AVR101: High Endurance EEPROM Storage

8-bit AVR® Microcontroller

Application Note

Features

- Circular Buffer in EEPROM
- RESET Protection of EEPROM Buffer
- Increased Endurance of EEPROM Storage

Introduction

Having a system that regularly writes parameters to the EEPROM can wear out the EEPROM, since it is only guaranteed to endure 100 k erase/write cycles. Writing the parameters to a circular buffer in EEPROM where each of the elements in the buffer can endure 100 k erase/write cycles can circumvent this. However, if the system is exposed to RESET conditions, such as power failures, the system needs to be able to identify the correct position in the circular buffer again. This document describes how to make safe high endurance parameter storage in EEPROM.

Theory of Operation

By having a circular buffer (O-buffer) in EEPROM it is possible to increase the number of times that a parameter can be stored in EEPROM. If the buffer has two levels the number of times that the parameter can be stored is twice the endurance of one single EEPROM cell: 200 k erase/writes. By using this approach it is possible to increase the number of times a parameter can be stored by increasing the O-buffer size. In other word, the idea is to distribute the storage of the parameter over several EEPROM locations to achieve increased parameter storage endurance. When using the O-buffer approach the parameter storage endurance equal the number of memory locations used in the O-buffer times the endurance of a single EEPROM location.

All O-buffers need a pointer to the last location written. To be able to recover the position of the pointer, e.g., after power loss, a second O-buffer can be used. The secondary O-buffer should not hold the specific address, but just a “sign” showing the state of the Parameter Buffer. By making the two O-buffers similar in size and by letting their relative buffer pointers operate in parallel it is possible to identify the last used location in the parameter O-buffer. Figure 1 illustrates an eight level O-buffers.

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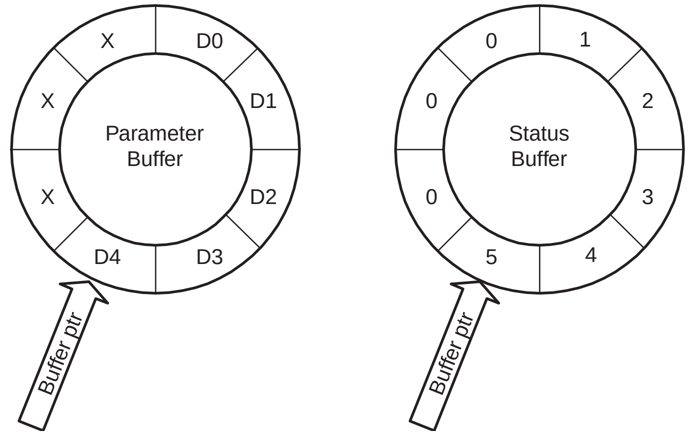
Figure 1. Parallel O-buffers in EEPROM



When writing to the Parameter Buffer the Status Buffer is also updated: The Buffer Pointer points to the same element in both the of the Parameter Buffer and the Status Buffer. The value of the Status Buffer element equivalent to the last element written to in the Parameter Buffer is increased by 1, also when wrapping from the end to the beginning of the buffer. After a RESET it is then possible to look through the Status Buffer, finding the last Status Buffer element changed by finding the location where the difference between a buffer element and the next buffer element is bigger than 1.

Note that it is important to initialise the EEPROM memory of the Status Buffers before it is used the first time. If this is not done it may not be possible to find the correct location of the last used buffer element. The problem will only occur if a RESET condition occurs before the O-buffer has completed a full "tour" round the circle. The best solution to make sure that the buffer has been initialised is to erase/program it along with the erase/programming of the Flash Memory.

One should be aware that this method of providing additional endurance for the parameter storage is memory hungry. One way of reducing this is to re-use the Status O-buffer for multiple parameters. This requires that all parameters are stored at the same time, so that all buffers are operated in parallel.

Code Example

The code example was developed using IAR EWAVR 2.26C and the ATmega16 as target device.

The code example consists of 4 functions: findCurrentEepromAddr(), which identifies where in the Parameter Buffer to continue after RESET; EeReadBuffer(), which reads the parameter from the buffer; EeWriteBuffer(), which stores the parameter in the Parameter Buffer. Finally, there is a main function, which illustrates how to use the other function.

The functions are described by flow charts below. The main function is not described as flow chart.

Figure 2. Find Current EEPROM Address

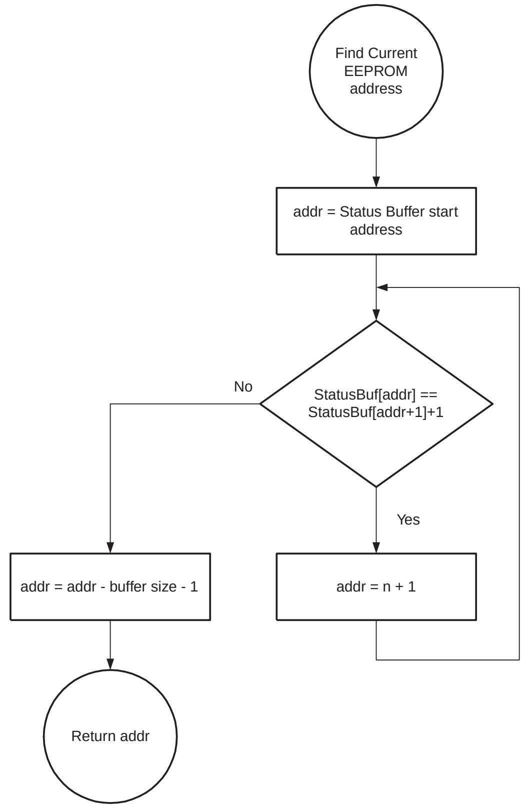


Figure 3. EEPROM Read Buffer

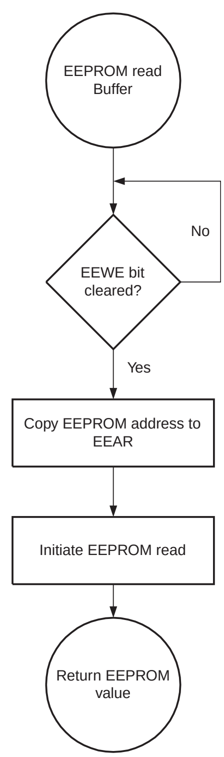
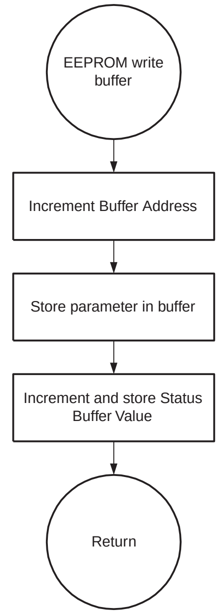


Figure 4. EEPROM Write Buffer



Atmel Headquarters

Corporate Headquarters
2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 487-2600

Europe
Atmel Sarl
Route des Arsenaux 41
Case Postale 80
CH-1705 Fribourg
Switzerland
TEL (41) 26-426-5555
FAX (41) 26-426-5500

Asia
Room 1219
Chinachem Golden Plaza
77 Mody Road Tsimhatsui
East Kowloon
Hong Kong
TEL (852) 2721-9778
FAX (852) 2722-1369

Japan
9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
TEL (81) 3-3523-3551
FAX (81) 3-3523-7581

Atmel Operations

Memory
2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 436-4314

Microcontrollers
2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 436-4314

La Chantrerie
BP 70602
44306 Nantes Cedex 3, France
TEL (33) 2-40-18-18-18
FAX (33) 2-40-18-19-60

ASIC/ASSP/Smart Cards
Zone Industrielle
13106 Rousset Cedex, France
TEL (33) 4-42-53-60-00
FAX (33) 4-42-53-60-01

1150 East Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906
TEL 1(719) 576-3300
FAX 1(719) 540-1759

Scottish Enterprise Technology Park
Maxwell Building
East Kilbride G75 0QR, Scotland
TEL (44) 1355-803-000
FAX (44) 1355-242-743

RF/Automotive
Theresienstrasse 2
Postfach 3535
74025 Heilbronn, Germany
TEL (49) 71-31-67-0
FAX (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906
TEL 1(719) 576-3300
FAX 1(719) 540-1759

Biometrics/Imaging/Hi-Rel MPU/
High Speed Converters/RF Datacom
Avenue de Rochepleine
BP 123
38521 Saint-Egreve Cedex, France
TEL (33) 4-76-58-30-00
FAX (33) 4-76-58-34-80

e-mail
literature@atmel.com

Web Site
http://www.atmel.com

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