



## AVR100: Accessing the EEPROM

### Features

- Random Read/Write
- Sequential Read/Write
- Runnable Test/Example Program

### Introduction

This application note contains routines for access of the EEPROM memory in the AVR Microcontroller. Two types of Read/Write access has been implemented:

- Random read/write: The user must set up both data and address before calling the Read or Write routine
- Sequential read/write: The user needs only to set up the data to be read/written. The current EEPROM address is automatically incremented prior to access. The address has to be set prior to writing the first byte in a sequence

The application note contains four routines which are described in detail in the following sections. This application note contains routines for accessing the EEPROM in all AVR devices.

### Random Write - Subroutine "EEWrite"

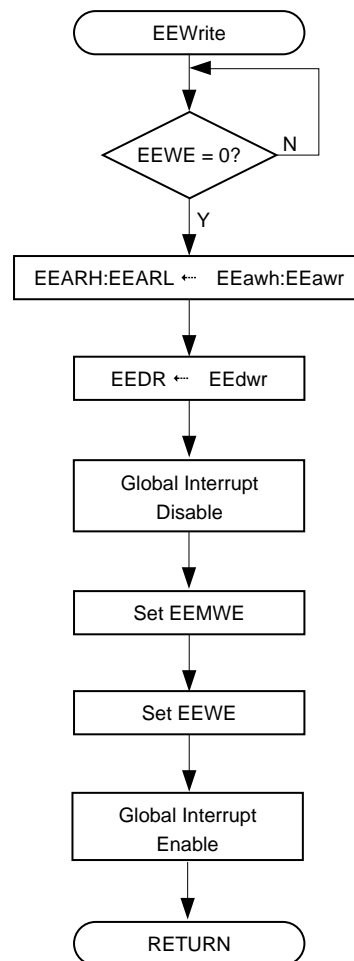
Three register variables must be set up prior to calling this routine:

- EEdwr - Data to be written
- EEawr - Address low byte to write
- EEawrh - Address high byte to write

The subroutine waits until the EEPROM is ready to be programmed by polling the EEPROM Write Enable - EEWB bit in the EEPROM Control Register - EECR. When EEWB is zero, the contents of EEdwr is transferred to the EEPROM

Data Register - EEDR, and the contents of EEawrh:EEawr is transferred to the EEPROM Address Register - EEARH:EEARL. First the EEPROM master write enable - EEMWE is set, followed by the EEPROM write strobe EEWB in EECR. See Figure 1.

Figure 1. "EEWrite" Flow Chart



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## Random Read - Subroutine “EERead”

Prior to calling this routine, two register variables must be set up:

EEard - Address of low byte to read from

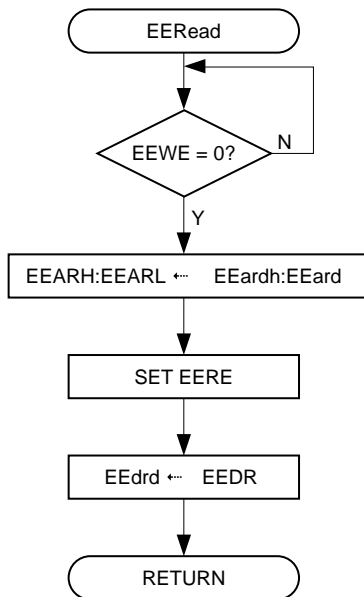
EEardh - Address of high byte to read from

The subroutine waits until the EEPROM is ready to be accessed by polling the EEWB bit in the EEPROM Control Register - EECR. When EEWB is zero, the subroutine transfers the contents of EEardh:EEard to the EEPROM Address Register - EEARH:EEARL.

It then sets the EEPROM Read Strobe - EERE.

In the next instruction the content of the EEDR register is transferred to the register variable EEard. See Figure 2.

**Figure 2.** “EERead” Flow Chart



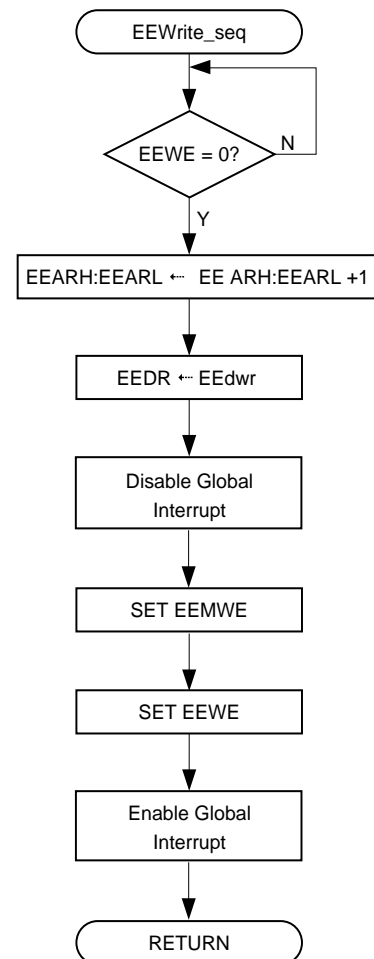
## Sequential Write - Subroutine “EEWrite\_seq”

Prior to calling this routine, one register variable must be set up:

EEdwr\_s - Data to write

The subroutine waits until the EEPROM is ready to be programmed by polling the EEWB bit in the EEPROM Control Register - EECR. When EEWB is zero and the contents of the EEPROM address register - EEARH:EEARL are read into the register variable EEWTMPH:EEWTMP. EEwtmp is incremented and written back to EEARH:EEARL. This increments the current EEPROM address by one. The contents of EEdwr is then transferred to the EEPROM Data Register - EEDR, before EEWB in EECR is set, and then EEMWB is set. See Figure 3.

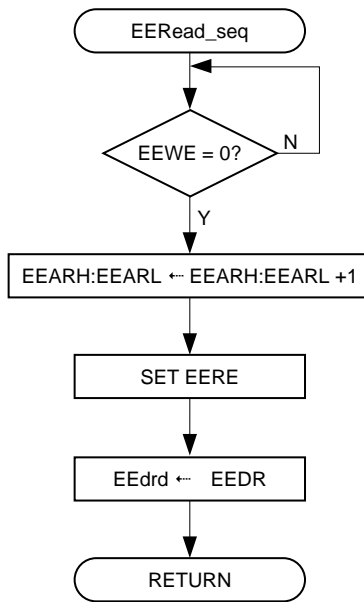
**Figure 3.** “EEWrite\_seq” Flow Chart



## Sequential Read - Subroutine “EERead\_seq”

The subroutine waits until the EEPROM is ready to be accessed by polling the EWE bit in the EEPROM Control Register - EECR. The subroutine then increments the current EEPROM address by performing the following operation: Transfer EEAR to the register variable EERTMPH:EERTMP, increments this register and writes the new address back to EEARH:EEARL. The routine then sets the EEPROM Read Strobe - EERE twice. Finally, the EEPROM data is transferred from EEDR to the register variable EErd\_s. See Figure 4.

**Figure 4.** “EERead\_seq” Flow Chart for 8515



**Table 1.** CPU and Memory Usage

| Function    | Code Size | Cycles | Example Register Usage                | Description                      |
|-------------|-----------|--------|---------------------------------------|----------------------------------|
| EEWrite     | 10 words  | 15     | R16, R17, R18                         | EEPROM Random Location Write     |
| EERead      | 7 words   | 11     | R0, R17, R18                          | EEPROM Random Location Read      |
| EEWrite_seq | 13 words  | 19     | R24, R25, R18                         | EEPROM Sequential Location Write |
| EERead_seq  | 10 words  | 17     | R0, R24, R25                          | EEPROM Sequential Location Read  |
| Reset       | 8 words   | 8      | R16                                   | Example Initialisation           |
| Main        | 39 words  | -      | R16, R19, R20                         | Example Program                  |
| TOTAL       | 87 words  | -      | R0, R16, R17, R18, R19, R20, R24, R25 | -                                |

## Optimization for different devices

Not all the instructions are necessary for all devices. If the device has an EEPROM of 256 bytes or less, the high address of the EEPROM address register doesn't need to be changed. On the AT90S1200, the EEMWE bit in the EEGR doesn't have to be set.

See the section EEPROM Read/Write in the datasheet for further information.

## Test Program

The application note assembly file contains a complete program which calls the four subroutines as a test of operation, and also as an example of usage. The test program is suitable for running in AVR Studio.

The test programs contains comments on how to port the code to work on any AVR-part.

**Note:** If the code initiates a write to EEPROM shortly after reset, keep in mind the following: If EEPROM contents are programmed during the manufacturing process, the MCU might change the code shortly after programming. When the programmer then verifies the EEPROM contents, this might fail because the EEPROM contents have already been modified by the MCU. Also notice that some in-system programmers will allow the MCU to execute a short time between each step in the programming and verification process.



Table 2. Peripheral Usage

| Peripheral      | Description                            | Interrupts Enabled |
|-----------------|--|--------------------|
| 8 I/O Pins      | LEDs (example only)                    | -                  |
| 1 I/O Pin       | Button (example only)                  | -                  |
| 10 bytes EEPROM | Target EEPROM Locations (example only) | -                  |

avr100.asm

```

;**** APPLICATION NOTE AVR100 *****
;*
;* Title:           Accessing the EEPROM
;* Version:        2.0
;* Last updated:   98.10.14
;* Target:         AT90S8515
;* Suitable for:   Any AVR with internal EEPROM
;*
;* Support E-mail: avr@atmel.com
;*
;* DESCRIPTION
;* This Application note shows how to read data from and write data to the
;* EEPROM. Both random access and sequential access routines are listed.
;* The code is written for 8515. To modify for 90S4414,90S2313,90S2323...
;* apply the following changes:
;*- Remove all entries to EEPROM Address Register High Byte EEARH
;*
;* To modify for 90S1200, apply the changes above. In addition:
;*- Remove all writes to EEMWE
;*
;*
;* Change log
;*V2.098.10.14 (jboe)Bugfix, changed to support AT90S8515
;*V1.197.07.04 (gk) Created
;*****
.include "8515def.inc"

    rjmpRESET;Reset Handle

;*****
;*
;* EEWrite
;*
;* This subroutine waits until the EEPROM is ready to be programmed, then
;* programs the EEPROM with register variable "EEdwr" at address "EEawr:EEawr"
;*
;* Number of words   : 7 + return
;* Number of cycles  : 11 + return (if EEPROM is ready)
;* Low Registers used:None
;* High Registers used :3 (EEdwr,EEawr,EEawrh)
;*
;*****

```

```

;***** Subroutine register variables

.def    EEdwr    =r16            ;data byte to write to EEPROM
.def    EEawr    =r17            ;address low byte to write to
.def    EEawrh   =r18            ;address high byte to write to

;***** Code

EEWrite:
    sbic    EECR,EEWE            ;if EEWE not clear
    rjmp   EEWrite              ; wait more

    out     EEARH,EEawrh        ;output address high byte, remove if no high byte exist
    out     EEARL,EEawr        ;output address low byte

    out     EEDR,EEdwr         ;output data
    cli                    ;disable global interrupts
    sbi     EECR,EEMWE         ;set master write enable, remove if AT90S1200 is used
    sbi     EECR,EEWE         ;set EEPROM Write strobe
                                ;This instruction takes 4 clock cycles since
                                ;it halts the CPU for two clock cycles

    sei                    ;enable global interrupts
    ret

;*****
;*
;* EERead
;*
;* This subroutine waits until the EEPROM is ready to be programmed, then
;* reads the register variable "EEdrd" from address "EEardh:EEard"
;*
;* Number of words      : 6 + return
;* Number of cycles     : 9 + return (if EEPROM is ready)
;* Low Registers used   :1 (EEdrd)
;* High Registers used  :2 (EEard,EEardh)
;*
;*****

;***** Subroutine register variables

.def    EEdrd    =r0            ;result data byte
.def    EEard    =r17            ;address low to read from
.def    EEardh   =r18            ;address high to read from

;***** Code

EERead:

```



```
sbic      EECR,EWE          ;if EWE not clear
rjmp     EERead            ; wait more

out      EEARH,EEardh      ;output address high byte, remove if no high byte exist
out      EEARL,EEard       ;output address low byte

sbi      EECR,EERE         ;set EEPROM Read strobe
                          ;This instruction takes 4 clock cycles since
                          ;it halts the CPU for two clock cycles

in       EEdrd,EEDR        ;get data
ret
```

```
*****
```

```
;*
;* EEWrite_seq
;*
;* This subroutine increments the EEPROM address by one and waits until the
;* EEPROM is ready for programming. It then programs the EEPROM with
;* register variable "EEdwr_s".
```

```
;* Number of words      : 12 + return
;* Number of cycles     : 15 + return (if EEPROM is ready)
;* Low Registers used   :None
;* High Registers used  :3 (EEdwr_s,EEwtmp,EEwtmpH)
;*
*****
```

```
***** Subroutine register variables
```

```
.def     EEwtmp =r24          ;temporary storage of address low byte
.def     EEwtmpH=r25         ;temporary storage of address high byte
.def     EEdwr_s=r18        ;data to write
```

```
***** Code
```

```
EEWrite_seq:
```

```
sbic      EECR,EWE          ;if EWE not clear
rjmp     EEWrite_seq        ;wait more

in       EEwtmp,EEARL        ;get address low byte
in       EEwtmpH,EEARH       ;get address high byte, remove if no high byte exists
adiw     EEwtmp,0x01         ;increment address
out      EEARL,EEwtmp        ;output address low byte
out      EEARH,EEwtmpH       ;output address byte, remove if no high byte exists

out      EEDR,EEdwr_s        ;output data
cli      ;disable global interrupts
sbi      EECR,EEMWE         ;set master write enable, remove if 90S1200 is used
sbi      EECR,EWE          ;set EEPROM Write strobe
```

```

;This instruction takes 4 clock cycles since
;it halts the CPU for two clock cycles
sei          ;enable global interrupts
ret

;*****
;*
;* EERead_seq
;*
;* This subroutine increments the address stored in EEAR and reads the
;* EEPROM into the register variable "EEdrd_s".

;* Number of words      : 9 + return
;* Number of cycles     :13 + return (if EEPROM is ready)
;* Low Registers used   :1 (EEdrd_s)
;* High Registers used  :2 (EErtmp,EErtmph)
;*
;*****

;***** Subroutine register variables

.def        EErtmp =r24          ;temporary storage of low address
.def        EErtmph=r25         ;temporary storage of high address
.def        EEdrd_s=r0         ;result data byte

;***** Code

EERead_seq:
    sbic    EECR,EWE           ;if EWE not clear
    rjmp    EERead_seq        ;wait more
;The above sequence for EWE = 0 can be skipped if no write is initiated.

; Read sequence
    in     EErtmp,EEARL        ;get address low byte
    in     EErtmph,EEARH       ;get address high byte, remove if no high byte exists
    adiw   EErtmp,0x01         ;increment address
    out    EEARL,EErtmp        ;output address low byte
    out    EEARH,EErtmph       ;output address high byte, remove if no high byte exists

    sbi    EECR,EERE           ;set EEPROM Read strobe
                                ;This instruction takes 4 clock cycles since
                                ;it halts the CPU for two clock cycles
    in     EEdrd_s,EEDR        ;get data
    ret

```

```

;*****
;*
;* Test/Example Program
;*
;*****

;***** Main Program Register variables

.def    counter =r19
.def    temp     =r20

;***** Code

RESET:
;***** Initialize stack pointer
;* Initialize stack pointer to highest address in internal SRAM
;* Comment out for devices without SRAM

        ldi     r16,high(RAMEND)      ;High byte only required if
        out     SPH,r16               ;RAM is bigger than 256 Bytes
        ldi     r16,low(RAMEND)
        out     SPL,r16

;***** Initialize portB
;* Port B is used to verify the operation of the EEPROM read
;* and write routines.

        ldi     r16,0xff              ; DDRB=0xff ->PortB=output
        out     DDRB,r16

;***** Initialize portD
;* bit0 of PortD is used to start the test program

        ldi     r16,0xff              ; Enable all PortD pull-ups
        out     PORTD,r16

;***** Program start
;*

main:   in      r16,PIND               ; Wait for user to push button on PD0
        sbrc   r16,0
        rjmp   main

;***** Program a random location

        ldi     EEdwr,$aa
        ldi     EEawrh,$00

```



```

    ldi        EEawr,$10
    rcall     EEWrite                ;store $aa in EEPROM location $0010

;***** Read from a random location

    ldi        EEardh,$00
    ldi        EEard,$10
    rcall     EERead                ;read address $10
    out       PORTB,EEdrd           ;output value to Port B

;***** Fill the EEPROM address 1..64 with bit pattern $55,$aa,$55,$aa,...

EEWrite_wait:
    sbic      EECR,EWE              ;if EWE not clear
    rjmp     EEWrite_wait          ; wait more
; The above sequence for EWE = 0 can be skipped if it is guaranteed that no write is
; running when now changing the EEARL and EEARH registers.

    ldi      counter,63             ;init loop counter
    clr     temp
    out     EEARH,temp             ;EEARH <- $00
    clr     temp
    out     EEARL,temp             ;EEARL <- $00 (start address - 1)

loop1: ldi      EDdwr_s,$55
    rcall   EEWrite_seq            ;program EEPROM with $55
    ldi     EDdwr_s,$aa
    rcall   EEWrite_seq            ;program EEPROM with $aa
    dec     counter                ;decrement counter
    brne   loop1                  ;and loop more if not done

;***** Copy 10 first bytes of EEPROM to r1-r11

EERead_wait:
    sbic      EECR,EWE              ;if EWE not clear
    rjmp     EERead_wait           ; wait more
; The above sequence for EWE = 0 can be skipped if it is guaranteed that no write is
; running when we later change the EEARL and EEARH registers.

    clr     temp
    out     EEARH,temp             ;EEARH <- $00
    ldi     temp,$00
    out     EEARL,temp             ;EEARL <- $00 (start address - 1)

    clr     ZH
    ldi     ZL,1                   ;Z-pointer points to r1

loop2: rcall   EERead_seq           ;get EEPROM data
    st      Z,EEdrd_s              ;store to SRAM
    inc     ZL

```



```
    cpi      ZL,12      ;reached the end?  
    brne    loop2      ;if not, loop more  
  
forever:  
    rjmp    forever    ;This is the end. On completion, the program ends up here
```





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