RSC-164
Recognition • Synthesis • Control

General Purpose Microcontroller Featuring Speech Recognition, Speech & Music Synthesis, Speaker Verification and Audio Record/Playback

GENERAL DESCRIPTION

The RSC-164, from the Interactive Speech™ family of products, is a low-cost microcontroller designed for use in consumer electronics. The RSC-164 combines an 8-bit microcontroller with high-quality speaker-independent and speaker-dependent speech recognition, speech synthesis, speaker verification, four-voice music synthesis, and voice record and playback. Products can use one or all of the RSC-164 features in a single application.

The RSC-164 employs a sophisticated neural network that learns to classify sound data. On-chip speech recognition algorithms reach an accuracy of greater than 96% for speaker-independent recognition and greater than 99% for speaker-dependent recognition. Sensory's neural network approach (patent pending) eliminates the need for expensive signal processing or extensive RAM storage.

The highly-integrated nature of the chip reduces external parts count. A complete system may be built with few additional parts other than a battery, speaker, microphone, and audio input support circuitry. Low power requirements make the RSC-164 an ideal solution for battery-powered and hand-held devices.

FEATURES

Full Range of Speech Capabilities

- Speaker-independent speech recognition
- Speaker-dependent speech recognition
- High quality speech synthesis and sound effects
- Speaker verification
- Four-voice music synthesis
- Voice record & playback

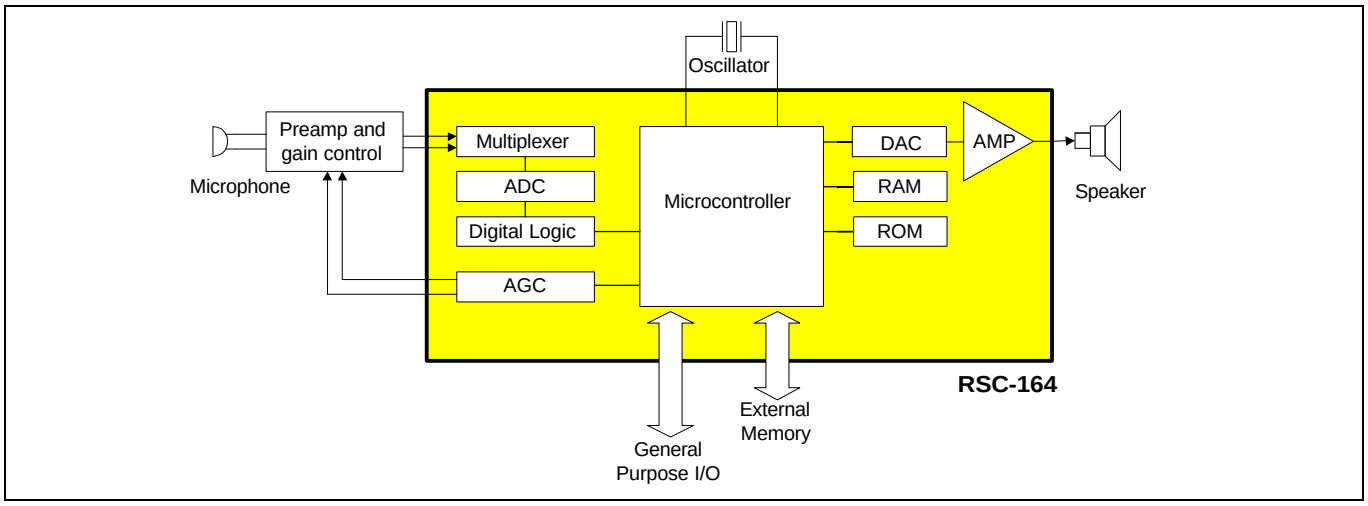
Integrated Single-Chip Solution

- 4 MIPS 8-bit microcontroller
- On-chip A/D and D/A converters, digital filtering
- 32kHz clock for time keeping
- Internal 64kbytes ROM; 384 bytes RAM
- 16 general purpose I/O lines
- External memory bus: 16-bit Address, 8-bit Data
- On-chip output amplifier for direct speaker drive

Low Power Requirements

- 3.5 - 5.0V supply
- ~10mA operating

RSC-164 Block Diagram



RSC-164 OVERVIEW

The RSC-164 is a member of the Interactive Speech™ line of products from Sensory. It features a high-performance 8-bit microcontroller with on-chip A/D, D/A, RAM and ROM. The RSC-164 is designed to bring a high degree of integration and versatility into low-cost, power-sensitive consumer applications.

Various functional units have been integrated onto the CPU core in order to reduce total system cost and increase system reliability without degrading system performance. The RSC-164 delivers 4 MIPS of integer performance at 14.32 MHz providing maximum performance at minimum cost.

The CPU core embedded in the RSC-164 is an 8-bit, variable-length-instruction, microcontroller. The instruction set is loosely based on Intel's 8051™, and has a variety of addressing mode *mov* instructions. The RSC-164 processor avoids the limitations of dedicated A, B, and DPTR registers by having completely symmetrical source and destinations for all instructions. The 384 bytes of internal RAM are organized as a Register Space.

SPEECH RECOGNITION

The RSC-164 uses a neural network to perform speaker-independent or speaker-dependent speech recognition. Speaker-dependent recognition requires external memory to store speech recognition information (e.g., SRAM, Flash Memory). Speaker-independent recognition requires on-chip or off-chip ROM to store the words to be recognized. The RSC-164 has several additional speech recognition features as described below.

Continuous listening allows the chip to continuously listen for a specific word. With this feature a product can be used in a normal environment and only "activates" when a specific word, preceded by quiet, is spoken.

Consecutive entry allows the chip to handle several voice inputs in succession as long as each input is surrounded by one-half second of quiet.

SPEECH AND MUSIC SYNTHESIS

The RSC-164 provides high-quality speech synthesis by using a hybrid of a time-domain compression scheme that improves on conventional ADPCM and a customized reuse of sounds. Speech synthesis requires on-chip or off-chip ROM to store audio sounds for synthesis.

The RSC-164 provides high-quality, low-cost four-voice music synthesis which allows multiple, simultaneous instruments for harmonizing. Music synthesis has low ROM requirements - a 2-3 minute song requires under 5 kbytes of incremental memory. The RSC-164 uses a MIDI-like system to generate music.

RECORD AND PLAYBACK

The RSC-164 can perform audio record and playback at various compression levels depending on the quantity and quality of playback desired. Data rates of under 14,000 bits per second are achievable while maintaining very high quality reproduction. The RSC-164 also performs silence removal to improve sound quality and reduce memory requirements.

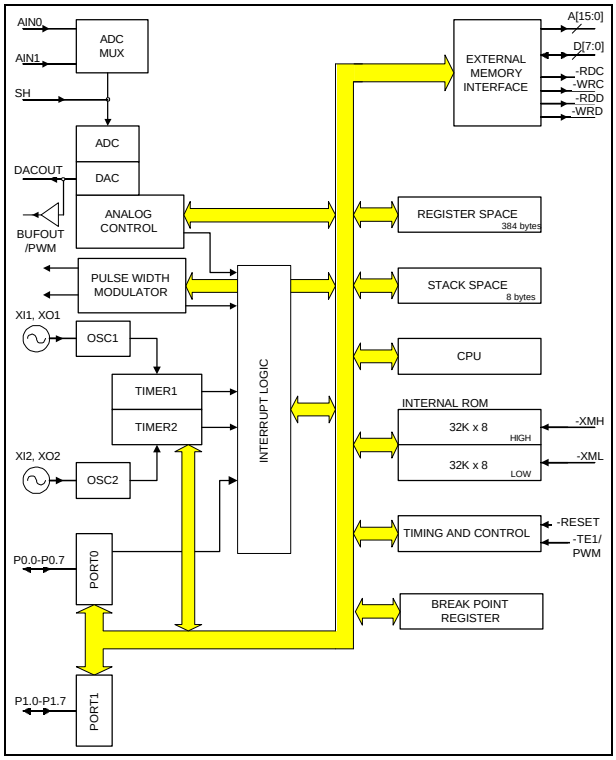
SPEAKER VERIFICATION

The RSC-164 can also perform text-dependent speaker verification. After a speaker trains the chip on a specific word, the chip is able to identify whether that word is spoken by the original speaker, thus providing biometric security.

POWER

The typical operating current is 10 mA operating at 14.32 MHz. Lowering clock frequency reduces power consumption, although speech recognition requires a 14.32 MHz clock.

RSC-164 Architecture Diagram



RSC-164 ARCHITECTURE

The RSC-164 is a highly integrated device that combines:

- 8-bit microcontroller
- On-chip ROM (64 kbytes) and RAM (384 bytes), and the ability to address off-chip RAM or ROM
- A/D converter and D/A converter

The RSC-164 has an external memory interface, with 16-bit addresses and a 8-bit data buses, for accessing external memory. It also has an internal ROM that can be enabled or disabled (partially or fully) by pin inputs (signals -XMH, -XML).

Two bi-directional ports provide 16 general purpose I/O pins to communicate with external devices. The RSC-164 has a high frequency (14.32 MHz) oscillator as well as a low frequency (32,768 Hz) oscillator suitable for timekeeping applications. The processor clock can be selected from either source, with a selectable divider value. The device performs speech recognition when running at 14.32 MHz. The RSC-164 also supports programmable wait states to allow the use of slower external devices. There are two programmable 8-bit counters / timers, one derived from each oscillator.

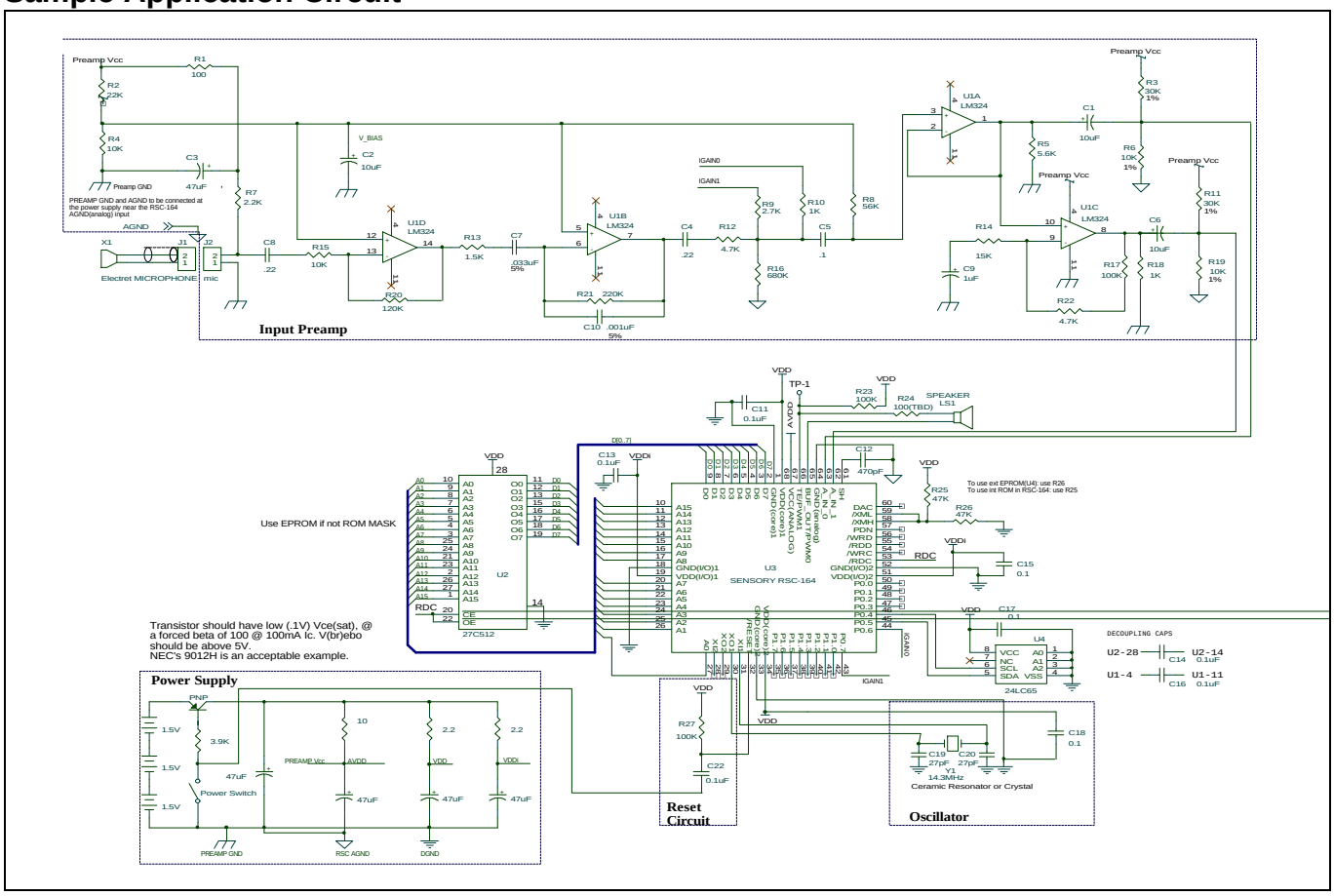
A microphone with an external preamp converts sound into an audio signal that is fed to the RSC-164. The gain of the external preamp may be controlled by the RSC-164 by using two of the I/O lines. The RSC-164 uses an ADC (Analog-to-Digital Converter) to convert incoming analog speech signal into digital data. The output audio signal of the RSC-164 is derived from a DAC (Digital-to-Analog Converter) or PWM (Pulse Width Modulator).

USING THE RSC-164

Creating applications using the RSC-164 requires the development of electronic circuitry, software code, and speech/music data files. Software code for the RSC-164 can be developed by Sensory or by external programmers using the RSC Development Kit. For more information about development tools and services, please contact Sensory. A typical product will require about $0.80 - $1.50 (in high volume) of additional components, in addition to the RSC-164.

The following sample circuit provides an example of how the RSC-164 might be used.

Sample Application Circuit



RSC-164 INSTRUCTION SET

The instruction set for the RSC-164 has 52 instructions comprising 8 move, 7 rotate, 11 branch, 11 register arithmetic, 9 immediate arithmetic, and 6 miscellaneous instructions. All instructions are 3 bytes or fewer, and no instruction requires more than 8 clock cycles to execute.

GENERAL PURPOSE I/O

The RSC-164 has 16 general purpose I/O pins (P0.0-P0.7, P1.0-P1.7). Each pin can be programmed as an input with weak pull-up (~200kΩ equivalent device); input with strong pull-up (~10kΩ equivalent device); input without pull-up, or as an output. This is accomplished by having 32 bits of configuration registers for the I/O pins (Port Control Register A and Port Control Register B for ports 0 and 1).

EXTERNAL MEMORY

The RSC-164 includes an external memory interface that allows connection with memory devices for speaker-dependent speech recognition, audio record/playback, extended durations of speech and music synthesis, and enhanced product functionality.

Separate data and address buses allow use of standard EPROMs, ROMs, SRAMs, and flash memory with little or no additional decoding. Provision of separate read and write signals for each external memory space further simplifies interfacing. The RSC-164 includes 8 data lines (D[7:0]) and 16 address lines (A[15:0]), along with associated control signals for interfacing to external memory.

Using flash memory and EEPROM will require custom code development. The RSC-164 can connect serially through two I/O lines to a serial EEPROM for applications with low data storage requirements.

OSCILLATORS

Two independent oscillators in the RSC-164 provide a high-frequency clock and a 32kHz time-keeping clock. The oscillator characteristics are as follows:

Oscillator #1: Pins XI1, XO1
14.32 MHz (3.5V-5.0V)

Oscillator #2 Pins XI2 and XO2
32768 Hz (3.5V-5.0V)

Oscillator #1 works with an external crystal, a ceramic resonator or LC. Use of Oscillator #2 requires a crystal for precision timing.

CLOCK

The RSC-164 uses a fully static core – the processor can be stopped (by removing the clock source) and restarted without causing a reset or losing contents of internal registers. Static operation is guaranteed from DC to 14.32 MHz.

Typically the processor clock runs from a 14.32 MHz crystal with no divisor and one wait state. This creates internal RAM cycles of 70 nsec duration and internal ROM or external cycles of 140 nsec duration. Careful design of external decoding logic and close analysis of gate delays may allow operation with memories having access times as slow as 120 nsec.

TIMERS/COUNTERS

The two independent oscillators of the RSC-164 provide counts to two internal timers. Each of the two timers consists of an 8-bit reload value register and an 8-bit up-counter. The reload register is readable and writeable by the processor.

INTERRUPTS

The RSC-164 allows for five interrupt sources, as selected by software. Each has its own mask bit and request bit in the IMR and IRQ registers respectively. The following events can generate interrupts:

- Positive edge on Port 0, bit 0
- Overflow of Timer 1
- Overflow of Timer 2
- Sensory reserved functions
- Completion of PWM sample period

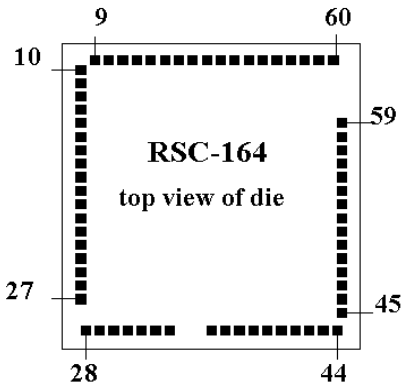
ANALOG OUTPUT

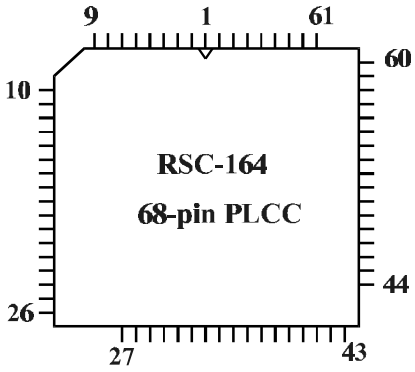
The RSC-164 offers two separate options for analog output. The DAC (Digital to Analog Converter) output provides a general purpose 10-bit analog output that may be used for speech output (with the inclusion of an audio amplifier), or other purposes requiring an analog waveform. For speech applications that require driving a small speaker, the PWM (Pulse-Width Modulator) output can be used instead of the DAC output. The PWM output can directly drive a 32 ohm speaker.

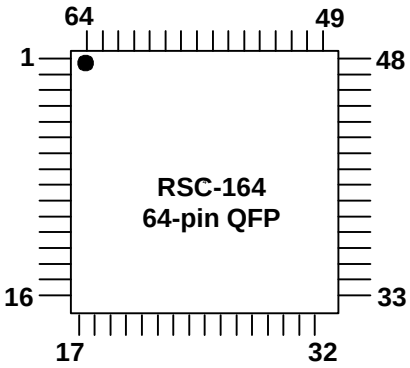
PACKAGING

The RSC-164 can be purchased as bare unpackaged die or packaged in 68-pin PLCC, 64-pin QFP packages, or 68- pin COB.

DIE BOND PAD, PLCC AND QFP PIN DRAWINGS







Name	PLCC Pin/ Die Pad	QFP Pin	Description	I/O
AGND	64	52	Analog Ground. For noise reasons, analog and digital grounds should connect together only at the RSC-164.	-
A[15:0]	10-17, 20-27	1-8, 11-18	External Memory Address Bus	O
AIN0	63	51	Analog In, low gain. (range AGND to AVDD/2.)	I
AIN1	62	50	Analog In, hi gain (8X input amplitude of AIN0, same range)	I
AVDD	67	55	Analog Voltage. For noise reasons, keep this supply independent of digital circuitry.	-
PWM0	65	53	Pulse Width Modulator Output0	O
DACOUT	60	48	Analog Output (unbuffered).	O
D[7:0]	2-9	57-64	External Data Bus	I/O
GND	1, 18, 33, 52	9, 22 41, 56	Digital Ground, CPU core (pins 1 and 33) and I/O (pins 18and 52)	-
PDN	57	NA	Power Down. Active high when powered down.	O
P1[7:0], P0[7:0]	35-42, 43-50	24-31, 32-39	General Purpose Port I/O. Pin P0.0 can act as an external interrupt input. All I/O pins can act as “wake up” inputs.	I/O
-RDC	53	42	External Code Read Strobe	O
-RDD	55	44	External Data Read Strobe	O
-RESET	32	21	Reset	I
SH	61	49	Sample and Hold. Connect a 470 pF capacitor from here to AGND.	I
-TE1/PWM1	66	54	Test Mode *or* Pulse Width Modulator Output1 (multiplexed)	I *or* O
VDD	34, 68	23	Digital Supply Voltage (core)	-
VDDi	19, 51	10, 40	Digital Supply Voltage (I/O line)	-
-WRC	54	43	External Code Write Strobe	O
-WRD	56	45	External Data Write Strobe	O
-XMH	58	46	External Hi-memory enable (low active)	I
-XML	59	47	External Low-memory enable (low active)	I
XO1	30	19	Oscillator 1 output (high frequency)	O
XI1	31	20	Oscillator 1 input	I
XO2	29	NA	Oscillator 2 output (32768 Hz)	O
XI2	28	NA	Oscillator 2 input	I

DC CHARACTERISTICS

(T_O = 0°C to +70°C, Vdd = 5V)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
$\mathbf{V_{IL}}$	Input Low Voltage	-0.1		0.75	V	
$\mathbf{V_{IH}}$	Input High Voltage	2.5		Vdd+0.5	V	
$\mathbf{V_{OL}}$	Output Low Voltage		0.3	0.5	V	$\mathbf{I_{OL}}$= 4 mA
$\mathbf{V_{OH}}$	Output High Voltage	4.0	4.3		V	$\mathbf{I_{OL}}$= -4 mA
$\mathbf{I_{IL}}$	Logical 0 Input Current					
$\mathbf{I_{CC1}}$	Digital Supply Current		10		mA	Osc1 Freq=14.32 MHz, CPU clock divide by 1
$\mathbf{I_{CC2}}$	Analog Supply Current		0.15		mA	Osc1 Freq=14.32 MHz, CPU clock divide by 1
$\mathbf{I_{CC3}}$	Digital Supply Current, Standby					Power-down mode
$\mathbf{I_{CC4}}$	Analog Supply Current, Standby					Power-down mode
Rpu	Pull-up resistance P0.0-P1.7	10	400	Hi-Z	kΩ	selected with software

A.C. CHARACTERISTICS (EXTERNAL MEMORY ACCESSES)

(T_O = 0°C to +70°C, Vdd = 5V; load capacitance for outputs = 80 pF; Osc=14.32 MHz)

SYMBOL	PARAMETER	CPU=osc/1, 1 WS		CPU=osc/2, 0WS		UNITS
		MIN	MAX	MIN	MAX	
1/TCL1	Processor Clock frequency		14.32		7.16	MHz
TRLRH	-RDC (-RDD) Pulse Width		140		140	ns
TRLAV	-RDC (-RDD) Low to Address valid		5		5	ns
TALRAX	Address hold after -RDC (-RDD)		0		0	ns
TRAVDV	Address valid to Valid Data In		135		135	ns
TRHDX	Data Hold after -RDC (-RDD)	0		0		ns
TWLWH	-WRC (-WRD) Pulse Width		140		140	ns
TAVWL	Address Valid to -WRC (-WRD)	35		70		ns
TALWAX	Address Hold after -WRC (-WRD)	35		70		ns
TWDVAV	Write Data Valid to Address Valid		5		5	ns
TWHQX	Data Hold after -WRC (-WRD)	35		70		ns

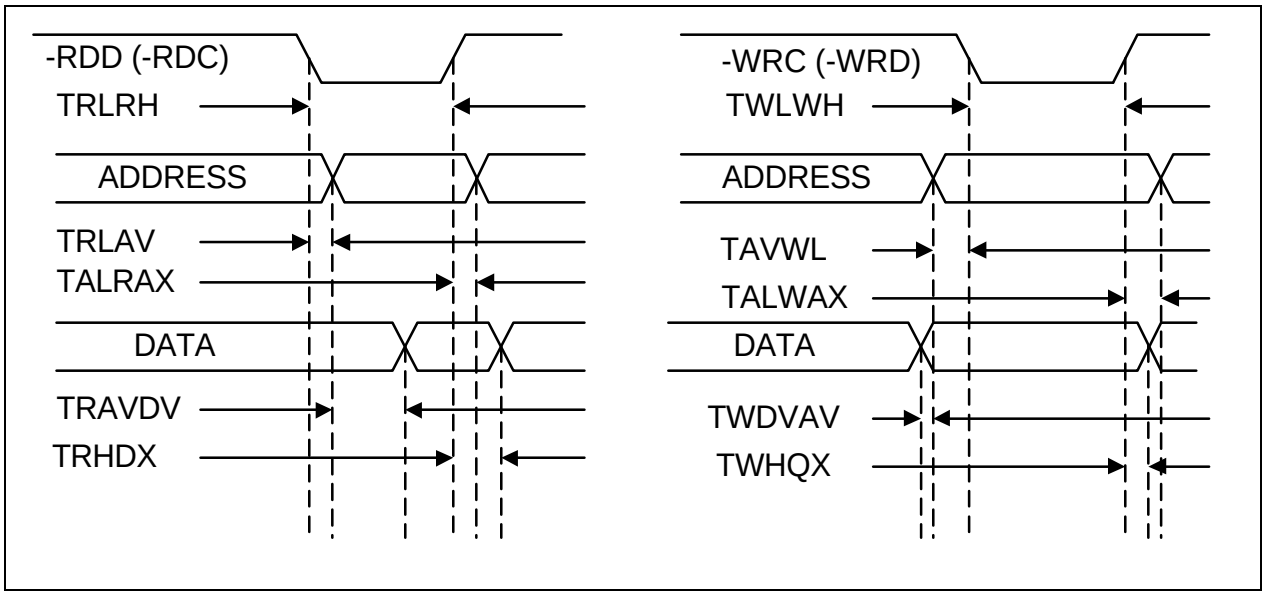
ABSOLUTE MAXIMUM RATINGS

Any pin to GND	-0.1V to +7.5V
Operating temperature (T_O)	0°C to +70°C
Soldering temperature	260°C for 10 sec
Power dissipation	TBD
Operating Conditions	0°C to +70°C; VDD=3.5 - 5.0V; VSS=0V

WARNING: *Stressing the RSC-164 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.*

TIMING DIAGRAMS

Note that the -RDC signal does not necessarily pulse for every read from code space, but may stay low for multiple cycles.



External Read Timing **External Write Timing**

ORDERING INFORMATION

Part	Suffix	Description
RSC-164	none	Unpackaged RSC-164 in die form
RSC-164	P	RSC-164 in 68-pin PLCC package
RSC-164	Q	RSC-164 in 64-pin QFP package
RSC-164	C	RSC-164 in 68-pin COB package

THE INTERACTIVE SPEECH™ PRODUCT LINE

The Interactive Speech line of ICs was developed to *"bring life to products"* through advanced speech and audio technology. These chips allow products to think, talk, hear and play music. The Interactive Speech chips were designed for consumer telephony products and cost-sensitive consumer electronic applications such as home electronics, personal security, and personal communication. The product line includes general purpose microcontrollers (RSC-164, RSC-164i, RSC-132i) and application specific standard speech ASSPs (Voice Password™ and Voice Direct™).

RSC-164i

The RSC-164i is very similar in functionality to the RSC-164 and can perform speech recognition, speaker verification, speech and music synthesis, and general product control. This chip requires a custom mask of the on-chip ROM for each customer application and is ideal for high volume applications. This chip has limited I/O pins and limited access to external memory.

RSC-132i

The RSC-132i, the lowest cost member of the RSC series, is a speech enabled microcontroller designed specifically for the toy industry. The RSC-132i can support various combinations of speech technologies. The RSC-132i combines an 8-bit microcontroller with high quality speaker-independent and speaker-dependent speech recognition, speech synthesis, and speaker verification. This chips has 32 kBytes of ROM and limited I/O pins

Voice Password™ ASSP

The Voice Password™ ASSP provides consumer products with low cost biometric security. The chip lets products "lock out" unauthorized access by verifying key words and/or voices. Using text dependent speaker verification technology, Voice Password can secure products at a variety of security thresholds for many different applications.

Voice Direct™ ASSP

The Voice Direct™ ASSP provides cost-sensitive products with speaker-dependent speech recognition, speech synthesis and DTMF tone generation. This easy-to-use, pin-configurable chip requires no custom programming and can recognize up to 60 trained words. The Voice Direct™ ASSP is most ideal for consumer telephony products which feature voice dialing.

IMPORTANT NOTICES

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