The AVR MultiKitB

www.gabotronics.com

Introduction

MultiKitB is a multi purpose development kit using AVR microcontrollers. It is targeted for anyone who wants to start learning AVR micros. The big thing about MultiKitB is that it is also a fully featured **M**ixed **S**ignal **O**scilloscope with frequency analysis. The MultiKitB is preprogrammed with a bootloader which allows firmware updates and programming your own applications.

The MultiKitB demonstrates:

- LCD Displays
- Analog to Digital Converters
- Rotary Encoders
- RS-232 Interface & Xmodem file transfer
- Multiplexing LEDs
- Generating negative voltages
- Reading multiple switches with a single pin
- Fast Fourier Transforms
- Random numbers
- Linked Lists

These topics are demonstrated with 6 applications:

DEMO: A physics simulation of particles
SKTCH: Popular painting game
3D: Demo using accelerometer to change viewing angle of a sphere
PIANO: Mini Piano with dual frequency output
FRCTL: Fractal to demo simple math and random numbers
RS232: RS-232 Terminal

The MultiKitB requires a DC power of 6V, 100mA.

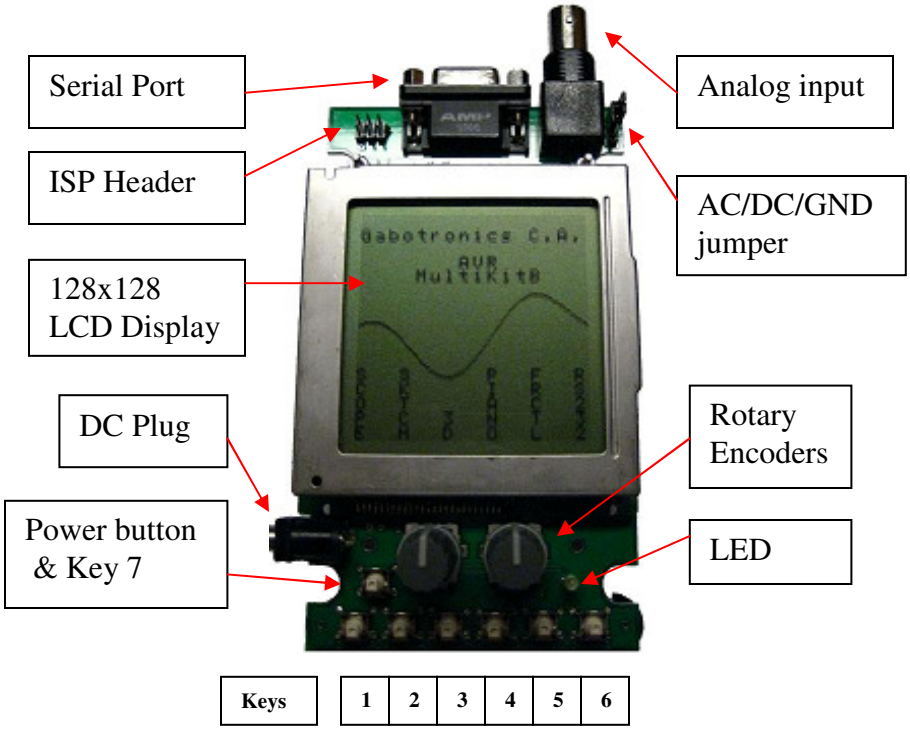
To power on the MultiKitB, press K7 for at least half a second.
You will hear two clicks.

To power down the MultiKitB, press K7 for at least 2 seconds.
You will hear the power down sound..

If using an external programmer, K7 needs to be pressed while programming the MultiKitB.

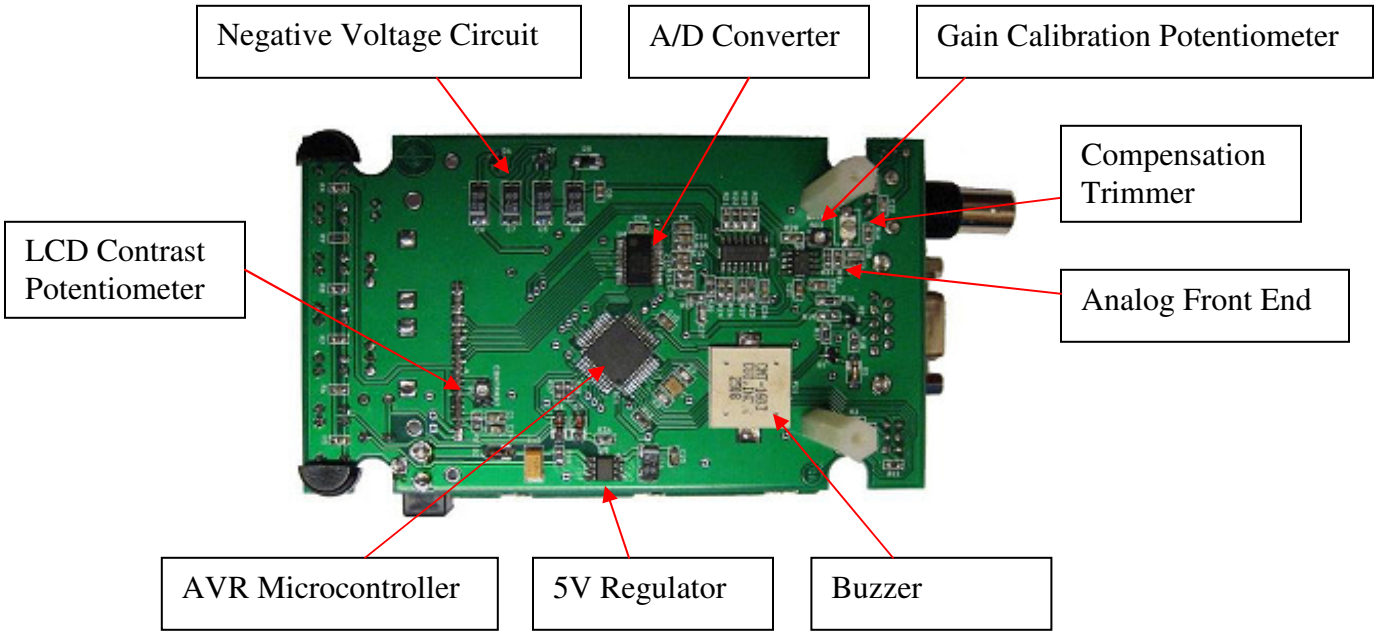
MultiKit Hardware Overview

FRONT:

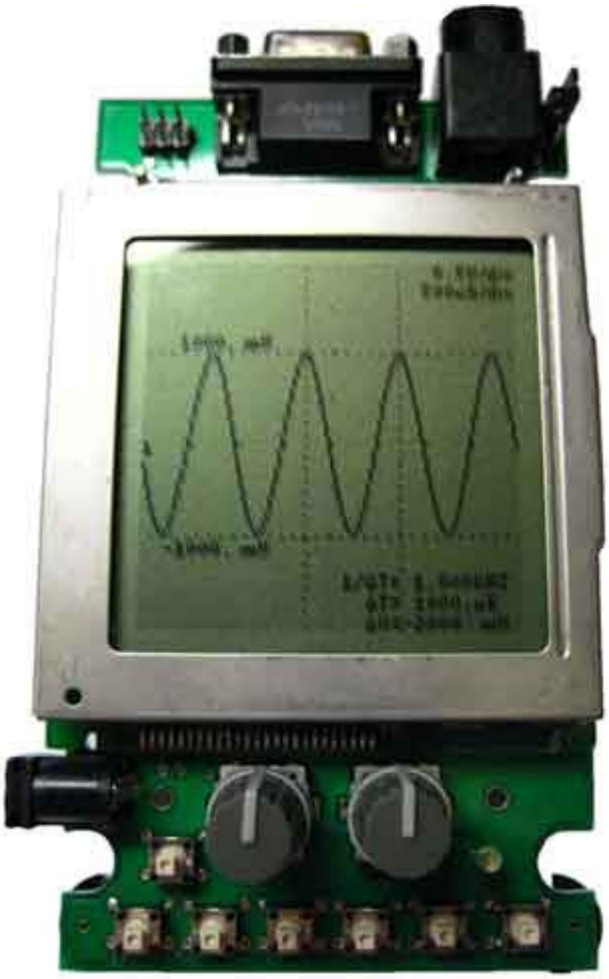


Keys	1	2	3	4	5	6

BACK:



Mixed Signal Oscilloscope



Specifications:

1 Analog Input
Input Impedance: 1MΩ
Maximum Input Voltage: +/- 25V
(+/- 250V if using a 10:1 probe)
A/D Converter Resolution: 8 bits
Max Sample Rate: 3.2MS/s
Trigger jitter: 312.5nS
3 Digital Inputs: 5V level

Features:

Time Base (S/division): `5u, 10u, 20u, 50u, 100u, 200u, 500u, 1m, 2m, 5m, 10m, 20m, 50m, 0.1, 0.2, 0.5, 1, 2`

Gain (Volts / division): `20m, 50m, 0.1, 0.2, 0.5, 1, 2, 5`

Horizontal Cursors
Vertical Cursors
Automatic Average and Peak to Peak measurements
Fast Fourier Transform
Export to BMP through RS-232 using HyperTerminal

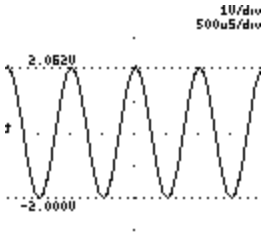
One time division consists of 16 pixels.
Example: 5uS / division = 5uS / 16 pixels ==> 312.5nS / pixel

One gain division consists of 16 pixels

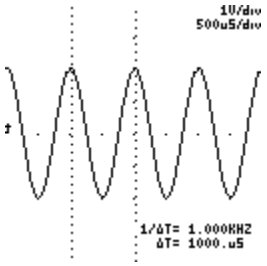
Scope Instructions:

K1: Set rotary encoders to control Gain and Rate.

K2: Set rotary encoders to control horizontal cursors,
Toggles horizontal cursors on and off.

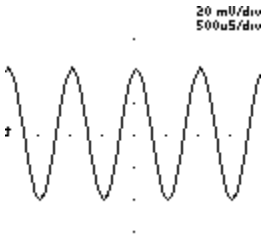


K3: Set rotary encoders to control vertical cursors,
Toggles vertical cursors on and off.

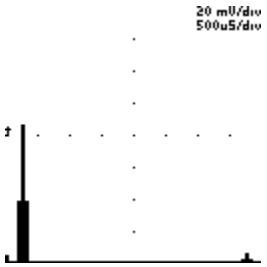


K4: Toggle Math Function on and off:

- In normal mode:
  Displays the Average (DC) &
  Peak to Peak voltage (PP) of
  the waveform

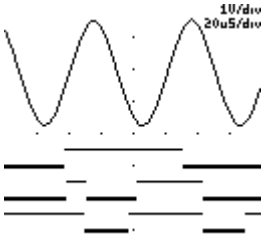


- In FFT mode:
  Displays the fundamental frequency
  of the waveform



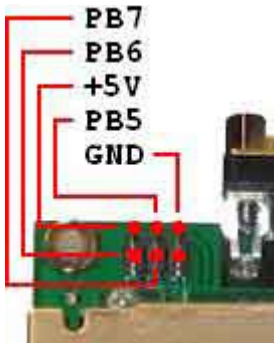
K5: Toggle FFT mode

K6: Digital inputs control, K6 cycles between these modes:



Digital inputs on. Analog trigger	Digital inputs on. PB5 digital trigger	Digital inputs off. PB5 digital trigger	Digital inputs off. Analog trigger

The trigger will occur on the rising edge of the pulse.
Note: K6 only controls the trigger source, enabling the oscilloscope trigger is set with K7 (example: setting the trigger to NORMAL). The digital inputs are the lines used for the ISP (PB5, PB6, PB7).
When a digital line is "low", the trace will be 2 pixels wide.



K7: Sets the rotary encoders for trigger control

Rotary Encoder 1: Sets the trigger level
Move encoder up for rising edge trigger
Move encoder down for falling edge trigger
The arrow on the left side of the LCD represents the trigger level and edge direction

Rotary Encoder 2: Sets the trigger mode:

- NORMAL mode (trace when trigger occurs)
- FREE (trace continuously)
- Single NORMAL (trace once when trigger occurs)
- Single FREE (trace once)

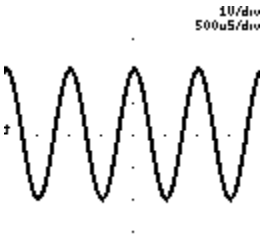
Once in trigger control, the behavior of K7 also changes:
If in Normal or Free mode, K7 will toggle between RUN and STOP
If in Single mode, K7 will allow one more trace to be drawn

NOTE: Keys K1 thru K6 are disabled when the scope is waiting for the trigger (NORMAL modes). If the scope doesn't have a signal that continuously triggers the scope, K1-K6 will not respond. This is a necessary behavior since the trigger is detected by software, keys K1 thru K6 are checked continuously using the AVR's ADC and would add trigger jitter if left enabled. Key K7 and rotary encoders are never disabled.

WORKAROUND to enable K1-K6 at the absence of a trigger:

1) Use K7 to STOP the scope.
2) Adjust the trigger level to find the signal
3) Set the FREE trigger mode

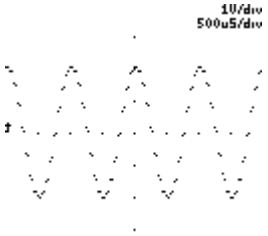
K1 and K2: Toggle between:



- Normal display
- Persistent display (traces will not be erased):

TIP: The persistent display is useful as a data logger or to catch glitches in the waveform

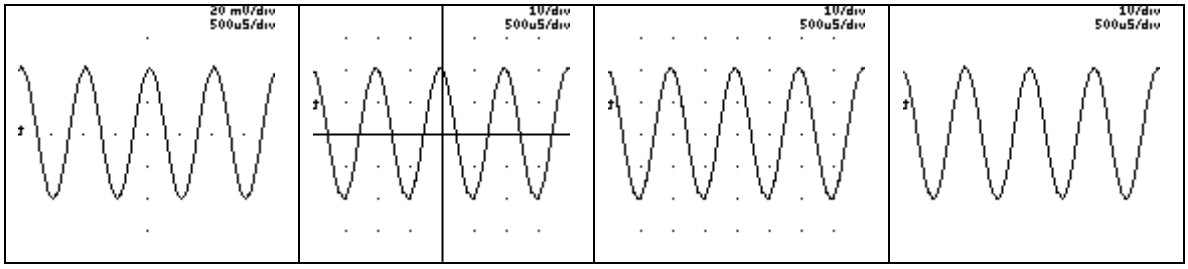
K2 and K3: Toggle between:



- Line display (default mode, a line is drawn from sample to sample)
- Dot display (each sample is displayed as a single pixel):

TIP: The dot display is useful at slow sampling rates or when used in combination with the persistent mode.

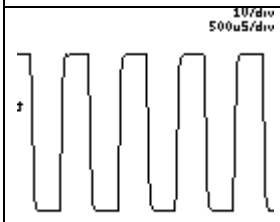
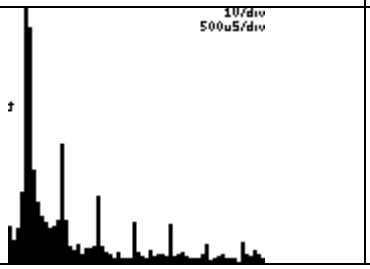
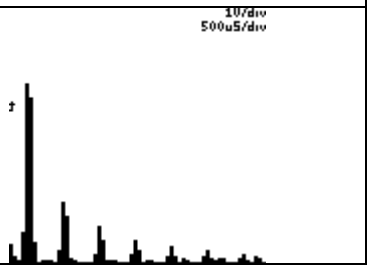
K3 and K4: Change between different grid types:



K4 and K5: Toggle between:

- Hamming window for FFT (default)
- No Hamming window for FFT

The Hamming window is useful when the number of cycles of the waveform is not an integer. Example:

≈ 4.5 cycles	No Window	Hamming Window
		

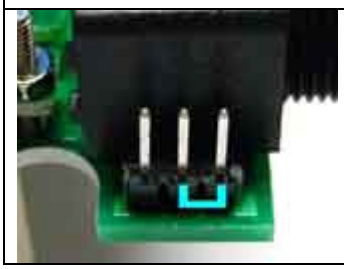
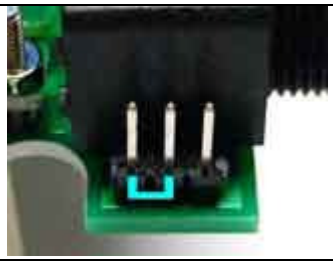
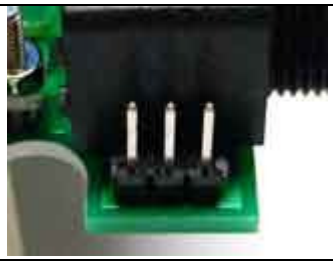
K1 and K3: Toggle between:

- Show Gain and Rate settings
- Don't show Gain and Rate settings

K2 and K4: Automatic offset calibration. Make sure the input is connected to ground.

K1 and K5: exit Scope

AC/DC/GND Jumper: Selects the different input coupling options:

DC Coupled	Ground	AC Coupled
		

To export a BMP file to a PC:

1) Open HyperTerminal.

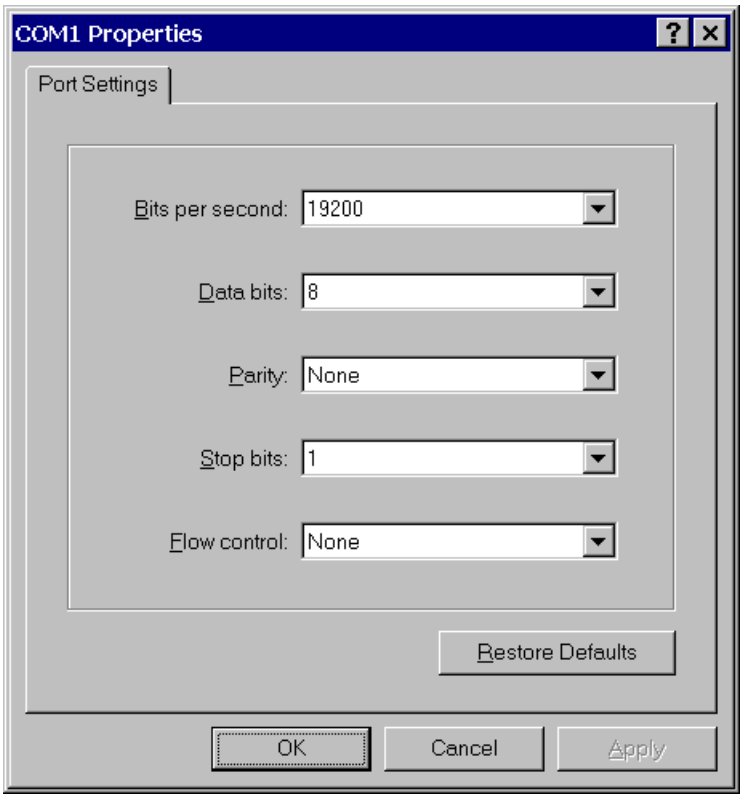
2) Enter a name for a new connection (example: multikit).

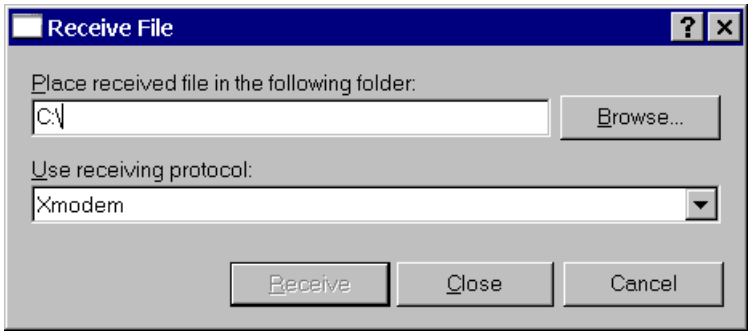
3) Enter the COM port where the MultiKit is connected.

4) Select 19200 bits per second, 8 data bits, Parity None, 1 Stop bit, Flow control None.

5) In the Transfer menu, select Receive File.
6) Enter a folder where to save the file and use the XMODEM protocol.

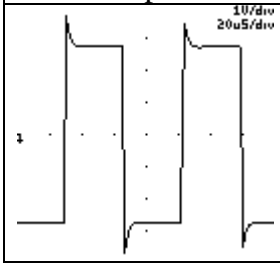
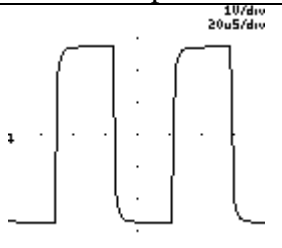
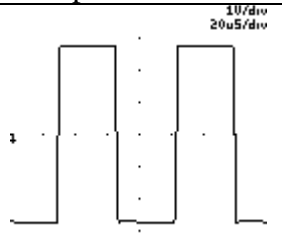
7) Enter a file name with a BMP extension and press OK.





Analog gain and frequency compensation adjustments

The MultiKitB is calibrated during assembly, but if you require to adjust it, follow this procedure: Apply a squarewave with a known amplitude (or use a meter to measure it). Adjust pot R33 until the voltage is correct. Adjust trimmer C19 until the waveform is a squarewave.

Over compensated	Under compensated	Compensated ok!
		

Demonstration Applications

The source code includes a demonstration project with 6 applications.

DEMO

This is a simple physics simulation of particles. Each particle is represented by a pixel moving on the screen. The forces between particles can be electric type or spring type. This application also demonstrate the use of linked lists.

Use the rotary encoders to move the first particle on the list.

K1: Toggles friction on/off.
K2: Toggles gravity on/off.
K3: Toggles chain mode on/off. When the chain mode is enabled, each particle will interact only with the previous and following particle on the list.
K4: Toggles the force type electric/spring. Electric Force =q1*q2/d^2. Spring Force =k*d
K5: Removes the last particle from the list
K6: Creates a new particle at a random location
K7: Exit

SKTCH

This is a simple game to demonstrate the rotary encoders.

Use the rotary encoders to move the pen.

Buttons:
K1: Erase screen
K2: Pen erases
K3: Pen draws 50%
K4: Pen draws 100%
K5: Thick pen
K6: Thin pen
K7: Exit

3D

This is a simple application to demonstrate 3D math.

Use the rotary encoders to change the viewing angle of the sphere.

To exit press K7

PIANO: Simple piano to demonstrate the use of the buzzer. To exit press K7

FRCTL

This is a simple application to demonstrate fractals and random numbers

Buttons:
K1: Sierpinski Triangle
K2: Sierpinski Hexagon
K3: Mandelbrot Fractal
K4: Zoom out Mandelbrot
K5: Zoom in Mandelbrot
K6: Koch Fractal
K7: exit

RS232

This is a simple RS-232 terminal application. Settings are:

19200 bps 8 data bits, No Parity, 1 Stop bit, No Flow control

Typing in HyperTerminal will display in the MultiKit
Pressing the K1 to K6 keys will display the letters a thru f in the HyperTerminal window.
To exit press K7

MultiKitB Bootloader

The MultiKitB is preprogrammed with a bootloader. The bootloader allows self programming of the microcontroller thru the serial port, so an external programmer is not required to do firmware updates or to program your own applications. There are several PC applications that can communicate with the bootloader, the most used are AVRDUDE (included in the WinAVR package) and AVRProg.This guide will focus on the AVRProg, which is part of the AVR Studio Environment.

To program the microcontroller follow these steps:

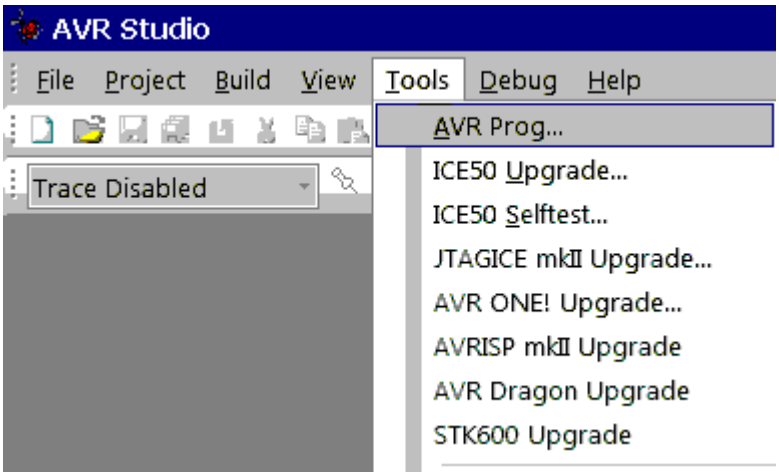
1) To enter the bootloader, the MultiKitB must be powered off, then press the K6 key and then the K7 (power) key simultaneously. You will see the following message:

```
Gabotronics MultiKitB
Bootloader  Ver x.x
```

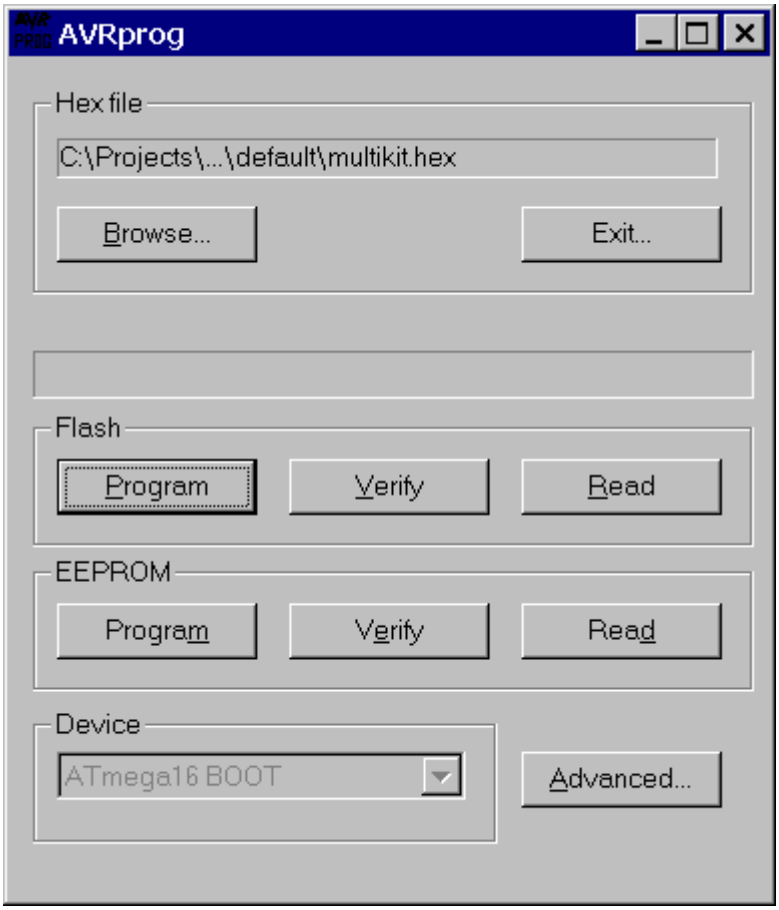
(where x.x is the version of the bootloader)

The MultiKitB will now wait until it detects commands from the PC.

2) Start AVR Studio and under Tools, select AVRPROG:



3) Select the HEX file to program by clicking on Browse.



4) Click on the Program button inside the Flash area. The MultiKitB will show progress as the data is received.

5) Select the EEP file to program by clicking on Browse.

6) Click on the Program button inside the EEPROM area. The MultiKitB will show progress as the data is received.

7) Click the Exit button. The MultiKitB will shut down. Close the AVRProg window.

NOTE: If the EEPROM doesn't need to be changed, steps 5 and 6 can be omitted.

Gabotronics
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