

INTRODUCTION TO THE STK500

AN INTRODUCTION TO PROGRAMMING AVR MICROCONTROLLERS USING THE STK500
DEVELOPMENT BOARD

SEAN ELLIS

DEC 2001



TABLE OF CONTENTS

Introduction	2
Installing AVRstudio and avr-gcc	2
The STK500 Package.....	4
Setting Up The STK500	9
Installing AVR Studio	10
Creating a Project.....	13
Assembling a Program.....	16
Running the Program	20

Introduction

Assumptions

A certain amount of knowledge is assumed, including the ability to launch programs, navigate the Windows file system, to create folders, and to copy files from one folder to another. A basic knowledge of PC hardware is also required, sufficient to connect a cable to a free serial ("COM") port.

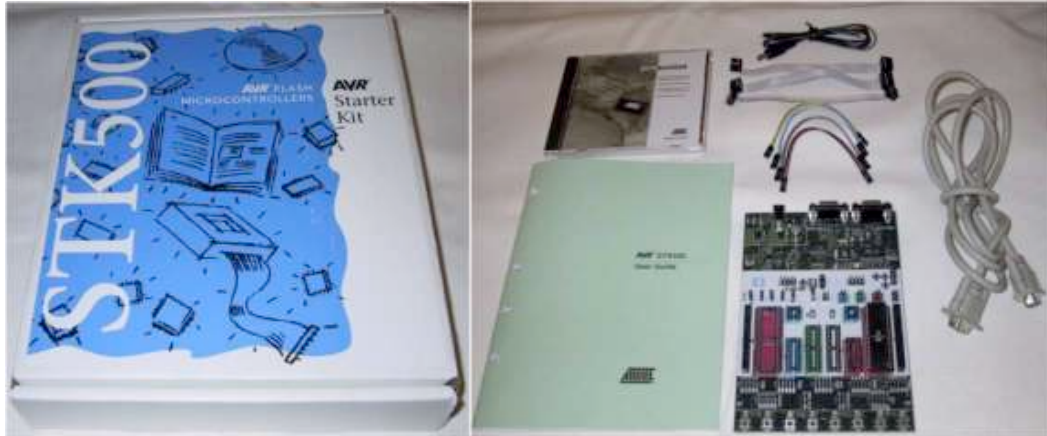
Installing AVRstudio and avr-gcc

This page gets us familiar with the STK500 package contents.

What's In The Box?

The first thing to do is to unpack the items from the box, onto a clean, flat work area.

As you open the box, on top is a list of the contents, which may differ slightly from those listed here. For example, some distributors may include an additional sample microcontroller.



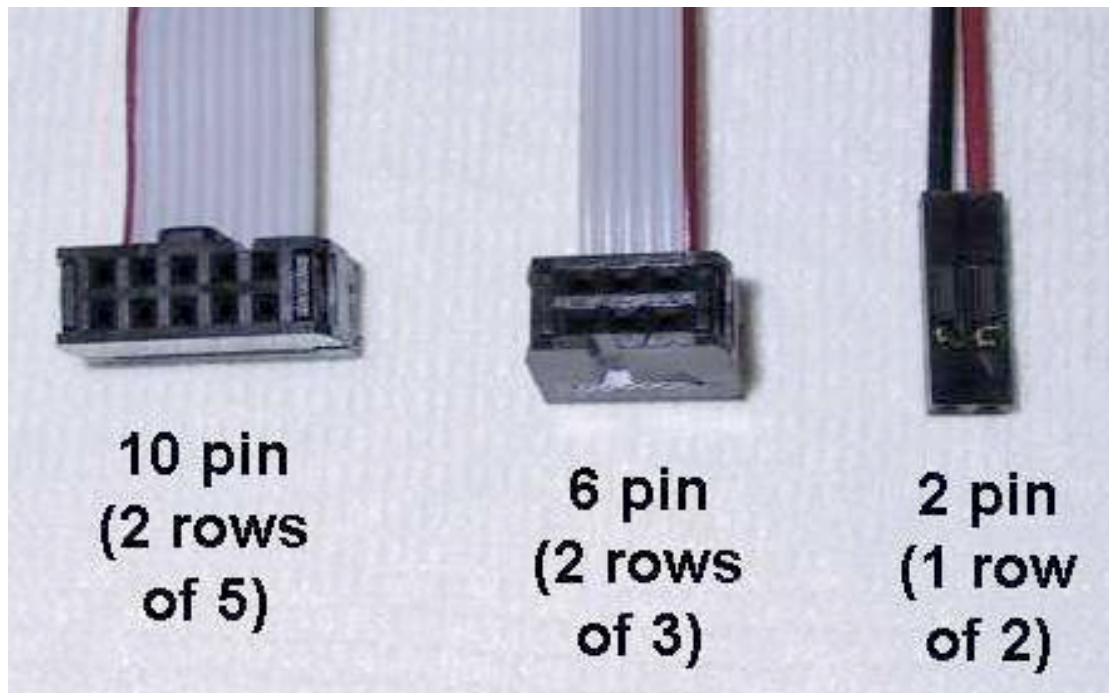
The Box and Contents

There should be a user guide booklet, which includes reference information about the board, as well as its own Getting Started guide (Section 2). This set of webpages reiterates much of the information in the Getting Started section, so you can use either this page or the User Guide to get up and running, according to your own preference.

Under the paperwork is a CD which contains a snapshot of the Atmel website, including all the information and data sheets for AVR microcontrollers and the AVR Studio software which you will need later.

Under this is the main board itself, in an anti-static bag. It is important to remember that modern electronic devices can easily be damaged by static electricity, so try to ensure that you reduce static whenever you are handling the board or the AVR chips that fit into it.

Along with the board are some bags containing grey and colored jumper cables for connecting various parts of the STK500 together. These come in 10 pin, 6 pin, and 2 pin varieties.



Not shown here are the supplied serial cable, which is about 1.5m long with a 9-pin connector on each end, and is for connection to the PC. There is also a bare power cable with a suitable power plug on one end, for use in case your power supply does not have the correct connector to power the board.

Additional Items

In addition to the contents of the STK500 starter kit itself, you will need a suitable power supply. This should be able to supply at least 500mA at 10-15v DC, and be fitted with a 2.5mm power plug. These are commonly available for powering small electrical items, and you should be able to get one at any consumer electronics shop. Polarity is not important, since the STK500 is designed to accept either polarity of connector.

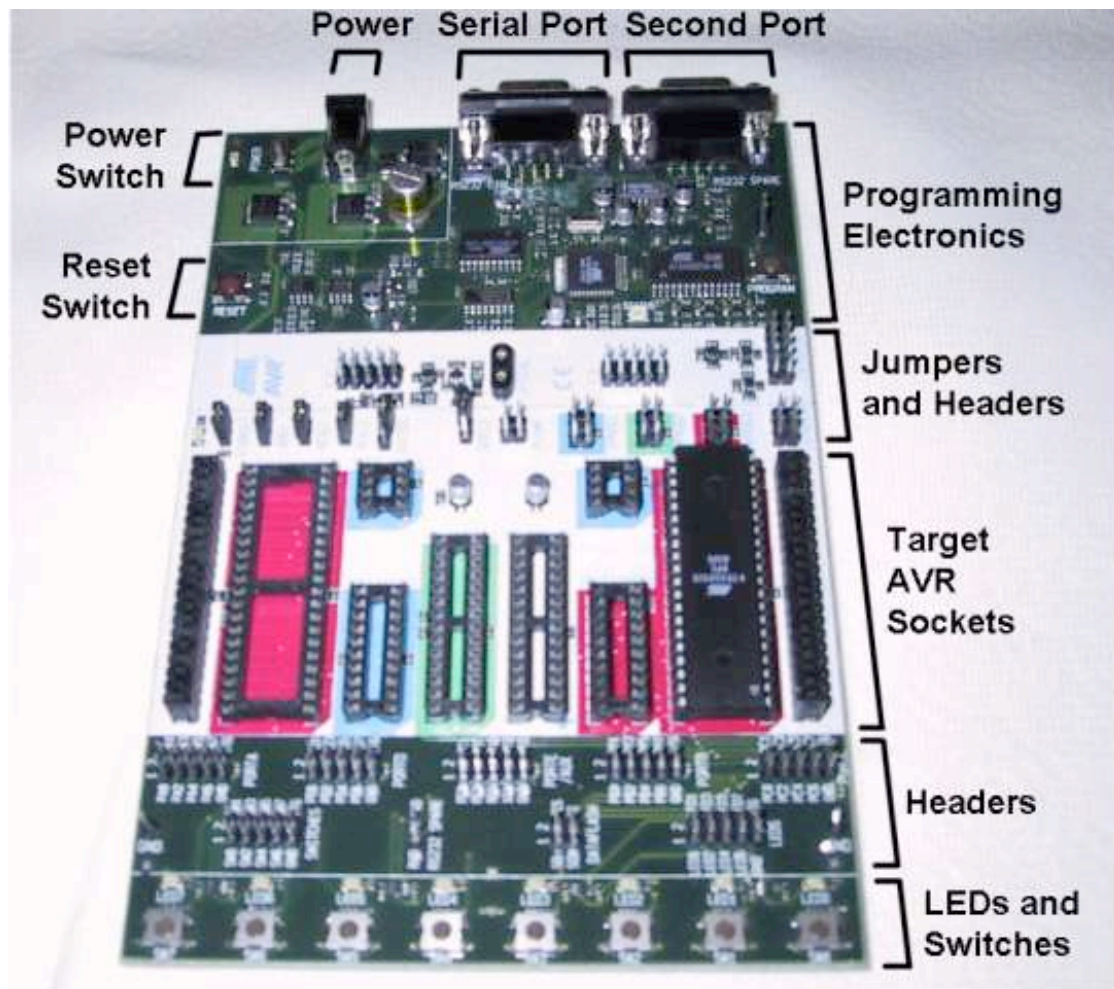


A Typical Power Supply

In later steps we will be connecting the STK500 to a PC, so you should have one of those as well. The Atmel AVR Studio software requires a PC (Pentium or above recommended), with at least 16MB of RAM, 7MB of hard drive space free, Windows 95, 98, NT or 2000, and a free serial (COM) port. This description covers virtually any new PC-compatible computer bought in the last 5 years or so.

The Board Itself

If you place the board so that the row of pushbutton switches is towards you, and the power and serial connectors are away from you, we can take a look at the basic layout of the board.



The STK500 Board

Starting from the bottom, first there is a row of eight pushbutton switches, each of which has a small LED lamp above it. These can be connected to the microcontrollers using the array of connectors just above. There is then a large white area, which is where the AVR chips to be programmed are inserted. Usually, a STK500 comes with a AT90S8515 (8515 for short) chip mounted in the large socket on the right. The green area at the top contains the programming electronics, and the connectors for power and communications.

The STK500 Package

This page gets the STK500 powered up safely, and checks that both it and the supplied AVR microcontroller are working correctly.

Checking The Board Options

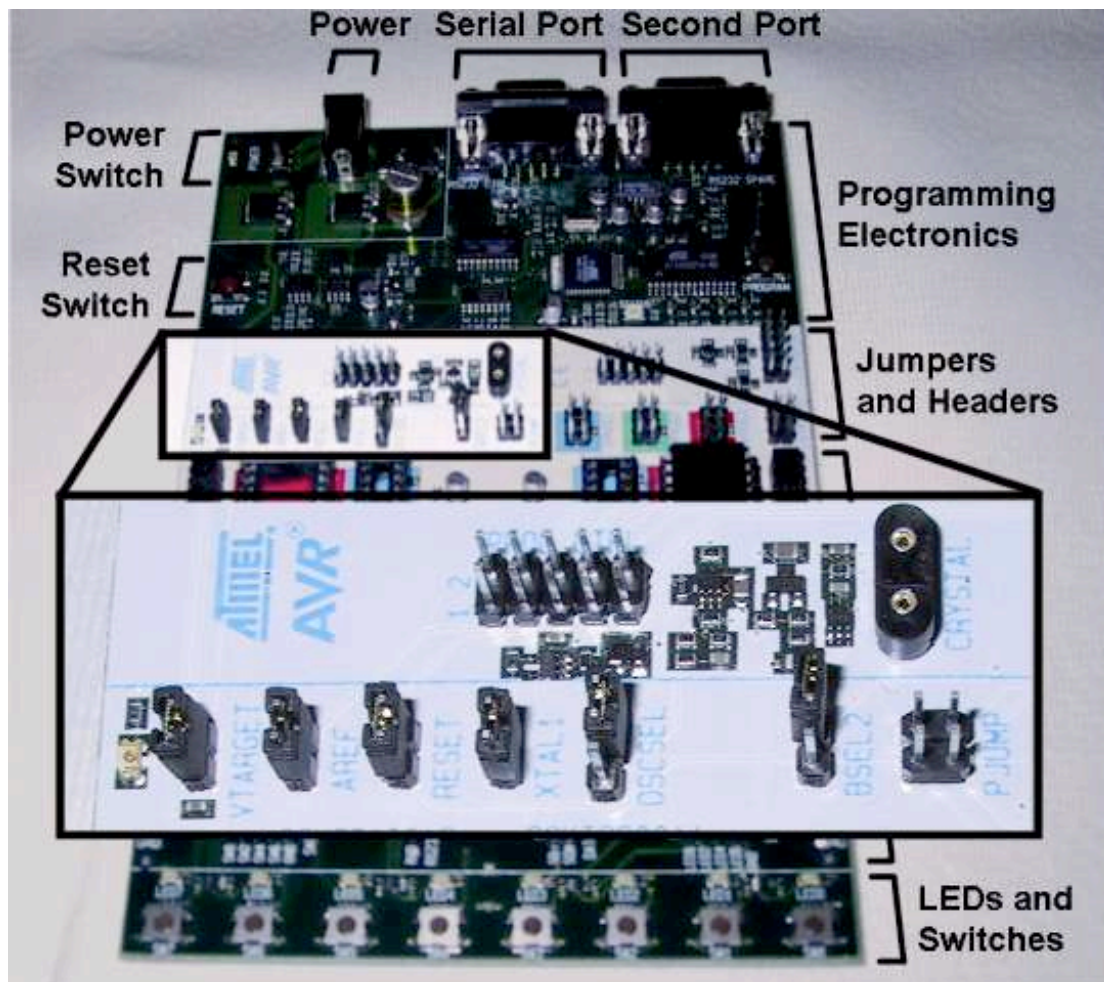
The STK500 is a sophisticated piece of equipment, and as such has several different modes of operation. These are selected by connecting (or leaving unconnected) specific sets of pins on the board.



Jumper Positions

To connect a pair of pins, a small connector is pushed onto them. These connectors are commonly referred to as "jumpers". A pair of pins is said to be "closed" when a jumper is pushed on between them, and "open" if not. It is often common practice to push the jumper onto just one pin for an "open" condition, so that it doesn't get lost. The picture above shows a typical two-pin jumper in a closed and open position, and a three-pin jumper closed between pins 1 and 2, or 2 and 3 (three pin jumpers always have pin 1 marked).

The STK500 should come with all its jumpers set up to select a sensible default set of options, but it is worth checking that they are indeed in this default configuration before we go any further.



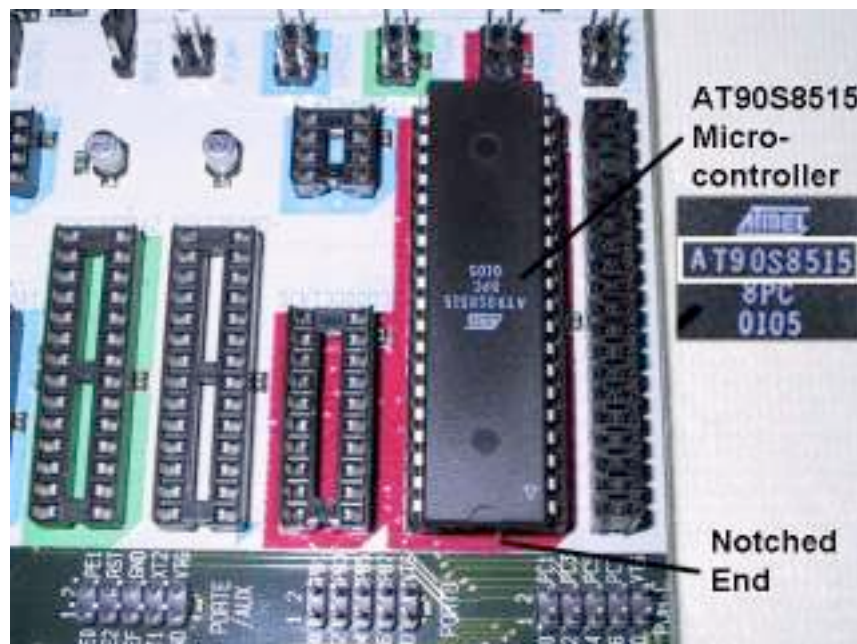
Default Jumper Positions

The jumpers are located at the top of the white area, on the left, and are labelled (from the outside in) VTARGET, AREF, RESET, XTAL1, OSCSEL, and BSEL2. These should be in the state indicated in the picture, and are also printed on the

underside of the board for easy reference. The defaults are:

- VTARGET closed
- RESET closed
- XTAL1 closed
- OSCSEL closed between pins 1 and 2
- BSEL2 open

One other thing that is worth checking is that the pre-installed AT90S8515 microcontroller is present and inserted the right way round. It should be a large, 40 pin chip in the large socket on the right of the board, with the notched end toward the row of switches. If you have a brand new STK500, then this is very unlikely to be missing or misaligned.



Correct 8515 Orientation

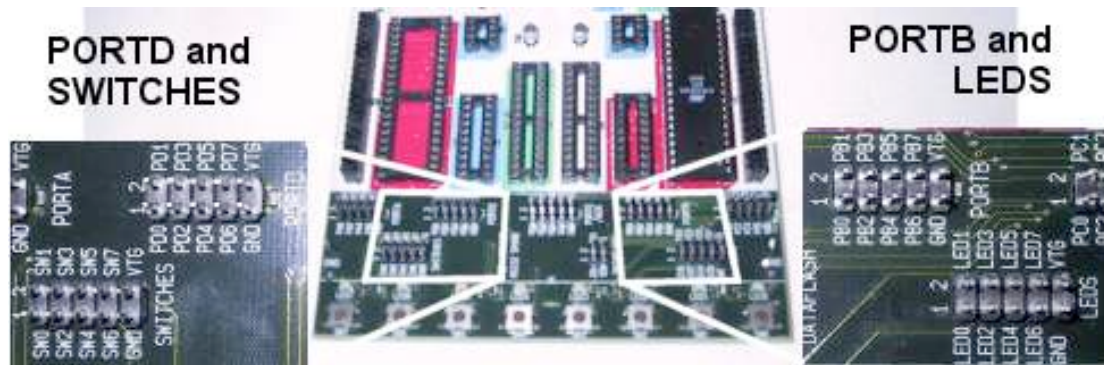
Testing The Board

Before we connect the board to anything else, it is best to test it in isolation. This will verify that the board is operating correctly.

The installed 8515 comes with a test program already programmed into it, which is very handy. But before we can run it, we need to connect some of the outputs from the microcontroller to the LEDs and switches on the board.

On the right hand side, just above the switches, is a group of 10 pins labelled "LEDS". These need to be connected to the corresponding group of 10 pins just above and to the left labelled "PORTB". In general, a group of pins arranged in this way and intended for a cable to plug into them is known as a "header", so these are the LEDS header and the PORTB header.

On the left are two similar headers labelled PORTD and SWITCHES.



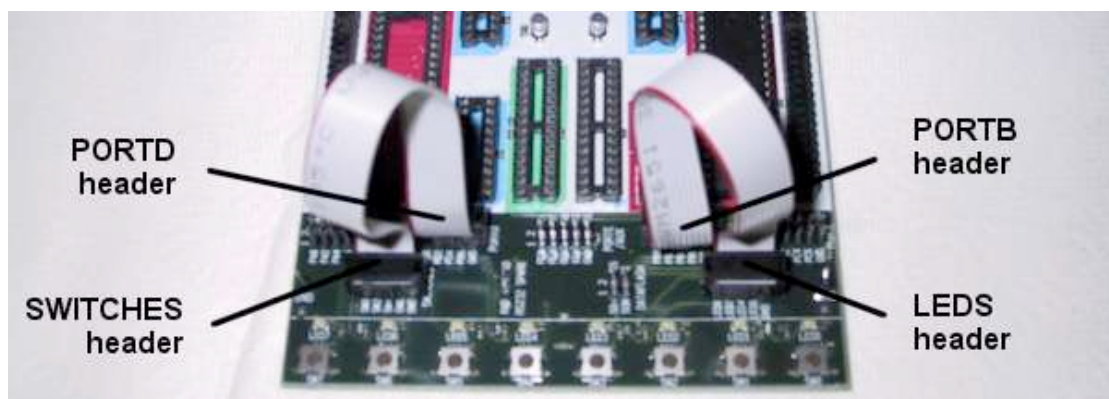
Close up of headers

One thing to notice is that each pin is individually labelled: on the LEDS header we have LED0 to LED7, GND and VTG for the LEDs, and on PORTB we find PB0 to PB7, GND and VTG. It is important that we connect the headers up in such a way that LED0 connects to PB0, LED1 to PB1, and so on. Most particularly we must ensure that the two GND pins connect, and that the two VTG pins connect, as these are the pins which carry the main power supply.

Similarly, to connect the switches we should connect SW0 to PB0, SW1 to PB1, and so on.

It is a good idea to do three things when connecting cables to headers: First, ensure power is off. You might make a temporary connection due to a shaky hand, but that will not matter if there is no power going into the board. Second, check that the cable is connected the right way round. Third, check that the cable is connected the right way round once again. Whilst you may notice that steps two and three are very similar, it really does not hurt to be sure!

To connect each set of two headers, use one of the short 10-pin to 10-pin jumper cables supplied. To ensure that the cables are not twisted (which would connect the wrong pins), ensure that the red stripe is on the left in both cases.



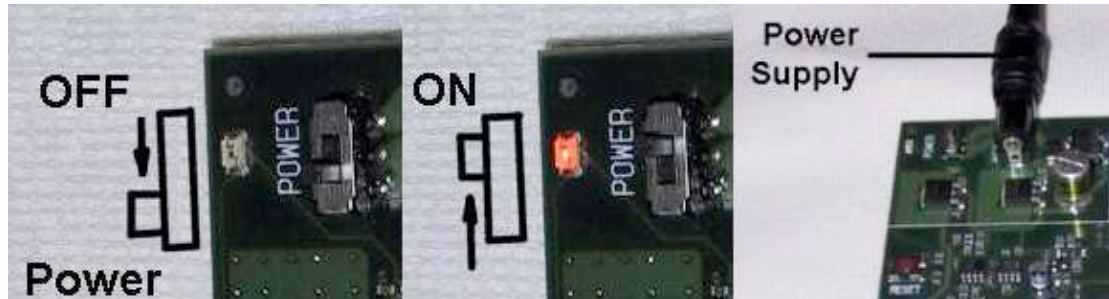
Connecting the cables

I'll say this one more time: it's very important to ensure that cables are attached the right way round, as putting them in the wrong way round can damage the STK500 and/or the microcontroller inserted into it.

As an aside, you may be wondering why we're connecting ports B and D, when there are ports A, C and E available too. The overriding reason is that the test program is written to use these ports, which is because they are physically the easiest ones to connect on the board. They are also present on almost all AVR devices.

With the switches and LEDs connected (did I mention to double check the orientation of the connecting cables?), we are ready to power on.

First, ensure that the power switch on the STK500 is off (the toggle should be in the position farthest from the edge of the board).

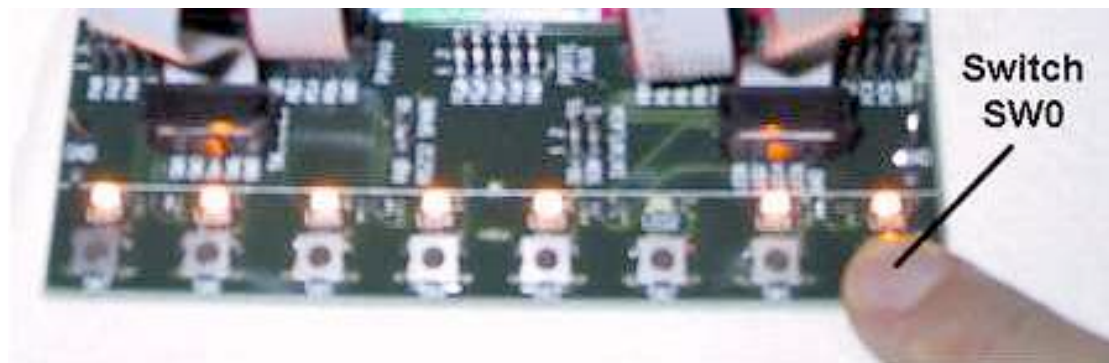


Power switch and connections

Plug your power supply into the wall, switch it on (if it has a switch - most wall-mounted power supplies like mine do not), and connect it to the power socket at the top left of the board.

Are you sure your cables are all connected the right way round? If so, switch on the power switch.

With the switch on, three small LEDs should light immediately. The red one next to the power switch indicates that power is available to the STK500 itself. The green one at the top left of the central white area indicates that power is getting to the installed microcontroller, and the green one on the right near the top indicates that the programming hardware is ready to go.



LEDs should blink when switch SW0 is pressed

The test program is set to respond to the push button switches at the bottom of the board. Press switch SW0 (at the right) briefly. If everything is OK, most of the LEDs should light. This is a good indication. Press and hold SW0 and the LEDs will start flashing, with each LED flashing half as quickly as the one on its immediate right. (This is known as a "counting" pattern.)

Each switch has a different effect on the LED patterns:

- SW0 "counts down".
- SW1 "counts up".
- SW2 moves the current LED pattern right.
- SW3 moves the current LED pattern left.
- SW4 lights every LED which is dark, and vice versa.
- SW5 same as SW4, but only as far as the rightmost dark LED.

- SW6 swaps LED0 with LED4, LED1 with LED5, LED2 with LED6 and LED3 with LED7.
- SW7 does nothing

If everything went well, congratulations! You now have a working and healthy STK500. The next page will take you through installing the software.

Otherwise...

Troubleshooting

Here are a few troubleshooting suggestions.

Nothing Happens When I Switch On

The most obvious thing to check is that the power supply is turned on and giving power. If you have a voltmeter, check that the voltage coming out of the power supply is sufficient to drive the STK500 board (10 to 15 volts), and that the current rating is sufficient (500mA or above).

The Power Lights Are On But Nothing Happens Otherwise

Check that you have connected the LED and Switch jumper cables correctly, paying attention to the alignment of the pins and the polarity of the cables. Check that the jumpers on the board are in the default positions. Check that there is actually a microcontroller installed in the board!

There Are Some LEDs On But They Don't Do What I Expect

The chances are that, if you are not the first user of the STK500, the microcontroller has been reprogrammed, erasing the test program supplied by default. In this case, you will have to progress to the next page, install the programming software and reload the test program.

Setting Up The STK500

AVR Studio is a free suite of Windows software from Atmel that enables you to create, edit, and assemble programs for the AVR microcontrollers, and then transfer them to real AVR chips installed in the STK500 board and run them. This page gets us ready to install the AVR Studio software. It is assumed that you have set up and checked your STK500 evaluation board as outlined in the previous page.

Requirements

The Atmel AVR Studio software requires a PC (Pentium or above recommended), with at least 16MB of RAM, 7MB of hard drive space free, Windows 95, 98, NT or 2000, and a free serial (COM) port. This description covers virtually any new computer bought in the last 5 years or so.

In order to read or print the user manual, you will also need appropriate Adobe Acrobat viewer software. This is distributed on the Atmel CD that came with the STK500, so assuming that your CD-ROM drive is drive D:, you can install it by running the file D:\adobe\windows\ar40eng.exe (that cryptic filename is short for "Acrobat Reader 4.0 English").

This version of the software should work fine with the user manual. However, if you don't have access to the Atmel CD, the latest version of the Acrobat reader is available for free download from [Adobe](#) themselves at their [Acrobat Reader download page](#). The current version at time of writing is about 8.6 megabytes, or

just under an hour's download on a typical modem connection.

Obtaining AVR Studio

Atmel are continuously upgrading AVR Studio, so it is a good idea to work with the latest version. Although there is a version of AVR Studio included on the Atmel CD that comes with the STK500, it is best to take the time to download the latest version either from Atmel's website or here on AVRfreaks.net.

On AVRfreaks, the latest version is available in the Tools section of the site. I am not going to link directly to the downloads, since [the download page for AVR Studio](#) always contains links to the very latest version. You can also find this page by selecting the Tools tab, then selecting Assembler from the left hand list of tool categories, then selecting AVR Studio from the resulting list of links.

To begin with, you will want to download two files from the Tools page - the AVR Studio Install File (astudio3.exe), and the AVR Studio 3 User Guide (doc1019.pdf).

The AVR Studio install file is about 6 megabytes in size, which translates as about 30 minutes download time on a typical dialup connection. To download, just click on the link and choose "Save to disk" when prompted. You will need only need this file disk temporarily, so choose a temporary folder such as C:\Temp to save it into.

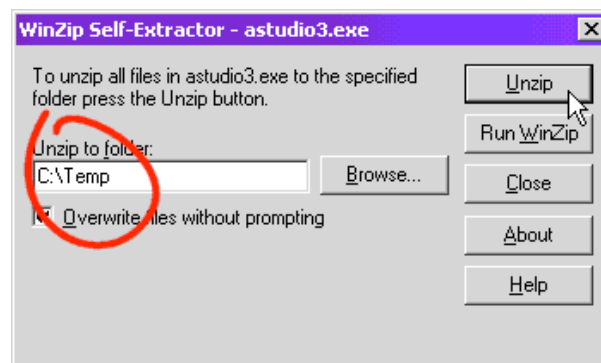
You will also need to download the user guide. This is much smaller, about 173 kilobytes, well under 2 minutes' download time. This you will need to save somewhere more permanent. I suggest that you navigate to your "My Documents" folder, and make a new folder under that called "AVR", and save the user guide in there.

Installing AVR Studio

This page installs the AVR Studio software.

The Installation Process

Find the install file you saved to disk in the previous step, and run it by double-clicking on it. This starts the install process. (The process itself is quite quick, and actually takes less time to do than it does to read this guide!)



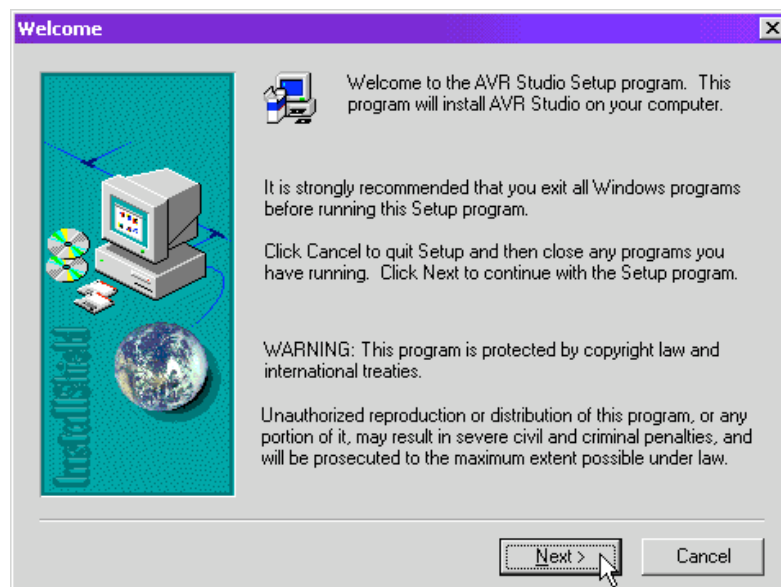
Unzipping the files

The first stage of the install unpacks all the files from the installer to a temporary location. The dialog box that appears suggests a temporary folder to use during

this process, but we'll need to find this folder later so it is easier just to type C:\Temp as the folder to use. Once this is done, click on the Unzip button to continue.

Assuming everything went well, a small message box appears, reporting the successful unpacking of the files to C:\Temp. Click on the OK button to continue. This takes us back at the unpacking dialog. Click on the Close button to finish this part of the installation.

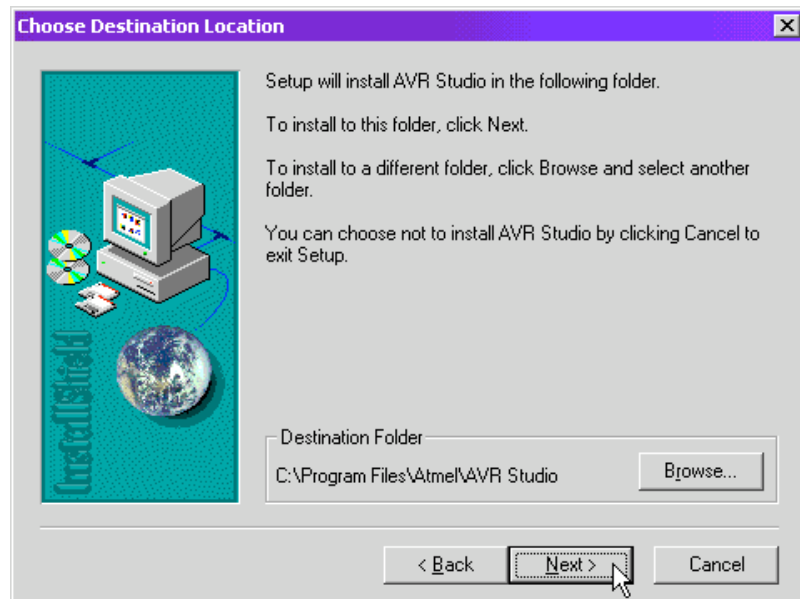
This has unpacked all the files we need to install into a new folder under C:\Temp, called "cdrom". (Presumably because this installation is also destined for future versions of the Atmel CD.) Select the "cdrom" folder and double-click on the SETUP.EXE program in order to run it.



Installation splash screen

You will be presented with the installer's introduction screen. This advises you to close all other Windows programs before continuing with the installation, and so this is definitely a good idea. Once the installer is the only thing running, click on the Next button.

The next step is the lawyer's favorite dialog box - the one that contains the software license. I am not a lawyer, and so cannot advise you on whether this license suits you or not, but the bottom line is that if you don't click the Yes button to accept the terms of the license, you don't get to play with the software. Let's assume you click "Yes" and carry on to the next screen...



Choose destination folder

The next dialog in the sequence suggests a default folder in which to install AVR Studio. The suggestion seems like the right place to put it to me, but if you disagree you have the chance to change the folder by clicking on the Browse button. Once you are happy, click Next to continue.

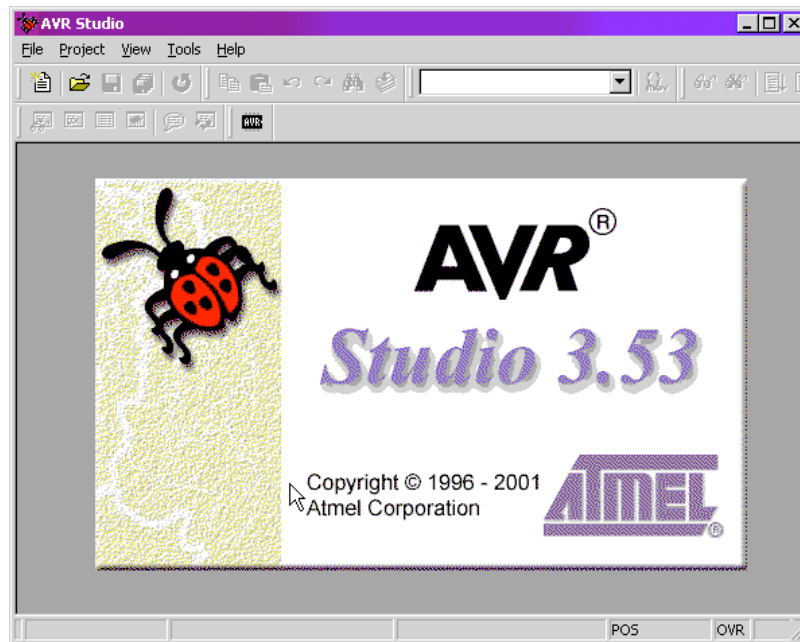
(Nearly there.) The next screen asks for the name of the folder which will appear in the start menu. You have the chance to edit this name if you don't like the default. Once you are happy, click Next.

At this point, the actual installation of the files into their final locations takes place, which may take a few seconds.

The final screen asks for permission to restart the machine. In general, I am very forgetful, so I always give my permission to restart immediately. Otherwise, I run the risk of forgetting to do so and getting problems because of it. If you choose the Restart Now option, clicking Finish will restart your computer and finish the installation. If you choose the Restart Later option, clicking Finish will mean that the final finishing touches to the installation will only happen next time you restart, so you will have to restart manually before proceeding to the next step.

Running AVR Studio

If everything has gone well with the install (remember to restart the computer if you haven't already), you should have a new folder in your Start menu, which if you accepted the default name will be called "Atmel AVR Tools". Inside this is a shortcut to the AVR Studio program. Click it to start AVR Studio.



AVR Studio Running

The initial splash screen will appear and the AVR Studio development environment is presented. This is a bit bare to start with since we haven't created anything yet. Almost all the icons in the toolbars are greyed out, since they have no effect until we load or create a project to edit.

Creating a Project

This page gets us started with the AVR Studio software, creating a very simple example project.

The Program

The simplest AVR program which has a visible output just lights one of the LEDs on the STK500 board. The example program here lights LED0, the rightmost in the row of eight LEDs above the pushbuttons on the near end of the board, and then halts.



A closeup of LED0

The actual detail of how the program works is not particularly relevant at this stage - like the program already loaded into the AVR in a new STK500, it is used to demonstrate the *process* of creating a program.

We cannot easily write the program directly in a form which is downloadable onto the chip. Why not? Because programs written directly for the chip itself are the next best thing to incomprehensible. For example, here is the actual code we are going to download onto the chip.

B89A C098 FFCE

Each 4-digit code represents a single instruction that the AVR can carry out. This is easy for simple computers to deal with, but a nightmare for humans.

Obviously, we need a better way of dealing with this. A program which converts a more readable form of each instruction into these numeric codes is known as an assembler, and the AVRasm assembler is included with AVRStudio.

Our assembler listing is pretty small - only 5 lines long, and only 3 of those actually translate into instructions. Here it is:

```
.include "8515def.inc"
.org 0

sbi DDRB,0
cbi PORTB,0

halt: rjmp halt
```

We will go through this program in more detail in the basic assembly language tutorial later on. For now, we can treat it as a "black box" that stands in place of any assembly language program.

Creating the Projects Folder

AVR Studio organises all the files and settings for a single program as a "project", which resides in its own folder on your hard drive. AVR Studio itself will create a new folder for each project, but will not create the folder that the project folders themselves are stored in. (For example, if you want to put your project in C:\Projects\LED0, then AVR Studio will quite happily create the LED0 folder, but only if the folder C:\Projects already exists.)

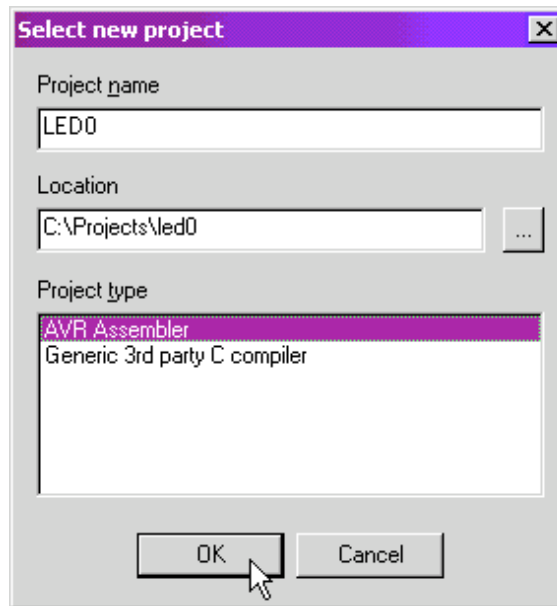
If you do not have an existing folder to put all your projects in, create one called "C:\Projects" .

Creating the Project

Our ultimate goal is to type the program into the computer, feed it through the assembler, and download it to the chip on the STK500. To do this, we will create a new project in AVR Studio. With the housekeeping out of the way, now we can start the AVR Studio software.

Once the splash screen has disappeared, you should be left with a blank work area and a set of menus and toolbars along the top, much as you would expect from a Windows application.

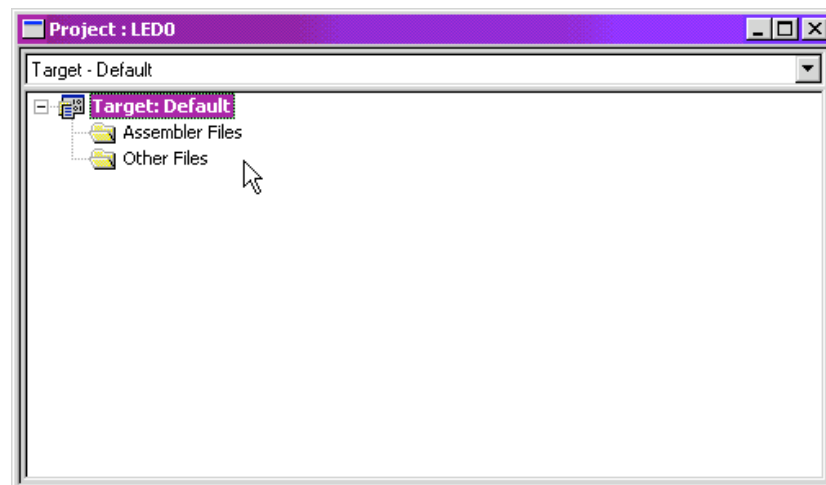
To create a new project, pull down the Projects menu and select New... The Select New Project dialog box will appear. It is here that we get to set some of the most basic options for our project.



The Select New Project dialog box

For this project, we will set its name to "LED0", and where it is to be stored will be "C:\projects\led0". We also need to indicate what type of project it is. In this case, we have a choice of "AVR Assembler" or "Generic 3rd Party C Compiler". Since this, and all the other projects later in this series, are assembler projects, we should select "AVR Assembler" for this one. When all is correct, click OK and the project will be created.

We should now have a view of the project in the Project window. This window has two folders in it, labelled "Assembler files" and "Other files". Both of these folders are empty at the moment, because we haven't actually created any files to go into them yet - this is just a view onto the project folder.



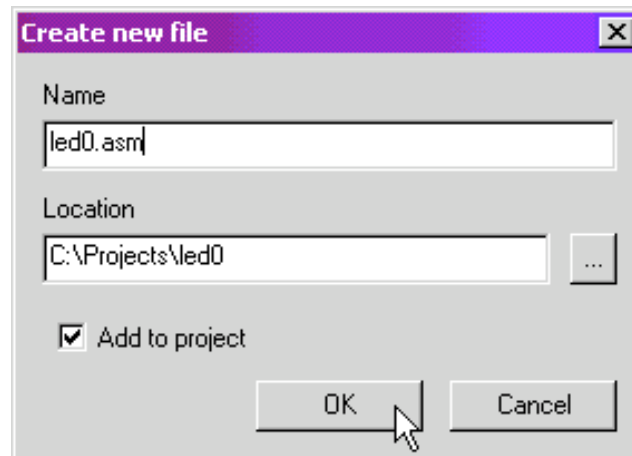
The Project window

Assembling a Program

This page explains the various steps in editing and assembling a simple program.

Creating the Program File

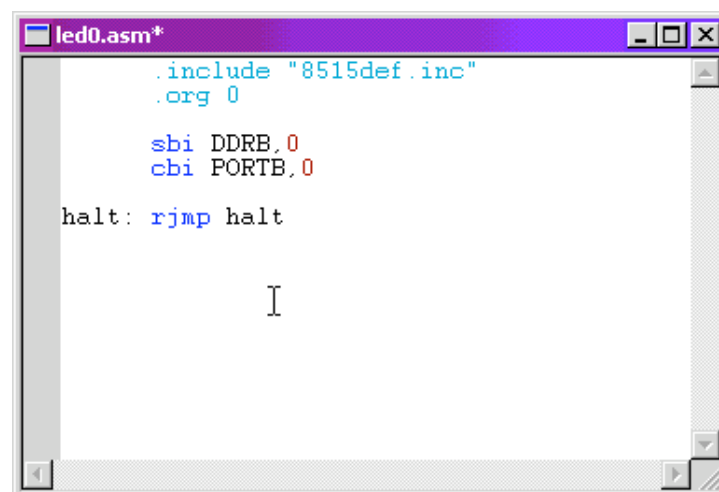
To create a new file, pull down the File menu and select New Text File... The Create New File dialog will appear, prompting for the name of the file to create.



The Create New File dialog box

The name we want is "led0.asm", with the .asm extension signifying that it is going to be an ASseMbler file. The location field should already be set to the current project folder, "C:\Projects\led0". The "Add to project" check box should be checked, since we do want to add this new file to the project. Once all this is correct, click OK.

A new, empty window opens, entitled led0.asm, displaying the contents of the new file. It is blank, since we haven't written anything into it yet. (You may also notice that a new item has appeared in the Projects window, also entitled led0.asm.) Into the new window, we need to type (or cut-and-paste) the assembly language program we wrote above.



The led0.asm file window

The editor software within AVR Studio recognises the .asm extension on the file, and realises that this is an assembly language program. In this case, it will highlight particular things within the program using different colors. This is

perfectly normal and is designed to give additional cues to the user while writing programs.

Here is the program again (in black and white) for cut-and-paste purposes:

```
.include "8515def.inc"
.org 0

sbi DDRB,0
cbi PORTB,0

halt: rjmp halt
```

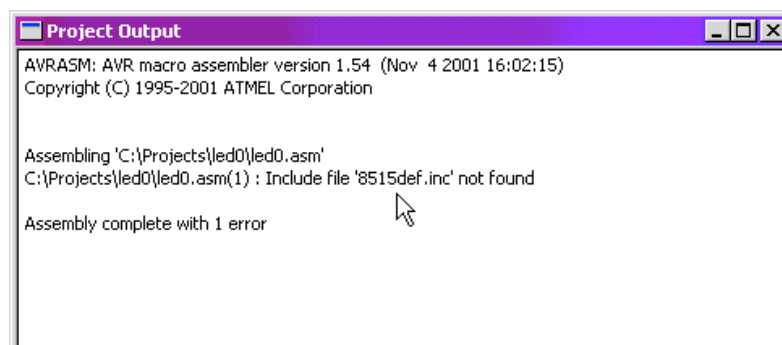
Always save work regularly. To save the file, pull down the File menu and select Save. This will save the file to the disk.

Assembling the Program

Let us now try assembling the program. To do this, either pull down the Project menu and select Assemble, or press key F7. This submits the program we just wrote to the assembler, which tries to interpret it and convert it to raw machine instructions.

The assembler itself opens a new window to inform you of what happened. In this case, it is not good news. The assembly process failed. The last line shows a summary of what happened, and as it says there was 1 error.

So, am I presenting a faulty program? Have I just been stringing you along all this time? Not quite. We will have to read through the rest of the output to understand why.



The Project Output window

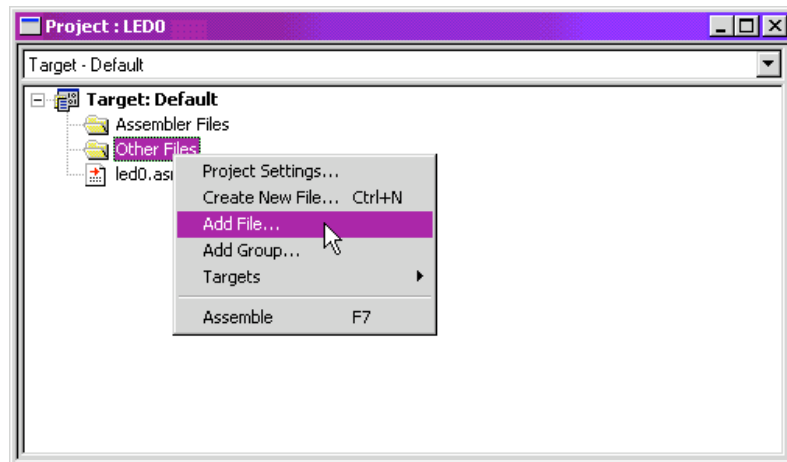
The first two lines are just the copyright information for the assembler software itself. Then there is a line of information telling us what the assembler is doing, assembling our file, c:\projects\led0\led0.asm. However, the next line is the informative one. Again, it tells us which file was being assembled when it found the error - c:\projects\led0\led0.asm, and it also includes the line number it was assembling in brackets. Here, it is (1), indicating that the error is in the very first line of our program.

The rest of the line details the error, and indicates that it is not our program that is at fault, but the assembler cannot find the file called "8515def.inc" file which was specified on the first line. This file (as well as corresponding files for all the different AVRs) is included with the assembler, but since it's not actually in our project, the assembler does not know where to find it. We must copy it into our project folder.

Close the Project Output window, since it won't be needed for a while.

All of the .inc files for all of the possible AVR devices are initially installed with AVR Studio, into the folder C:\Program Files\Atmel\AVR Studio\Appnotes. Using Windows Explorer, or by exploring from My Computer, copy the file 8515def.inc from this folder to our project folder, C:\Projects\LED0.

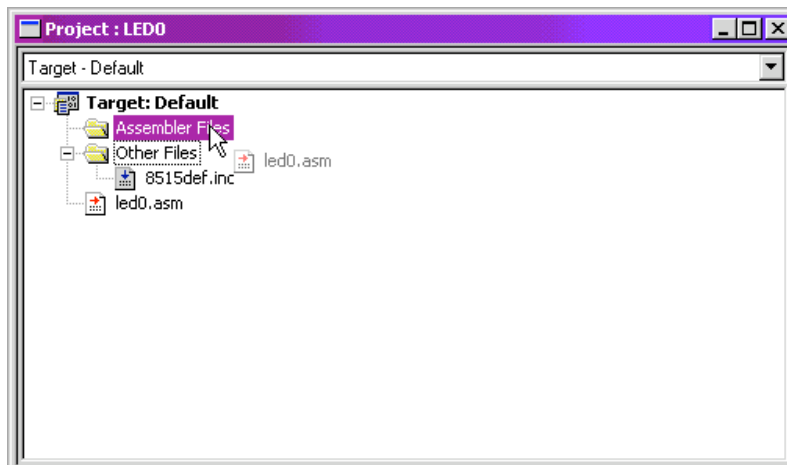
Back in AVR Studio, we must add this file to our project. It's not an assembler file *per se* so we will add it to the "Other Files" group. In the project window, right-click on Other Files and select Add File... from the pop-up menu.



Adding a file

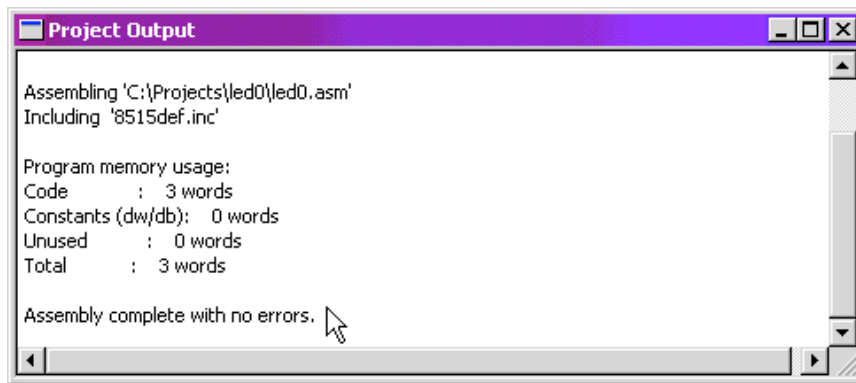
Select 8515def.inc from the file selection dialog and click Open. If you cannot see it, choose "All files" from the "Files of type" dropdown first.

8515def.inc should now be visible under the "Other Files" group. Notice that when we created the original led0.asm file, it was not placed under the "Assembler Files" group by default, so while we are assigning things to groups we can do it now. Simply drag-and-drop the file into the "Assembler Files" group.



Drag and drop led0.asm

Let us check if this actually worked. Assemble the project again using the menu (Project, Assemble) or press F7. The Project Output window reappears, and with a bit of luck this time the bottom line has a very happy message indeed - "Assembly complete with no errors". We have just successfully assembled our first program.

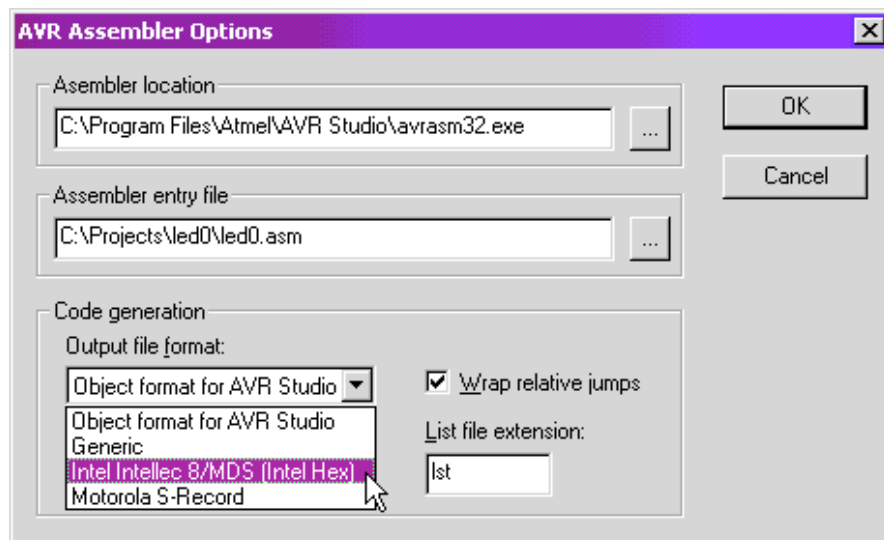


Assembly successful

(If it does not say this, recheck that led0.asm is exactly as printed above, and that 8515def.inc is indeed in the right folder.)

Before we can run the file, there is one final adjustment that needs to be made to the project. By default, the assembler is set up to output instructions in a form that AVR Studio's built-in AVR simulator software can deal with. If, as we do, we want to run the program on a real AVR, we must change the output format for the assembler.

From the Project menu, select Project Settings... The Project Settings dialog box appears. From the Output File Format drop-down, select the option labelled "Intel Intellec 8/MDS (Intel HEX)". This is the name of the file format that the STK500 programming software understands (known for short as "hex" format). Click OK.



Project settings

Re-assemble the program by pressing F7. The output window should appear with no errors as before. We now have an assembled file ready for transfer into the AVR on the STK500.

Running the Program

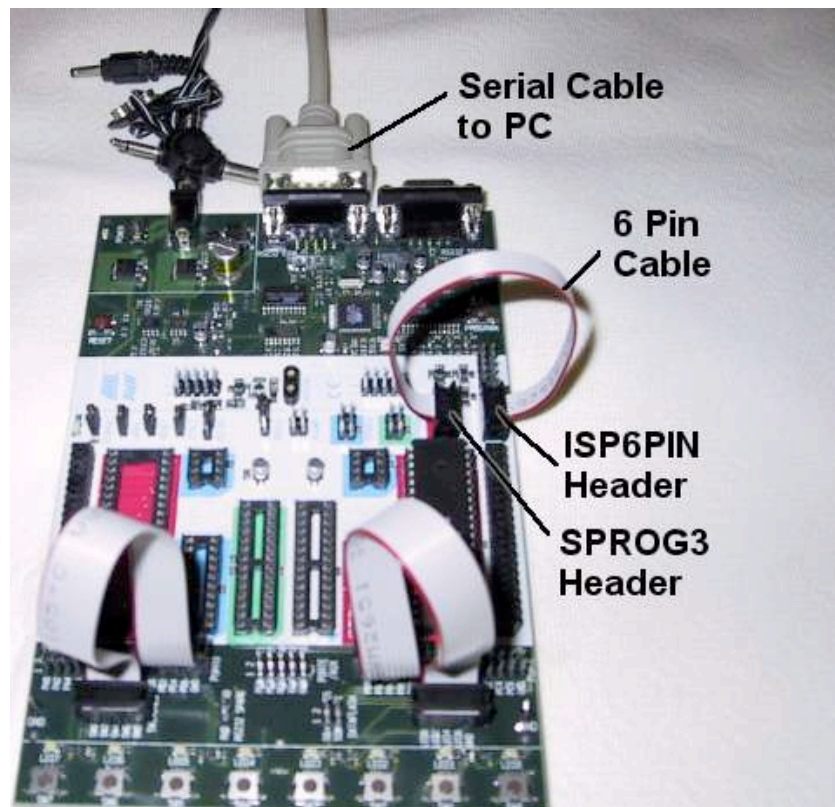
This page shows how to download a program to the STK500 and run it.

Downloading the Program

In order to run the program, we need to transfer it to the STK500, and to do that we need to connect the programming electronics to the AVR on board. First, ensure power to the STK500 is off.

We are going to use the simplest form of programming, serial programming, so we must connect the appropriate serial programming headers together. First, find the two 6 pin headers near the rear end of the 8515 chip, on the right, labelled ISP6PIN and SPROG3. SPROG3 is connected to the appropriate pins on the 8515, which is why it has a red background and so does the 8515 socket.

Using the 6 pin cable that came with the STK500, connect these two headers together, ensuring that the cable is not twisted.

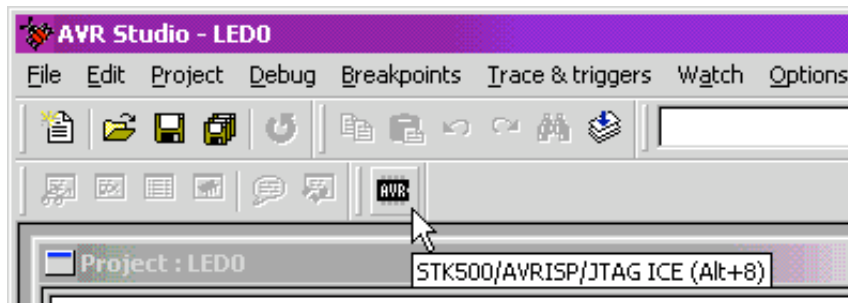


Connections for downloading

Next, using the serial cable supplied, connect the leftmost serial connector (labelled RS232 CONTROL) to a spare serial port on your PC. Most PCs have at least one suitable 9-pin serial port on the back panel, often labelled COM1 or COM2.

Once this is connected, switch on the STK500 and we are ready to attempt a programming session.

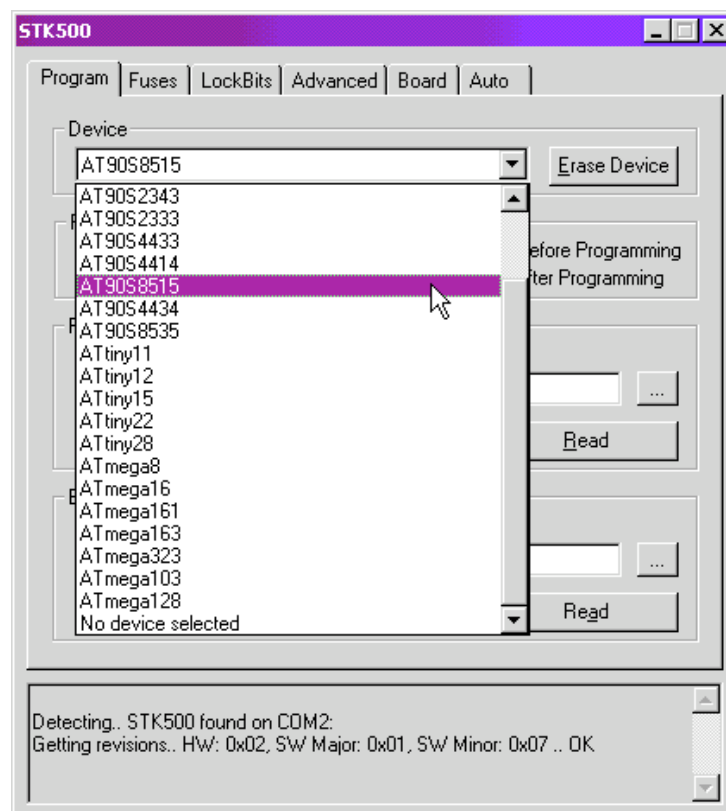
Back in AVR Studio, click on the AVR chip on the toolbar to start the programming software.



Programmer icon

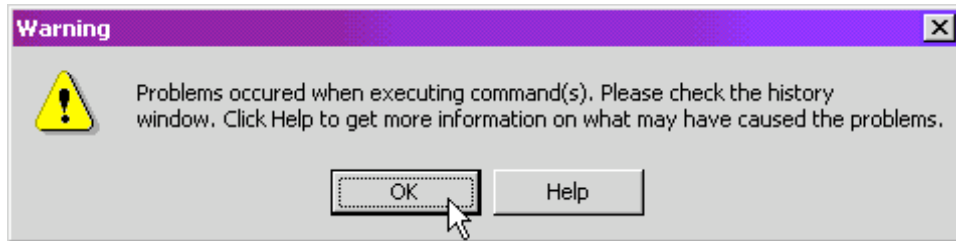
The STK500 dialog box appears. In the text area at the bottom you should see a message indicating that your STK500 has been detected, and showing what revisions of hardware and software are present. If not, ensure that the power to the STK500 is on, and that the serial cable is connected to the correct port both on the STK500 and the computer, and then close the dialog and try again.

Assuming the STK500 is detected, the first thing we need to do here is to tell the programming software what device it is going to be programming. Select AT90S8515 from the Device drop-down.



Choose your device

Before programming, it is a good idea to erase any program already in the device. Click the Erase Device button. If everything is OK, then the text area at the bottom of the dialog should indicate that everything is OK. If not, dismiss any error dialogs and double-check your wiring again.

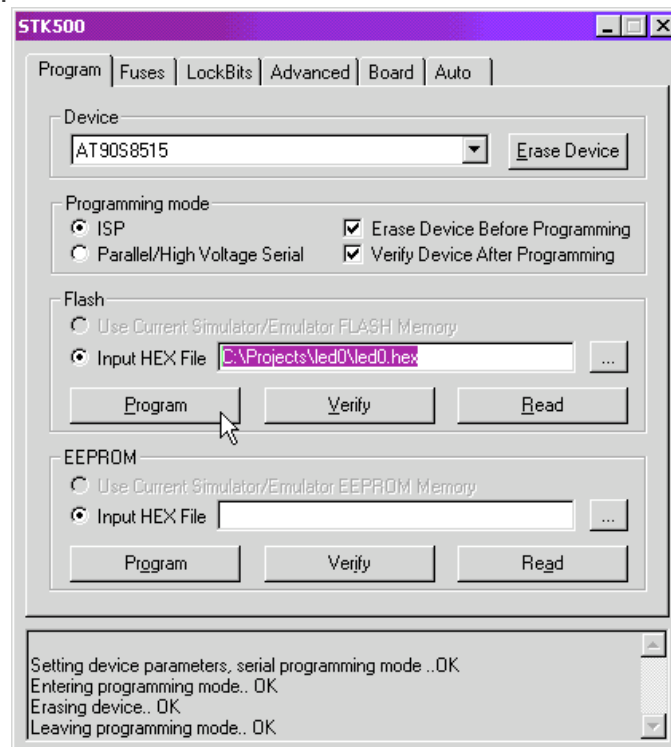


Communications problem? Double-check wiring.

To program the device, we must tell the software which file to send to it. To find the file, click the "..." browse button in the "Flash" area, to the right of the "Input Hex File" space. (The program is stored on the chip in so-called flash memory.)

A file dialog appears which should be in the project folder, showing the file led0.hex. Select this file and click Open to open it.

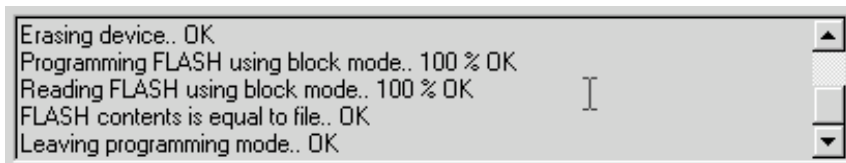
Now, the moment of truth. Still in the Flash area of the dialog box, click the Program button.



Program the device

You may notice some activity on the leftmost LEDs while the AVR is being programmed - this is normal and is due to the signals for programming being carried on pins PB5, PB6 and PB7, which we have connected to the LEDs. Once this settles down, and the programming is finished, the actual program will start and light the rightmost LED. You can now close the programming dialog.

The text area at the bottom of the programming dialog should also indicate that everything worked correctly.



Programming succeeded

Running the Program

If LED0 is lit, then the program was downloaded and run successfully.



The light of achievement

Further Qualification

The two lines containing the constant value 0 can be changed, to use any value from 0 to 7 (although both lines must use the same value). For each value from 0 to 7, the corresponding LED will then be lit. For example, the following will light LED4 instead of LED0:

```
.include "8515def.inc"
.org 0

sbi DDRB, 4
cbi PORTB, 4
```

```
halt: rjmp halt
```

Try editing the program to light different LEDs, to get familiar with the sequence of events. (To re-open a file which has been closed, double-click on it in the project view.) A reminder: after editing the program, you will need to save it, re-assemble it, and download it to the board again.

Recap

You should now know how to use the AVR Studio software to create simple AVR projects, edit assembly language, assemble programs, and download them to the STK500.

Useful resources for next steps include:

- The [AT90S8515 data sheet](http://www.atmel.com/atmel/acrobat/doc0841.pdf) (<http://www.atmel.com/atmel/acrobat/doc0841.pdf>), which is a comprehensive reference to the architecture of the 8515.
- The [AVR Instruction Set Reference](http://www.avrfreaks.net/Tools/showtools.php?ToolID=127) (<http://www.avrfreaks.net/Tools/showtools.php?ToolID=127>), which as it suggests is the definitive reference for assembly language.