

Downloading, Installing and Configuring WinAVR

Author: Colin O'Flynn

Editor: Eric Weddington

Table of Contents

1.0 Introduction to WinAVR.....	1
2.0 Getting WinAVR.....	1
3.0 Installing WinAVR.....	3
4.0 Makefiles.....	4
5.0 Setting up Programmers Notepad.....	8
6.0 Your First WinAVR Project.....	11
7.0 More Information.....	17
8.0 Glossary.....	17

1.0 Introduction to WinAVR

WinAVR is not just one tool, like many other software names. WinAVR is instead a set of tools, these tools include avr-gcc (the command line compiler), avr-libc (the compiler library that is essential for avr-gcc), avr-as (the assembler), avrdude (the programming interface), avarice (JTAG ICE interface), avr-gdb (the de-bugger), programmers notepad (editor) and a few others. These tools are all compiled for Microsoft Windows and put together with a nice installer program.

When referring to the version, you are most of the time referring to the version of the compiler, avr-gcc. For example currently WinAVR includes version 3.3 of avr-gcc. However, it is not WinAVR 3.3 as some people call it, to refer to which release you are using that is done by date. For example WinAVR 20030424. The 20030424 is a date code, which is discussed later.

2.0 Getting WinAVR

The WinAVR website is located at:

<http://winavr.sourceforge.net/>

This site contains information on WinAVR, including some very useful links, notes, and news. You should first go to this site to see if there is any important information you should know about WinAVR before downloading (different releases, etc).

You should now go to the SourceForge.net project site for WinAVR, the exact address being:

<http://sourceforge.net/projects/winavr/>

Then scroll to around the middle of the page, and click on the 'Download' link for the latest version of WinAVR:

Project UNIX name: winavr
 Registered: 2002-11-27 10:07
 Activity Percentile (last week): 0%
 View project activity [statistics](#)
 View list of [RSS feeds](#) available for this project

Latest File Releases

Package	Version	Date	Notes / Monitor	Download
AVR COFF	AVR COFF Beta	May 19, 2003	-	Download
SRecord	1.12	January 28, 2003	-	Download
WinAVR	20030424	April 23, 2003	-	Download

[View ALL Project Files]

Public Areas

- [Project Home Page](#)
- [Tracker](#)
- [Bugs \(0 open / 6 total \)](#)
Bug Tracking System
- [Support Requests \(0 open / 2 total \)](#)

Latest News

WinAVR 20030424 Released
arcenum - 2003-04-28 09:23
[\[Read More/Comment\]](#)

WinAVR 20030312 Released
arcenum - 2003-03-12 13:44
[\[Read More/Comment\]](#)

When you click on this link you are brought to the files page, with your choice highlighted in colour:

Below is a list of all files of the project. The release you have chosen is **highlighted**. Before downloading, you may want to read Release Notes and ChangeLog (accessible by clicking on release version).

Package	Release & Notes	Filename	Size	D/L	Date Arch.	Type
AVR COFF						
	AVR COFF Beta				2003-05-19 23:00	
		WinAVR-avrcoffbeta-install.exe	1658653	14	i386	.exe (32-bit Windows)
SRecord						
	1.12				2003-01-28 23:00	
		Srecord-1_12-bin-install.exe	364283	1984	i386	.exe (32-bit Windows)
		Srecord-1_12-src-install.exe	306290	719	i386	.exe (32-bit Windows)
WinAVR						
	20030424				2003-04-23 23:00	
		WinAVR-20030424-bin-install.exe	12417601	3479	i386	.exe (32-bit Windows)
		WinAVR-20030424-src-install.exe	12302242	958	i386	.exe (32-bit Windows)
	20030312				2003-03-11 23:00	
		WinAVR-20030312-bin-install.exe	13239192	7866	i386	.exe (32-bit Windows)

In this case the latest version is dated 20030424, which means Year 2003, 4th month (April), 24th day. You will want the WinAVR-xxxxxxx-bin-install.exe, where xxxxxxxx is the date code for that file. The WinAVR-xxxxxxxsrc-install.exe includes the source code, which you probably won't need.

After you click on the filename, you will be asked to select a mirror. This is the server you will download the file from. You can select any mirror, although it is best to select a location close to you. If one mirror doesn't have the file (which can happen if the file has just been released), or is slow, go back to this page and select a new mirror:

Host	Location	Continent	Download
	Brookfield, WI	North America	12127 kb
	Reston, VA	North America	12127 kb
	Chapel Hill, NC	North America	12127 kb
	Dublin, Ireland	Europe	12127 kb
	Zurich, Switzerland	Europe	12127 kb
	Minneapolis, MN	North America	12127 kb
	Phoenix, AZ	North America	12127 kb

Now save the file to a location where you will be able to get it, or optionally just open it from the current location.

Now that you have WinAVR there might be some other packages you need. For example for the 20030424 release you can also update the COFF file creation (this is the file type used by AVRStudio). This is recommended, and you can go back to the 'files' page to find this. The file is called WinAVR-avrcoffbeta-install.exe at the writing of this document. However that is no longer needed anymore, since chances are you are reading this document after the next release of WinAVR came out (sometime in September 2003), which has everything included.

3.0 Installing WinAVR

First you must run the file you downloaded, and then you will be presented with several licenses which you must accept. As WinAVR is actually a combination of many different pieces software, there are many different licenses for each one. Many use the GNU GPL license, but not all. You can scroll down to see what licenses are used.

Then you can set the directory to install WinAVR to, c:\WinAVR being default.

Finally click 'install' and let WinAVR install everything! When its done the README file will pop up, please read it! It contains a lot of important information on WinAVR and how to use it.

4.0 Makefiles

You may or may not have used other compilers, but most have a nice simple GUI and a 'compile' button. The avr-gcc compiler is different though, in a way that makes it more powerful. It can be used right on the command line, without a GUI at all. However it can also be configured to work with many different GUIs, and customised as much as you like.

One of the reasons this can be done is avr-gcc uses makefiles. A makefile tells the compiler what commands to run, what files to compile and link, the sort of output to create, and can also do other things (such as program the chip). A makefile can really just be thought of as a file that contains a list of commands to run, although in reality it is more powerful than that as it also has variables and other features. Makefiles have the name Makefile (there is no extension) by default, and are processed by a program called make. To use it, simply type at the command line (assuming you were in the d:\mydir\myproj1\ directory already):

```
d:\mydir\myproj1> make <CR>
```

(the <CR> means press the enter key). The make program will then find the makefile in the current directory and execute this makefile. If there is no makefile, it will create an error. If make is not found, it means that the proper directories are not in your path. This is where Windows looks for the program to execute, and should have been done by the WinAVR install process. See the WinAVR README file for more information on how to solve this.

Another important thing to note is that the Makefiles have different targets. Each target can do a different thing, depending on your Makefile. To use these targets, you simply append the target name as an argument to make:

```
d:\mydir\myproj1> make <target> <CR>
```

All of the Makefiles that you use with the AVR have at least two targets:

all

clean

The 'make all' is the same as also typing just 'make'. Make all is the default, and in the case of the AVR will compile all your source code files and create a .hex for you. Make clean will remove all the temporary files, the .hex file, and the .cof file. This gets you ready for an entirely new compile.

When working on a project, you will probably have several source code files. If you compile all of them then change one, and run make again the make program will only re-compile the minimum number of files (ie: the ones that changed). This can save a lot of time, especially if you have many source code files. However sometimes you have to do a complete re-compile, the is the case if you for example change the optimization level. When you change the optimization level none of the source files have changed, so just running 'make' won't do anything as it thinks there is no need to re-compile anything. You must first run 'make clean' then 'make' to have the change take effect.

As well the WinAVR release has this target:

coff

This target creates the .cof file, which you use in conjunction with AVRStudio to debug your project. This simple COFF format is older now, and is used for AVRStudio 4.06 and earlier (including AVRStudio 3.x). As a result the new extended COFF format (extcoff) has been created. For this reason this target was added to the makefile:

extcoff

This format should be used with AVRStudio 4.07 or later (the file still has the extension .cof).

Another target you likely will have is:

program

This will take the .hex file created by make and program it into the FLASH memory of your AVR.

At this point it is suggested that you look at a sample makefile to see what they look like. You should find one in your WinAVR sample directory (<c:\WinAVR\sample>). The file should be called Makefile with no extension. If you have installed the COFF upgrade though it may be called Makefile.cof. In that case rename Makefile to Makefile.old and rename Makefile.cof to Makefile.

Since makefiles have no extension you can't set a default program to open them. However you can use any text editor to edit them; lets use Programmers Notepad. A shortcut should have appeared on your desktop for it, but if not you can find it in the pn directory of your WinAVR install (<c:\WinAVR\pn\pn.exe>).

There is one more very important thing to discuss before finally editing our makefile though. This is the issue of tabs in the makefiles. For almost every other program, three or four spaces and a tab character are exactly the same. However for a makefile they are not. A tab character indicates the beginning of a command, and as such you should not use tabs in your makefile unless you are adding a command that should be executed (ie: a program name). A handy way to see the difference is to goto the 'View' menu of PN and check the 'mark whitespace' box. Here is an example of improper makefile editing:

```
234 begin:
235     →@$(BEGIN)
236     ...echo "This will fail horribly"
237
```

I have attempted to add an 'echo' command here. As you can see with the 'mark whitespace' feature the 'tab' is marked with a long arrow, while spaces are dots. This makefile uses spaces in front of the 'echo' command, which will result in an error. Instead it should look like this:

```
234 begin:
235     →@$(BEGIN)
236     →echo "This will not fail horribly"
237
```

If you are getting errors about an improper separator, you likely either used a tab where you shouldn't have, didn't use a tab where you should have, or forgot a space somewhere.

Now we can look at our makefile and change it; open up Makefile in PN. The first line of interest should be a line where you set the MCU type, and might look like:

```
# MCU name
```

```
MCU = atmega128
```

To change this just erase the atmega128 and write in the processor you used. You can find a list of all the supported types and their names in the avr-libc documentation (see end of this document for link). It is fairly straightforward, some examples are: at90s2313 at90s8515 atmega8 attiny22 at86rf401

The next line of interest is where you specify the 'project name' essentially. For example if you want your project name to be myproj1 then the main C source file (the one with the main() routine in it) should be myproj1.c. The resulting hex file will be myproj1.hex, and the COFF file will be myproj1.cof. The line will look like:

```
# Target file name (without extension).
TARGET = main
```

You can also specify additional C source files that your project uses. So for example you might have foo.c which includes the interface routines, which are accessed by main.c. To add this there are a few ways of doing it. You can just append it onto the end of the 'SRC =' line like this:

```
SRC = $(TARGET).c foo.c
```

Or you could use the += function to addend it on but at a different spot:

```
SRC = $(TARGET).c
```

```
SRC += foo.c
```

Finally you can use a '\ ' so that foo.c is listed on the next line but still read as being on the same line as the 'SRC =' line.

```
SRC = $(TARGET).c \
foo.c
```

If you have assembly files to link you can add them to the 'ASRC =' lines. Assembly files must end with .S (capital S), and NOT .s (small s). It is beneficial to take back-ups of your assembly files before the first time you compile, for the reason that if you accidentally changed the extension or an error occurred that results in your asm files being deleted on a 'make clean'. See the avr-libc manual for more information on how to create ASM files with avr-gcc.

```
ASRC = myasmfile.S
```

You will also see a optimization level as well. This is how well the compiler will optimise the code, and legal levels are 0 (no optimization), 1, 2, 3, and s. Each level is *different*, and level 3 is not always the best. Each level will perform different tasks on the code in order to make it as fast and small as possible (except level 0, which does nothing). If you use level 3 it is *most likely* to create the largest code size, but also *may* create the fastest. Level s is an optimization for code size, but is a good all-around level.

```
OPT = s
```

If your makefile supports a 'program' target, you will also find some options for programming the AVR.

However this is not very universal, so refer to the comments in the makefile for more detailed information. For example Koen Van den Heuvel shows how to configure it to use a “Bascom or Sample” Parallel port programmer:

```
Run C:\winAVR\bin\install_giveio.bat to enable the parallel port use in
AvrDUDE. AvrDUDE is the downloader used by WinAVR.
```

```
Change the following settings in the make file to make it work with the programming
cable:
```

```
AVRDUDE_PROGRAMMER = bascom
AVRDUDE_PORT = lpt1
```

The final topic to adding additional include directories when compiling. This is a fairly simple thing to do, and you may have to change the makefile a bit if it doesn't have an apparent place to add them in. The first thing to do is check if your makefile already has a line that looks like this:

```
EXTRINC_DIRS =
```

If it doesn't that proceed with the following instructions. Locate the compiler flags line. It may look something like this:

```
CFLAGS = -g -O$(OPT) \
    -funsigned-char -funsigned-bitfields -fpack-struct -fshort-enums \
    -Wall -Wstrict-prototypes \
    -Wa,-ahlms=$(<:.c=.lst)
```

The change it by adding `$(patsubst %,-I %,$(EXTRINC_DIRS))` so it will look like this:

```
CFLAGS = -g -O$(OPT) \
    -funsigned-char -funsigned-bitfields -fpack-struct -fshort-enums \
    -Wall -Wstrict-prototypes \
    -Wa,-ahlms=$(<:.c=.lst) $(patsubst %,-I %,$(EXTRINC_DIRS))
```

This is telling the compiler to take the contents of EXTRINC_DIRS and insert a -I before every word and include them on the compiler line. This is the syntax of how the compiler adds extra include directories in. Now we need to define this variable somewhere. Go near the top of the makefile and write this line:

```
EXTRINC_DIRS = c:\foo\inc c:\myproj2\inc c:\salvo\inc
```

This example will add the directory `c:\foo\inc`, `c:\myproj2\inc`, and `c:\salvo\inc` to the include locations. Of course you don't have these directories likely so you would want to remove them from the EXTRINC_DIRS line so the line just reads

```
EXTRINC_DIRS =
```

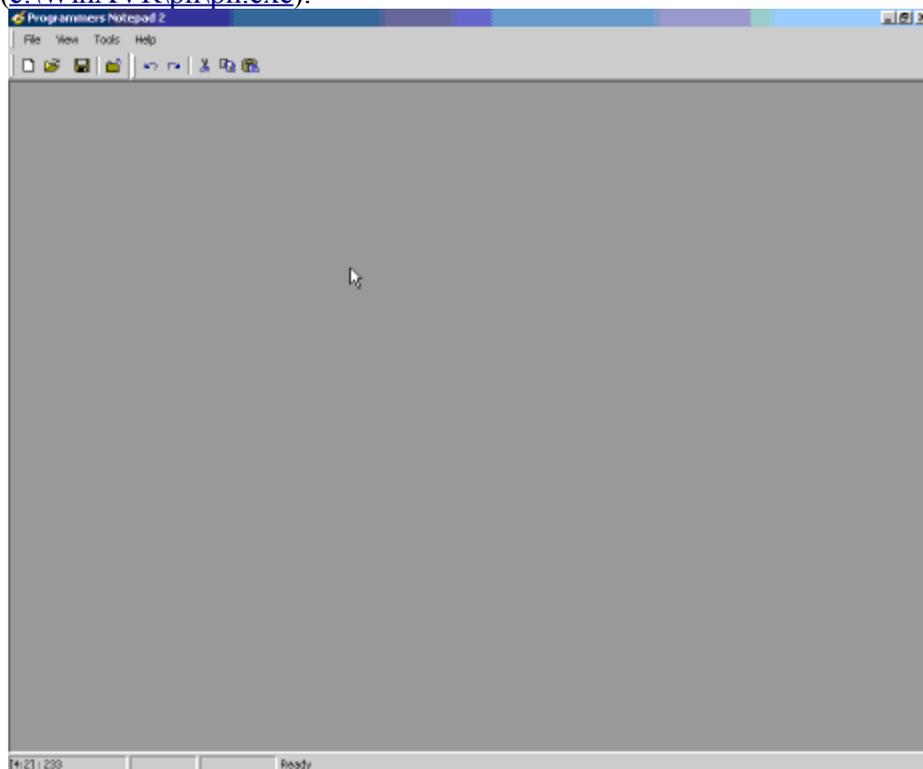
As well if you want these directories available for assembly files, add the `$(patsubst %,-I %,$(EXTRINC_DIRS))` to the end of the assembly flags ('AFLAGS =' line).

The makefile is a very powerful tool. The make manual is available in the WinAVR\doc\gnu directory (<C:\WinAVR\doc\gnu\make.html>) and it is highly suggested to take a look at it.

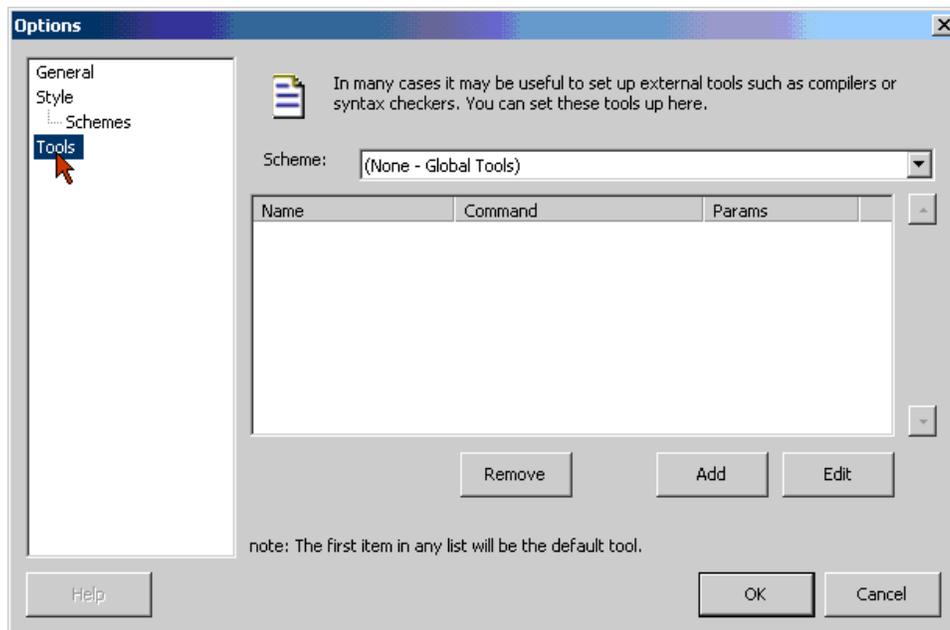
A final note about Makefiles if all this seems too confusing: Jörg Wunsch has made a program called Mfile. This program is available at <http://www.sax.de/~joerg/mfile/> for you to download, and it is a makefile generator. It is still recommended you become familiar with the power of the makefile, but if you are just starting out this program will be very useful. When you download the file unzip its contents to your WinAVR directory. You will find two files of interest: the first is README. This is just a text file, so when you click on it tell Windows to open it with notepad. Read this file! Then you can also read the help file, and you should have enough of an understanding to use Mfile.

5.0 Setting up Programmers Notepad

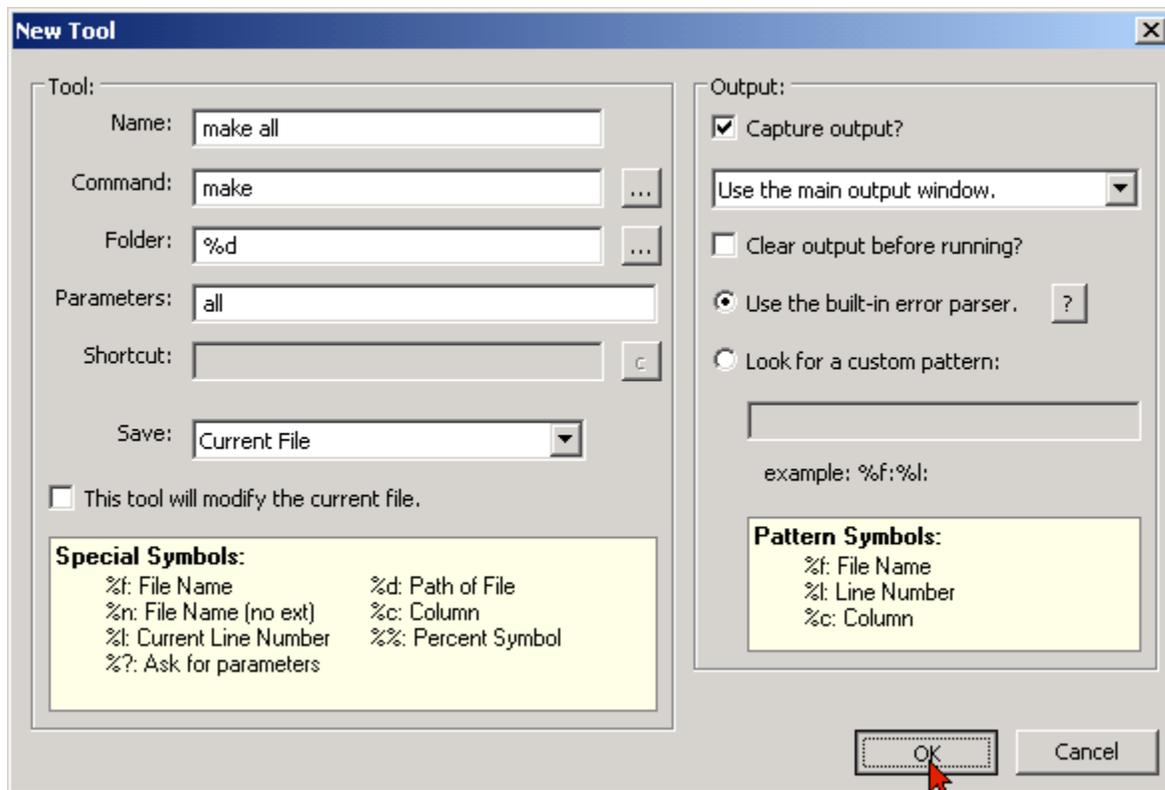
Programmers Notepad (PN) is a editing tool with syntax highlighting. As well it can be configured so that you don't have to do much command line typing, which makes it easier to work with. First open up PN using either the shortcut on your desktop or doing to your WinAVR directory, opening the pn folder and running pn.exe (<c:\WinAVR\pn\pn.exe>).



The main window is fairly bland right now, as nothing is open. However first lets set up PN for use with WinAVR. Go to the Tools→Options menu, and click on the 'Tools' text at the side of the dialogue that comes up.



Now click on the 'Add' button to add a tool. Then enter the data you want (examples are in a table). For example my 'Make All' target looks like this:



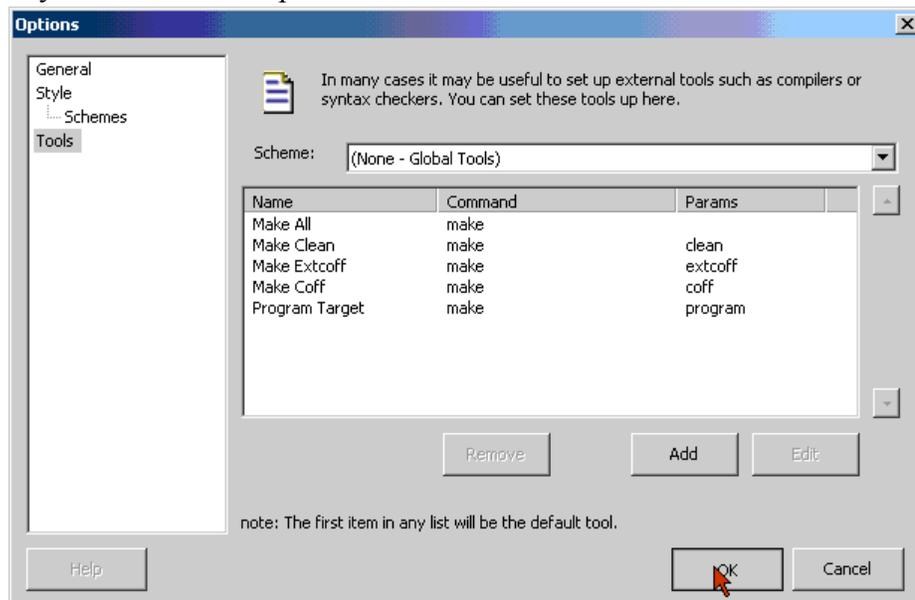
Lets talk about the options. The 'Name' option is just the name of the tool as you see it on the tools menu.

The 'Command' is the command-line tool to run, and its ran with the parameters in the 'Parameters' text box, in the directory specified by 'Folder'. So the example above is the same as opening a MS-DOS prompt, going to the current working directory of the file you have active, and typing “make all”. The 'Capture Output' option should be selected and set to 'Use the main output window.', this will print the result of running 'make all' into a little window normally at the bottom of the screen. There is an option to clear the window before running, I don't like the window cleared as that way I can scroll back in history and look at what my previous compiles or actions were. Also the 'Save' option might be handy, as this lets you save the current file before running the command. Remember that if you run 'make all' on an unsaved file, it means your changes won't be included in the compile. So setting this to save the current file (or all files) makes one less step you have to do. The final option of importance is one that asks to use the built-in error parser, which is what you want to do. This error parser has handy features like click on the error message to jump to the line.

You can continue to add more tools, the following table shows what my set-up is:

Name	Command	Folder	Parameters	Capture Output?	This tool will modify..	Save:	Clear Output?	Use Built-in Parser.
Make All	make	%d	all	Main	No	Current File	No	Yes
Make Clean	make	%d	clean	Main	No	None	No	Yes
Make Extcoff	make	%d	extcoff	Main	No	None	No	Yes
Make Coff	make	%d	coff	Main	No	None	No	Yes
Program Device	make	%d	program	Main	No	None	No	Yes

Now hit OK and your tools are set up.

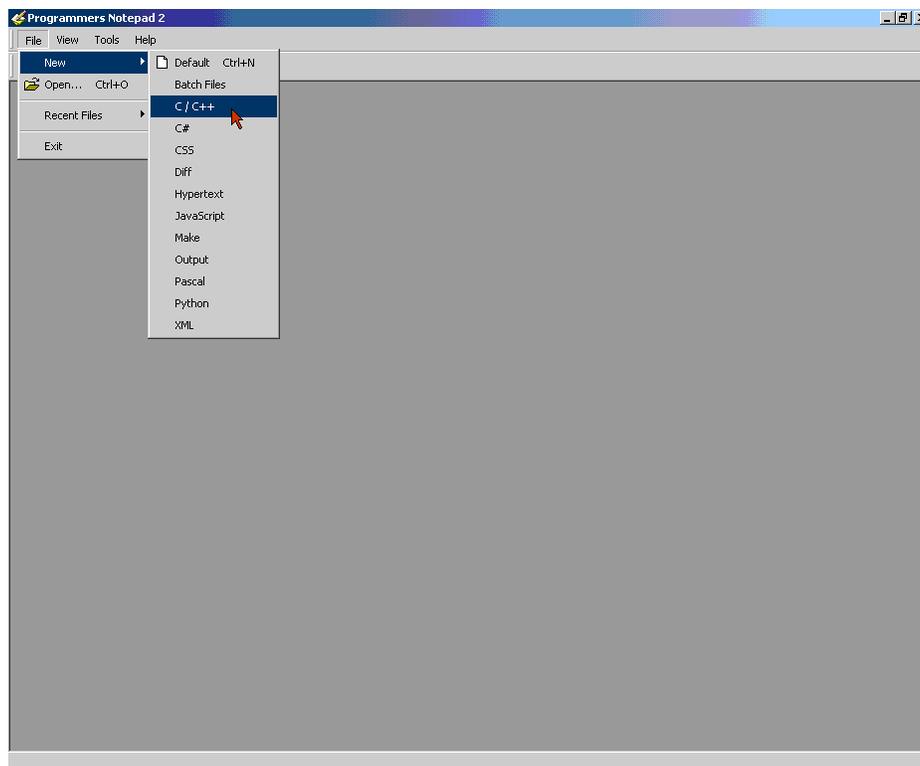


At this point if you go to the 'Tools' menu nothing will have changed, as you have to open a file for the tools to become visible, but Programmers Notepad is now set up for use.

6.0 Your First WinAVR Project

This simple project will show you how to use WinAVR to actually do something. You will have to be familiar with the C language, and also familiar with Atmel AVR.

Open Programmers Notepad, and start a new C file:



In that C file write out this program (don't worry about errors, they are supposed to be there):

```
#include <avr/io.h>
#include <avr/delay.h>

void main (void)
{
    unsigned char counter;

    //set PORTB for output
    DRB = 0xFF;
```

```

while (1)
{

//set PORTB.2 high
PORTB |= 1<<2;

//wait (10 * 120000) cycles = wait 1200000 cycles
counter = 0;
while (counter != 5)
{
//wait (30000 x 4) cycles = wait 120000 cycles
_delay_loop_2(30000);
counter++
}

//set PORTB.2 low
PORTB &= ~(1<<2);

//wait (10 * 120000) cycles = wait 1200000 cycles
counter = 0;
while (counter != 5)
{
//wait (30000 x 4) cycles = wait 120000 cycles
_delay_loop_2(30000);
counter++
}

}

return 1;
}

```

Lets look at some of this programs important points. The first line (`#include <avr/io.h>`) includes the main header file for the AVR. It defines all the various registers for the AVR you have selected in the makefile (such as `DDRB`, `PORTB`, etc). All of the include will be in the `avr/include` part of the WinAVR directory (<c:\WinAVR\avr\include>), and the files that you would only find on the AVR platform are in the `avr` directory (for example `stdio.h` is available across many platforms, but `interrupt.h` is not).

The next line includes the `delay.h` file, which has some functions for holding the program execution for a while. In this case it makes the LED blink visible.

The next line of interest sets `PORTB` to be an output. If you read the AVR data-sheet you will discover that the `DDRB` is written to `0xFF` to set all of `PORTB` to an output. In this example program `DDRB` has been written incorrectly as `DRB` to show the error-reporting mechanisms of AVR-GCC.

The `while(1)` statement results in an endless execution of the loop, as `while(1)` is equivalent to writing a statement such as `while(2==2)` which always equates to true.

To set an individual port pin high, the format `PORTB |= 1<<2;` is used. This means take the current value of `PORTB`, and logically OR it with the result of 1 shifted left 2 times.

To set an individual port pin low, a bit-mask is used that takes the format `PORTB &= ~(1<<2);`. This means take the value of `PORTB`, and logically AND it with the 'opposite' of 1 left right 2 times. So 1 shifted left 2 times is 00000100, and the complement (opposite) of this is 11111011. No matter what value you AND this with, the result will be xxxxx0xx (where x could be anything).

There is a few errors in the program, they are supposed to be there. Save the file to a new folder as `test1.c`. Open the `c:\WinAVR\sample\Makefile` in Programmers Notepad and immediately save it to the same directory as your new C file you just saved (make sure it is called `Makefile` with no extension). You will have to edit the `Makefile` to work with your project (try it for yourself first). Now attempt to compile the program by going to `Tools→Make All`.

If you get an error that looks like this:

```
make: *** No rule to make target `main.o', needed by `main.elf'.
```

Then you didn't set the source code files properly. Check your `Makefile` to make sure the `'TARGET ='` line looks like:

```
TARGET = test1
```

and the `'SRC ='` line looks like:

```
SRC = $(TARGET).c
```

and try again. You should get some errors that look this:

```
test1.c:9: warning: return type of `main' is not `int'
test1.c: In function `main':
test1.c:13: error: `DRB' undeclared (first use in this function)
test1.c:13: error: (Each undeclared identifier is reported only once
test1.c:13: error: for each function it appears in.)
test1.c:28: error: parse error before `}' token
test1.c:40: error: parse error before `}' token
test1.c:45:10: warning: no newline at end of file
make: *** [test1.o] Error 1
```

Start with the first one, even though it is a warning. It tells you that the return type of `main` is not an `'int'`, which according to ANSI C it should be. So you should change that in your source file. To save time, just click on the error and it will jump to the line in your source code as shown:

```

2 #include <avr/delay.h>
3
4 void main (void)
5 {
6     unsigned char counter;
7
8     //set PORTB for output
9     DRB = 0xFF;
10
11     while (1)
12     {
13
14         //set PORTB.2 high
15         PORTB |= 1<<2;
16
17         //wait (10 * 120000) cycles = wait 1200000 cycles
18         counter = 0;
19         while (counter != 5)
20         {
21             //wait (30000 x 4) cycles = wait 120000 cycles
22             _delay_loop_2(30000);
23             counter++;
24         }
25
26         //set PORTB.2 low
27         PORTB &= ~(1<<2);
28
29         //wait (10 * 120000) cycles = wait 1200000 cycles
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
2206
2207
2208
2209
2210
2211
2212
2213
2214
2215
2216
2217
2218
2219
2220
2221
2222
2223
2224
2225
2226
2227
2228
2229
2230
2231
2232
2233
2234
2235
2236
2237
2238
2239
2240
2241
2242
2243
2244
2245
2246
2247
2248
2249
2250
2251
2252
2253
2254
2255
2256
2257
2258
2259
2260
2261
2262
2263
2264
2265
2266
2267
2268
2269
2270
2271
2272
2273
2274
2275
2276
2277
2278
2279
2280
2281
2282
2283
2284
2285
2286
2287
2288
2289
2290
2291
2292
2293
2294
2295
2296
2297
2298
2299
2300
2301
2302
2303
2304
2305
2306
2307
2308
2309
2310
2311
2312
2313
2314
2315
2316
2317
2318
2319
2320
2321
2322
2323
2324
2325
2326
2327
2328
2329
2330
2331
2332
2333
2334
2335
2336
2337
2338
2339
2340
2341
2342
2343
2344
2345
2346
2347
2348
2349
2350
2351
2352
2353
2354
2355
2356
2357
2358
2359
2360
2361
2362
2363
2364
2365
2366
2367
2368
2369
2370
2371
2372
2373
2374
2375
2376
2377
2378
2379
2380
2381
2382
2383
2384
2385
2386
2387
2388
2389
2390
2391
2392
2393
2394
2395
2396
2397
2398
2399
2400
2401
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415
2416
2417
2418
2419
2420
2421
2422
2423
2424
2425
2426
2427
2428
2429
2430
2431
2432
2433
2434
2435
2436
2437
2438
2439
2440
2441
2442
2443
2444
2445
2446
2447
2448
2449
2450
2451
2452
2453
2454
2455
2456
2457
2458
2459
2460
2461
2462
2463
2464
2465
2466
2467
2468
2469
2470
2471
2472
2473
2474
2475
2476
2477
2478
2479
2480
2481
2482
2483
2484
2485
2486
2487
2488
2489
2490
2491
2492
2493
2494
2495
2496
2497
2498
2499
2500
2501
2502
2503
2504
2505
2506
2507
2508
2509
2510
2511
2512
2513
2514
2515
2516
2517
2518
2519
2520
2521
2522
2523
2524
2525
2526
2527
2528
2529
2530
2531
2532
2533
2534
2535
2536
2537
2538
2539
2540
2541
2542
2543
2544
2545
2546
2547
2548
2549
2550
2551
2552
2553
2554
2555
2556
2557
2558
2559
2560
2561
2562
2563
2564
2565
2566
2567
2568
2569
2570
2571
2572
2573
2574
2575
2576
2577
2578
2579
2580
2581
2582
2583
2584
2585
2586
2587
2588
2589
2590
2591
2592
2593
2594
2595
2596
2597
2598
2599
2600
2601
2602
2603
2604
2605
2606
2607
2608
2609
2610
2611
2612
2613
2614
2615
```

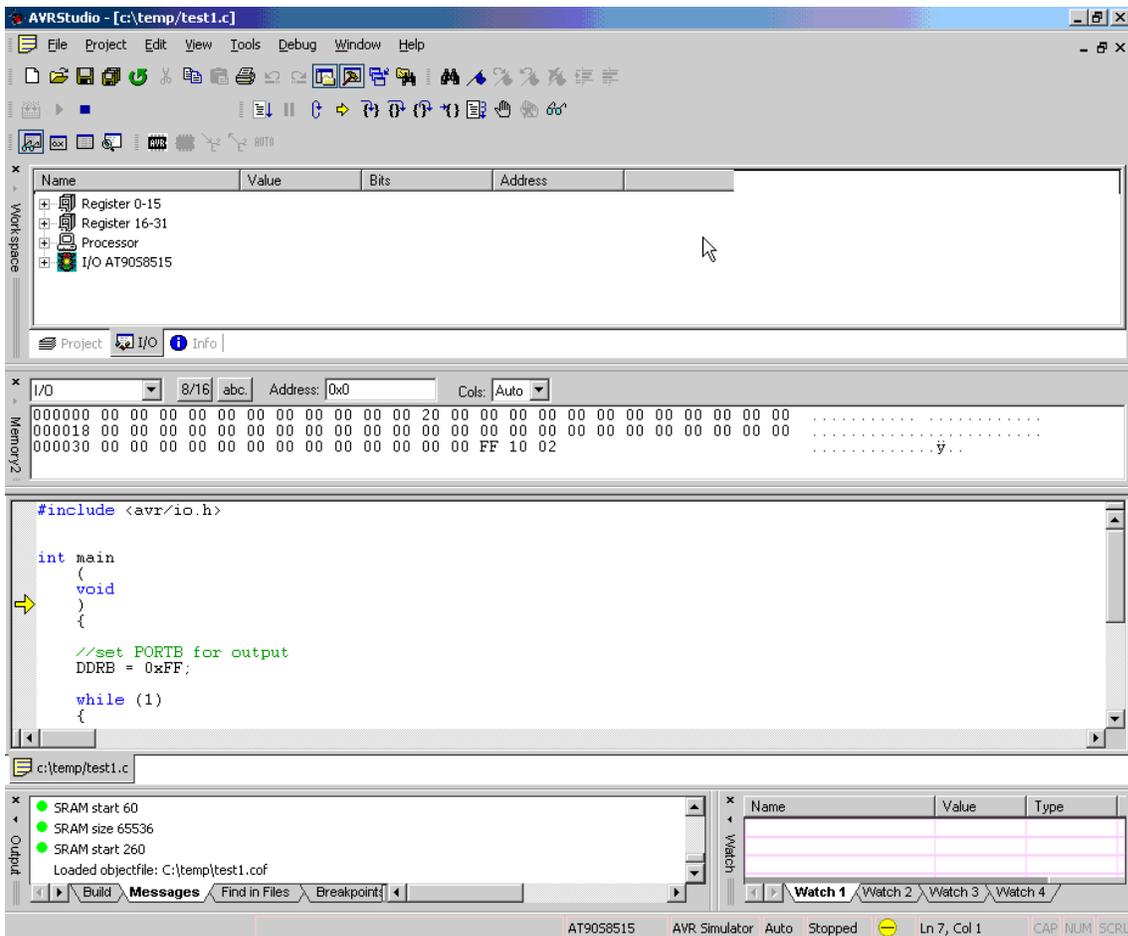
```
void main (void)
{
    //set PORTB for output
    DRB = 0xFF;

    while (1)
    {
        //set PORTB.2 high
        PORTB |= 1<<2;

        //set PORTB.2 low
        PORTB &= ~(1<<2);
    }

    return 1;
}
```

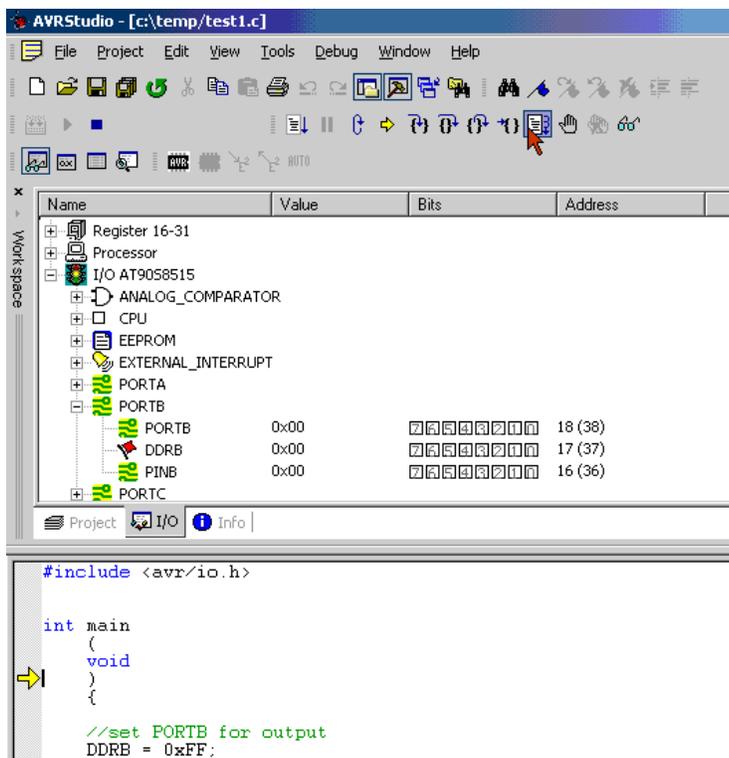
Save the file, and run Make Coff (if you plan on using AVR Studio 3.x or AVR Studio 4.06 or earlier) or Make Extcoff (if you plan on using AVR Studio 4.07 or later). Then open up AVR Studio, and open the test1.cof file. You may also have to select a chip type; set it to what it was in your Makefile. At this point your screen should look something like this (AVR Studio 4.07):



There is a lot that you can do with this screen, so much in fact its recommended you consult the help-file of AVR Studio in the Help→AVR Studio User Guide menu.

If you are missing some of the windows you can find them in the 'View' menu.

Now in the workspace expand the 'I/O' tree, then expand 'PORTB'. Finally press the AutoStep button and watch PORTB.2 toggle between 1 and 0. You can also single-step using the F11 key, which is the 'Step Into' shortcut.



7.0 More Information

There is lots to learn about WinAVR and the tools it contains. You can look in the WinAVR doc directory (<c:\WinAVR\doc>) directory for more documentation. As well the WinAVR site at <http://winavr.sourceforge.net> provides a lot of useful information including news and links. If you have not already gone to this site it is suggested to do this.

Likely the most useful documentation will be the avr-libc documentation (<C:\WinAVR\doc\avr-libc\avr-libc-user-manual\index.html>), which you can find in the doc\avr-libc directory, available in many formats. You can find the latest avr-libc information at the avr-libc website which is <http://www.nongnu.org/avr-libc> Please check out the FAQ in the avr-libc user manual at least, as it includes all sorts of useful information if you are new to the AVR and/or avr-gcc.

8.0 Glossary

ANSI – the American National Standards Institute. Normally in reference to AVRs it will be about a compiler being 'ANSI C compliant'. This means that it follows a certain set of standards, and hopefully code written on one ANSI C compiler can be compiled on another ANSI C compiler with minimal changes.

ASM – Assembly files, assembly being the actual machine language the AVR uses.

COFF – **C**ommon **O**bject **F**ile **F**ormat. However in the context of the AVR it is referred to as the file format that AVR Studio uses for its debugging. AVR Studio 4.07 and later also supports an extended COFF format that has a few extra features. The WinAVR package is able to make both types of COFF files, although you may need to add the COFF extension package on.

GNU – A recursive acronym for **G**NU's **N**ot **U**nix and is pronounced “guh-NEW”. GNU is responsible for a good part of the tools in WinAVR, such as gcc. In reality though since the tools are open source it is really many people's hard work that makes the tools what they are today.

GPL – The **G**NU **P**ublic **L**icense. The GPL is what the gcc compiler and a few other tools is released under, and it sets the terms of its use.

GUI – **G**raphical **U**ser **I**nterface. This is where the interface for a program has buttons and windows and whatnot, as opposed to using the command line.

ihex – The **I**ntel **H**ex file format, which is what most of the AVR programmers use. This is the normal file type generated by avr-gcc.

PN – **P**rogrammers **N**otepad. A versatile editor for several different types of files, and is included in WinAVR.