An AVR programmer development base on the UNO

Introducing the UNO AVR programmer

An Atmega 328 device pre-loaded with the Arduino bootloader and the UNO hardware make a very effective combination for developing and running C applications. It is also quite straightforward to program the UNO using a range of external programmers or with another UNO. Arduino is in fact a very flexible system for developing AVR applications. The purpose of the development described here is to extent this flexibility, making it easy to convert the UNO into a general purpose programmer for a number of the Atmega devices.

An Arduino application "UNO_AVR_programmer" is introduced that is hosted on the UNO and enables it to be used to program Atmega devices as follows:

Flash with a hex file loaded at address zero.
Flash with a text file loaded from the maximum address.
The configuration bytes.
The EEPROM with a file containing text and numbers.

Two Atmel Studio 7 applications are provided for an Atmega target device.

The first, "Cal_auto_plus_manual" is used to calibrate the target device.
The second, "text_reader" contains the subroutines needed to read text from the flash and EEPROM.
Sample text files are also provided.

Once programming is complete, the target device is automatically put into the run state and the UNO reset button must be pressed to reinitialise the programmer.
Note: Atmel Studio has been chosen because it can build projects for any Atmega device.

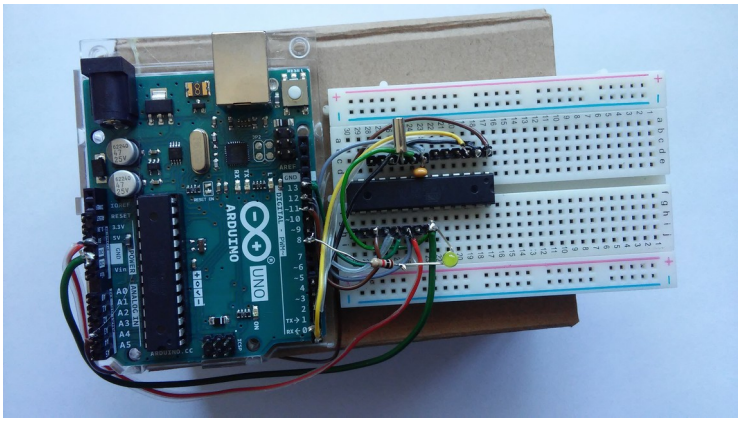
UNO_AVR_ programmer Hard Ware.

A photograph of the HW is shown below. An Atmega 168 target is loaded into some plug-in prototyping breadboard and the following connections between the UNO and target are made:

UNO output		Atmega 168 target pin and pin number	
5V		5V	7 & 20
0V		0V	8 and 22
Rx		USART TXD	3
Tx		USART RXD	2
Digital 11	MOSI	MOSI	17
Digital 12	MISO	MISO	18
Digital 13	SCK	SCK	19
A3		Reset	1

In addition the following extra components are used;

A watch crystal between pins 9 and 10 (TOSC1 and TOSC2) of the target device
A 100nF capacitor between pins 7 and 8 of the target device
A led and 1K resistor between digital output 8 (PB0) of the UNO and 0V.



UNO Programmer HW:

The UNO and breadboard are mounted on a cardboard box.

Note especially the 100nF capacitor beside the crystal. This is particularly important for obtaining an accurate user OSCCAL value.

A user interface for the UNO_AVR programmer

A PC application normally used for sending hex files to the target processor hardware has not been written. Instead a terminal program is used and the entire hex file is sent to the UNO. Arduino comes with a basic terminal program and there are several others on the web.

My favourite can be downloaded from https://sites.google.com/site/terminalbpp/. But take care to download the version 20130820, other versions may have an issue with the "scroll" button. Settings for the terminal program are: Baud rate: 38400, 8 data bits, no parity, 1 stop bit and no handshaking.

Running the "UNO_AVR_programmer"

Connect the UNO to the PC and open the Arduino application "UNO_AVR_programmer". It should upload OK. Check the comm port number if there are problems.

Open the terminal program. User prompt "s s s s ….." should be generated.
Left click the mouse in the grey area at the bottom of its window and press 's'.
The programmer should respond with the message "Target_not_detected".

Complete the test jig and repeat. This time the response should be either

"Atmega unknown"
or
"Atmega 168/P detected. (Assuming an Atmega168 target)
Press -p- to program flash, -e- for EEPROM or -x- to escape."

If the target is not recognised its details can be added to the file "Device_characteristics" which is opened by Arduino alongside the main subroutine and header file.

<u>Programming hex files</u>

Press 'p' to program a hex file.
Click the "Send File" box and send a hex file when requested.
Press '0' at the "Integer(0-FF)?" prompt.
The file size and config bytes should be printed out.
Note: The config bytes have not been programmed.
For an unused device this gives the default configuration bytes

These use the calibrated RC oscillator for the system clock. Usually if not always they also ensure that the watch dog timer is always on and the chip erase command also clears the EEPROM.

Programming the configuration bytes

Press ‘P’ rather than ‘p’ to program both the hex file and calibration bytes. It is important to check their settings first. Values already entered in file “Device_characteristics” put the watch dog under program control and ensure the EEPROM is only deleted by specific user action. (Press ‘s’ then ‘d’ at the user prompt.)

Programming text files

> If ‘y’ is pressed at the “Text_file? y or n” prompt a text file will be requested and immediately echoed back to the terminal program.
> Which ever is pressed the program will automatically be launched.
> Note that the baud rate must temporarily be reduced while the text is being uploaded.

Programming the EEPROM

At the “s s s…….” prompt press ‘s’, ‘e’ and ‘w’.
Press ‘0’ at the “Integer(0-FF)?” prompt and send the file.
Note that the file has to be sent several times however there is no need to change the baud rate.
At the AK prompt press any key.

Each string is terminated in a null character and is echoed to the screen together with its address.
User applications will require these addresses so that they can print the strings out.
Sample text files are included for both flash and EEPROM.

An easy way to obtain the addresses is to copy the file that has been echoed to the screen into a spreadsheet. This separates the address from the text so that they can be copied back into the original text file.

Target device calibration

The application “Cal_auto_plus_manual” stores calibration bytes in the top two addresses of the target device eeprom. User applications can do without the crystal. Instead they read these bytes and use them to replace the default value of the OSCCAL register.
There is of course no need to restrict the target device to using its internal RC oscillator. However it is the default selection and is in many cases very convenient to do so.

Running the “Cal_auto_plus_manual” application

Connect the programmer to the PC and open the terminal program.
Download the hex file as described above.
There is no text file.
Auto cal will start running automatically and the following dialogue will be printed.

> “Calibrating Atmega 168/P
> New OSCCAL value 78 (for example)
> Press 'x' to finish or Any Other Key for manual cal”

Reading text from the Flash and EEPROM

Upload the application “Text reader” followed by the text file.
The text strings are echoed to the terminal program in numbered format.
Three subroutines are introduced:

“string_counter()”: This counts the number of strings programmed to the flash.
“print_string_num(string_num)”: This prints out any numbered string.
“Char_from_flash()” which implements the “lpm” (load program memory) command.

Note:
Each string is terminated by a null character and the final one is terminated by two.
Both subroutines also need to know the size of the flash in words (3FFF for the Atmega 328).

Code is also included to read strings from the EEPROM.

Configuring the programmer for a range of target devices.

Details of the target device must be entered in the subroutine “set_up_target_parameters()” present in file “Device_characteristics”.

Details have already been entered for the Atmega 48, 88, 168, 328, 32, 644 and ATtiny44 devices.
The user can enter details for their chosen device.

Target device data required by the programmer

To program text, data and the calibration bytes

EE_size	The amount of EEPROM in bytes
FlashSZ	The amount of flash in words

To identify the device more fully:
The second signature and third signature bytes

More details of the flash:

PageSZ	The page size in words
Pamask	The page address mask which equals FlashSZ – PageSZ.

The configuration bytes:
Fuses: extended, high and low and the lock byte

Setting up user programs

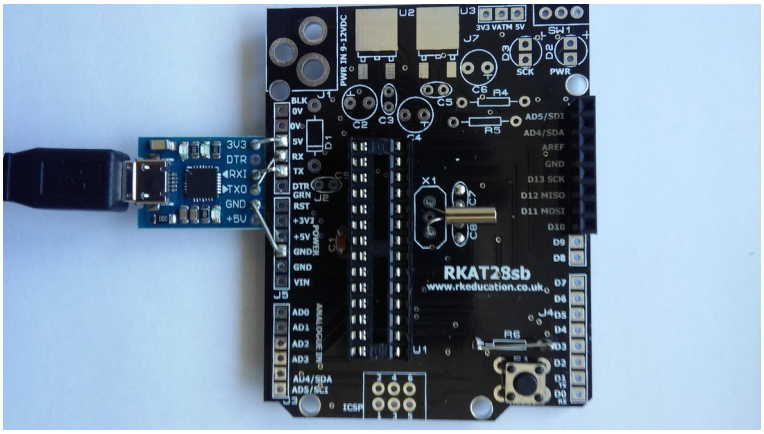
“UNO Programmer” programs the second and third of the target’s signature bytes at the top of its EEPROM. In all the top six locations should be considered as reserved. These are

EE_size - 1	User calibration byte. (This it the top EEPROM byte)
EE_size - 2	User calibration byte repeated.
EE_size - 3	The default calibration byte.
EE_size - 4	Signature byte 2
EE_size - 5	Signature byte 3
EE_size - 6	EE_top the last byte available for use by the user text/data.

Application “Text_reader_Studio” is intended as a template.
Code segment “setup_HW” is contained in Resources\Text_reader.h
It calls code segment “set_device_type_and_memory_size”.
This reads the second and third signature bytes.
The second determines the device size, the third the exact type (i.e. Atmega 168).

Note:
This process simplifies porting programs between one Atmega device and another.
Thanks to the Atmega architecture it is not necessary to know the EEPROM size to read the signature byte.

Test jig for programmed devices



Consists of an RKAT28sb Arduino shield
plus
CP2102 micro USB bridge.

Both available on ebay.

18pF trimmer capacitors are used with the watch crystal.

A device having been programmed on the UNO AVR programmer HW was transferred to the test jig where it functioned satisfactorily. A crystal was also added to confirm that the user calibration byte obtained using breadboard was compatible with a double sided pcb.

NOTE: if reloading the UNO_programmer the target device Rx/Tx ports will usually have to be temporarily disconnected.

Issues:
The terminal program is able to download a hex file large enough to fill an Atmega 168.
Larger files will have to split into two or more parts which can be downloaded in succession.

Having modified the Programmer code it will be necessary to disconnect the target UART before the new Arduino code can be uploaded.

Attiny48 comes with a USI device rather than a UART and no Timer 2. It is planned that issue 2 of this project will deal with calibrating the Attiny48 and programming the USI.

It appears that the UNO Tx pin in connected to the device Tx pin.
Similarly the Rx pins are connected together.
In some conventions Rx is connected to Tx and visa-versa. The important thing is that connecting them the wrong way round does not appear to result in any HW damage.

The sample programs supplied will not run on the default calibration bytes. The first time a device is programmed, programming should be initiated using the P keypress rather than p. Assuming of course that the device data has been correctly entered into the UNO “device characteristics file”. In particular the WDT should be under program control, chip erase should not affect the EEPROM, an 8MHz clock is required derived from the internal RC oscillator.