Electrons - AVR Fuses HOWTO Guide

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The process of programming fuse bits involves: • Determining the byte value for the affected fuse byte(s), • Actually programming the fuses on the chip. We'll go through an example of the process and covers each step. Bits of Interest The ATmega8 ships with safe default settings for its clock source and startup time, which specify that an internal 1 MHz RC oscillator is to be used. This ensures that you can get the chip working with minimal setup but lets assume you want to take advantage of a faster/more stable/more useful clock through the use of an external crystal. By checking the <i>Clock Sources</i> section of the datasheet, you can see that the clocking options are set using 4 <i>CKSEL</i> bits that specify the type of clock source the chip will use, and the <i>CKOPT</i> bit (which tells the chip to pay attention to our CKSEL bits and influences startup time). The actual bits you use depend on the hardware you've got. Here we'll say we're using a 2MHz crystal. In this case, we determine that we should also ensure the CKOPT bit is 1. Now that we know which bits we wish to set we need to know where they fit in, in the grand fuse byte scheme of things. To do this, have a look at the following tables, which indicate the position and function of each bit in the low and high fuse bytes (for the ATmega8). Image but the box of the datasheet set the color of the datasheet set in the low and high fuse bytes (for the ATmega8).	The first hum recipients of		Programmir								
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Bit Name Description Default	Medical Cente Buckyballs			ne ATmega8).	h fuse bytes (for t	low and hig					
	Could Disrupt				Byte						
	(2005/12/15) A new study,		Default	cription	Name Des						
7 BODLEVEL Brown out detector trigger level 1 (unprogrammed) 6 BODEN Brown out detector apple	conducted at Vanderbilt by	ROD	,								
6BODENBrown out detector enable1 (unprogrammed, no BOD)5SUT1Select start-up time1 (unprogrammed)	chemical	(עטס נ									
4SUT0Select start-up time0 (programmed)3CKSEL3Select Clock source0 (programmed)	enginee		0 (programmed)	t start-up time	SUT0 Sele	4					
2 CKSEL2 Select Clock source 0 (programmed)			0 (programmed)	t Clock source	CKSEL2 Sele	2					
1 CKSEL1 Select Clock source 0 (programmed) 0 CKSEL0 Select Clock source 1 (unprogrammed)			,								

1 of 4

```
Fuse High Byte
 Bit
                            Description
                                                                                  Default
                Name
 Number
               RSTDISBL Select if PC6 is I/O pin or RESET pin
 7
                                                                                 1 (unprogrammed PC6 is RESET-pin)
6
               WDTON WDT always on
                                                                                  1 (unprogrammed, WDT enabled by WDTCR)
5
                                                                                 0 (programmed, SPI programming enabled)
               SPIEN
                          Enable Serial Program and Data Downloading
4
               CKOPT
                           Oscillator options
                                                                                 1 (unprogrammed)
                                                                                 1 (unprogrammed, EEPROM not preserved)
                           EEPROM memory is preserved through the Chip Erase
3
               EESAVE
2
               BOOTSZ1 Select Boot Size
                                                                                 0 (programmed)
               BOOTSZ0 Select Boot Size
1
                                                                                 0 (programmed)
                BOOTRST Select Reset Vector
0
                                                                                 1 (unprogrammed)
As you can see, our CKSEL settings are to be set in bits 0 to 3 of the low fuse byte, while CKOPT is bit 4 of the high fuse byte. Even though we only wish to affect the CKSEL and CKOPT bits, we must program the entire low and high fuse bytes. We want to set:
Low fuse bits: XXXX 1100
High fuse bits:XXX1 XXXX
without disturbing the bits in the "X" positions.
Byte Values
Determining the byte values required for the low and high fuses first involves discovering the current values for the "X" bits above. Your <u>hardware programmer</u> can allow you to do this.
If you are using uisp you'd use something like:
$ uisp -dprog=stk500 -dserial=/dev/ttyS0 -dspeed=115200 -dpart=atmega8 --rd_fuses
Fuse Low Byte = 0xE1
Fuse High Byte = 0x91
Calibration Byte = 0x00 -- Read Only
Lock Bits = 0xff
You can convert these hex values to binary (for use below) using any decent calculator program.
If you've been using avrdude, you can extract the high and low fuse bytes like so (adjusting the programmer, device and port options to match your hardware and setup):
$ avrdude -c stk500 -p m8 -P /dev/ttyS0 -U hfuse:r:high.txt -U lfuse:r:low.txt
  avrdude: Device signature = 0x003d04
  avrdude: reading hfuse memory:
  avrdude: writing output file "high.txt"
  avrdude: reading lfuse memory:
  avrdude: writing output file "low.txt"
  avrdude done. Thank you.
Avrdude doesn't make getting to the fuse info as simple... the bytes are actually saved raw in the high.txt and low.txt files. You can use a hex editor to look at the value of the byte in each file. If you are lucky enough to use a Unix workstation, like Linux, then you can just run this one-liner for each file to view the binary representation of the hyter.
of the bytes:
$ od -d high.txt | head -1 | sed -e 's/0000000 *//' | \
  xargs -i perl -e '$str= unpack("B32", pack("N",{})); $str =~ s/.*([01]{4})([01]{4})$/$1 $2/; \
print "$str\n";'
1101 1001
$ od -d low.txt | head -1 | sed -e 's/0000000 *//' | \
  xargs -i perl -e '$str= unpack("B32", pack("N",{})); $str =~ s/.*([01]{4})([01]{4})$/$1 $2/; \
  print "$str\n";'
1110 0001
Note that the Atmel documentation names the bits in order of significance, so from bit 7 to 0:
low fuse bits: 1110 0001
low fuse pos.: 7654 3210
So in our example, CKSEL3..0 is 0001 (a setting for the calibrated internal RC oscillator, according to the data sheet). To determine the byte values we wish to have, we apply the bit "mask" developed above and overwrite relevant bits of each fuse byte.
Low original bits: 1110 0001
Low fuse mask:
                           XXXX 1100
Low new bits:
                           1110 1100
High original bits: 1101 1001
                           XXX1 XXXX
High fuse mask:
High new bits:
                           1101 1001
Once that is done, we can convert the new bytes back to hexadecimal for use with the hardware programmer.
Note that, as the CKOPT bit was already unprogrammed (1) in this example, the high fuse byte has not changed 
and doesn't need to be reprogrammed. The low fuse has changed, though, to a hex value of 0xECand must
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therefore be written to the microcontroller memory.

Lighting Fuses

Now that we have determined the new value for the low fuse byte, our work is done. Simply performing the inverse operation using the programmer will write the new byte to the chip:

\$ avrdude -c stk500 -p m8 -P /dev/ttyS0 -U lfuse:w:0xEC:m

As you can see, programming the chip is easy. The majority of the work involves determining which options you want to set, how to set them and where the new bits actually go. And that means getting to know the relevant Atmel datasheet.

Final things To Remember

The fuses aren't erased when the AVR memory is erased, so reprogramming the fuses everytime the device is reprogrammed is **not** required. Since the fuses are not cleared by a memory erase, it can cause problems if incorrect settings are selected.

It may be possible to disabled In-System Programming (through the SPIEN fuse) while performing in-system programming. If you do this, you will no longer be able to program the chip in this manner (you need to use parallel programming to change this setting, which may mean removing the chip from the circuit and using another hardware programmer, such as the STK500).

It may also be possible to disable the RESET pin (RSTDISBL fuse). If this happens, the RESET pin must be pulled very high (12V) to program the chip and the circuit must tolerate this.

Some fuses just can't be changed through ISP Programming. If fuses cannot be changed through ISP Programming, Parallel Programming is required to alter the fuses.

The lock bits are fuses that can be used to lock down the chip, but this can lock you out as well!

You can use the $_{-v}$ switch to avrdude while reading the fuse bytes. The verbose output includes lots of neat info concerning the chip and current settings. Here is the output for an ATmega162, which shows that this chip has extended fuse (efuse) and lock byte, in addition to the low and high fuse bytes:

\$ avrdude -v -c stk500 -p m162 -P /dev/ttyS1 -U hfuse:r:high.txt:r -U lfuse:r:low.txt:r avrdude Version 4.4.0									
Using Port : /dev/ttyS1 Using Programmer : stk500 AVR Part : ATMEGA162 Chip Erase delay : 9000 us PAGEL : P00 BS2 : P00 RESET disposition : dedicated RETRY pulse : SCK serial program mode : yes parallel program mode : yes Memory Detail :									
Memory Type	Paged		Page Size	#Pages	MinW	MaxW		Polled	
	-			-					
	yes	16384				4500			
-	no	512				9000			
	no	1				16000 16000			
	no no		0			16000			
	no	1				16000			
signature		3	0	0	0	0	0x00	0x00	
calibration	no	1	0	0	0	0	0x00	0x00	
Programmer Type : STK500 Description : Atmel STK500 Hardware Version: 2 Firmware Version: 1.14 Vtarget : 5.1 V Varef : 5.1 V Oscillator : 3.686 MHz SCK period : 1.1 us You are now ready to play with your AVR's fuses, just remember to double-check those values before performing the write! Enjoy.									
Level:		Article							
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Level: <u>Article</u>									
Comments									
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Electrons - AVR Fuses HOWTO Guide



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