5 V, T_A = 0 to 70°C, f_{RTO} = 8.192 MHz (PLL setting = 7 Ch)‡			±0.03		%/°C
$\Delta f_{(RTO\text{-}res)}$	Resistance deviation	V_{DD} = 4.5 V, T_A = 25°C, $R_{(OSC)}$ = 470 KΩ at ±1%, f_{RTO} = 8.192 MHz (PLL setting = 7 Ch)‡			±1%		

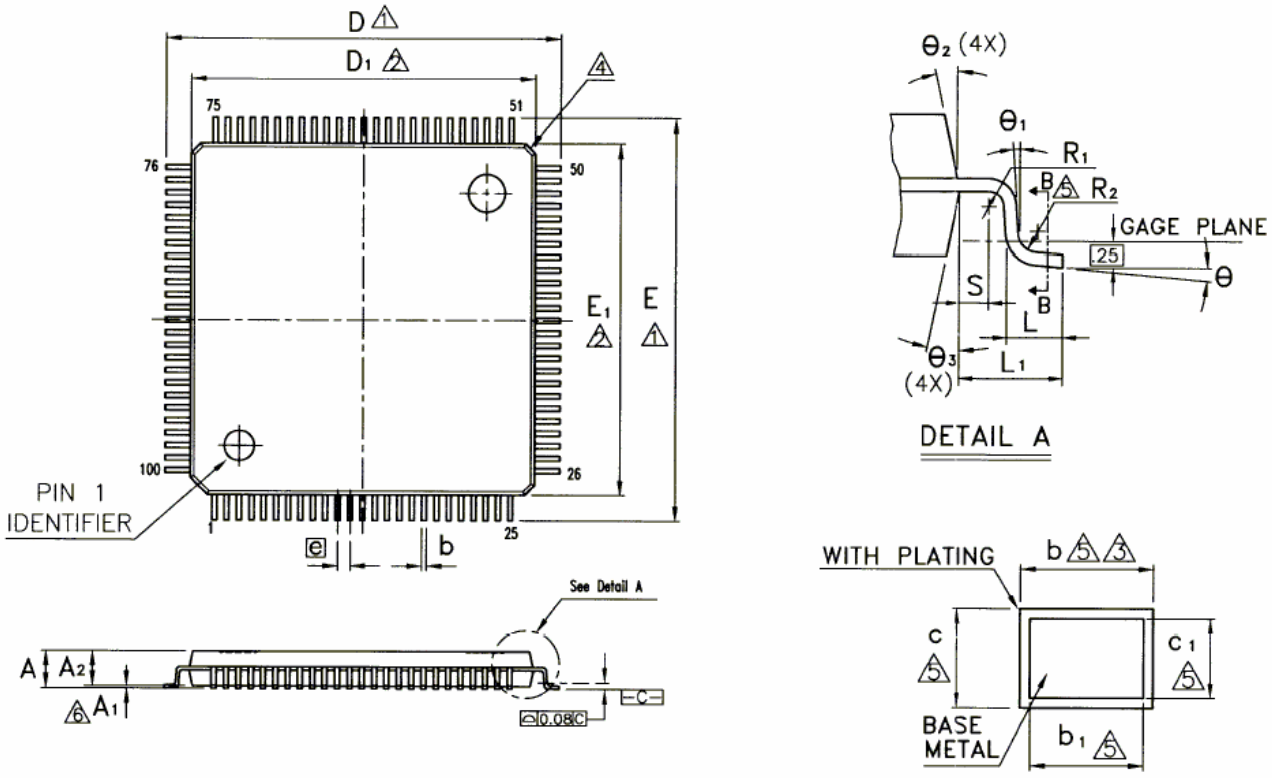
† Operating current assumes all inputs are tied to either V_{SS} or V_{DD} with no input currents due to programmed pullup resistors. The DAC output and other outputs are open circuited.
‡ The best trim value is selected at nominal temperature and voltage but the deviation due to the trim error is ignored.
§ Typical voltage and current measurement taken at 25°C
¶ Cannot exceed 15 mA total per internal V_{DD} pin. Port A, B share 1 internal V_{DD} pin; Port C, D share 1 internal V_{DD}

External Component Absolute Values

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$R_{(RTO)}$	RTO external resistance	T_A = 25°C, 1% tolerance		470	KΩ
$C_{(PLL)}$	PLL external capacitance	T_A = 25°C, 10% tolerance		3300	pF

Mechanical Data

LQFP 100 PLASTICQUAD FLATPACK (14x14x1.4 mm)



Symbol	Dimension in mm			Dimension in inch		
	Min	Nom	Max	Min	Nom	Max
A	-	-	1.60	-	-	0.063
A1	0.05	-	0.15	0.002	-	0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
b	0.17	0.22	0.27	0.007	0.009	0.011
b1	0.17	0.20	0.23	0.007	0.008	0.009
c	0.09	-	0.20	0.004	-	0.008
c1	0.09	-	0.16	0.004	-	0.006
D	15.85	16.00	16.15	0.624	0.630	0.636
D1	13.90	14.00	14.10	0.547	0.551	0.555
E	15.85	16.00	16.15	0.624	0.630	0.636
E1	13.90	14.00	14.10	0.547	0.551	0.555
e	0.50 BSC			0.20 BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030
L1	1.00 REF			0.039 BSC		
R1	0.08	-	-	0.003	-	-
R2	0.08	-	0.20	0.003	-	0.008
S	0.20	-	-	0.008	-	-
θ	0°	3.5°	7°	0°	3.5°	7°
θ1	0°	-	-	0°	-	-
θ2	12° TYP			12° TYP		
θ3	12° TYP			12° TYP		

Notes:

A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-022

Die Bond-out Coordinates

Die Size = **144.88 x 147.64 Mil**
Pad Size = **256 x 256 Mil**
Units = **Metric**

Pad	Pin	X-Axis Min	Y-Axis Min	X-Axis Max	Y-Axis Max
1	82	3402.53	622.82	3488.53	708.82
2	83	3402.53	776.82	3488.53	862.82
3	84	3402.53	930.82	3488.53	1016.82
4	85	3402.53	1084.82	3488.53	1170.82
5	86	3402.53	1238.82	3488.53	1324.82
6	87	3402.53	1392.82	3488.53	1478.82
7	88	3402.53	1546.82	3488.53	1632.82
8	89	3402.53	1700.82	3488.53	1786.82
9	90	3381.68	1852.09	3467.68	1938.09
10	91	3380.92	1957.97	3466.92	2043.97
11	92	3402.53	2110.12	3488.53	2196.12
12	93	3402.53	2264.12	3488.53	2350.12
13	94	3402.54	2418.12	3488.54	2504.12
14	95	3402.54	2572.12	3488.54	2658.12
15	96	3402.53	2726.12	3488.53	2812.12
16	97	3402.53	2880.12	3488.53	2966.12
17	98	3402.53	3034.12	3488.53	3120.12
18	99	3402.53	3188.12	3488.53	3274.12
19	100	3370.73	3325.11	3456.73	3411.11
20	5	3174.50	3395.51	3260.50	3481.51
21	6	3066.70	3395.62	3152.70	3481.62
22	7	2958.55	3395.51	3044.55	3481.51
23	8	2825.20	3395.61	2911.20	3481.61
24	9	2696.92	3426.74	2782.92	3512.74
25	10	2591.16	3426.74	2677.16	3512.74
26	11	2486.92	3426.74	2572.92	3512.74
27	12	2381.16	3426.74	2467.16	3512.74
28	13	2276.92	3426.74	2362.92	3512.74
29	14	2171.16	3426.74	2257.16	3512.74
30	15	2066.92	3426.74	2152.92	3512.74
31	16	1961.16	3426.74	2047.16	3512.74
32	17	1829.33	3396.38	1915.33	3482.38
33	31	133.08	3075.02	219.08	3161.02
34	32	133.08	2959.97	219.08	3045.97
35	33	111.44	2843.09	197.44	2929.09
36	34	111.44	2731.75	197.44	2817.75
37	35	111.44	2615.10	197.44	2701.10
38	36	111.44	2503.80	197.44	2589.80
39	37	111.44	2392.50	197.44	2478.50
40	38	111.44	2249.28	197.44	2335.28
41	39	111.47	2088.83	197.47	2174.83
42	40	111.47	1934.83	197.47	2020.83
43	41	111.47	1780.83	197.47	1866.83
44	42	111.47	1626.83	197.47	1712.83
45	43	111.47	1472.83	197.47	1558.83
46	44	111.47	1318.83	197.47	1404.83
47	45	111.47	1164.84	197.47	1250.84
48	46	111.47	1010.84	197.47	1096.84
49	47	111.44	897.45	197.44	983.45
50	48	111.44	786.15	197.44	872.15
51	49	111.44	674.88	197.44	760.88
52	50	132.30	565.86	218.30	651.86

Ordering Information

Part	Ordering P/N	Shipping P/N	Description
SC-601 DIE	**SC601-R**	65-xxxx-x (ROM specific)	Tested, Singulated SC-601 die in waffle pack.
SC-601 LQFP	**SC601-RL1**	65-xxxx-x (ROM specific)	SC-601 100 pin 14x14x1.4mm LQFP

The Interactive Speech™ Product Line

The Interactive Speech line of ICs and software was developed to “bring life to products” through advanced speech recognition and audio technology.
The Interactive Speech Product Line was designed for consumer telephony products and cost-sensitive consumer electronic applications such as home electronics, personal security, and personal communication.
The product line includes award-winning RSC series general-purpose microcontrollers and tools, SC series of speech microcontrollers, plus a line of easy-to-implement chips that can be pin-configured or controlled by an external host microcontroller. Sensory’s software technologies run on a variety of microcontrollers and DSPs.

RSC Microcontrollers and Tools

The RSC product line contains low-cost 8-bit speech-optimized microcontrollers designed for use in consumer electronics. All members of the RSC family are fully integrated and include A/D, pre-amplifier, D/A, ROM, and RAM circuitry. The RSC family can perform a full range of speech/audio functions including speech recognition, speaker verification, speech and music synthesis, and voice record/playback. The family is supported by a complete suite of evaluation tools and development kits.

SC Microcontrollers and Tools

The **SC-6x** product line features the highest quality speech synthesis ICs at the lowest data rate in the industry. The line includes a 12.32 MIPS processor for high-quality low data-rate speech compression and MIDI music synthesis, with plenty of power left over for other processor and control functions. Members of the SC-6x line can store as much as 37 minutes of speech on chip and include as much as 64 I/O pins for external interfacing. Integrating this broad range of features onto a single chip enables developers to create products with high quality, long duration speech at very competitive price points.

Application Specific Standard Products (ASSPs)

Voice Direct™ 364 provides inexpensive speaker-dependent speech recognition and speech synthesis. This easy-to-use, pin-configurable chip requires no custom programming and can recognize up to 60 trained words in slave mode, and 15 words in stand-alone mode. Ideal for speaker-dependent command and control of household consumer products, Voice Direct 364 is part of a complete product line that includes the IC, module, and Voice Direct 364 Speech Recognition Kit.

Voice Extreme™ simplifies the creation of fully custom speech-enabled products by offering developers the capability of programming the chip in a high-level C-like language. Program code, speech data, and even record and playback information can be stored on a single off-chip Flash memory. Based on Sensory's RSC-364 speech processor, Voice Extreme includes a highly efficient on-chip code interpreter, and is supported by a comprehensive suite of low-cost development tools.

Software and Technology

Voice Activation™ micro footprint software provides advanced speech technology on a variety of microcontroller and DSP platforms. A flexible design with a broad range of technologies allows manufacturers to easily integrate speech functionality into consumer electronic products.

Fluent Speech™ small footprint software recognizes up to 50,000 words; offers Animated Speech with the ability to automate enunciation and articulation; performs text-to-speech synthesis in either male or female voices; provides noise and echo cancellation, performs Wordspotting for natural language usage; offers telephone barge-in; and provides continuous digit recognition.

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