

AVR[®] STK500

User Guide



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Section 1

Introduction

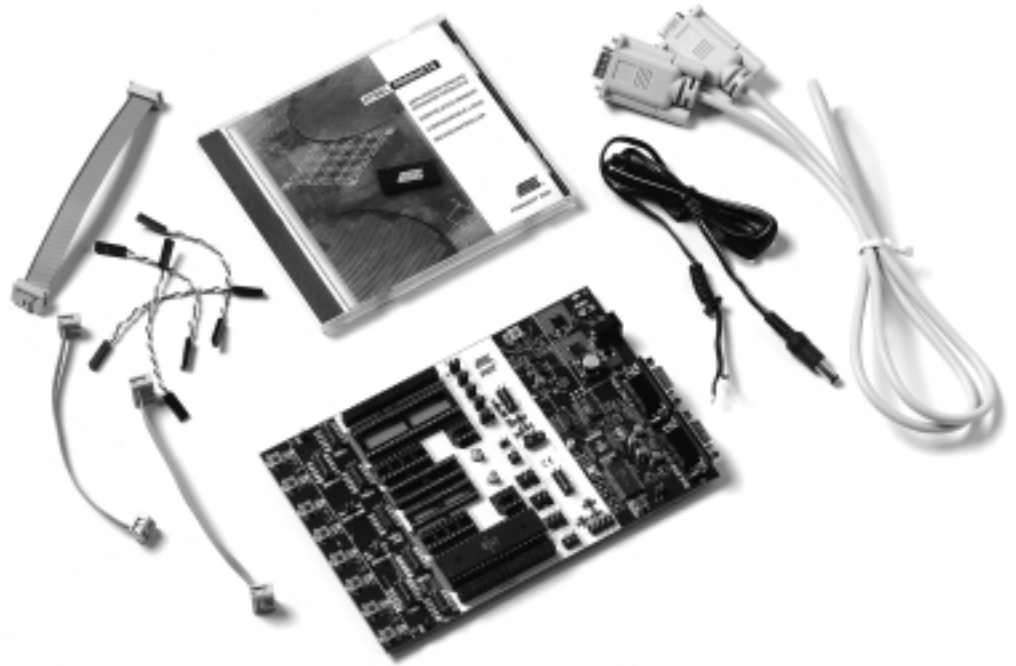
Congratulations on your purchase of the STK500 AVR[®] Flash MCU Starter Kit. The STK500 is a complete starter kit and development system for the AVR Flash microcontroller from Atmel Corporation. It is designed to give designers a quick start to develop code on the AVR and for prototyping and testing of new designs.

1.1 Starter Kit Features

- AVR Studio[®] Compatible
- RS232 Interface to PC for Programming and Control
- Regulated Power Supply for 10 - 15V DC Power
- Sockets for 8-pin, 20-pin, 28-pin and 40-pin AVR Devices
- Parallel and Serial High-voltage Programming of AVR Parts
- Serial In-System Programming (ISP) of AVR Parts
- In-System Programmer for Programming AVR Parts in External Target System
- Reprogramming of AVR Parts
- 8 Push Buttons for General Use
- 8 LEDs for General Use
- All AVR I/O Ports Easily Accessible through Pin Header Connectors
- Additional RS232 Port for General Use
- Expansion Connectors for Plug-in Modules and Prototyping Area
- On-board 2-Mbit DataFlash[®] for Nonvolatile Data Storage

The STK500 is supported by AVR Studio, version 3.2 or newer. For up-to-date information on this and other AVR tool products, please read the document “avrtools.pdf”. The newest version of AVR Studio, “avrtools.pdf”, and this user guide can be found in the AVR section of the Atmel Web site.

Figure 1-1. STK500



1.2 Device Support

The system software currently has support for the following devices in all speed grades:

- AT90S1200
- AT90S2313
- AT90S2323
- AT90S2333
- AT90S2343
- AT90S4414
- AT90S4433
- AT90S4434
- AT90S8515
- AT90S8535
- ATmega161
- ATmega163
- ATtiny11
- ATtiny12
- ATtiny15
- ATtiny28

Support for new AVR devices may be added in new versions of AVR Studio. The latest version of AVR Studio is always available from www.atmel.com.



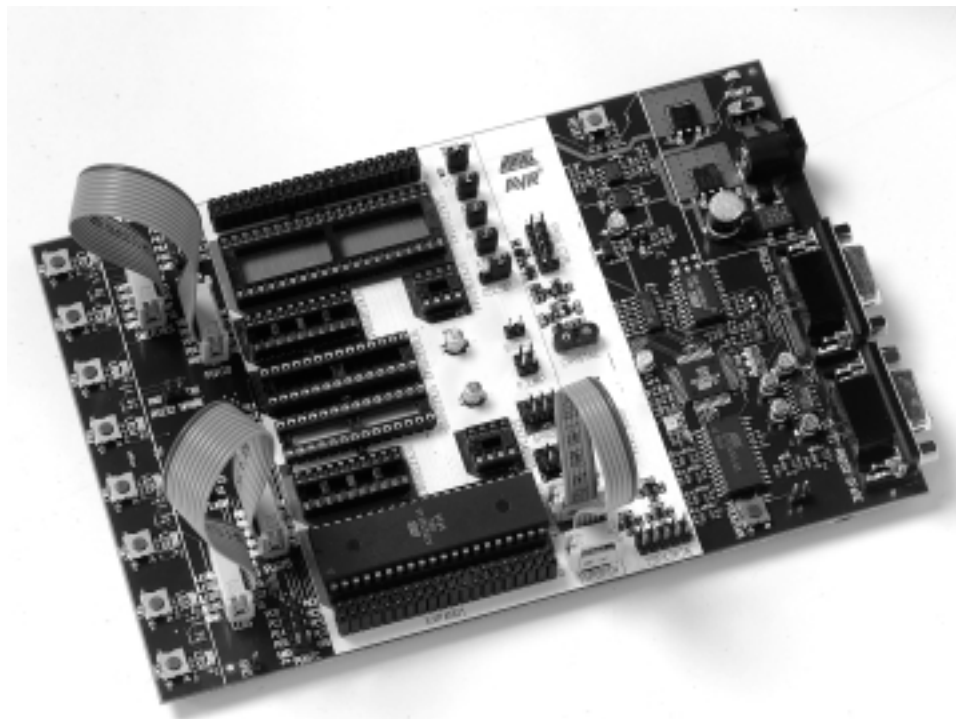
Section 2

Getting Started

-
- 2.1 Unpacking the System**
- Kit contents:
- STK500 starter kit evaluation board
 - Cables for STK500:
 - (2 pcs) 10-wire cables for I/O ports and parallel mode programming
 - (1 pc) 6-wire cable for in-system programming
 - (4 pcs) 2-wire cable for UART and DataFlash connections
 - 9-pin RS-232 cable
 - DC power cable
 - Atmel CD-ROM with datasheets and software
 - AT90S8515-8PC sample microcontroller
-
- 2.2 System Requirements**
- The minimum hardware and software requirements are:
- 486 processor (Pentium® is recommended)
 - 16 MB RAM
 - 7 MB free hard disk space
 - Windows® 95, Windows 98, Windows NT® 4.0 or higher, or Windows 2000
 - 115200 baud RS-232 port (COM port)
 - 10 - 15V DC power supply, 500 mA min.
-
- 2.3 Quick Start**
- The STK500 starter kit is shipped with an AT90S8515-8PC microcontroller in the socket marked SCKT3000D3. The default jumper settings will allow the microcontroller to execute from the clock source and voltage regulator on the STK500 board.
- The microcontroller is programmed with a test program that toggles the LEDs. To test the program, make sure the microcontroller is properly inserted and that the notch on the microcontroller matches the notch on the socket.
- Use the supplied 10-pin cables to connect the header marked "PORTB" with the header marked "LEDS", and connect the header marked "PORTD" with the header marked "SWITCHES". The connections are shown in Figure 2-1.
- An external 10 - 15V DC power supply is required. The input circuit is a full bridge rectifier, and the polarity of the input voltage can be selected either positive or negative center connector. Connect the power cable between a power supply and the STK500. Apply 10 - 15V DC to the power connector. The power switch turns the STK500 main

power on and off. The red LED is lit when power is on, and the status LEDs will go from red, via yellow, to green. The green LED indicates that the target V_{CC} is present. The program now running in the AT90S8515 will respond to pressed switches by toggling the LEDs.

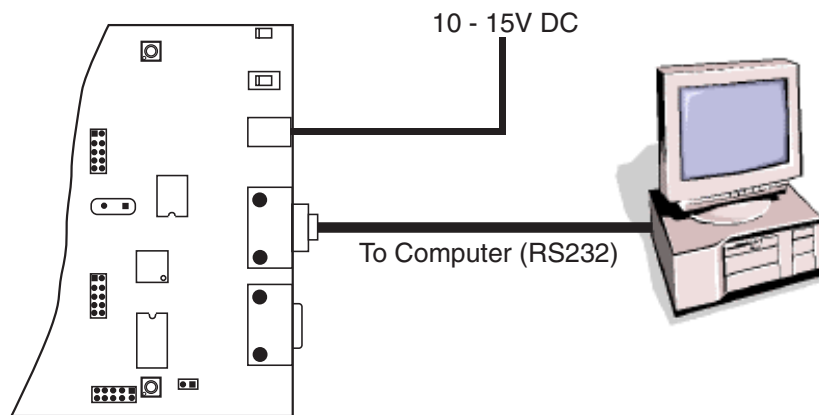
Figure 2-1. Default Setup of STK500



The starter kit can be configured for various clock and power sources. A complete description of the jumper settings is explained in paragraph 3.8 on page 3-13 and on the reverse side of the starter kit.

2.3.1 Connecting the Hardware

Figure 2-2. Connection to STK500



To program the AT90S8515, connect the supplied 6-wire cable between the ISP6PIN header and the SPROG3 target ISP header as shown in Figure 2-1. Paragraph 3.7.1 on page 3-8 describes the programming cable connections.

Connect a serial cable to the connector marked "RS232 CTRL" on the evaluation board to a COM port on the PC as shown in Figure 2-2. Install AVR Studio software on the PC.

Instructions on how to install and use AVR Studio are given in Section 5 on page 5-1. When AVR Studio is started, the program will automatically detect to which COM port the STK500 is connected.

2.3.2 Programming the Target AVR Device

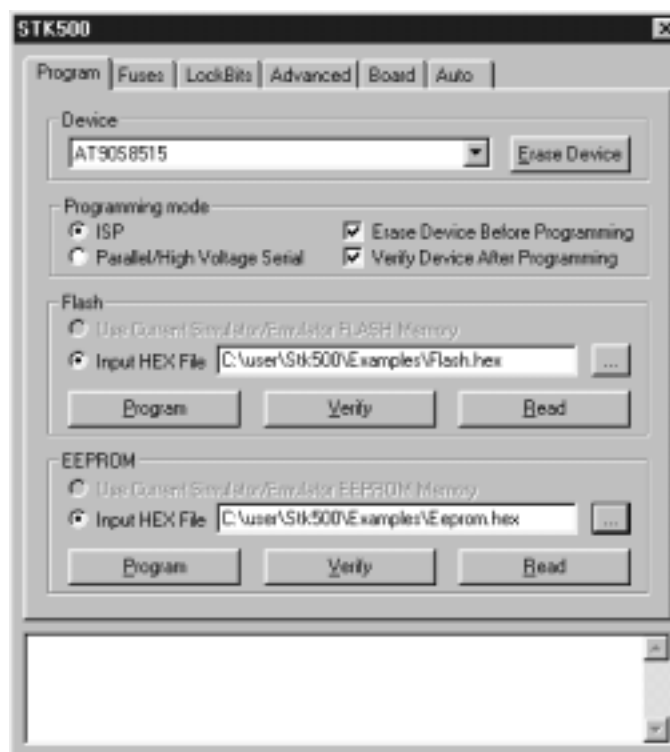
The STK500 is controlled from AVR Studio, version 3.2 and higher. AVR Studio is an integrated development environment (IDE) for developing and debugging AVR applications. AVR Studio provides a project management tool, source file editor, simulator, in-circuit emulator interface and programming interface for STK500.

To program a hex file into the target AVR device, select “STK500” from the “Tools” menu in AVR Studio.

Select the AVR target device from the pull-down menu on the “Program” tab and navigate to the “example” directory located in the AVR Studio installation directory. Select the “example1.hex” file.

Click the “erase” button, followed by the “program” button. The status LED will now turn yellow while the part is programmed, and when programming succeeds, the LED will turn green. If programming fails, the LED will turn red after programming. See the troubleshooting guide in Section 7 on page 7-1.

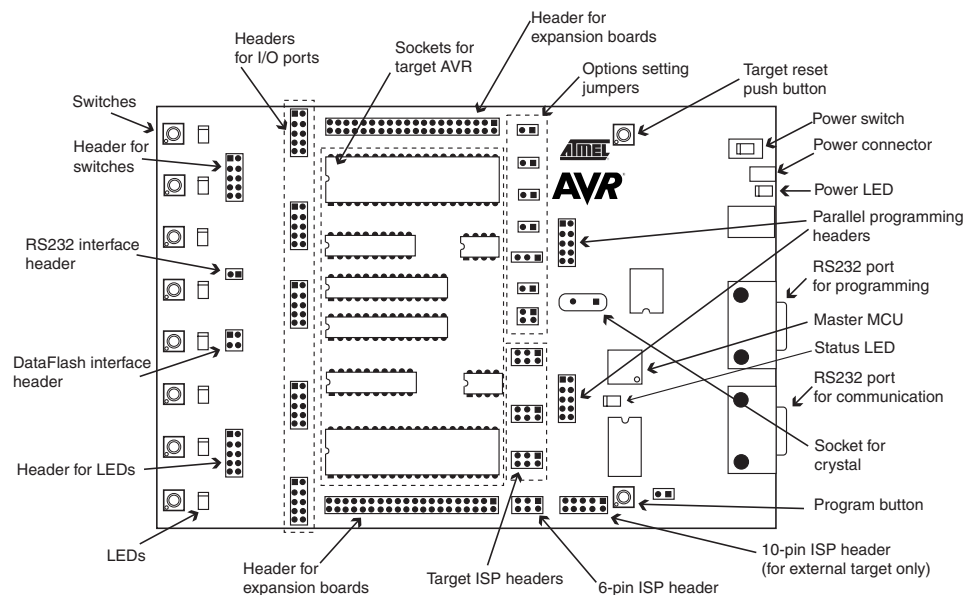
Figure 2-3. AVR Studio STK500 Programming Menu



Complete descriptions of using the STK500 interface in AVR Studio are given in Section 5 on page 5-1.

Hardware Description

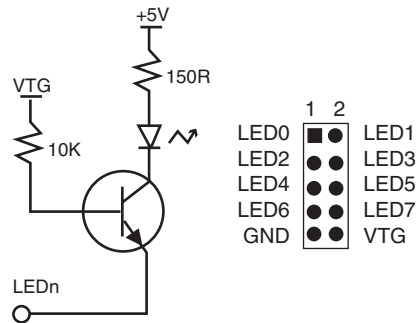
Figure 3-1. STK500 Components



3.1 Description of User LEDs

The STK500 starter kit includes 8 yellow LEDs and 8 push-button switches. The LEDs and switches are connected to debug headers that are separated from the rest of the board. They can be connected to the AVR devices with the supplied 10-wire cable to the pin header of the AVR I/O ports. Figure 3-4 shows how the LEDs and switches can be connected to the I/O port headers. The cables should be connected directly from the port header to the LED or switch header. The cable should not be twisted. A red wire on the cable indicates pin 1. Confirm that this is connected to pin 1 on each of the headers. Figure 3-2 shows how the LED control is implemented. This solution will give the same amount of light from the LED for all target voltages from 1.8V to 6.0V.

Figure 3-2. Implementation of LEDs and LED Headers

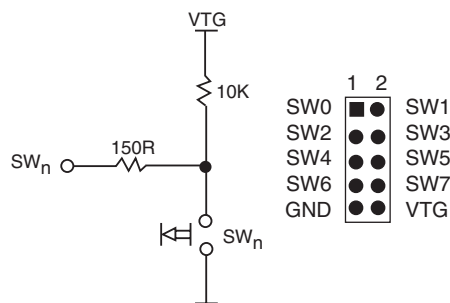


Note: The AVR can source or sink enough current to drive an LED directly. In the STK500 design, a transistor with two resistors is used to give the same amount of light from the LED, whatever the target voltage (VTG) may be, and to turn off the LEDs when VTG is missing.

3.2 Description of User Switches

The switches connected to the debug headers are implemented as shown in Figure 3-3. Pushing a switch causes the corresponding SWx to be pulled low, while releasing it will result in VTG on the appropriate switch header connector. Valid target voltage range is $1.8V < VTG < 6.0V$.

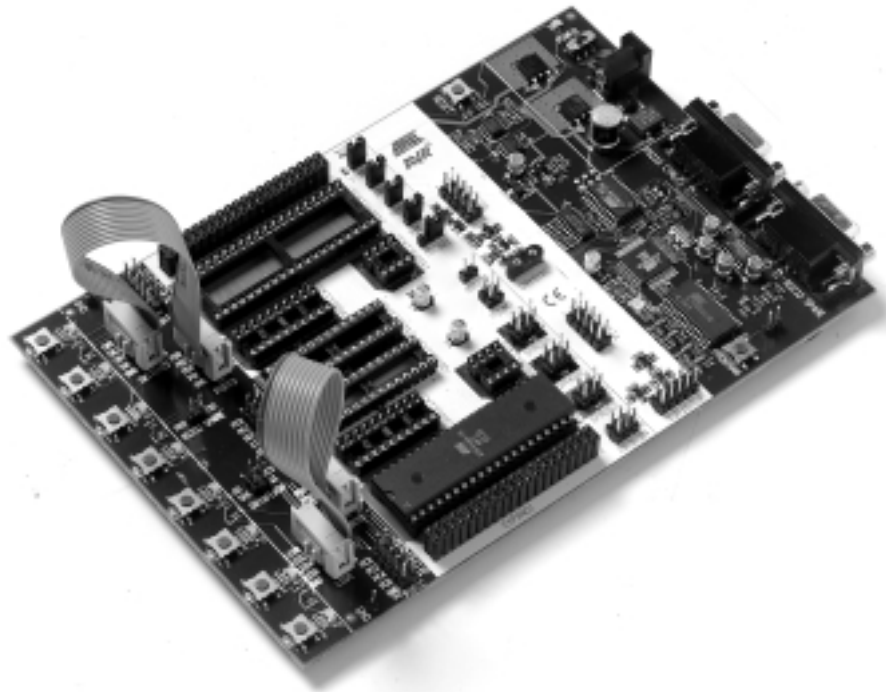
Figure 3-3. Implementation of Switches and Switch Headers



Note: In the AVR you can enable internal pull-ups on the input pins, removing the need for an external pull-up on the push button. In the STK500 design we have added an external 10K pull-up to give all users a logical “1” on SWn when the push button is not pressed. The 560R resistor limits the current going into the AVR.

3.3 Connection of LEDs and Switches

Figure 3-4. Connection of LEDs and Switches to I/O Port Headers

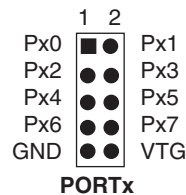


Any I/O port of the AVR can be connected to the LEDs and switches using the 10-wire cables. The headers are supplied with VTG (target V_{CC}) and GND lines in addition to the signal lines.

3.4 Port Connectors

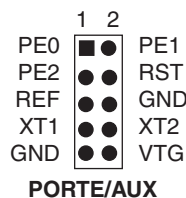
The pinout for the I/O port headers is explained in Figure 3-5. The square marking indicates pin 1.

Figure 3-5. General Pinout of I/O Port Headers



The PORTE/AUX header has some special signals and functions in addition to the PORTE pins. The pinout of this header shown in Figure 3-6.

Figure 3-6. Pinout of Port E Header



The special functions of this port are:

■ **PE0 - PE2:**

Table 3-1. Port E Connection

	ATmega161	AT90S4414/AT90S8515
PE0	PE0/ICP/INT2	ICP
PE1	PE1/ALE	ALE
PE2	PE2/OC1B	OC1B

- **REF:** Analog reference voltage. This pin is connected to the AREF pin on devices having a separate analog reference pin.
- **XT1:** XTAL 1 pin. The internal main clock signal to all sockets. If the XTAL1 jumper is disconnected, this pin can be used as external clock signal.
- **XT2:** XTAL 2 pin. If the XTAL1 jumper is disconnected, this pin can be used for external crystal with the XT1 pin.

The headers for the LEDs and switches use the same pinout as the I/O port headers. The pinout of the switch header is explained in Figure 3-7 and the pinout for the LED header is explained in Figure 3-8. The square marking indicates pin 1.

Figure 3-7. Pinout of the Switch Header

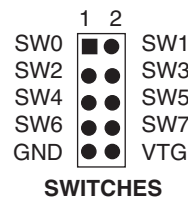
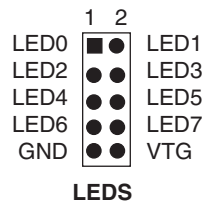


Figure 3-8. Pinout of the LED Header



3.5 Description of User RS232 Interface

The STK500 includes two RS232 ports. One RS232 port is used for communication with AVR Studio. The other RS232 can be used for communication between the target AVR microcontroller in the socket and a PC serial port connected to the RS232. To use the RS232, the UART pins of the AVR need to be physically connected to the RS232.

The 2-pin header marked “RS232 SPARE” can be used for connecting the RS232 converter to the UART pins on the target AVR microcontroller in the socket. Use the 2-wire cable to connect the UART pins to the RS232. The connection is shown in Figure 3-9. The block schematic of the RS232 connection is shown in Figure 3-10.

Figure 3-9. Connection of I/O Pins to UART

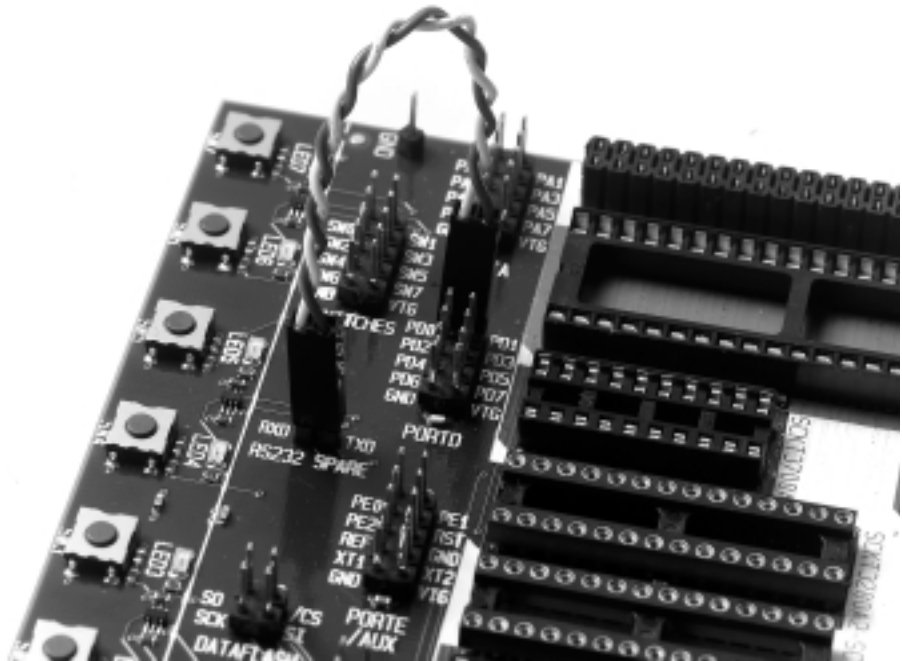
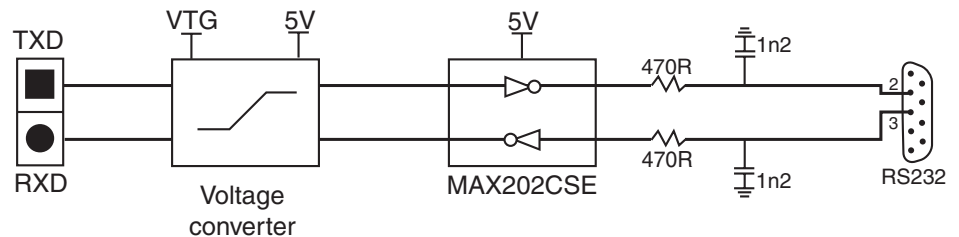


Figure 3-10. Schematic of UART Pin Connections



3.6 Description of DataFlash Pins

An AT45D021 2-Mbit DataFlash is included on the STK500 for nonvolatile data storage. A DataFlash is a high-density Flash memory with SPI serial interface. A detailed datasheet of the DataFlash can be obtained from the Flash memory section of the Atmel CD-ROM or from the Atmel Web site.

The DataFlash can be connected to the I/O pins of the microcontroller sockets. The 4-pin header marked “DATAFLASH” can be used for connecting the SPI interface of the DataFlash to the I/O pins on the target AVR microcontroller in the socket. 2-wire cables are included with STK500 for connecting the DataFlash to the I/O pins. The supplied 10-wire cables can also be used if the DataFlash is connected to the hardware SPI interface on PORTB of the AVR microcontroller. The connection of the I/O pins is shown in Figure 3-13. The block schematic of the DataFlash connection is shown in Figure 3-14, for connection of the DataFlash to the AVR hardware SPI interface. The SPI interface pinout is shown in Figure 3-11 and Figure 3-12.

Figure 3-11. PORTB SPI Pinout (40-pin Parts)

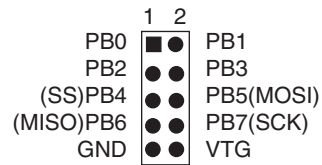


Figure 3-12. PORTB SPI Pinout (28-pin Analog Parts)

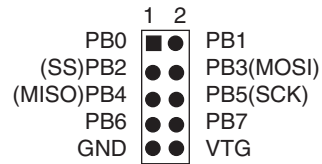


Figure 3-13. Connection of I/O Pins to DataFlash for AT90S8515

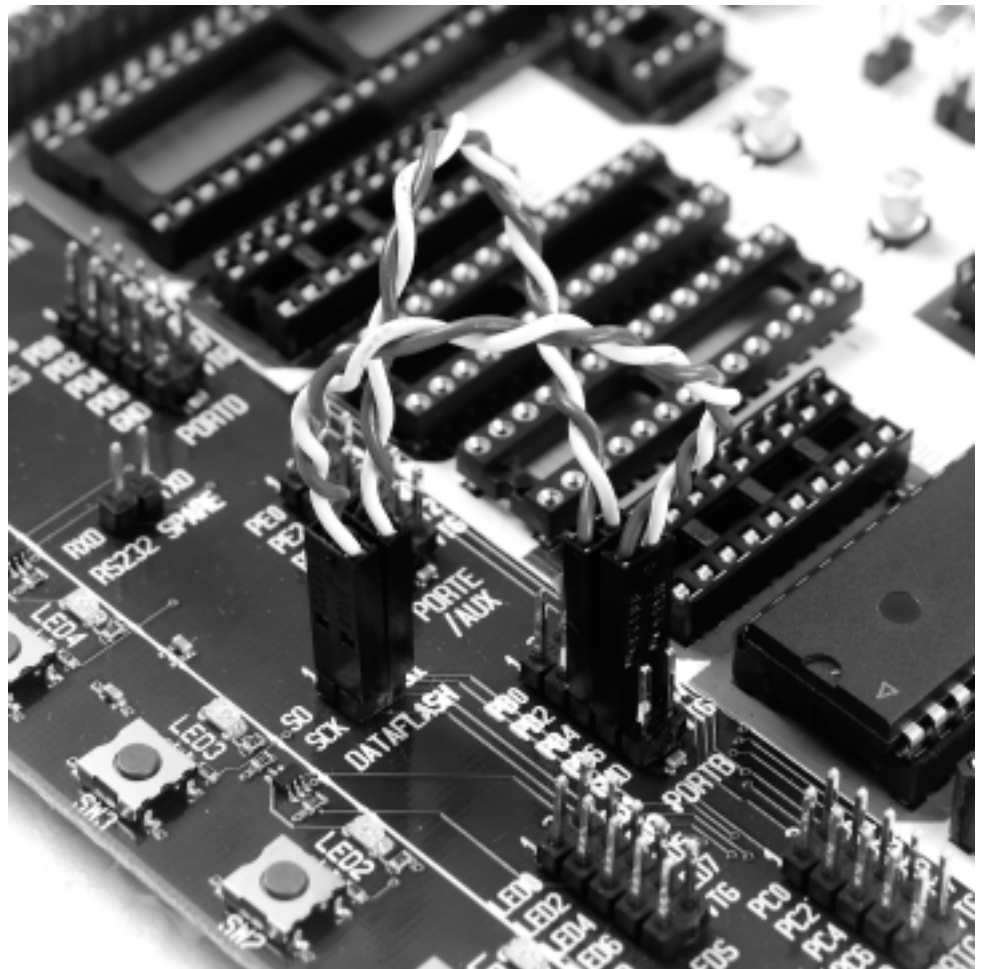
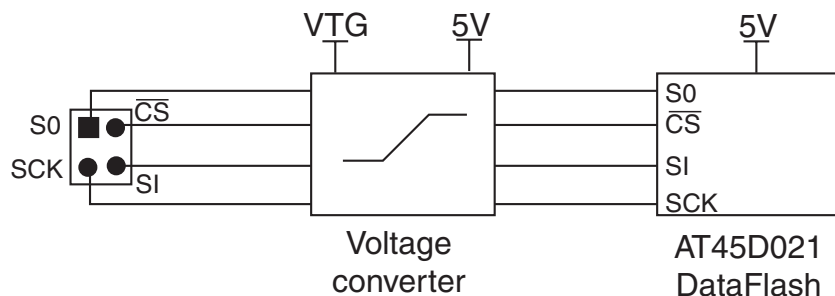


Figure 3-14. Schematic of DataFlash Connections



3.7 Target Socket Section

The programming module consists of the eight sockets in the white area in the middle of the starter kit. In these sockets the target AVR devices can be inserted for programming and used in the application.

Note: Only one AVR device should be inserted in the sockets at a time.

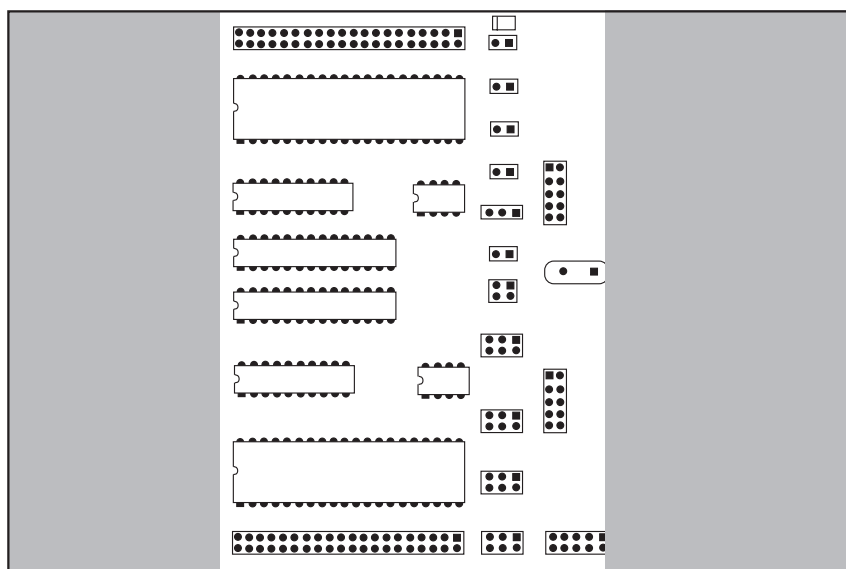
The AVR Flash memory is guaranteed to be correct after 1,000 programming operations; the typical lifetime of the Flash memory is much longer.

Note: When inserting a device in the socket, notice the orientation of the device.

The notch on the short side of the part must match the notch on the socket. If the device is inserted the wrong way, it may damage the part and the starter kit.

The socket section is used for both running applications and target device programming.

Figure 3-15. The STK500 Programming Module



The part inserted in the socket can be programmed in the system from AVR Studio with two different methods:

1. AVR In-System Programming (ISP) running at the parts normal supply voltage.
2. High-voltage programming, where the supply voltage is always 5 volts.

Four general nets (VTARGET, RESET, XTAL1 and AREF) can be connected to the socket section.

The following sections describe how to use both programming methods. For instructions on using the AVR Studio programming software, see Section 5, "Using AVR Studio" on page 5-1.

3.7.1 ISP Programming

In-system programming uses the AVR internal SPI (serial peripheral interface) to download code into the Flash and EEPROM memory of the AVR. ISP programming requires only V_{CC} , GND, RESET and three signal lines for programming. All AVR devices except AT90C8534, ATtiny10, ATtiny11 and ATtiny28 can be ISP programmed. The AVR can be programmed at the normal operating voltage, normally 2.7V - 6.0V. No high-voltage signals are required. The ISP programmer can program both the internal Flash and EEPROM. It also programs fuse bits for selecting clock options, start-up time and internal brown-out detector (BOD) for most devices.

High-voltage programming can also program devices that are not supported by ISP programming. Some devices require high-voltage programming for programming certain fuse bits. See the high-voltage programming section on page 3-10 for instructions on how to use high-voltage programming.

Because the programming interface is placed on different pins from part to part, three programming headers are used to route the programming signals to the correct pins. A 6-wire cable is supplied for connecting the ISP signals to the target ISP header. A color coding system and a number system are used to explain which target ISP header is used for each socket.

During ISP programming, the 6-wire cable must always be connected to the header marked "ISP6PIN". When programming parts in the blue sockets, connect the other end of the cable to the blue SPROG1 target ISP header. When programming parts in the green socket, use the green SPROG2 target ISP header. And when programming parts in the red sockets, use the red SPROG3 target ISP header. Table 3-2 shows which socket suits which AVR device, and which SPROG target ISP header to use for ISP programming.

The 6-wire cables should be connected directly from the ISP6PIN header to the correct SPROG target ISP header. The cable should not be twisted. A colored wire on the cable indicates pin 1. Confirm that this is connected to pin 1 on each of the headers.

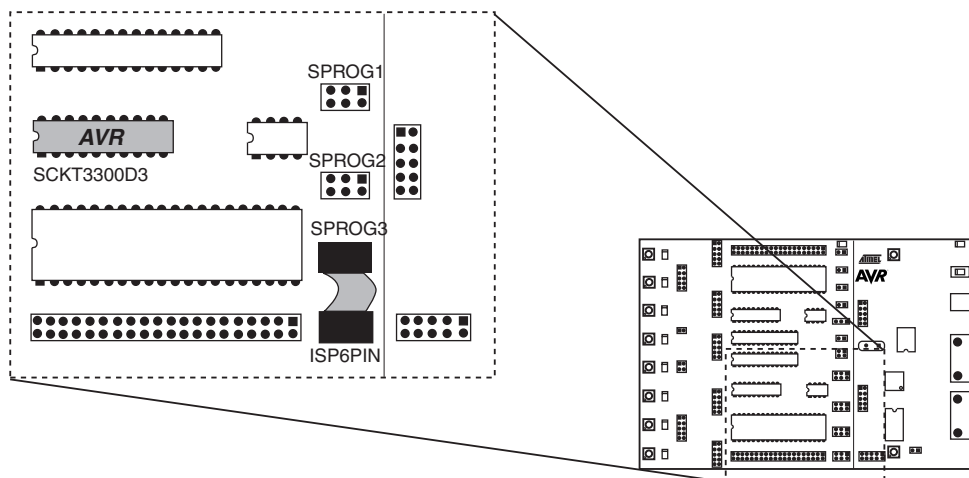
When programming 8-pin devices, note the following: Pin 1 is used both as RESET and as PB5 on some devices (ATtiny11, ATtiny12 and ATtiny15). Pin 1 on the 8-pin sockets SCKT3400D1 and SCKT3400D1 are connected to PB5. The RESET signal used during ISP programming is therefore not connected to pin 1 on these sockets. This signal must be connected by placing a wire between RST and the PORTE header and PB5 on the PORTB header.

Table 3-2. AVR Sockets

AVR Devices	STK500 Socket	Color	Number	Target ISP Header
AT90S1200 AT90S2313	SCKT3300D3	Red	3	SPROG3
AT90S2323 AT90S2343 ATtiny12	SCKT3400D1	Blue	1	SPROG1. Connect RST on PORTE to PB5 on PORTB.
ATtiny11	SCKT3400D1	Blue	1	High-voltage programming only
ATtiny28	SCKT3500D-	None	–	High-voltage programming only
AT90S4414 AT90S8515 ATmega161	SCKT3000D3	Red	3	SPROG3
AT90S4434 AT90S8535 ATmega163	SCKT3100A3	Red	3	SPROG3
AT90S2333 AT90S4433	SCKT3200A2	Green	2	SPROG2
ATtiny15	SCKT3600A1	Blue	1	SPROG1. Connect RST on PORTE to PB5 on PORTB.
N/A	SCKT3700A1	Blue	1	Socket is not in use in this version of STK500

Figure 3-16 shows an example of how AT90S2313 can be in-system programmed. The 6-wire cable is connected from the ISP6PIN header to the red SPROG3 target ISP header, and the AT90S2313 part is inserted in the red socket marked “SCKT3100D3”.

Figure 3-16. Example Connection for Programming AT90S2313



It is not necessary to remove the 6-wire cable from its ISP position while running a program in the AVR. The port pins used for ISP programming can be used for other purposes in your program.

Hardware Description

3.7.2 High-voltage Programming

For high-voltage programming, a 12V programming voltage is applied to the RESET pin of the AVR device. All AVR devices can be programmed with high-voltage programming, and the target device can be programmed while it is mounted in its socket.

Two different methods are used for high-voltage programming: 8-pin parts use a serial programming interface, while other parts use a parallel programming interface. The programming signals are routed to the correct pins of the target device using the cables supplied with STK500.

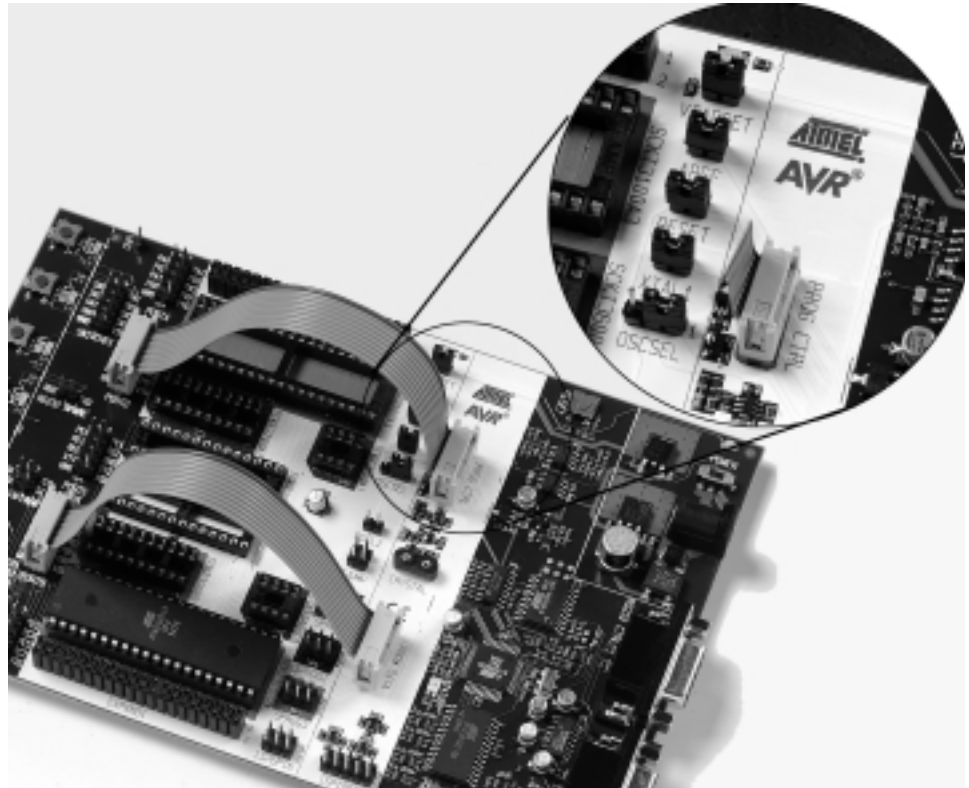
Table 3-3 summarizes the programming method and special considerations when using high-voltage programming.

Table 3-3. High-voltage Programming Settings

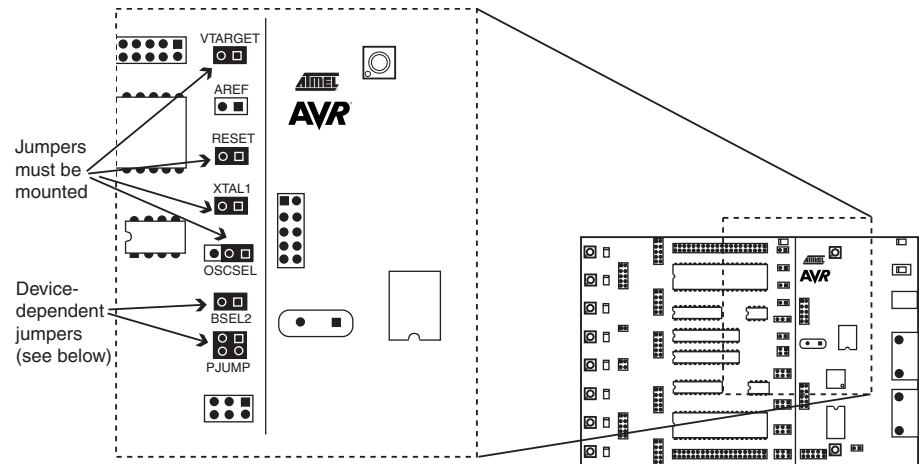
AVR Devices	STK500 Socket	Color	Number	High-voltage Programming Method
AT90S1200 AT90S2313	SCKT3300D3	Red	3	Parallel high-voltage programming. Connect PROG CTRL header to PORTD and PROG DATA to PORTB, as shown in Figure 3-17 on page 3-11.
AT90S4414 AT90S8515	SCKT3000D3	Red	3	
AT90S4434 AT90S8535	SCKT3100A3	Red	3	
ATtiny28	SCKT3500D-	None	–	
ATmega161	SCKT3000D3	Red	3	Parallel programming as above; mount BSEL jumpers
ATmega163	SCKT3100A3	Red	3	
AT90S2333 AT90S4433	SCKT3200A2	Green	2	Parallel programming as above; mount PJUMP jumper
AT90S2323 AT90S2343 ATtiny11 ATtiny12	SCKT3400D1	Blue	1	Serial high-voltage programming
ATtiny15	SCKT3600A1	Blue	1	
N/A	SCKT3700A1	Blue	1	Socket not in use in this version of STK500

3.7.2.1 Parallel High-voltage Programming

To use high-voltage programming, the programming signal must be routed to the AVR I/O pins. The two 10-wire cables supplied with the STK500 can be used to connect the PROG DATA header to the PORTB header and the PROG CTRL header to the PORTD header, as shown in Figure 3-17.

Figure 3-17. Connection for Parallel High-voltage Programming

Some of the jumper settings on STK500 must be changed when using high-voltage programming. Figure 3-18 explains these jumper settings.

Figure 3-18. Jumper Settings for High-voltage Programming

Hardware setup for parallel high-voltage programming:

1. Switch power off.
2. Place the device to program in its socket according to Table 3-3 on page 3-10.
3. Connect the headers PROGDATA and PORTB with the 10-wire cable.
4. Connect the headers PROGCTRL and PORTD with the 10-wire cable.
5. Mount jumper OSCSEL on pins 1 and 2 to select software-controlled clock.

6. Mount jumper XTAL1 to route the oscillator signal to the device.
7. Mount jumpers VTARGET and RESET.
8. When programming AT90S2333 or AT90S4433, mount both PJUMP jumpers. The 2-wire cables can be used instead of jumpers.
9. When programming ATmega163 or ATmega161, mount the BSEL2 jumper. A 2-wire cable can be used instead of jumpers.
10. Disconnect target system.
11. Switch power on.

For a complete description of jumper settings, see paragraph 3.8, “Jumper Settings”.

Note: Remove the hardware setup for high-voltage programming before starting a debug session.

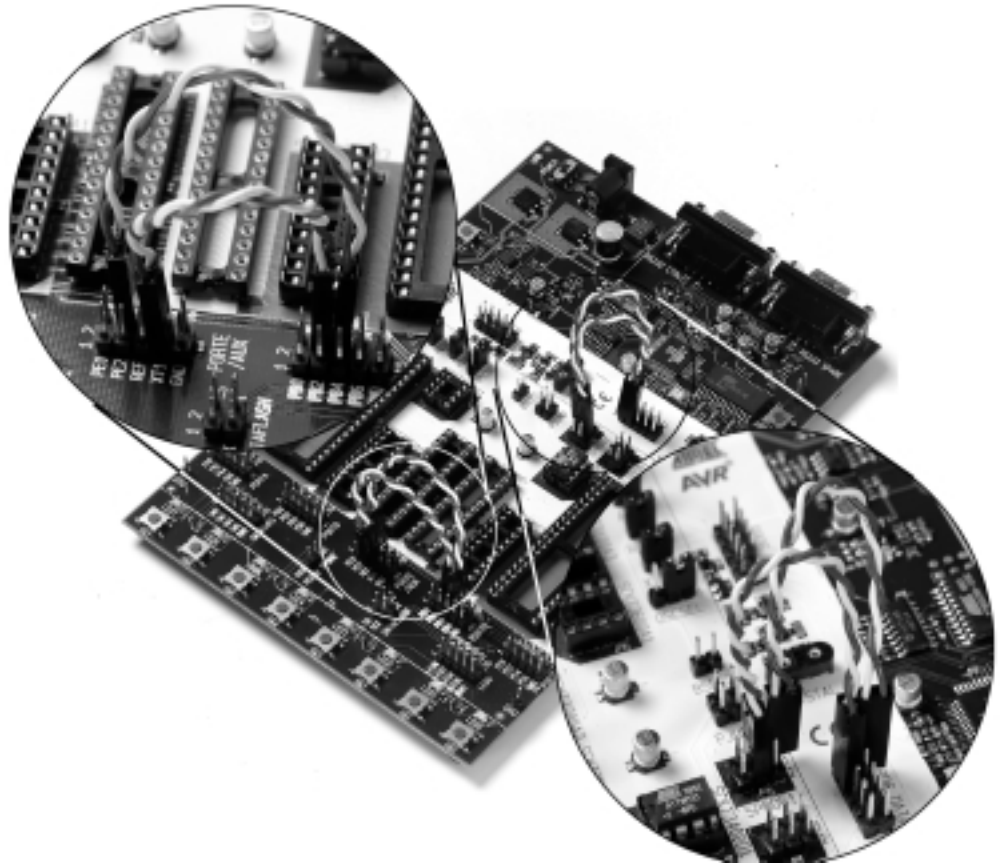
3.7.2.2 Serial High-voltage Programming

The 8-pin AVRs have too few pins to use parallel communication during high-voltage programming. They use serial communication instead.

This means that fewer signals have to be routed. Hardware setup for serial high-voltage programming is as follows:

1. Switch power off.
2. Place the device to program in its socket according to Table 3-3 on page 3-10.
3. Mount jumper OSCSEL on pins 1 and 2 to select software-controlled clock.
4. Mount jumper XTAL1 to route the oscillator signal to the device.
5. Mount jumpers VTARGET and RESET.
6. Use one 2-wire cable to connect the PB3 pin (pin 4) on the PORTB header to the XT1 pin (pin 7) on the PORTE/AUX header. This will connect the clock system to the AVR device.
7. Use another 2-wire cable to connect the PB5 pin (pin 6) on the PORTB header to the RST pin (pin 3) on the PORTE/AUX header. This will connect the reset system to the AVR device.
8. Use a third 2-wire cable to connect the PB0 and PB2 pins (pins 4 and 3) on the SPROG1 header to the DATA0 and DATA2 pins (pins 1 and 3) on the PROG DATA header.
9. Use the last 2-wire cable to connect the PB1 pin (pin 1) on the SPROG1 header to the DATA1 pin (pin 2) on the PROG DATA header.
10. Switch power on and you are ready to program.

All connections are shown in Figure 3-19.

Figure 3-19. Connection for Serial High-voltage Programming

- 3.8 Jumper Settings** A master MCU and eight jumpers control the hardware settings of the starter kit. During normal operation these jumpers should be mounted in the default position. To configure the starter kit for advanced use, the jumpers can be removed or set to new positions. The jumper settings and usage are explained in the following section. The default setting of the jumpers are shown in Figure 3-20.

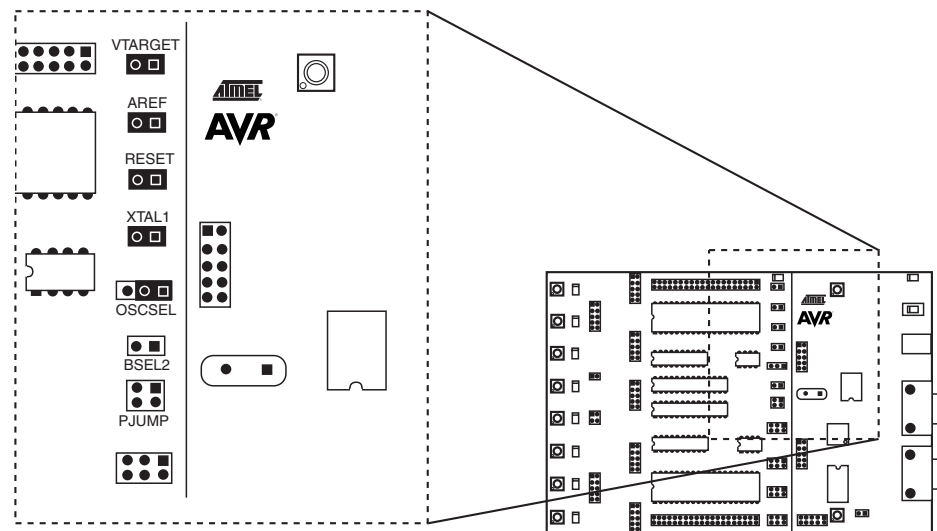
Figure 3-20. Default Jumper Setting

Table 3-4. Description of Jumpers

Jumper	Description of Default Setting
VTARGET	On-board VTARGET supply connected
AREF	On-board Analog Voltage Reference connected
RESET	On-board reset system connected
XTAL1	On-board clock system connected
OSCSEL	On-board oscillator selected
BSEL2	Unmounted. Used for high-voltage programming of ATmega161 and ATmega163
PJUMP	Unmounted. Used for high-voltage programming of AT90S2333 and AT90S4433

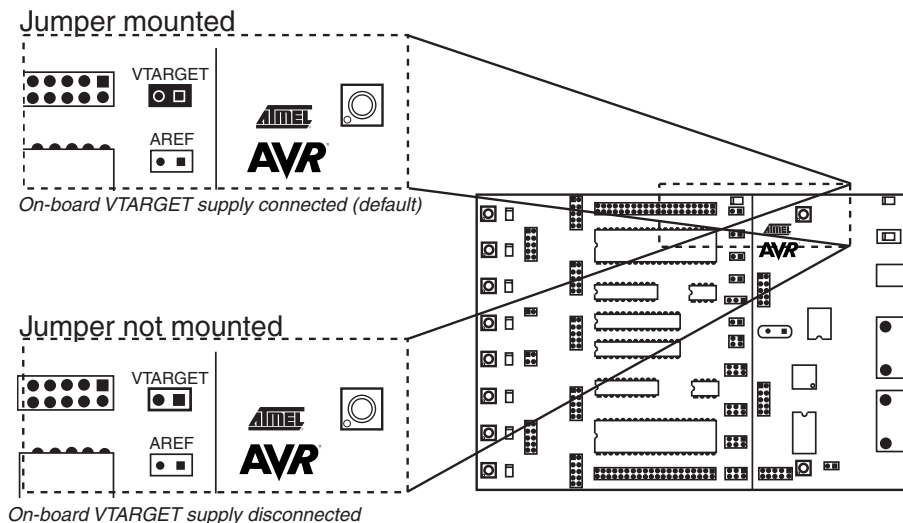
3.8.1 Target V_{CC} Settings, VTARGET

VTARGET controls the supply voltage to the target AVR microcontroller sockets. It can either be controlled from AVR Studio or supplied from an external source. If the VTARGET jumper is mounted, the on-board supply voltage is connected. The on-board supply voltage can be adjusted to 0 - 6V from AVR Studio. Always verify the respective datasheet for the AVR device operating voltage before adjusting VTARGET voltage.

If the VTARGET jumper is disconnected, target V_{CC} must be supplied from an external source at one of the VTG pins on the PORT headers. Figure 3-21 explains VTARGET jumper options.

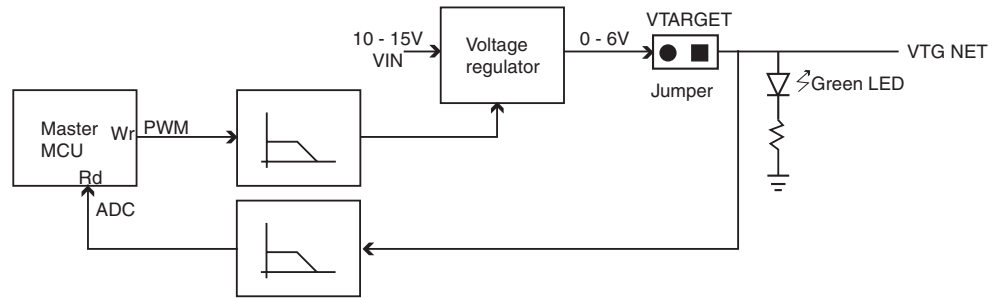
When using an external source for VTARGET, the user must control that VTARGET is at a higher voltage level than AREF (analog reference voltage). Always connect common ground (GND) when using an external VTARGET voltage.

Figure 3-21. VTARGET Jumper Options



The STK500 master MCU controls the target voltage using the internal PWM. Figure 3-22 shows the internal connection of the VTARGET signal.

Figure 3-22. VTARGET Connection



Note: The green LED will light when there is a voltage available on the VTG NET. It's impossible to use the debug or programming area of STK500 without VTG.

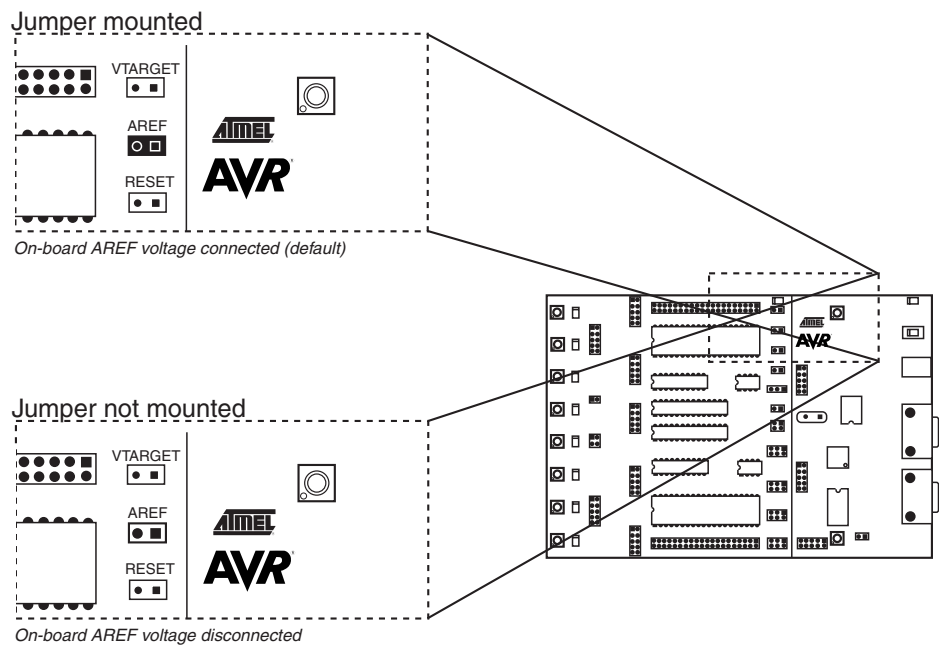
3.8.2 Analog Reference Voltage, AREF

The analog reference voltage (AREF) can supply the reference voltage to the on-chip A/D converter on the AVR. If the AREF jumper is mounted, the on-board analog reference voltage is connected to the AVR's AREF. The on-board analog reference voltage can be adjusted from AVR Studio to 0 - 6.0V, but not above VTARGET.

When the AREF jumper is disconnected, AREF voltage must be supplied from an external source at the AREF pin on the PORTE/AUX header (Figure 3-6). Figure 3-23 explains AREF jumper options.

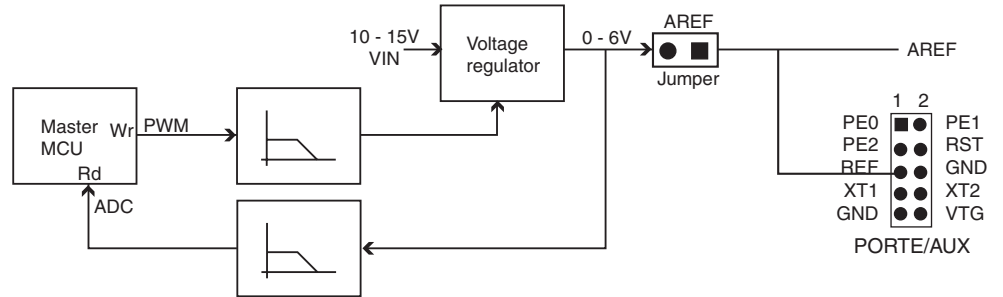
When using an external source for AREF, the user must control VTARGET at a higher voltage level than AREF. This can be controlled easily by reading the VTG value from AVR Studio before setting AREF.

Figure 3-23. AREF Jumper Options



The STK500 master MCU controls the analog reference voltage using the internal PWM. The AVR's AREF signal is also accessible on the PORTE header; this pin can also be used for external AREF signal. Figure 3-24 shows the internal connection of the AREF signal.

Figure 3-24. Internal AREF Connection



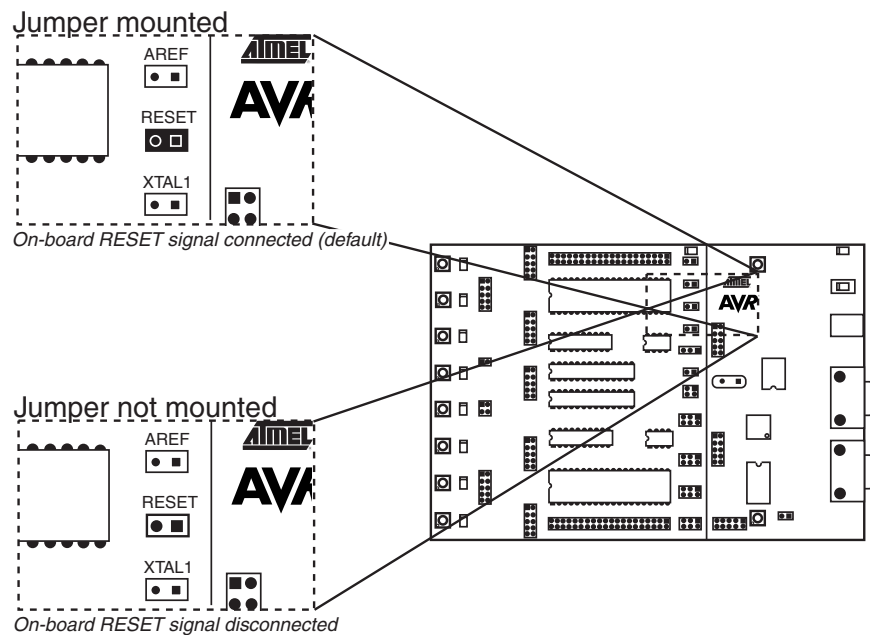
The AVR Studio-controlled analog reference voltage can also be used as an input to the analog comparator or for ADC measurements on the AVR. AVR's AREF signal can then be connected to VTG.

3.8.3 Reset Settings, RESET

The RESET jumper controls the RESET signal to the STK500. When ISP programming the target device in the socket, the master MCU programs the AVR device without interfering with the application. When the RESET jumper is mounted, the master MCU controls the RESET signal of the AVR. When the RESET jumper is not mounted, the RESET signal is disconnected. This is useful for prototype applications with an external reset system.

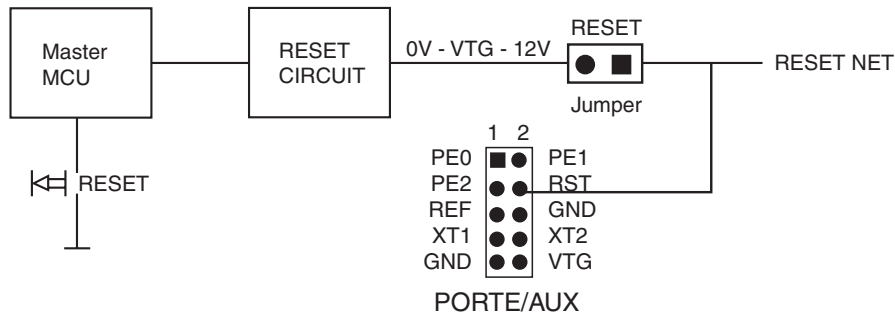
The RESET jumper must always be mounted when high-voltage programming an AVR device. When using an external reset system, it must allow the reset line to be controlled by the master MCU reset system during programming. The RESET button is disconnected if the RESET jumper is not mounted. Figure 3-25 explains the RESET jumper options.

Figure 3-25. RESET Jumper Options



The STK500 master MCU controls the RESET signal to the target AVR. The RESET signal is accessible on the PORTE/AUX header; this pin can also be used for external RESET signal. Figure 3-26 shows the internal connection of the RESET signal.

Figure 3-26. Internal RESET Connection



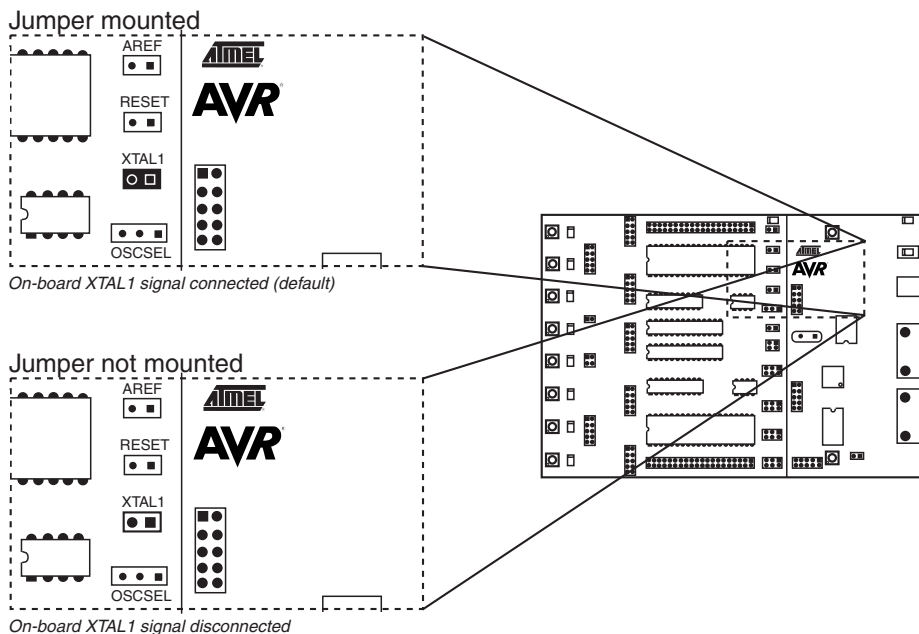
Note: During high-voltage programming, STK500 applies 12V to the AVR's RESET line. Thus, an external reset circuit not capable of handling this must be disconnected before high-voltage programming the AVR.

3.8.4 Clock Settings, XTAL1 and OSCSEL

STK500 includes several clock options for the target AVR. Setting the jumpers XTAL1 and OSCSEL controls the clock selections. OSCSEL determines what signal to route to the XTAL1 pin of the AVR.

When the XTAL1 jumper is connected, the STK500 internal clock system is used as main clock to the target AVR. When XTAL1 jumper is not mounted, the internal clock system is disconnected. This allows external clock signals or crystals to be used as target clock source for the AVR. Figure 3-27 illustrates the XTAL1 jumper option.

Figure 3-27. XTAL1 Jumper Options



When the XTAL1 jumper is not mounted, an external clock source or crystal can be connected to the PORTE header. This is shown in Figure 3-29.

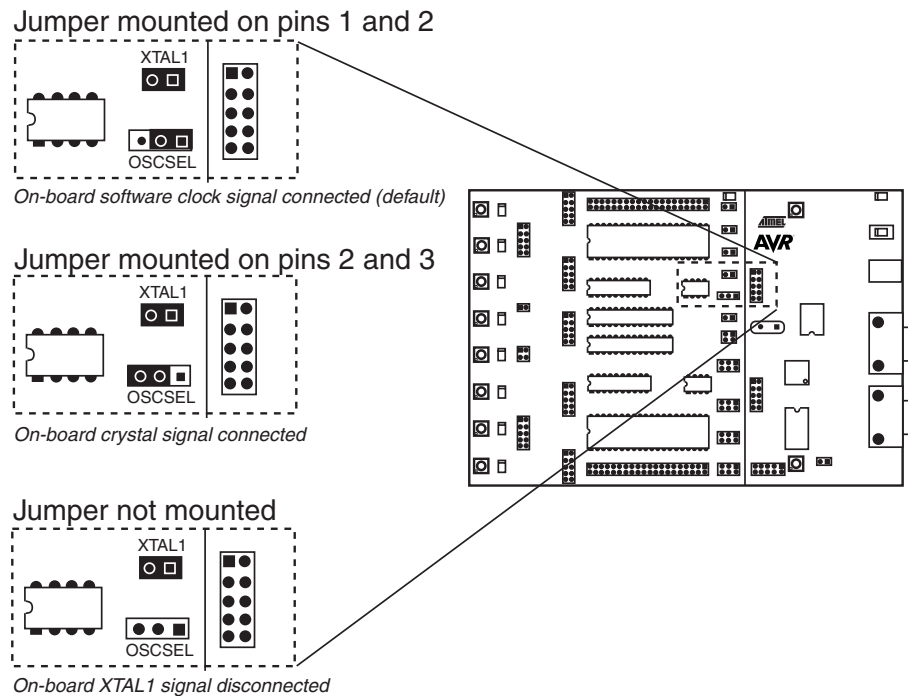
When the XTAL1 jumper is mounted, the STK500 internal clock system is used as main clock to the target AVR. The internal clock system can either use a crystal in the on-board crystal socket or a software-generated clock from the master MCU. The frequency of the software-generated clock can be set from 0 to 3.68 MHz. The default value is 3.68 MHz. Paragraph 5.3.5.3 on page 5-6 explains how to set the clock frequency from AVR Studio.

When using the STK500 software-generated clock system as main clock, the target AVR microcontroller fuses should be configured for “external clock” as clock source. This gives shortest start-up time for the microcontroller. For details of start-up time, see the datasheet for the AVR microcontroller. For an explanation of clock source fuses configuration, see paragraph 5.3.2 on page 5-3. Not all AVR devices have fuses for selection between using a crystal or oscillator as clock source.

The internal clock system is selected with the OSCSEL jumper. Figure 3-28 shows the jumper options for OSCSEL.

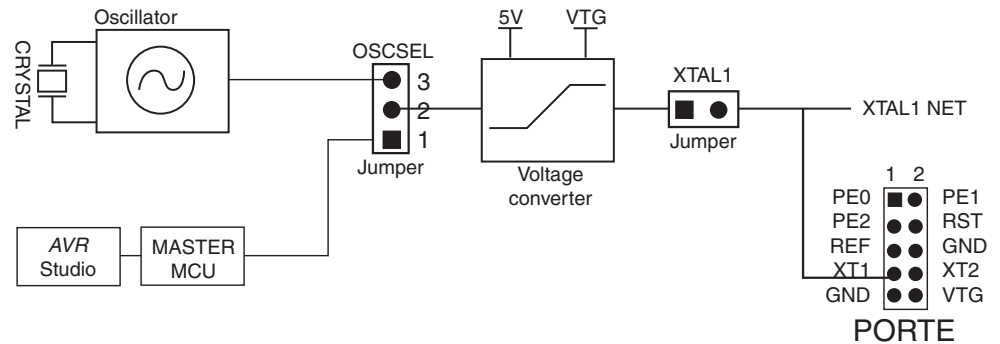
The on-board oscillator will work with ceramic resonators or crystals between 2 - 20 MHz (AT-cut, fundamental and parallel resonant crystals).

Figure 3-28. OSCSEL Jumper Options



When programming AVR in high-voltage programming mode, OSCSEL should be mounted on pins 1 and 2 to give the master MCU control of the target clock. This is explained in detail in paragraph 3.7.2 on page 3-10.

Note: In a real application with only one AVR connected to the crystal, there is no need for an external oscillator circuit. The STK500 has eight different AVR sockets connected to the same clock system. The long signal lines in this system makes it difficult to drive a crystal with the on-chip oscillators on the AVR. The oscillator on STK500 is designed to operate on all target voltages from 1.8 to 6.0V.

Figure 3-29. XTAL1 and OSCSEL Connections

- 3.8.5 BSEL2 Jumper** The BSEL2 jumper connects the Byte Select 2 signal for high-voltage programming of ATmega161 and ATmega163. The BSEL2 jumper should only be mounted when high-voltage programming ATmega161 or ATmega163. For descriptions of the Byte Select 2 signal, see the programming section of the ATmega161 and ATmega163 datasheet.
- 3.8.6 PJUMP Jumpers** The PJUMP jumpers route the programming pin of AT90S2333 and AT90S4433 to the programming lines when using high-voltage programming. The PJUMP jumpers should only be mounted when using high-voltage programming on AT90S2333 or AT90S4433. During debugging, high-voltage programming of other parts and ISP programming, these jumpers should not be mounted.
-
- 3.9 Expansion Connectors** STK500 has two expansion connectors, one on each side of the programming module. All AVR I/O ports, programming signals and control signals are routed to the expansion connectors. The expansion connectors allow easy prototyping of applications with STK500. The pinout of the expansion connectors is shown in Figure 3-31 and Figure 3-32.

Figure 3-30. Expansion Headers

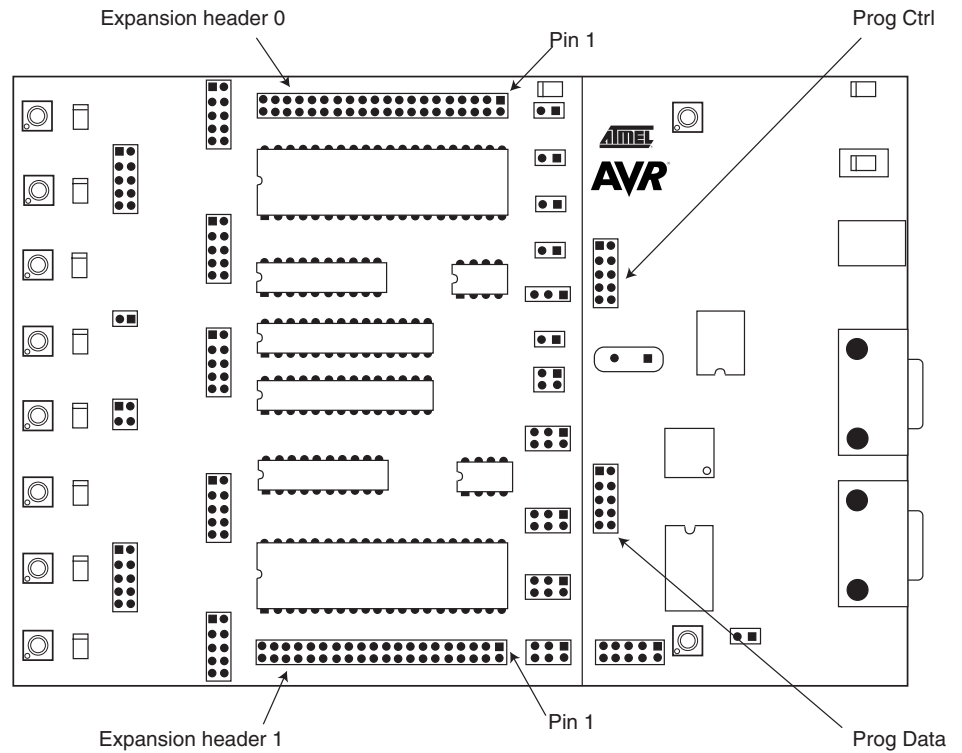
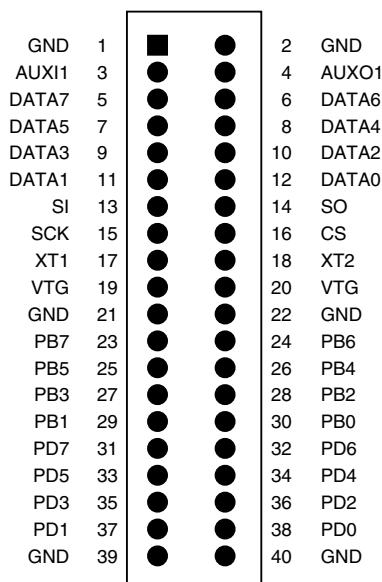


Figure 3-31. Expansion Connector 0 Pinout

GND	1	●	2	GND
AUXIO	3	●	4	AUX00
CT7	5	●	6	CT6
CT5	7	●	8	CT4
CT3	9	●	10	CT2
CT1	11	●	12	BSEL2
NC	13	●	14	REF
RST	15	●	16	PE2
PE1	17	●	18	PE0
GND	19	●	20	GND
VTG	21	●	22	VTG
PC7	23	●	24	PC6
PC5	25	●	26	PC4
PC3	27	●	28	PC2
PC1	29	●	30	PC0
PA7	31	●	32	PA6
PA5	33	●	34	PA4
PA3	35	●	36	PA2
PA1	37	●	38	PA0
GND	39	●	40	GND

Figure 3-32. Expansion Connector 1 Pinout**3.9.1 Signal Descriptions**

The signals AUX11, AUX10, AUXO1 and AUXO0 are intended for future use. Do not connect these signals to your application.

The DATA[7:0] and CT[7:1] signals are also found on the Prog Data and Prog Ctrl connectors. These signals and connectors are explained in paragraph 3.10 on page 3-21.

The BSEL2 signal is the same as that found on the BSEL2 jumper. This jumper is explained in paragraph 3.8.5 on page 3-19.

The SI, SO, SCK and \overline{CS} signals are connected to the DataFlash. Use of the DataFlash is described in paragraph 3.6 on page 3-5.

NC means that this pin is not connected.

The remaining signals are equal to those found on the PORT connectors, explained in paragraph 3.4 on page 3-3.

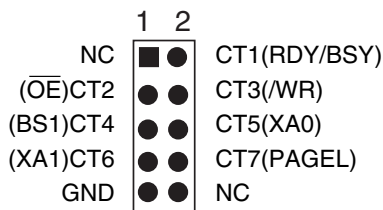
Note: DATA, CT and AUX signals are based on 5V CMOS logic. No voltage conversion to adapt to VTG is done on these signals.

3.10 Prog Ctrl and Prog Data Headers

The Prog Ctrl and Prog Data headers are used for high-voltage programming of the target AVR device. The placement of the headers is shown in Figure 3-30. During parallel high-voltage programming, the Prog Ctrl signals are routed to PORTD of the target device. The Prog Data signals are routed to PORTB. See paragraph 3.7.2 on page 3-10 for a complete description of high-voltage programming. The pinouts of the Prog Ctrl and Prog Data headers are shown in Figure 3-33 and Figure 3-34. For more information about high-voltage programming of AVR devices, see the programming section of each AVR datasheet.

Note: Prog Ctrl and Data connectors are connected directly to the master MCU without level converters. This means that these signals are always 5V logic.

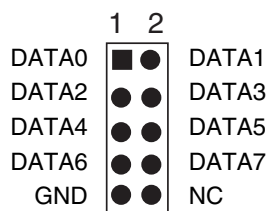
Figure 3-33. Prog Ctrl Header Pinout



The Prog Ctrl signals are normally used for the control signals when parallel high-voltage programming an AVR device.

Note: All Prog Ctrl signals are based on 5V CMOS logic. No voltage conversion to adapt to VTG is done on these signals.

Figure 3-34. Prog Data Header Pinout

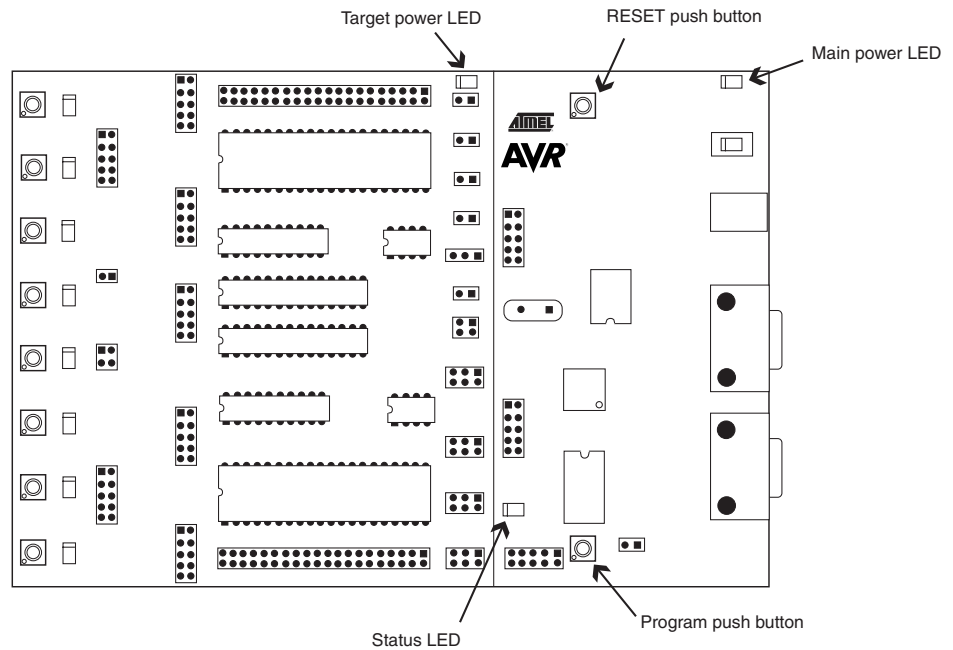


The Prog Data signals are used for the data bus when parallel high-voltage programming an AVR device. During ISP programming, DATA5 is used as MOSI, DATA6 is used as MISO and DATA7 is used for SCK.

Note: All Prog Data signals are based on 5V CMOS logic. No voltage conversion to adapt to VTG is done on these signals.

3.11 Miscellaneous

STK500 has 2 push buttons and 3 LEDs for special functions and status indication. The following section explains these features. Figure 3-35 shows the placement of these functions.

Figure 3-35. Special Functions and Status Indication LEDs

- 3.11.1 RESET Push Button** The RESET push button resets the target AVR device when pushed. The master MCU is not controlled by the RESET push button. When the RESET jumper is not mounted, the RESET push button is disabled.
- 3.11.2 PROGRAM Push Button** Future versions of AVR Studio may upgrade the master MCU on STK500. AVR Studio will then detect old software versions of STK500 and update the Flash program memory of the master MCU. To do this, the user is required to push the PROGRAM button when powering on STK500. AVR Studio issues instructions on how to perform the upgrade during the upgrade process.
- 3.11.3 Main Power LED** The red power LED is directly connected to the STK500 main power supply. The power LED is always lit when power is applied to STK500.
- 3.11.4 Target Power LED** The target power LED is connected to VCC lines (VTG) on the target AVR devices in the sockets. The target power LED is lit when power is applied to the target AVR device.
- 3.11.5 Status LED** The PROGRAM LED is a 3-color LED. During programming, the LED is yellow. When the target AVR device is successfully programmed, the LED will turn green. If programming fails, the LED will turn red to indicate that programming failed. When programming fails, check the troubleshooting guide in Section 7 on page 7-1. During start-up, the status LED will shift from red, through yellow, to green to indicate that the master MCU is ready.



Section 4

Installing AVR Studio

AVR Studio, with its Integrated Development Environment (IDE), is the ideal software for all AVR development. It has an editor, an assembler and a debugger and is front-end for all AVR emulators and the STK500 starter kit.

To install AVR Studio, insert the supplied Atmel CD-ROM databook in the computer and navigate to "Products > AVR 8-bit RISC > Software". Right-click with the mouse on the "AVRstudio.exe" file and select "save link as". Select an empty directory and save the file.

Execute the "AVRstudio.exe" file; this is a self-extracting file that will extract all required files to the current directory. Execute the "Setup.exe" file; this will guide you through the setup process.

Note: AVR Studio, version 3.2 or later, is required for STK500 support.



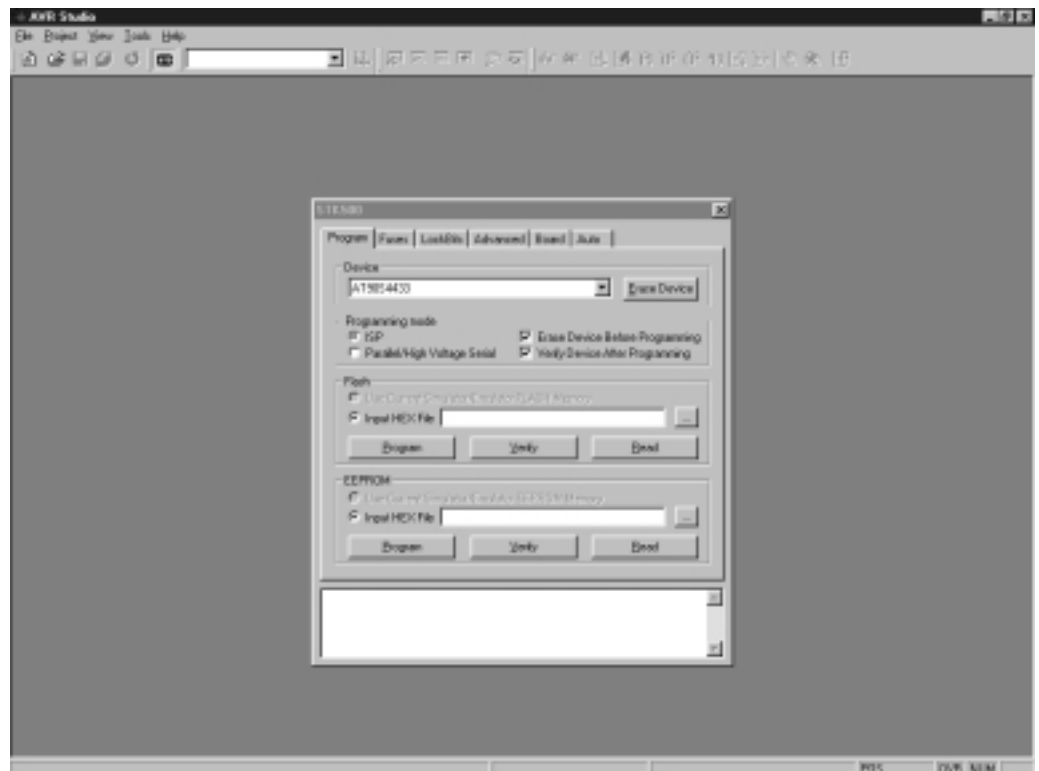


Section 5

Using AVR Studio

- | | | |
|--------------|--------------------------------------|--|
| 5.1 | Windows Software | In this section, the supporting software for STK500 will be presented and an in-depth description of the available programming options is given. |
| 5.2 | Starting the Windows Software | The software used for communicating with the STK500 development board is included in AVR Studio, version 3.2 and later. For information on how to install this software, please see Section 4 on page 4-1. Once installed, AVR Studio can be started by double-clicking on the AVR Studio icon. If default install options are used, the program is located in the Windows “Start menu > Programs > Atmel AVR Tools” folder. |
| 5.2.1 | Starting STK500 | Pressing the “AVR” button on the AVR Studio toolbar will start the STK500 user interface as shown in Figure 5-1. |

Figure 5-1. AVR Studio with STK500 User Interface




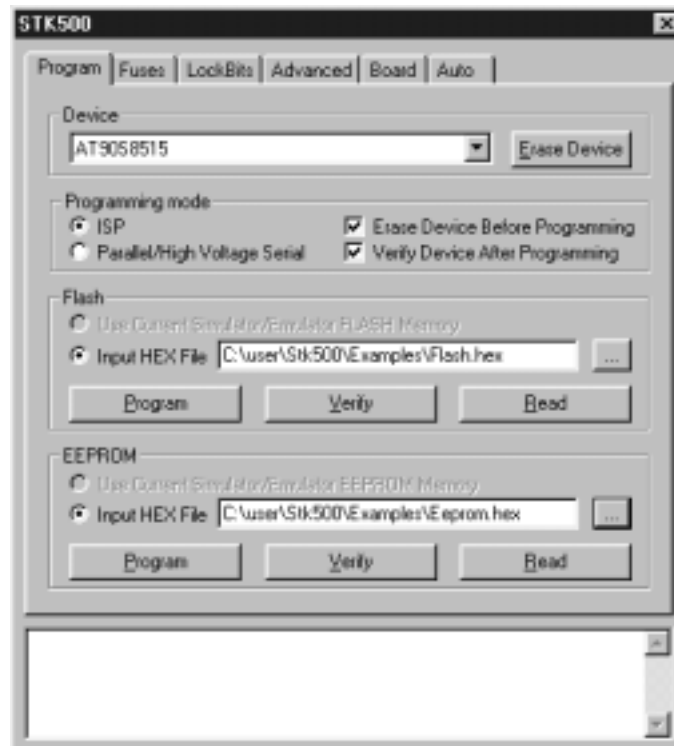

- 5.3 STK500 User Interface** The STK500 user interface includes powerful features for the STK500 development board. The available settings are divided into six groups, each selectable by clicking on the appropriate tab. Since different devices have different features, the available options and selections will depend on which device is selected. Unavailable features are grayed out.
- 5.3.1 “Program” Settings** The program settings are divided into four different subgroups.
- 5.3.1.1 Device** A device is selected by selecting the correct device from the pull-down menu. This group also includes a button that performs a chip erase on the selected device, erasing both the Flash and EEPROM memories.
- 5.3.1.2 Programming Mode** This group selects programming mode. For devices only supporting high-voltage programming, the ISP option will be grayed out. If both modes are available, select a mode by clicking on the correct method. Checking “Erase Device Before Programming” will force STK500 to perform a chip erase before programming code to the program memory (Flash). Checking “Verify Device After Programming” will force STK500 to perform a verification of the memory after programming it (both Flash and EEPROM).
- 5.3.1.3 Flash** If the STK500 user interface is opened without a project loaded in AVR Studio, the “Use Current Simulator/Emulator FLASH Memory” option will be grayed out. When a project is open, this option allows programming of the Flash memory content currently present in the Flash Memory view of AVR Studio. For more information about AVR Studio memory views, please take a look in the AVR Studio Help file.
- If no project is running, or the source code is stored in a separate hex file, select the “Input HEX File” option. Browse to the correct file by pressing the  button or type the complete path and filename in the text field. The selected file must be in “Intel-hex” format or “extended Intel-hex” format.

Figure 5-2. Program



5.3.1.4 EEPROM

If the STK500 user interface is opened without a project loaded in AVR Studio, the “Use Current Simulator/Emulator EEPROM Memory” option will be grayed out. When a project is open, this option allows programming of the EEPROM memory content currently present in the EEPROM Memory view. For more information about AVR Studio memory views, please take a look in the AVR Studio Help file.

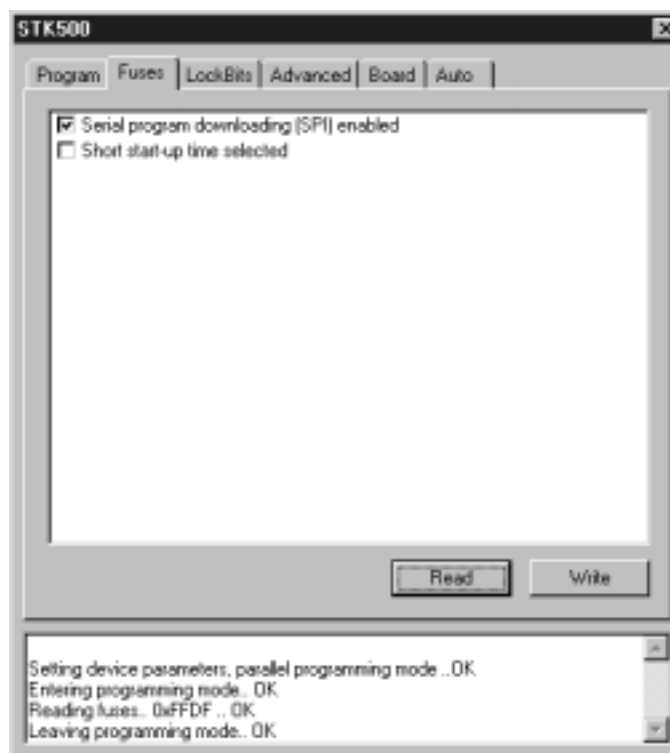
If no project is running, or the source code is stored in a separate hex file, select the “Input HEX File” option. Browse to the correct file by pressing the  button or type the complete path and filename in the text field. The selected file must be in “Intel-hex” format or “extended Intel-hex” format.

5.3.2 “Fuses” Settings

In the “Fuses” tab an overview of accessible fuses are presented. Some fuses are only available during high-voltage programming. These will be displayed but not accessible if operating in ISP programming mode. Press the “Read” button to read the current value of the fuses, and the “Write” button to write the current fuse setting to the device. Checking one of these check boxes indicates that this fuse should be enabled/programmed, which means writing a “0” to the fuse location in the actual device. Note that the selected fuse setting is not affected by erasing the device with a chip-erase cycle (i.e., pressing “Chip Erase” button in the “Program” settings).

Detailed information on what fuses are available in the different programming modes and their functions can be found in the appropriate device datasheet.

Figure 5-3. Fuses



5.3.3 “LockBits” Settings

Similar to the “Fuses” tab, the “LockBits” tab shows which lock modes are applicable to the selected device. All lock bits are accessible in both ISP and high-voltage programming. A lock mode may consist of a combination of setting multiple lock bits. This is handled by the STK500 user interface, and the correct lock bits are programmed automatically for the selected lock mode. Once a lock mode protection level is enabled, it is not possible to lower the protection level by selecting a “lower” degree of protection or by setting a different lock mode. The only way to remove a programmed lock bit is to perform a complete chip erase, erasing both program and data memories. One exception exists: If the target device has a programmed “EESAVE” fuse, the contents of the EEPROM will be saved even though a complete chip erase on the device is performed.

Figure 5-4. Lock Bits



5.3.4 “Advanced” Settings

The “Advanced” tab is currently divided into two subgroups.

5.3.4.1 Signature Bytes

By pressing the “Read Signature” button, the signature bytes are read from the target device. The signature bytes act like an identifier for the part. Please refer to the AVR datasheets to read more about signature bytes.

Figure 5-5. Advanced



5.3.4.2 Oscillator Calibration Byte

The oscillator calibration byte is written to the device during manufacturing, and cannot be erased or altered by the user. The calibration byte is a tuning value that should be written to the OSCCAL register in order to tune the internal RC oscillator.

5.3.4.3 Reading Oscillator Calibration Byte

By pressing the “Read Cal. Byte” button, the calibration value is read from the device and is shown in the “Value” text box. Note that the calibration byte is not directly accessible during program execution and must be written to a memory location during programming if it shall be used by the program. If this option is grayed out, the selected device does not have a tunable internal RC oscillator.

5.3.4.4 Writing Oscillator Calibration Byte

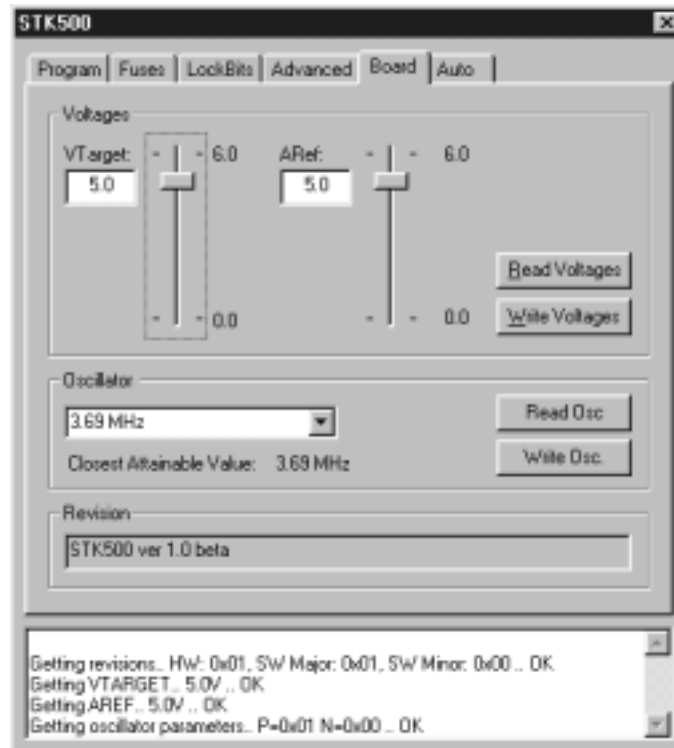
Since the calibration byte is not directly accessible during program execution, the user should write the calibration byte into a known location in Flash or EEPROM memory. Do this by writing the desired memory address in the “Write Address” text box and then press the “Write to Memory” button. The calibration byte is then written to the memory indicated by the “Flash” and “Eeprom” radio buttons.

5.3.5 “Board” Settings

The “Board” tab allows the changing of operating conditions on the STK500 development board. The following properties can be modified: VTARGET, AREF and oscillator frequency.

The interface is very flexible and it is possible to force the operating conditions beyond the recommended specifications for the device. Doing this is not recommended, and may damage the target device. The recommended operating conditions for the part are stated in the device datasheet.

Figure 5-6. Board



5.3.5.1 VTARGET

VTARGET controls the operating voltage for the target board. Through the use of the slide bar or the text box, this voltage can be regulated between 0 and 6.0V in 0.1V increments. Please refer to the device datasheet to find the specified voltage range for the selected device. Both voltages are read by pressing the “Read Voltages” button, and written by pressing the “Write Voltages” button.

The physical connection of the VTARGET voltage is shown in Figure 3-22 on page 3-15.

5.3.5.2 AREF

AREF controls the analog reference voltage for the ADC converter. This setting only apply to devices with AD converter. Through the use of the slide bar or the text box, this voltage can be regulated between 0 and 6.0V in 0.1V increments. Please refer to the device datasheet to find the valid voltage range for the selected device. Both VTARGET and AREF are read by pressing the “Read Voltages” button, and written by pressing the “Write Voltages” button.

It is not possible to set AREF to a higher voltage than VTARGET because this will permanently damage the AVR.

The physical connection of the AREF voltage is shown in Figure 3-24 on page 3-16.

5.3.5.3 Oscillator

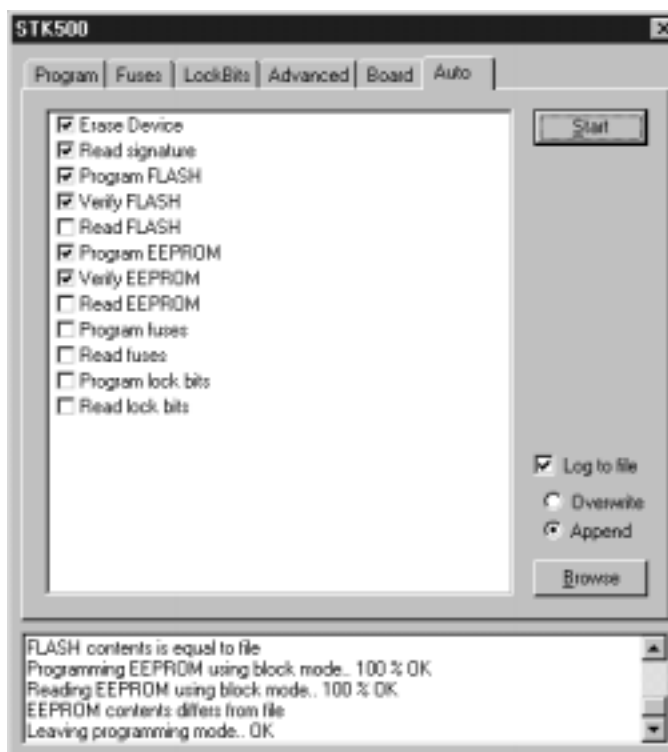
The STK500 development board uses a programmable oscillator circuit that offers a wide range of frequencies for the target device.

Since it is not possible to generate an unlimited number of frequencies, the STK500 user interface will calculate the value closest to the value written to the oscillator text box. The calculated value is then presented in the oscillator text box, overwriting the previously written number.

5.3.6 “Auto” Settings

When programming multiple devices with the same code, the “Auto” tab offers a powerful method of automatically going through a user-defined sequence of commands. The commands are listed in the order they are executed (if selected). To enable a command, the appropriate check box should be checked. For example, if only “Program FLASH” is checked when the “Start” button is pressed, the Flash memory will be programmed with the hex file specified in the “Program” settings. All commands depend on and use the settings given in the STK500 user interface.

Figure 5-7. Auto



It is possible to log the command execution to a text file by checking the “Log to file” check box.

5.3.6.1 Setting Up the System for Auto-programming

Click on the check boxes for the commands that you want the STK500 user interface to perform. A typical sequence where the device is erased and then programmed is shown in Figure 5-7. The chip is erased, both memories programmed and verified, and finally, fuses and lock bits are programmed.

Once configured, the same programming sequence is executed every time the “Start” button is pressed. This reduces both work and possibilities for errors due to operational errors.

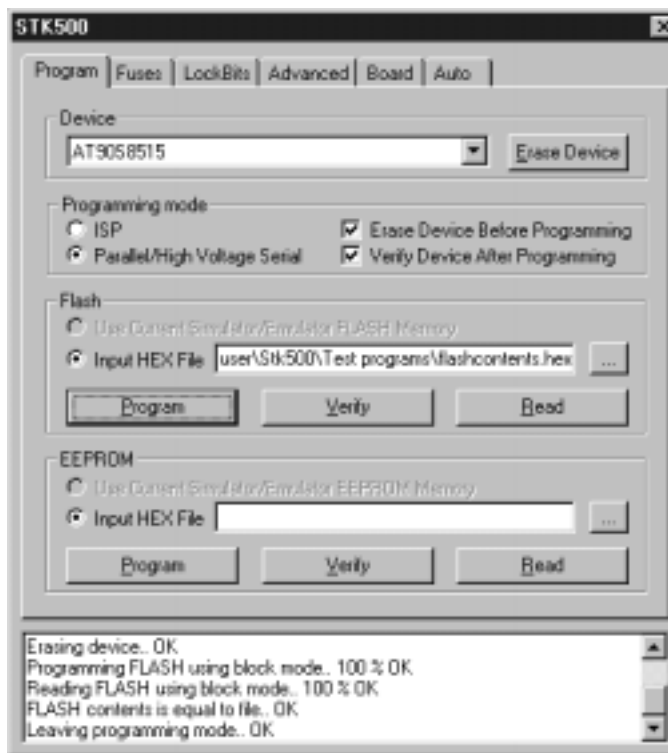
5.3.6.2 Logging the Auto-programming to a File

By clicking on the “Log to file” check box, all output from the commands are written to a text file. Select or create the file by pressing the “Browse” button and navigate to the location where the file is placed or should be created. The output is directed to this file, and can be viewed and edited using a text editor.

5.3.7 History Window

The History window is located at the bottom of the STK500 view. In this window the dialog between AVR Studio and STK500 is shown. For every new command performed, the old dialog is replaced with the new one.

Figure 5-8. History Window



5.4 Command Line Software

The DOS command line version of the STK500 software is useful for programming STK500 from external editors or for use in production programmers. Simple batch files can be made for automatic programming. Type `STK500 -?` for help.

Synopsis: `stk500`

```
[-d device name] [-m slp] [-if infile] [-ie infile] [-of outfile]
[-oe outfile] [-s] [-e] [-p flelb] [-r flelb] [-v flelb] [-l value]
[-y] [-f value] [-q] [-x value] [-af start,stop] [-ae start,stop]
[-c port] [-ut value] [-ua value] [-wt] [-wa] [-j value] [-b hls]
[-! n,p] [-?] [-t plt] [-t] [-n] [-g] [-z] [-hl?]
```

5.5 Parameters

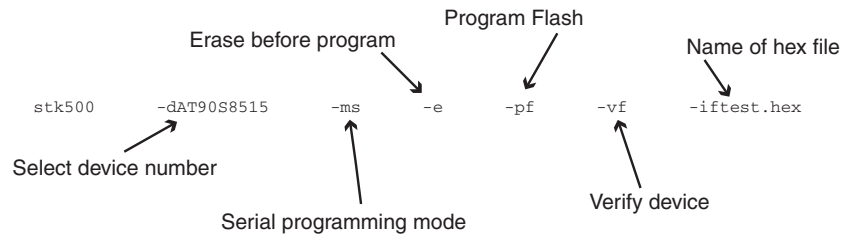
- `d` Device name. Must be applied when programming the device. See list below.
- `m` Select programming mode, serial (s) or parallel (p). Serial progr. mode is the default, and is used if this parameter is not applied.
- `if` Name of Flash input file. Required for programming or verification of the Flash memory. The file format is Intel Extended HEX.
- `ie` Name of Flash input file. Required for programming or verification of the EEPROM memory. The file format is Intel Extended HEX.
- `of` Name of Flash output file. Required for readout of the Flash memory. The file format is Intel Extended HEX.
- `oe` Name of EEPROM output file. Required for readout of the EEPROM memory. The file format is Intel Extended HEX.

- s Read signature bytes.
- e Erase device. If applied with another programming parameter, the device will be erased before any other programming takes place.
- p Program device; Flash (f), EEPROM (e) or both (b). Corresponding input files are required.
- r Read out device; Flash (f), EEPROM (e) or both (b). Corresponding output files are required
- v Verify device; Flash (f), EEPROM (e) or both (b). Can be used with -p or stand alone. Corresponding input files are required.
- l Set lock byte. "Value" is an 8-bit hex value.
- y Read back lock byte.
- f Set fuse bytes. "Value" is a 16-bit hex value describing the settings for the upper and lower fuse.
- q Read back fuse bytes.
- x Fill unspecified locations with a value (0x00 - 0xff). The default is to not program locations not specified in the input files.
- a.f Flash address range. Specifies the address range of operations. The default is the entire Flash. Byte addresses.
- ae EEPROM address range. Specifies the address range of operations. The default is the entire EEPROM. Byte addresses.
- c Select communication port; "com1" to "com8". If this parameter is omitted, the program will scan the comm. ports for the STK500.
- ut Set target voltage (VTARGET) in volts. "Value" is a floating point value between 0.0 and 6.0, describing the new voltage.
- ua Set adjustable voltage (AREF) in volts. "Value" is a floating point value between 0.0 and 6.0, describing the new voltage.
- wt Get current target voltage (VTARGET).
- wa Get current adjustable voltage (AREF).
- j Activate the application reset line. "Value" is number of milliseconds the RESET line is held active before it is released.
- b Get revisions; hardware revision (h) and software revision (s).
- ! Set oscillator parameters; "n" is the compare register value and "p" is the prescaler register value.
- ? Get oscillator parameters.
- t Get currently selected device parameters.
- n Get current programming mode.
- g Silent operation.
- z No progress indicator. For example, if piping to a file for log purposes, use this option to avoid the non-ASCII characters used for the indicator.
- h | ? Help information (overrides all other settings).

5.6 Syntax for Supported Devices

AT90S1200, AT90S2313, AT90S4414, AT90S4433, AT90S2333, AT90S8515, AT90S2323, AT90S2343, AT90S8535, AT90S4434, AT90C8534, ATmega103, ATmega161, ATmega163, ATtiny11, ATtiny12, ATtiny15, ATtiny28

Figure 5-9. Sample Usage





Section 6

In-System Programming of an External Target System

The STK500 can be used as a programmer to program AVR devices in other applications. There are two different ISP connector pinouts available: a 6-pin and a 10-pin version. Both are supported by STK500.

Figure 6-1. 6-pin ISP Connector Pinout

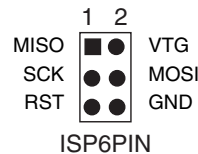
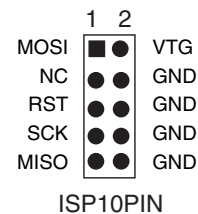


Figure 6-2. 10-pin ISP Connector Pinout



Select the device to be programmed in the same way as programming a device on the STK500. The V_{CC} of the target application is detected by STK500 and signals are converted into voltage levels suitable for the target system.

Note: If the other application has its own power supply to VTG, the jumper VTARGET must be removed before connecting STK500 to the other application. STK500 may be damaged if the VTARGET jumper is not removed.



Section 7

Troubleshooting Guide

Table 7-1. Troubleshooting Guide

Problem	Reason	Solution
The red power LED is not on.	The DC power cable is not connected.	Connect the DC power cable to the DC jack (page 2-2).
	Wrong power supply is used.	Check that the power supply is of DC type 10 - 15V, min. 500 mA (page 2-2).
	The power switch is off.	Turn on the power switch.
The preprogrammed example code does not toggle the LEDs.	There is no AVR device in the socket.	Plug the AVR device into the right socket (page 2-3).
	The LEDs are not connected to the I/O ports.	Connect the LEDS header to the PORTD header, and the SWITCHES header to the PORTB header (page 3-3).
	The Flash memory is erased.	Connect STK500 to a PC and reprogram the AVR device (page 2-3).
The AVR device cannot be programmed.	The PC serial cable is not connected.	Connect the serial cable to the PC COM port and the RS232PROG port.
	The AVR device is inserted in wrong socket.	Check that the correct socket is used (page 3-9).
	The AVR device is inserted with wrong orientation.	Check that the notch on the AVR socket matches the notch on the AVR device.
	The target ISP header is not connected.	Connect the 6-pin flexible cable from ISP6PIN header to the correct SPROG target ISP header (page 3-9).
	The jumpers settings are wrong.	Set jumper to default setup (page 3-14).
	The VTARGET voltage is too low.	Check the AVR datasheet for minimum operating voltage.
	The memory lock bits are programmed.	Erase the memory before programming.

Table 7-1. Troubleshooting Guide (Continued)

Problem	Reason	Solution
AVR Studio does not detect STK500.	Serial cable is not connected, or power is off.	Connect serial cable to RS232PROG and check power connections.
	PC COM port is in use.	Disable other programs that are using PC COM port. Change PC COM port.
	AVR Studio does not detect COM port.	Disable COM port auto-detection in AVR Studio file menu. Force COM port to correct COM port.



Section 8

Technical Support

For technical support, please contact avr@atmel.com. When requesting technical support for STK500, please include the following information:

- Version number of AVR Studio. This can be found in the AVR Studio menu, "Help > About".
- PC processor type and speed
- PC operating system and version
- What target AVR device is used (complete part number)
- Programming voltage
- Jumper settings
- A detailed description of the problem



Section 9

Example Applications

9.1 Using LEDs and Switches

Connect PORTB to LEDS and PORTD to SWITCHES.

LEDs will operate differently depending on what switch is pressed.

Tip: Copy the code from this document into AVR Studio.

```
;***** STK500 LEDS and SWITCH demonstration

.include "8515def.inc"

.def    Temp    =r16    ; Temporary register
.def    Delay   =r17    ; Delay variable 1
.def    Delay2  =r18    ; Delay variable 2

;***** Initialization

RESET:

    ser    Temp
    out    DDRB,Temp    ; Set PORTB to output

;**** Test input/output

LOOP:
    out    PORTB,temp    ; Update LEDS

    sbis   PIND,0x00    ; If (Port D, pin0 == 0)
    inc    Temp        ; then count LEDS one down
    sbis   PIND,0x01    ; If (Port D, pin1 == 0)
    dec    Temp        ; then count LEDS one up
    sbis   PIND,0x02    ; If (Port D, pin2 == 0)
    ror    Temp        ; then rotate LEDS one right
```

Example Applications

```
sbis  PIND,0x03      ; If (Port D, pin3 == 0)
rol   Temp           ; then rotate LEDS one left
sbis  PIND,0x04      ; If (Port D, pin4 == 0)
com   Temp           ; then invert all LEDS
sbis  PIND,0x05      ; If (Port D, pin5 == 0)
neg   Temp           ; then invert all LEDS and add 1
sbis  PIND,0x06      ; If (Port D, pin6 == 0)
swap  Temp           ; then swap nibbles of LEDS

;**** Now wait a while to make LED changes visible.
```

DLY:

```
dec   Delay
brne  DLY
dec   Delay2
brne  DLY

rjmp  LOOP           ; Repeat loop forever
```



Section 10

Warranty Statement

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