Easy R8C/M16C/M32C/R32C Flash Programming

DJ Delorie

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Easy R8C/M16C/M32C/R32C Flash Programming

This document will provide a basic understanding of how the R8C/M16C/M32C/R32C family of microprocessors can be programmed with new flash contents. To make things easier, we'll refer to any of these chips as "the chip" unless we're talking about a specific one. We refer to the machine providing the programming signals as "the host" regardless of how these signals are generated (serial port, USB, something else).

The simplest method to program from a host is the asynchronous serial mode, often called "serial mode 2". This mode lets you use a standard serial port, such as is found on most PCs, and two jumpers. One jumper is for nRESET, and the other is for the MODE or CNVss pin (different chips call them different things, we'll use MODE in this document). In addition, each chip may have other pins which must be pulled high or low for this mode; check the chip's hardware manual for details. Usually a high-valued resistor is sufficient for these pins. The serial pins on the chip are TTL logic, *not* RS-232 logic. You'll need a converter to connect to a standard serial port, or use a TTL-level USB-to-serial cable like FTDI's TTL-232R (5 volts) or TTL-232R-3V3 (3.3 volts). You can also connect the pins to the UART pins of some other MCU chip such as another M32C. You just need two serial pins (Tx and Rx), and two GPIO pins (nRESET and MODE).

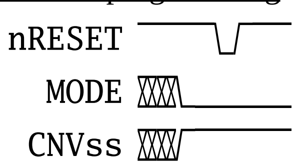
For example, in one of my projects, I have five R8C chips connected to an XScale chip which can program them as well as communicate with them. The five R8C RX lines are all tied together, and a multiplexer chooses which of the five TX lines the XScale listens to. The MODE lines are all tied together, and five XScale GPIO independently reset the R8Cs. The XScale can thus reset only the relevant R8C chip and program it; the others will ignore their MODE and RX lines.

Each chip has two program memories. The main memory is the user flash memory that holds your application, which is what we want to reprogram. There is a second smaller memory in each chip that contains a small bootloader program. When you want to program a new application, you tell the chip to boot from the second memory, and the bootloader there helps you download new data into the main flash memory through a simple communications protocol.

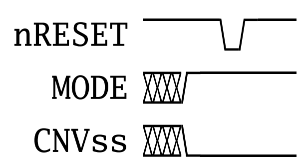
Reset

The chip decides which memory to boot from (user flash or bootloader) by checking the MODE pin at reset. If the MODE pin is high (it's normally pulled high with a resistor), the chip boots from user flash and runs your software. If it's low, the bootloader runs instead, and you can download new contents into the flash. For chips with CNVss, the functionality is the same but the logic is inverted:

Reset for programming



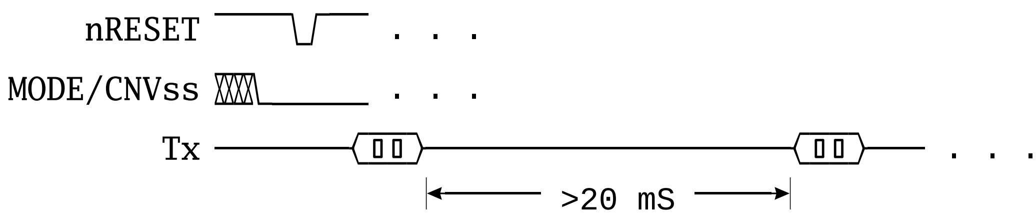
Reset to Run



You would normally leave the MODE pin unchanged except just before a reset. Fortunately, the timing is very loose on these - you can control these two pins with jumpers. On most eval boards, the pins are pulled high (or low, for CNVss) with resistors, so what you do is put the MODE jumper in place (which pulls MODE to ground), press the reset button, then run the host program which talks to the bootloader. When the programming is done, remove the MODE jumper, press the reset button, and your software runs.

Auto-Baud

In mode 2, the first thing you do is teach the bootloader what baud rate to use, since the bootloader doesn't know how fast the chip's clock is. Wait 3mS or so for the chip to come out of reset, then send 16 NUL bytes spaced 20 mS or more (I use 40 mS) apart. These bytes should be sent at 9600 baud, 8 bits, no parity, one stop bit. Different chips require different delays between bytes, but this should be long enough to work with them all. In this diagram we show the sequence - set MODE, reset, start sending NUL bytes. Note that all values shown for the Tx and Rx lines are in hex, so ⟨65⟩ is 0x65 (decimal 101), not decimal 65.



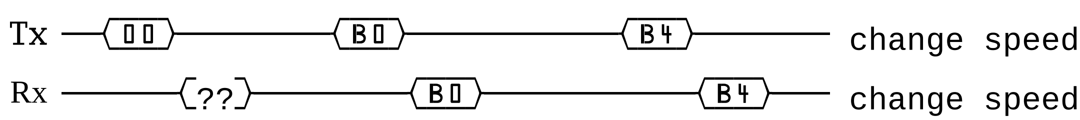
After sending the last byte, wait 2mS and then read any data that might have been sent back to the host. Sometimes there's a glitch at reset that looks like a byte, and some chips transmit a byte at the end of synchronization. By reading these optional bytes and clearing your receive buffer, you ensure you're in sync with the bootloader.

Baud Rate

The next step is to verify the autobaud rate, and set the desired baud rate. The initial synchronization is done at 9600 baud, but you can ask the chip to use a faster baud rate if your hardware (host and chip) support it. Baud changes are done with single byte commands, and the chip responds by sending you the same byte back:

9600	B0
19200	B1
38400	B2
57600	B3
115200	B4

The request is sent out with the old baud rate, and the chip responds with the **old** baud rate before changing it. Send the baud rate command, check the response, and if it's correct then change the baud rate at your end. So, after the last NUL byte is sent, read any pending bytes and send a request for 9600 baud to verify communications, then request your new baud rate and verify it:

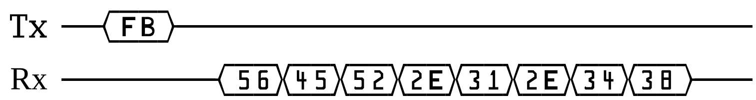


Note that not all baud rates will work; which ones work depend on what speeds your chips are running at. For some speeds, the chip might not be able to generate a baud clock accurately enough. Try them all until you find one that works reliably.

Bootloader Version

The next thing to do is ask the bootloader for its version number. It's not that useful from a program's point of view, but you can use it to make sure the baud rate is reliable. The request is a single byte

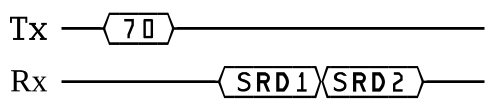
(0xFB), the response is eight bytes, intended to be human readable:



In the above example, the version string is "`VER.1.48`". The chips I've seen all follow this pattern (with various digits, of course), so my utility checks for each character to be the right type (specific letters, any digits, etc).

Status

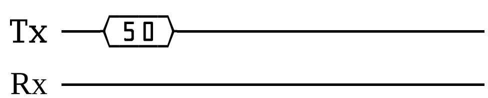
The next command to know is how to check the status of the bootloader. We use this command at various points to make sure the previous operation completed successfully. The request is a single byte (0x70), and response is two bytes:



There are only a couple of bits that we care about. Bit 7 of SRD1 is set when the bootloader is ready for another command. Bit 5 is set when an erase command fails. Bit 4 is set when a program command fails. Bits 3 and 2 of SRD2 tell you if you've "unlocked" the flash by providing the correct unlock key:

`xxxx 00xx`	No key provided yet
`xxxx 01xx`	Wrong key provided
`xxxx 11xx`	Correct key provided

Throughout this manual, when we say "check the status" we mean to run this command and check the status bits that are returned. You can also clear the status bits:

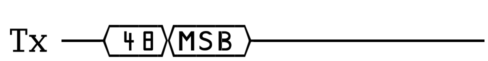


You should clear the status before erasing or programming the flash, as the error bits for those are cumulative.

Ok, now that we know how to talk to the bootloader, we need to start the process of downloading the new application into the flash. We first have to unlock the chip. Then we erase the flash. Then, for each page (256 bytes) of memory that needs to be programmed, we download that page then read it back to verify it.

Address Sizes

A quick note on address sizes... The commands we send to the chip all have 24-bit address parameters. This is because the protocol was designed for the M16C family, which has a 20-bit address. However, with the introduction of the R32C, which has a 32-bit address, a new command was added to provide the upper 8 bits of the address separately. Throughout this manual, where you see a command that takes a 24-bit address, for the R32C, you prefix it with this sequence (0x48, not 0x4B) to provide the extra bits:



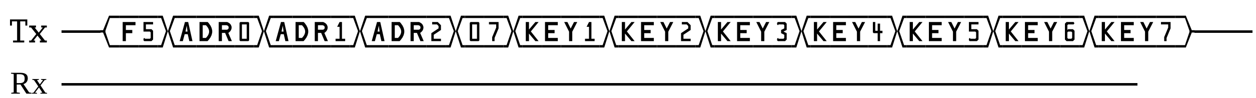
For example, to issue a fictitious command CMD with address 0x12345678, we'd do something like this:

Unlock

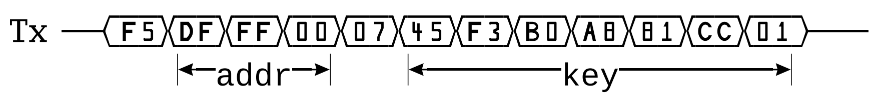
To unlock the chip, we need to know the flash locking code that was last programmed into it. Most development tools use either all zeros or all ones (0xff) for the default key, so if you don't know the right key you can try those. Each chip reserves seven bytes near the end (high addresses) of the flash, which vary by family:

Key Byte	R8C	M16C	M32C	R32C
1	0x00FFDF	0x0FFFDF	0xFFFFDF	0xFFFFFFE8
2	0x00FFE3	0x0FFFE3	0xFFFFE3	0xFFFFFFE9
3	0x00FFEB	0x0FFFEB	0xFFFFEB	0xFFFFFFEA
4	0x00FFEF	0x0FFFEF	0xFFFFEF	0xFFFFFFEB
5	0x00FFF3	0x0FFFF3	0xFFFFF3	0xFFFFFFEC
6	0x00FFF7	0x0FFFF7	0xFFFFF7	0xFFFFFFED
7	0x00FFFB	0x0FFFFB	0xFFFFB	0xFFFFFFEE

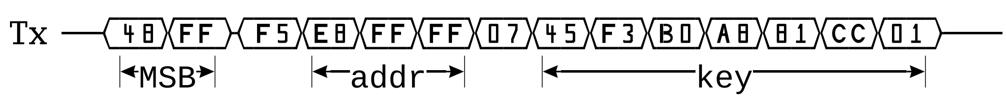
Always check the status after attempting to unlock the chip, to see if the key you provided is correct. The unlock request is one byte 0xF5 followed by the address of key byte one (from the above table, three bytes, least significant byte first), followed by the size of the key (0x07), followed by the seven key bytes (in the order indicated by the above table):



For example, to program an R8C/1B with a key of 45,F3,B0,A8,81,CC,01 we'd use these bytes to unlock it:



To program an R32C with a key of 45,F3,B0,A8,81,CC,01 we'd need to provide a 32-bit address:



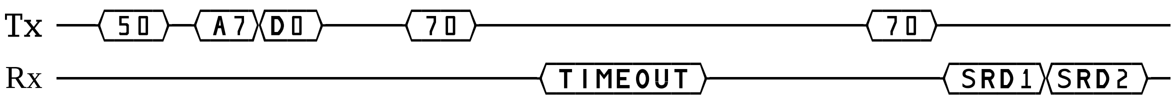
In my utilities, I try unlocking first all zeros, then all ones (0xff), stopping when I see the "correct key" code in the status response.

Ok, now for the actual programming part. There are three command you need to know how to do - erase, program, and verify. The programming sequence is to erase everything, then program the pages you need to program, reading each one back to verify it got copied correctly.

Also, in my utilities I forcibly set the flash locking key in the image I'm downloading to be all zeros, in case the tools don't set them to something meaningful. Also, I set the R8C watchdog byte to 0xff. If you actually use these features, you can include command-line options to leave them alone or set them to specific values.

Erase All

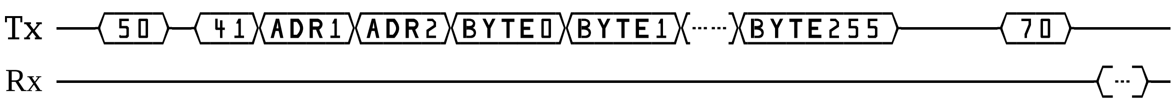
Erasing everything is easy. It's not as fast or as optimal as just erasing the blocks you need, but it's universal. Since this command takes a while to run, special precautions will be taken to properly clear and read the status.



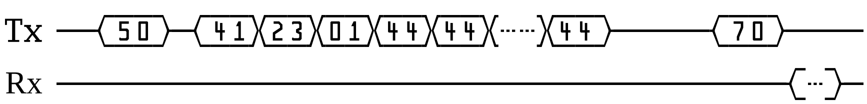
After you issue the format command (0xA7, 0xD0), set up a 1 second timeout on receive and start asking for status. If the status read times out, keep trying. I try 15 times. If you get data back but it doesn't make sense, or if it indicates that the erase isn't done, wait 500mS and flush any other bytes you may have received before trying again. This helps re-synchronize the status read, so that you're sure you're reading SRD1 first and not the old SRD2 first.

Program Page

A "page" of memory is 256 bytes, aligned on a 256 byte boundary. Since the address always ends in 0x00, only two bytes of address need be downloaded*. Send the middle byte first, followed by the high (MSB) byte, followed by 256 bytes of data:



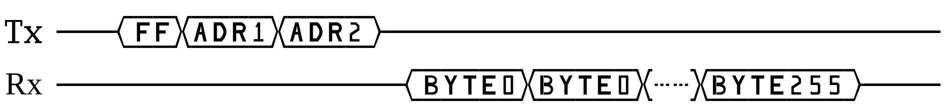
The same timeout/retry instructions apply here as for when erasing. So, for example, to write all fours to address 0x12300:



*For R32C, send the top 8 bits (bits 31-24) separately, with bits 23-16 then bits 15-8 in the command.

Page Read

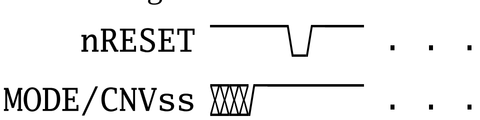
After you program each page, you should read it back to ensure it was programmed correctly. In my utilities, I retry the program/read/verify cycle three times before giving up (at which point, you need to erase the flash and start again). The sequence to read a page is similar to programming a page, in that you send the read page command (0xff), two of the three address bytes, then read 256 data bytes back:



Note that there is no need to clear or read the status, however it may be prudent to drain any bytes waiting on the Rx line to ensure you're in sync with the bootloader, before doing this command.

Done!

Once you've downloaded all the pages you need (don't forget the page that includes the reset vector), there's nothing left to do but reset in user mode and run your application!



Console

In my utilities, I have a command line option to maintain the connection to the serial port at this point, acting like a mini terminal emulator. At the very least, if your utility prints any received data to your screen, you can use the serial port on the chip as a "debug" stream. Even if you have to manually reset the chip, having this "console" open to the chip when you do, lets you see any messages that might be printed only once when your application starts (either through printf or some other function).

Conclusion

With the information in this document, you should be able to download your application into any of the R8C/M16C/M32C/R32C chips. However, keep in mind that you still need to read the chip-specific documentation (that chapter is usually called "Flash Memory Version" in the Renesas specs) and follow any requirements they indicate there.

Also, there are far more commands than this document covers, such as partial erasing, block locking, etc. To use those, you do need to know the specifics of the flash modules in each chip.

Renesas does publish a few specification documents about these commands, from which I've built up my utilities. Search the web for REJ05B0734, REJ05B0599, and MCU-M16C-95-0302.

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