RSC-4x Family Memory and In-System Programming

DESIGN NOTE

I. Overview

This document reviews the various memory types and structures commonly found on RSC-4x Family designs, and also describes several possible designs with external code/const memory storage, serial data memory, and In-System Programming (ISP).

II. Memory Types

There are several different memory options available for the RSC-4x Family. For full details on RSC-4128 and RSC-464 memory addressing, refer to the RSC-4128 datasheet (80-0206) and RSC-464 datasheet (80-0282).

A. Code/Const and Data Spaces

The RSC-4x Family implements the Harvard Architecture with two separate memory spaces: code/const space and data space.

1. Code/Const Space

Code/const space is primarily the memory space where the executable program resides, although other data may be stored here as well. Internal masked memory ***or*** external code/const space memory, but ***not*** both, may be used in a RSC-4128 design. The –XM pin determines whether internal mask memory or external memory is used. It is not possible to combine internal and external code/const space in the same design. This is a security feature which discourages creating external code to dump internal code memory contents.

The RSC-464 does not have an external address/data bus and therefore only internal masked memory may be used for code/const space on it.

a) Internal Code/Const Memory

The RSC-4128 has 128 Kbytes, and the RSC-464 64 Kbytes, of internal permanent masked ROM which can be used to store the executable program and other data. The masked ROM configuration is set during IC manufacture and cannot be changed in the field.

Internal memory access is selected by pulling high, or allowing the –XM pin to float high, during reset on the RSC-4128. The internal memory option is always selected for the RSC-464.

NOTE: There is a minimum order quantity (MOQ) associated with masked RSC-4128 or RSC-464 orders. Contact Sensory Sales for more information.

b) External Code/Const Memory

Designs that use more than 128 Kbytes of code/const memory, or can not meet the MOQ requirement, must use an external code/const memory in combination with an RSC-4128, with –XM pulled low. The external memory option is not available for the RSC-464. External code/const memory is accessed using the RSC-4128 address lines A0-A19, data lines D0-D7, and –RDR and –WRC read/write strobe control lines. Only parallel memory devices may be used for external code memory. There are many types of parallel memory devices available, but they can be grouped into two general categories: Erasable/reprogrammable (e.g. EEPROM, Flash) and Static (e.g. ROM, OTP PROM). Systems that use the first group may utilize In-System Programming, which is discussed in detail in Section IV.

2. **Data Spac**e

In addition to code/const memory, a design may include a separate memory for program data. The RSC-4128 and RSC-464 do not have any internal data space memory (though the const space may be used for data). Data space memory devices fall into two general categories: parallel and serial.

a) Parallel Data Memory

Parallel data space memory is accessed using the address lines A0-A19, data lines D0-D7, and –RDF and –WRD read/write strobe control lines on the RSC-4128. Parallel data memories may be dynamically writable, like Flash or EEPROM or RAM, or static like ROM and EPROM.

b) Serial Data Memory

Serial data space memory is accessed using the GPIO lines on either the RSC-4128 or RSC-464. Serial memory may be dynamically writable, like serial Flash, or static like serial ROM. Not all RSC data may be used with serial memories. For example, T2SI data can only be stored in parallel memory due to retrieval speed requirements.

III. Data Types

This section describes some of the most common RSC-4128 and RSC-464 resources that are stored in memory. This list is provided by way of illustration, and is not exhaustive.

	Code/Const	**Data**
Parallel (Static)	Program Code Technology Libraries SX Speech Data MIDI Instruments (1) MIDI Songs T2SI Models/Grammers	SX Speech Data MIDI Songs T2SI Models/Grammers
(Dynamic)	**(Not Available)**	SD/SV/WS Templates RP/RP-Msg
Serial (Static)	**(Not Available)**	SX Speech Data MIDI Songs
(Dynamic)	**(Not Available)**	SD/SV/WS Templates RP/RP-Msg (flash only)

Notes:
1. Some instruments may be placed anywhere in Code/Const memory. Others may only go in Code bank 1.

Figure 1 - Memory Grouping Chart

A. Application Program and Technology Code

Central to any RSC-4x Family program is the executable application program and underlying technology libraries. The application code is that part written by the developer. Technology libraries are provided by Sensory to perform underlying low-level API functions. Most developers will use the Sensory FluentChip speech software libraries, which contain over 200 API calls, and write their application on top of it.

The application program and technology code may be placed in either internal masked ROM, or in external parallel code/const memory space. They may not be placed in data space, nor may they be placed in serial memory. A typical application uses about 2 to 10 Kbytes, and the technology library code typically ranges from 10 to 35 Kbytes.

B. SX Data

SX is a method of synthesized speech output that allows the RSC-4x Family to "speak" words, sound effects or polyphonic music. SX Speech is created from WAV files by the companion Sensory speech compression tool QuickSynthesis. SX data is available in a number of different compression levels. Higher compression means more SX data may be stored in the same amount of memory while lower compression means better sounding output speech. Some data, like sound effects and music, need to be compressed at the lowest possible compression rates for acceptable output quality.

SX data may be placed in any memory space: either code/const space or data space, and in parallel or serial memory. SX data is available in a variety of compression levels ranging from 1 Kbyte/second (8 Kbits/second) down to 250 Bytes/second (2 Kbits/second). For maximum output quality, lightly compressed music, sounds effects and speech are available in 4 Kbytes/second (32 Kbits/second) ADPCM, and 7 Kbytes/second (56Kbits/second) PCM formats.

C. MIDI Music Data

MIDI is a method of synthesized music that allows the RSC-4x Family to play music. MIDI is composed of two data structures, instruments and songs. An instrument is the sounds of a particular musical instrument or other pitch scalable sound, and a song is the representation of all the notes and other information in a musical song.

MIDI instruments must be placed in parallel memory. Some MIDI instruments may be placed anywhere in code/const space, while others must be placed in Bank 0 of code space. MIDI instruments may not be placed in data space. MIDI songs may be placed in any memory space: either code/const space or data space, and in parallel or serial memory.

D. T2SI Acoustic Model and Grammar Data

T2SI (Text-to-Speaker-Independent) is a method of recognition of pre-programmed words and phrases. T2SI recognition sets are created using a companion software tool called Quick T2SI. A T2SI set consists of two data structures: an acoustic model and a grammar. The acoustic model contains all the phonemes needed to pronounce the words in that set, and the grammar data is a digital representation of the word pronunciations to be recognized. For example, the acoustic model data for a word like "pepper" would include the sounds "p", "eh" and "er". The "p" sound is repeated, so it only needs to be included in the acoustic model one time. For this example, the grammar might include the phonemes "p-eh-p-p-er". Each T2SI set is created with its own separate acoustic model and grammar files, but multiple sets' acoustic models may be combined into a single acoustic model to avoid repetition of phonemes already included. This allows overall program memory needs to be reduced.

T2SI data must be placed in parallel memory, and in either code/const space or data space. T2SI may not be placed in serial memory due to retrieval speed requirements. A typical T2SI acoustic model of 1 trigger word and about 10 command words of average length will use about 20 Kbytes. The maximum theoretical size of the English Language acoustic model (one that included every possible phoneme) would be about 42 Kbytes, so additional T2SI sets have a diminishing impact on storage requirements. Each T2SI grammar ranges from 1 to 12 Kbytes, depending on the number of words/phrases in that recognition set.

E. SD/SV/SDWS/SVWS Templates Data

SD/SV/SDWS/SVWS are a method of speech recognition that recognizes from a user-trained vocabulary. SD recognition sets are trained or defined during run-time and are grouped into sets of 1 to 64 entries, called templates. Multiple sets may be included in a design, but only one set may be recognized at a time. A template only contains information necessary for recognition – it does not contain any information for sound playback.

SD/SDWS are for the end user to create custom commands or triggers. SV/SVWS are for the end user to create voice passwords. They are similar technologies, but SV/SVWS is more discriminating of the individual.

SD/SV/SDWS/SVWS data may be placed in any writable data space memory. Either parallel or serial memory may be used. SD/SV/SDWS/SVWS Templates are 256 bytes in length, regardless of the length of the utterance used during training.

F. RP and RP Messaging Data

RP and RP-Messaging are a method of dynamically recording and subsequently playing back sound. Recordings are recorded at either 4-bits or 8-bits per sample. RP recordings are stored at a specified address in memory, while RP Messaging utilizes a memory manager to store and manage the recordings in memory.

RP and RP Messaging data may be placed in any writable data space memory. Either parallel or serial memory may be used. RP and RP Messaging recordings are available in two compression levels, 4-bit and 8-bit. 4-bit recordings use 4 Kbytes/second and 8-bit recordings use 7 Kbytes/second. In addition, if RP Messaging is used, then two 256-Byte tables are reserved for the directory and FAT table respectively.

IV. In-System Programmable Designs

A. ISP on the RSC-4128

In-System Programmability on the RSC-4128 presents two special challenges:

1. The RSC-4128 has 20 address lines and 8 data lines on its bus. The address pins are normally configured as outputs. They switch to a Hi-Z state when the chip goes into a low-power sleep mode, but the only way to get the chip into sleep mode is through software. Which presents a chicken-and-egg problem: how can the RSC-4128 enter into sleep mode so an external code Flash can be programmed, unless the external memory is already programmed with a sleep mode program?
2. The RSC-4128 cannot simultaneously run a program out of a Flash memory and reprogram that same Flash memory. During a Flash write cycle, the memory is briefly unavailable for reading and will return garbage if a read is attempted. But if the Flash is not ready when the RSC-4128 needs to fetch the next program instruction, then the RSC-4128 will fetch garbage and the program will likely crash.

B. Sample ISP Designs

1. Socketed Memory Designs

Although technically not an In-System Programmable design, perhaps the easiest way to change the executable program is to simply use a socketed memory. The memory chips can be removed and replaced with new ones with updated program code and data.

2. Masked Bootloader Designs

In a masked bootloader design, a bootloader program is masked into the RSC-4128 and the –XM pin is used to select whether internal or external program is run. An example of this programming scheme can be seen in the Sensory VR Stamp design. Refer to the “VR Stamp Module with Serial EEPROM” schematic (p/n 70-0066) for more information on this example. A developer can create a bootloader program required by their application and have it masked onto the RSC-4128.

NOTE: The special RSC-4128 parts masked with the Sensory VR Stamp bootloader are not commercially available. In any case, the developer should create a bootloader appropriate to their unique system requirements.

3. External Bootloader Designs

Sensory provides the Sensory ISP Reference Design Guide (p/n 50-0122), a reference ISP consisting of bootloader, schematics and documentation. It describes an ISP system utilizing three chips, an RSC-4128, an OTP containing the bootloader, and a code Flash memory to store the downloaded program.

The Sensory ISP Reference Design Guide can be downloaded from the Downloads page of Sensory's website.

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 technologies. It is designed for cost-sensitive consumer-electronic applications such as home electronics, home automation, toys, and personal communication. The line includes the award-winning RSC-4x family of mixed signal processors and tools, the *VR Stamp*™ 40-pin DIP module and tools, and the SC series of speech and music synthesis microcontrollers. It also includes our suite of software development kits, which are designed to run on non-Sensory processors and DSPs and support most popular operating systems.

RSC Microcontrollers and Tools

The RSC product family 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 recording/playback. The family is supported by a complete suite of evaluation and development toolkits.

Speech Recognition Modules and Tools

The VR Stamp™ is a complete speech recognition module based on the RSC-4x and is ideal for fast design and easy production. A low-noise audio channel and standardized 40-pin DIP footprint allow rapid prototyping, less debugging, and shorter time to market. The *VR Stamp Toolkit* includes everything needed to get started today, including VR Stamps, Module Programming Board, sample applications, and a complete set of development tools featuring the Phyton IDE and limited-life C compiler, QuickSynthesis™ 4 and Quick T2SI-Lite™ speech tools.

SC Microcontrollers and Tools

The SC-6x product family 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 processing and control functions. Members of the SC-6x line can store as much as 37 minutes of speech on-chip and include as many as 64 I/O pins for external interfacing. Integrating this broad range of features into a single chip enables developers to create products with high quality, long duration speech at very competitive price points.

FluentSoft™ Technology

FluentSoft™ Recognizer is the engine powering the FluentSoft™ SDK. It provides a noise-robust, large-vocabulary, speaker-independent solution with continuous digit recognition and word-spotting capabilities. This small-footprint software recognizes up to 5,000 words; runs on non-Sensory processors including Intel XScale, TI OMAP, and ARM9 platforms; and supports operating systems such as MS Windows, Linux, and Symbian.

3Dmsg™ Technology

3Dmsg's (www.3Dmsg.com) Animated Speech technology offers animated avatars with advanced speech recognition and synthesis capabilities for use in smartphones, language trainers, and kiosk applications. Facial expressions can be configured to show emotions and lip synchronization can be automatically driven from voice or text data.

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