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 Harvard 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.

```assembly
.include "at94kdef.inc"
.device AT94K
.def temp=r16

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

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
```
```assembly
setup:

    tst r0, message          ; 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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