Setup and Use of the LPM Instruction

Features
- **Use of the LPM (Load Program Memory) Instruction with the AVR® Assembler**
- **Load Constants from Program Memory**
- **Use of Look-up Tables**

Introduction

This application note describes how to access the constants saved in the Flash program memory of the microcontroller embedded in FPSLIC devices. The AVR microcontroller is based on a Harward architecture, this means that Address and Data memory use separate busses. This is necessary to achieve single cycle instructions execution speed. To be able to save constants in Flash memory the Load Program Memory, (LPM) instruction is included in the instruction set. The Assembly code with an example of the LPM instruction can be found in the FPSLIC Software section of the Atmel web site (http://www.atmel.com), under the **3049.asm** archive.

Use of the LPM

The LPM instruction is included in the AVR instruction set to load a data byte from the FLASH program memory into the register file.

The flash program memory of the AVR microcontroller is organized as 16-bit words. The register file and SRAM data memory are organized as 8 bits bytes. Special consideration must therefore be taken when loading data from program memory to data memory.

The Z-register in the register file is used to access the program memory. This 16-bit register pair is used as a 16-bit pointer to the program memory. The 15 most significant bits select the word address in program memory. Because of this, the word address is multiplied by 2 before it is put in the Z register.

Figure 1. Z Address Register
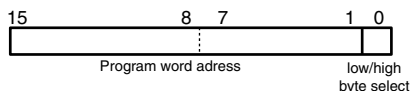
The least-significant bit of the Z address register selects either low byte (0) or high byte(1) of the program memory word. To calculate the low (ZL) an high (ZH) part of the address, use the LOW() and HIGH() functions.

To load data from random places in program memory, the Z register must be set up with the proper address each time a new address is accessed.

In program memory the data is organized with one byte in the low part of a program word and the next byte in the high part. Because of this, the message string will

appear as if every pair of characters has been swapped, when viewed in the memory view in AVR Studio®.

The program in this application note loads a string of bytes from the program memory and writes it to Port D. The program first initializes Port D so that all the pins are output. It loads the starting address of the string "Hello World" into Z register, as described above. Then a byte is loaded from program memory. The program checks whether or not the end of the string is reached (byte was zero). If the end is not reached yet the last read byte is put on Port D, a short delay is made, and the Z register is increased. The program then jumps back to load another byte.

```
;**** A P P L I C A T I O N   N O T E ***********************
;*
;* Title:        Load Program Memory
;* Version:      1.0
;* Last updated: 98.12.17
;* Target:       AT94K
;*
;* DESCRIPTION
;* This Application note shows how to use the Load Program Memory (LPM)
;* instruction. The application note loads the string "Hello World" from
;* program memory byte by byte, and puts it onto port D.
;*
;****************************************************************************


  .include "at94kdef.inc"
  .device  AT94K                   ; Specify device
  .def     temp=r16                ; Define temporary variable


  start:
    ldi    temp,low(RAMEND)
    out    SPL,temp                ; Set stack pointer to last internal RAM
location
    ldi    temp,high(RAMEND)
    out    SPH,temp

    ldi    temp,$ff
    out    PORTD,temp              ; Set all pins at port D high
    out    DDRD,temp               ; Set port D as output

  ; Load the address of 'message' into the Z register. Multiplies
  ; word address with 2 to achieve the byte address, and uses the
  ; functions high() and low() to calculate high and low address byte.

    ldi    ZH,high(2*message)      ; Load high part of byte address into ZH
    ldi    ZL,low(2*message)       ; Load low part of byte address into ZL

  loadbyte:
    lpm                            ; Load byte from program memory into r0
```

Setup and Use of the LPM Instruction

```
        tst    r0                          ; Check if we've reached the end of the
message
        breq   quit                        ; If so, quit

        out    PORTD,r0                     ; Put the character onto Port B
        rcall  one_sec_delay               ; A short delay

        adiw   ZL,1                         ; Increase Z registers
        rjmp   loadbyte

        quit:  rjmp quit

one_sec_delay:
    ldi    r20, 20
    ldi    r21, 255
    ldi    r22, 255
delay:
    dec    r22
    brne   delay
    dec    r21
    brne   delay
    dec    r20
    brne   delay
    ret

message:
.db "Hello World"
.db 0
```

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