

Loading Arduino bootloader to a custom Mega32U4 board

Since I own original Microchip dev tools like Pickkit 4, I want to use them, instead to ordering some third party or using Arduino as a programming interface.

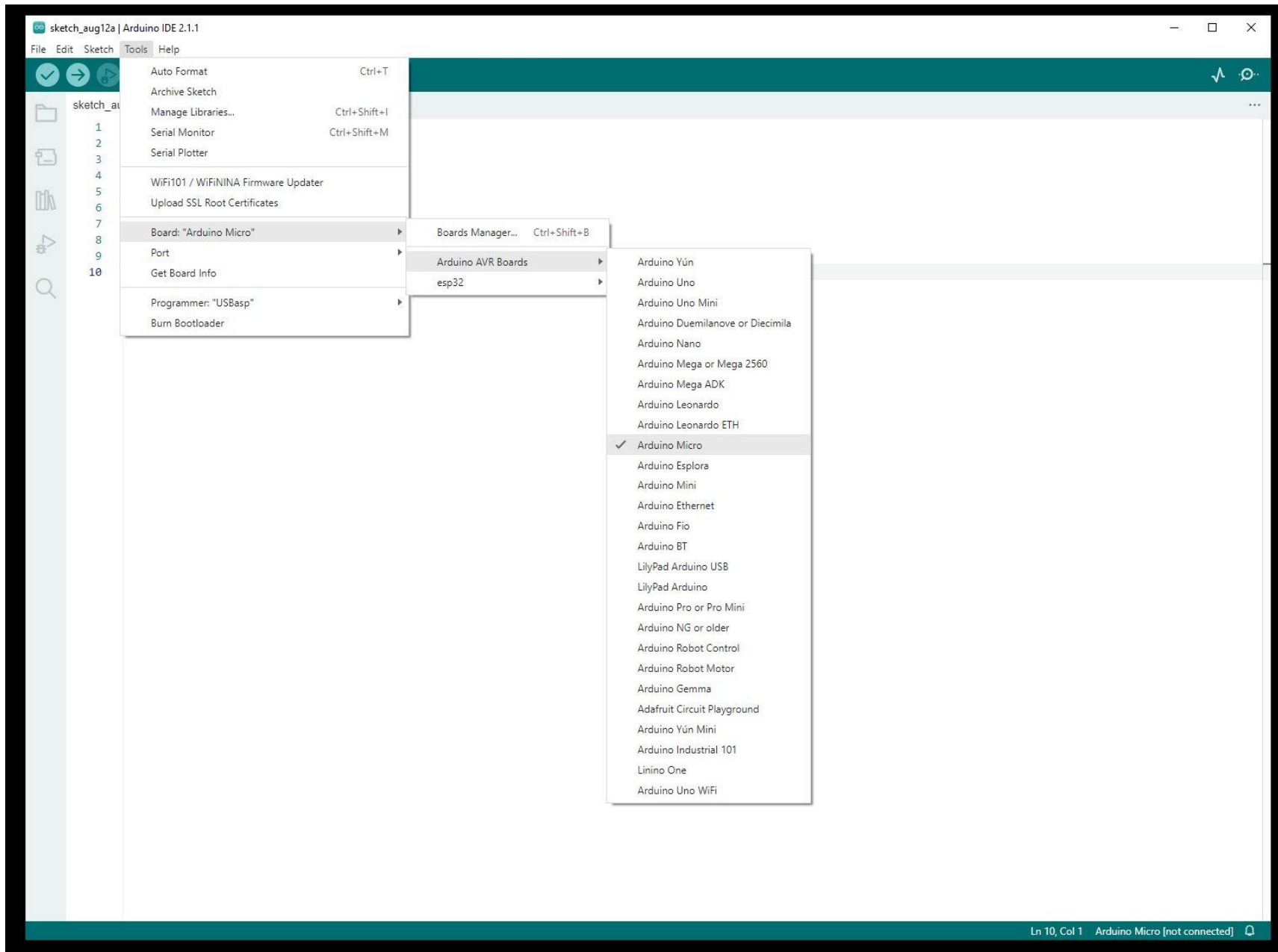
There are two problems, first to find the proper bootloader hex file. There are some files on the GitHub repository, but I was not able to find this specific one, nor could I find a clear explanation where those hex files are located.

The second problem is that even with this hex file programmed the chip doesn't work simply because the file does not include the required configuration words /the fuses/.

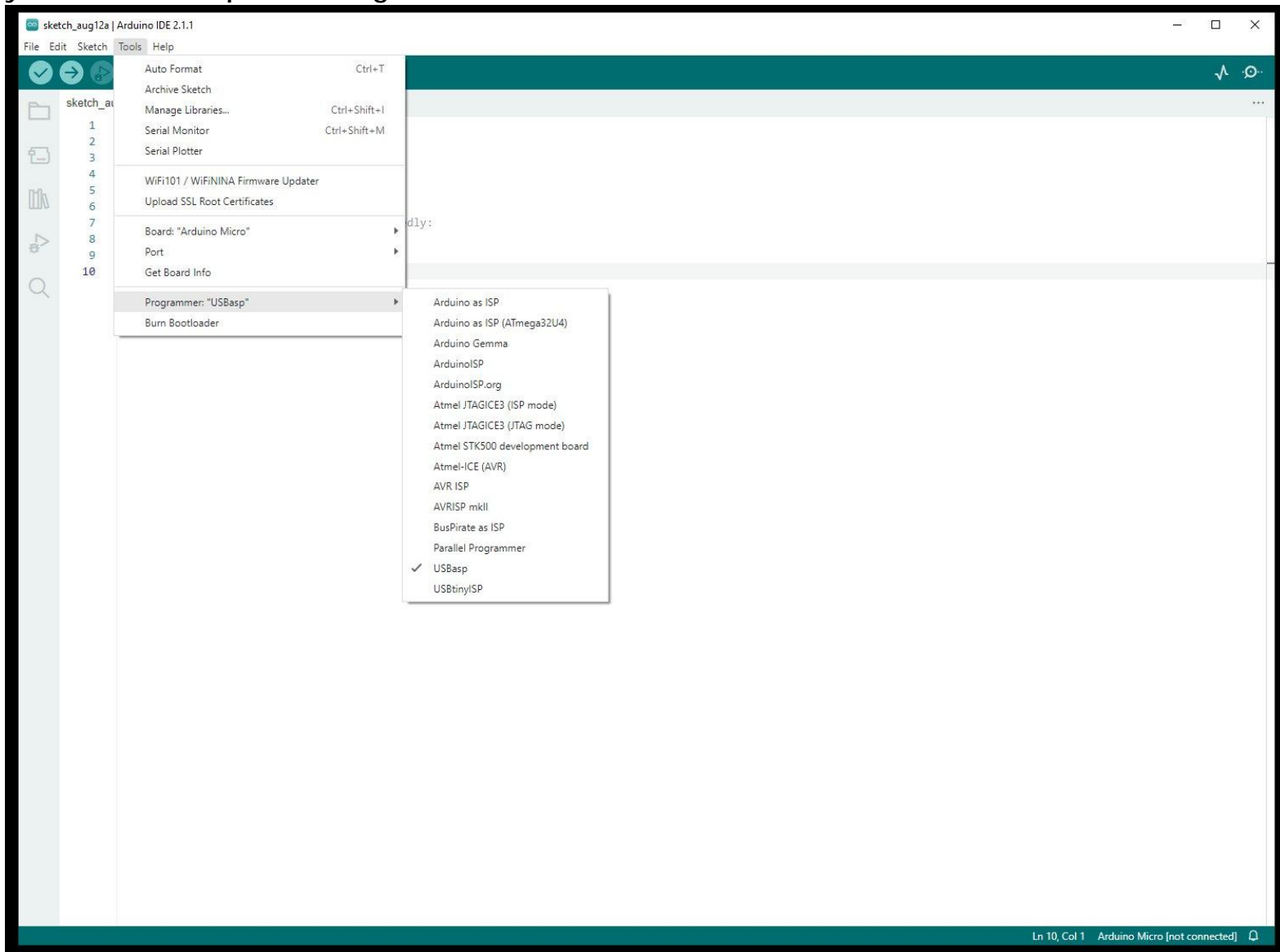
The first part of the job is to obtain the hex file and the fuses, that become to be quite simple task, probably many Arduino experts are familiar with this, but I think majority of the Arduino users are not exactly and experts, and most of the old school designer like me don't want to touch the Arduino products or IDE.

So here the simple steps, that waste me few hours:

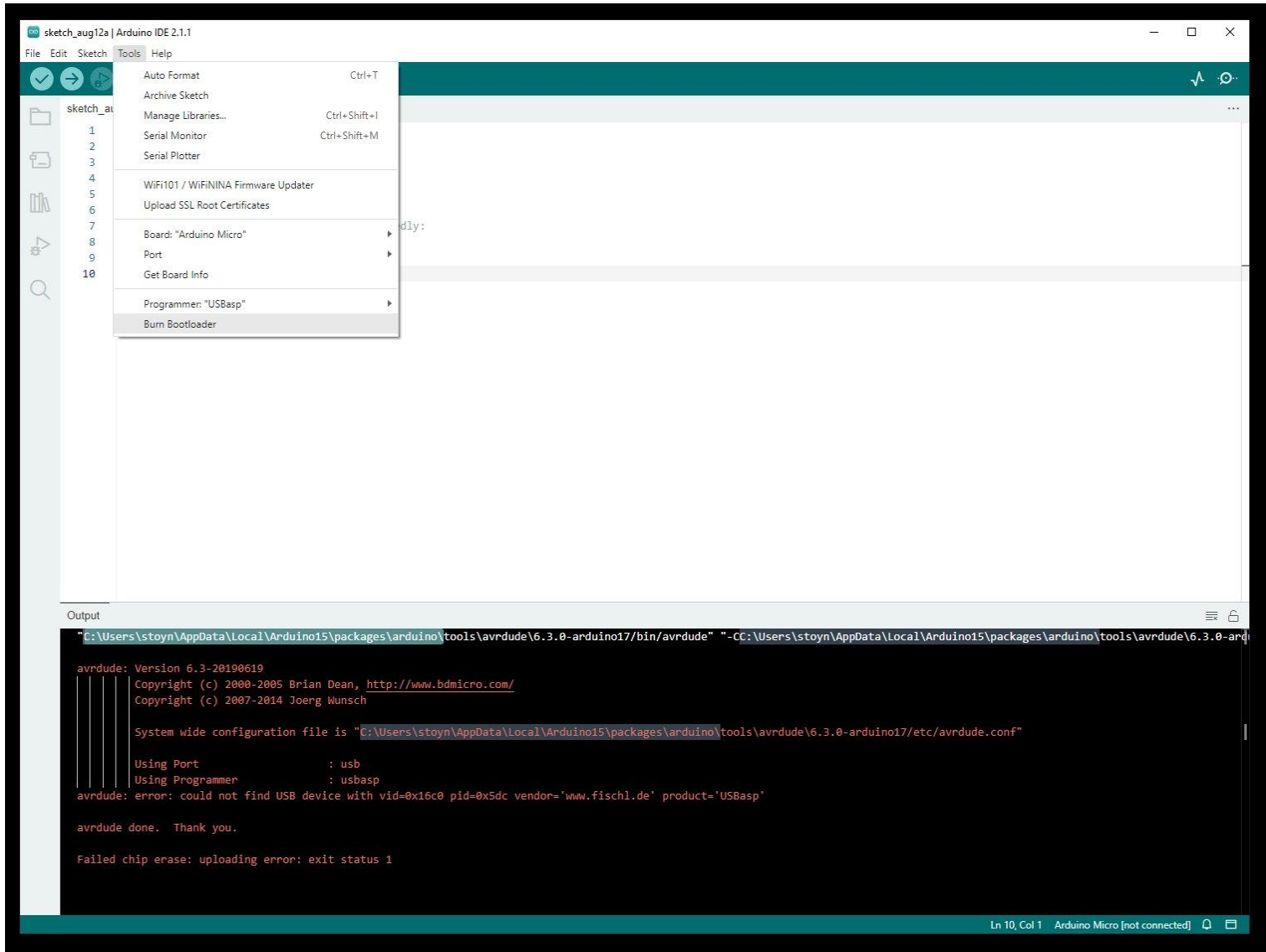
1. Set the Arduino with the board which firmware you want to use, in my case my design is very similar to the Arduino Micro.



2. Choose any of the supported programming interfaces, in my case USBasp, you no need to have it, but you need to setup something.



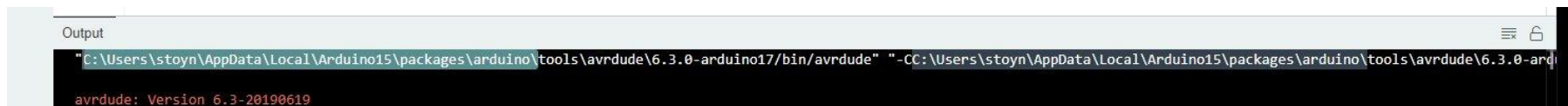
3. From tools click on "Burn bootloader"



The process naturally will fail, if you have one of the supported programming interfaces then you no need to read further, your board is already with the proper firmware.

In the top of the output window you will see the command line executed. From this line you need two things :

4. – the path where to search for the bootloader hex



```
Output
"C:\Users\stoy\n\AppData\Local\Arduino15\packages\arduino\tools\avrduide\6.3.0-arduino17\bin/avrduide" "-CC:\Users\stoy\n\AppData\Local\Arduino15\packages\arduino\tools\avrduide\6.3.0-ard
avrduide: Version 6.3-20190619
```

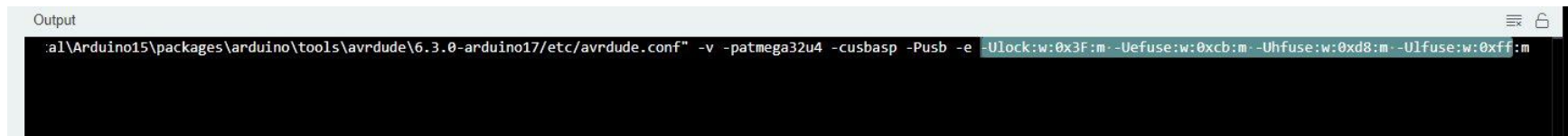
In that case : C:\Users\stoy\n\AppData\Local\Arduino15\packages\arduino\

And the full path to the AVR firmware we looking for is :

C:\Users\stoy\n\AppData\Local\Arduino15\packages\arduino\hardware\avr\1.8.6\bootloaders\caterina\Cat
erina-Micro.hex

This is the .hex file you need to load in to your programming software.

5. The configuration bytes low, high, extended and protection
You may find those at the end of the same line :



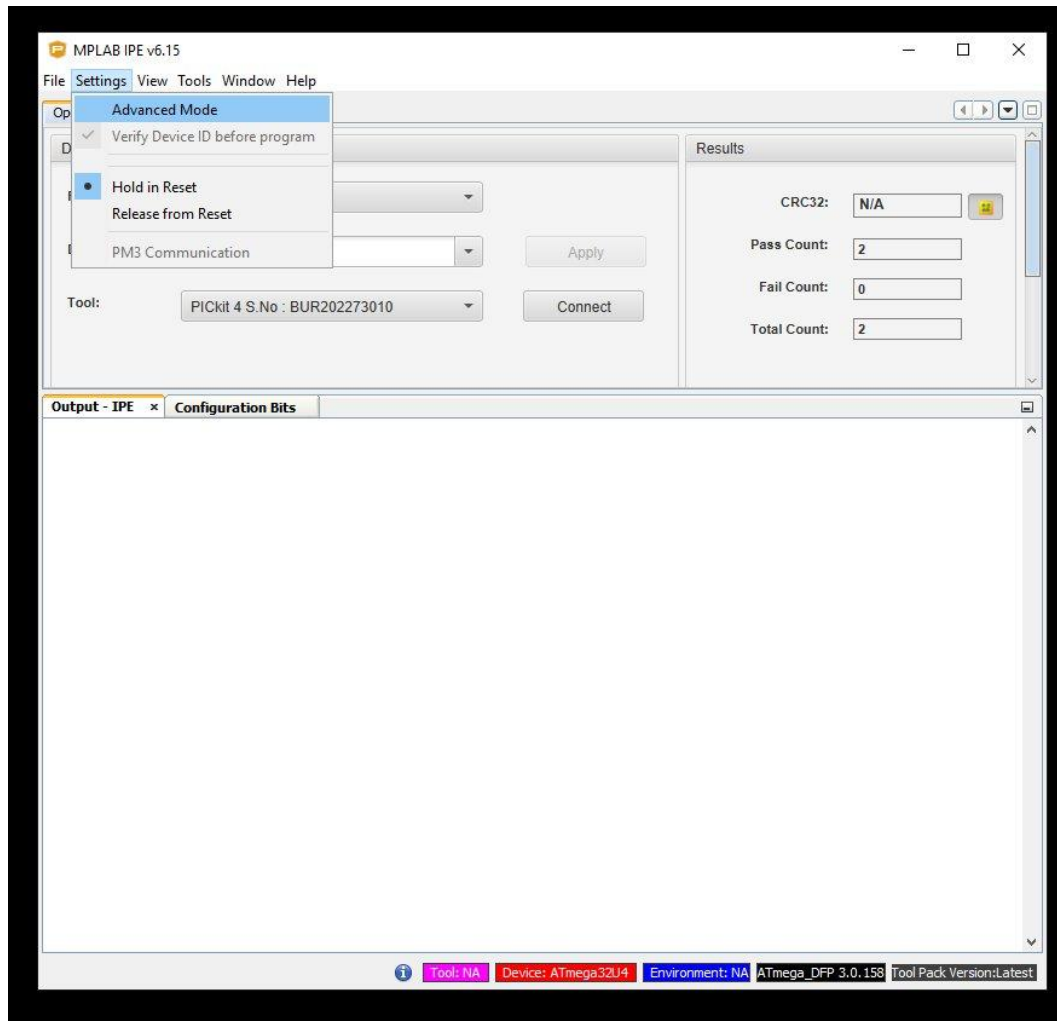
```
Output
al\Arduino15\packages\arduino\tools\avrduide\6.3.0-arduino17/etc/avrduide.conf" -v -patmega32u4 -cusbasp -Push -e -Ulock:w:0x3F:m -Uefuse:w:0xcb:m -Uhfuse:w:0xd8:m -Ulfuse:w:0xff:m
```

For this specific boards they are :

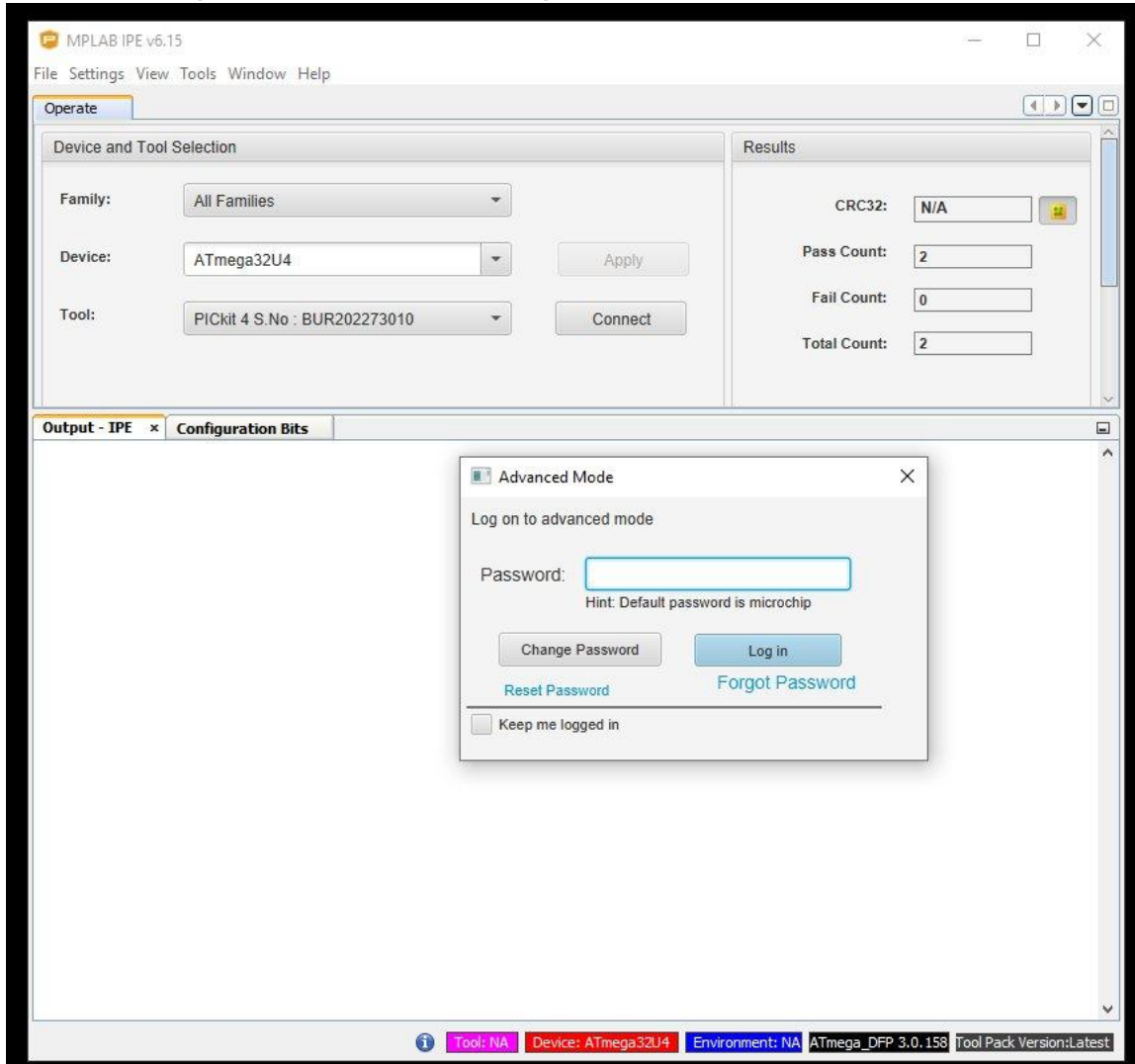
Low, 0xFF , High - 0xD8, Extended 0xF4 , Locked - 0xFF

With this you have both component required, the next steps are specific for Microchip IPE, but they will be similar to any other software.

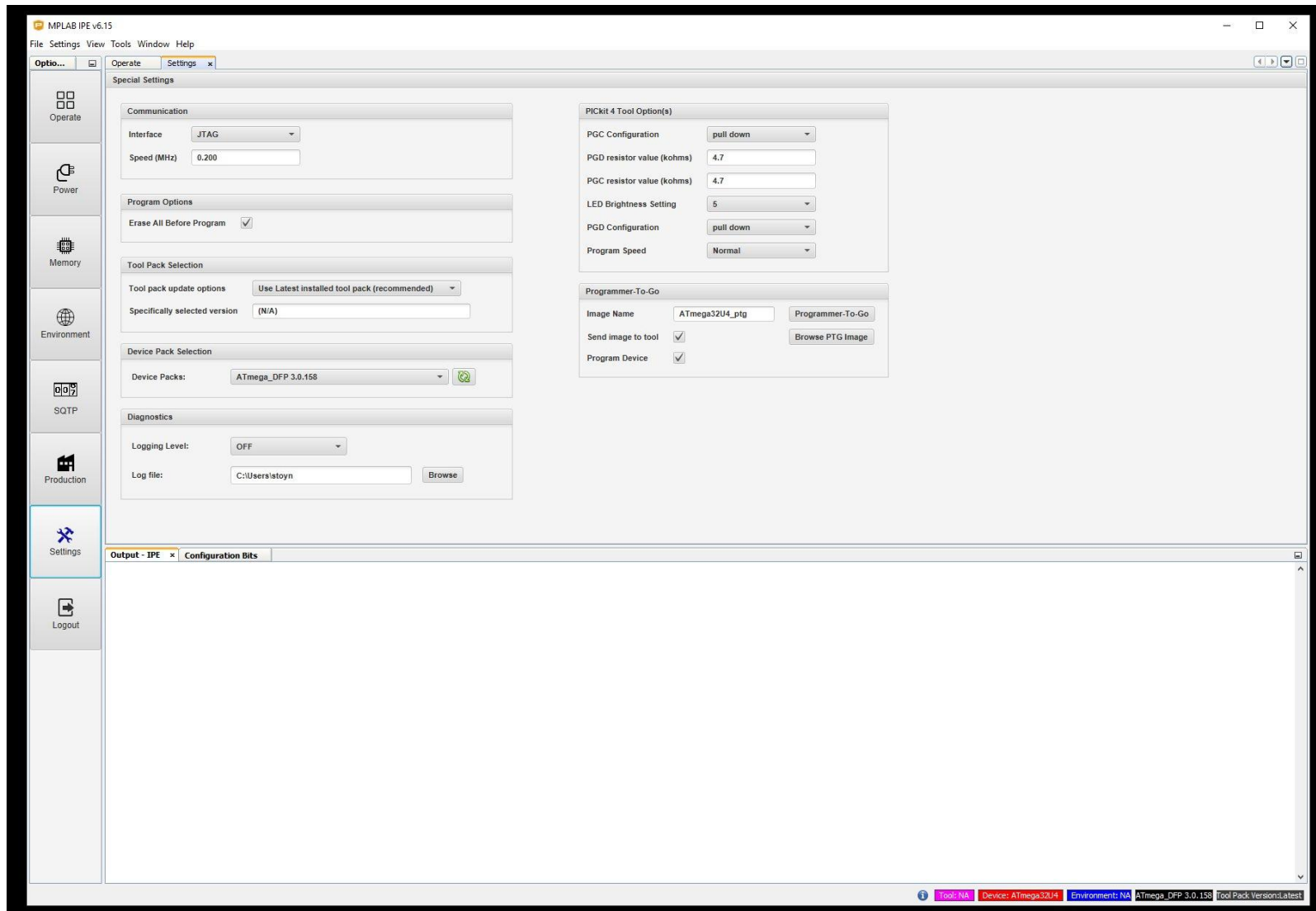
6. Switch in to Advance mode



7. The default password is "microchip"



8. Go to settings, and choose settings tab.



Here you need to choose the programming interface, in the case of PickKit4 this would be ISP.

The screenshot shows the MPLAB IPE v6.15 software interface. The 'Settings' window is open to the 'Special Settings' tab. The 'Communication' section has the 'Interface' dropdown menu open, showing 'JTAG' and 'ISP' options, with 'ISP' selected. The 'Program Options' section has 'Erase All Before Program' checked. The 'Tool Pack Selection' section has 'Use Latest installed tool pack (recommended)' selected. The 'Device Pack Selection' section has 'ATmega_DFP 3.0.158' selected. The 'Diagnostics' section has 'Logging Level' set to 'OFF' and a log file path 'C:\Users\stoy...' with a 'Browse' button. The 'PICKIT 4 Tool Option(s)' section has 'PGC Configuration' set to 'pull down', 'PGD resistor value (kohms)' set to '4.7', 'LED Brightness Setting' set to '5', and 'Program Speed' set to 'Normal'. The 'Programmer-To-Go' section has 'Image Name' set to 'ATmega32U4_ptg', 'Send image to tool' checked, and 'Program Device' checked. The status bar at the bottom shows 'Tool: NA', 'Device: ATmega32U4', 'Environment: NA', 'ATmega_DFP 3.0.158', and 'Tool Pack: Version:latest'.

Also set the programing speed to low

The screenshot shows the MPLAB IPE v6.15 Settings window. The 'Special Settings' tab is active, displaying various configuration options. The 'Program Speed' dropdown menu is open, showing 'Normal' and 'Low' options, with 'Low' selected. The 'Communication' section shows 'Interface' set to 'ISP' and 'Speed (MHz)' set to '0.200'. The 'Program Options' section has 'Erase All Before Program' checked. The 'Tool Pack Selection' section shows 'Use Latest installed tool pack (recommended)' selected. The 'Device Pack Selection' section shows 'ATmega_DFP 3.0.158' selected. The 'Diagnostics' section shows 'Logging Level' set to 'OFF' and 'Log file' set to 'C:\Users\stoyin'. The 'PICkit 4 Tool Option(s)' section shows 'PGC Configuration' set to 'pull down', 'PGD resistor value (kohms)' set to '4.7', 'LED Brightness Setting' set to '5', and 'Program Speed' set to 'Low'. The 'Programmer-To-Go' section shows 'Image Name' set to 'ATmega32U4_ptg', 'Send image to tool' checked, and 'Program Device' checked. The status bar at the bottom shows 'Tool: NA', 'Device: ATmega32U4', 'Environment: NA', 'ATmega_DFP 3.0.158', and 'Tool Pack: Version: Latest'.

MPLAB IPE v6.15
File Settings View Tools Window Help

Optio... Operate Settings x

Special Settings

Communication

Interface: ISP
Speed (MHz): 0.200

Program Options

Erase All Before Program:

Tool Pack Selection

Tool pack update options: Use Latest installed tool pack (recommended)
Specifically selected version: (N/A)

Device Pack Selection

Device Packs: ATmega_DFP 3.0.158

Diagnostics

Logging Level: OFF
Log file: C:\Users\stoyin

PICkit 4 Tool Option(s)

PGC Configuration: pull down
PGD resistor value (kohms): 4.7
LED Brightness Setting: 5
PGD Configuration: pull down
Program Speed: Normal (dropdown menu open showing Normal, Low)

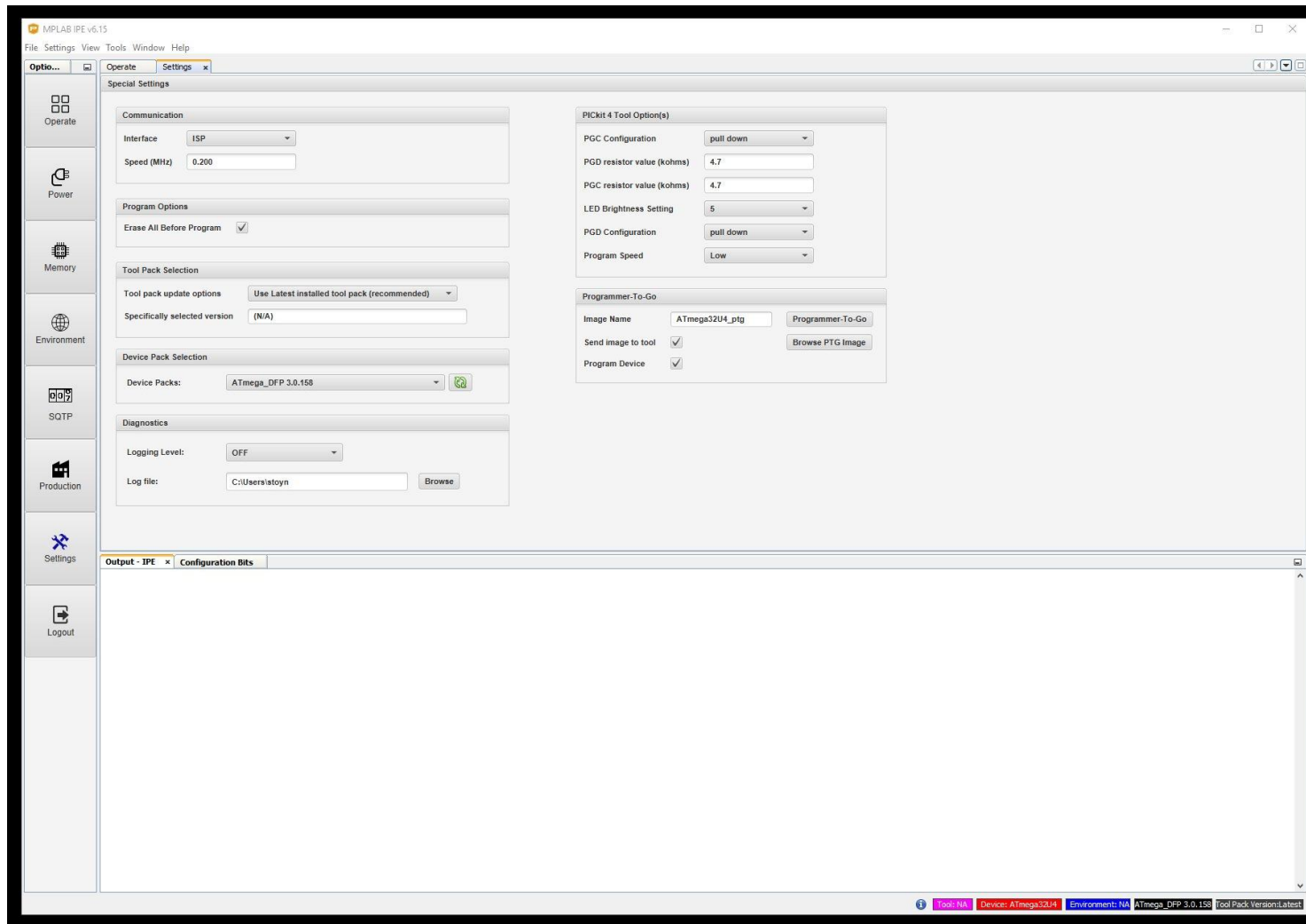
Programmer-To-Go

Image Name: ATmega32U4_ptg
Send image to tool:
Program Device:

Output - IPE x Configuration Bits

Tool: NA Device: ATmega32U4 Environment: NA ATmega_DFP 3.0.158 Tool Pack: Version: Latest

This how the settings tab should look when you done.



9. Set the target and connect.

The screenshot displays the MPLAB IPE v6.15 software interface. The window title is "MPLAB IPE v6.15" and the menu bar includes "File", "Settings", "View", "Tools", "Window", and "Help".

The interface is divided into several sections:

- Left Sidebar:** Contains icons for Operate, Power, Memory, Environment, SQTP, Production, Settings, and Logout.
- Operate Tab:** The active tab, showing:
 - Device and Tool Selection:** Family: All Families, Device: ATmega32U4, Tool: PICKit 4 S.No : BUR202273010. Buttons for Apply and Disconnect are present.
 - Results:** CP=OFF Checksum: N/A, CRC32: N/A, Pass Count: 2, Fail Count: 0, Total Count: 2.
 - Actions:** Program, Erase, Read, Verify, Blank Check buttons.
 - Hex File:** Click on browse to select a hex file. Buttons: Browse, Clear selection.
 - SQTP File:** Click on browse to select a SQTP file. Buttons: Browse, Clear selection.
- Output - IPE x Configuration Bits:** A text area showing connection logs:

```
.....  
  
Connecting to MPLAB PICKit 4  
  
Currently loaded versions:  
Application version.....02.00.05  
Boot version.....01.00.00  
PCB version.....4  
Script version.....00.06.05  
Script build number.....d39d75d73  
Tool pack version.....2.1.1763  
Target voltage detected  
Target device ATmega32U4 found.  
Device Revision Id = 0x0 (A)  
Device Id = 0x87
```
- Bottom Status Bar:** Displays: Tool: PICKit 4 S.No : BUR202273010, Device: ATmega32U4, Environment: NA, ATmega_DFP 3.0.158, Tool Pack Version: latest.

10. Load the bootloader hex file

The screenshot displays the MPLAB IPE v6.15 software interface. The main window is titled 'Settings' and is divided into several sections:

- Device and Tool Selection:** Family: All Families, Device: ATmega32U4, Tool: PICkit 4 S.No : BUR202273010. Buttons for 'Apply' and 'Disconnect' are visible.
- Results:** CP=OFF Checksum: N/A, CRC32: N/A, Pass Count: 2, Fail Count: 0, Total Count: 2.
- Buttons:** Program, Erase, Read, Verify, Blank Check.
- Hex File:** Click on browse to select a hex file. A 'Browse' button is present.
- SQTP File:** Click on browse to select a SQTP file.

A 'Hex file selection' dialog box is open, showing the file path: <code>C:\AppData\Local\Arduino15\packages\arduino\hardware\avr\1.8.6\bootloaders\caterina</code>. The file list contains the following entries:

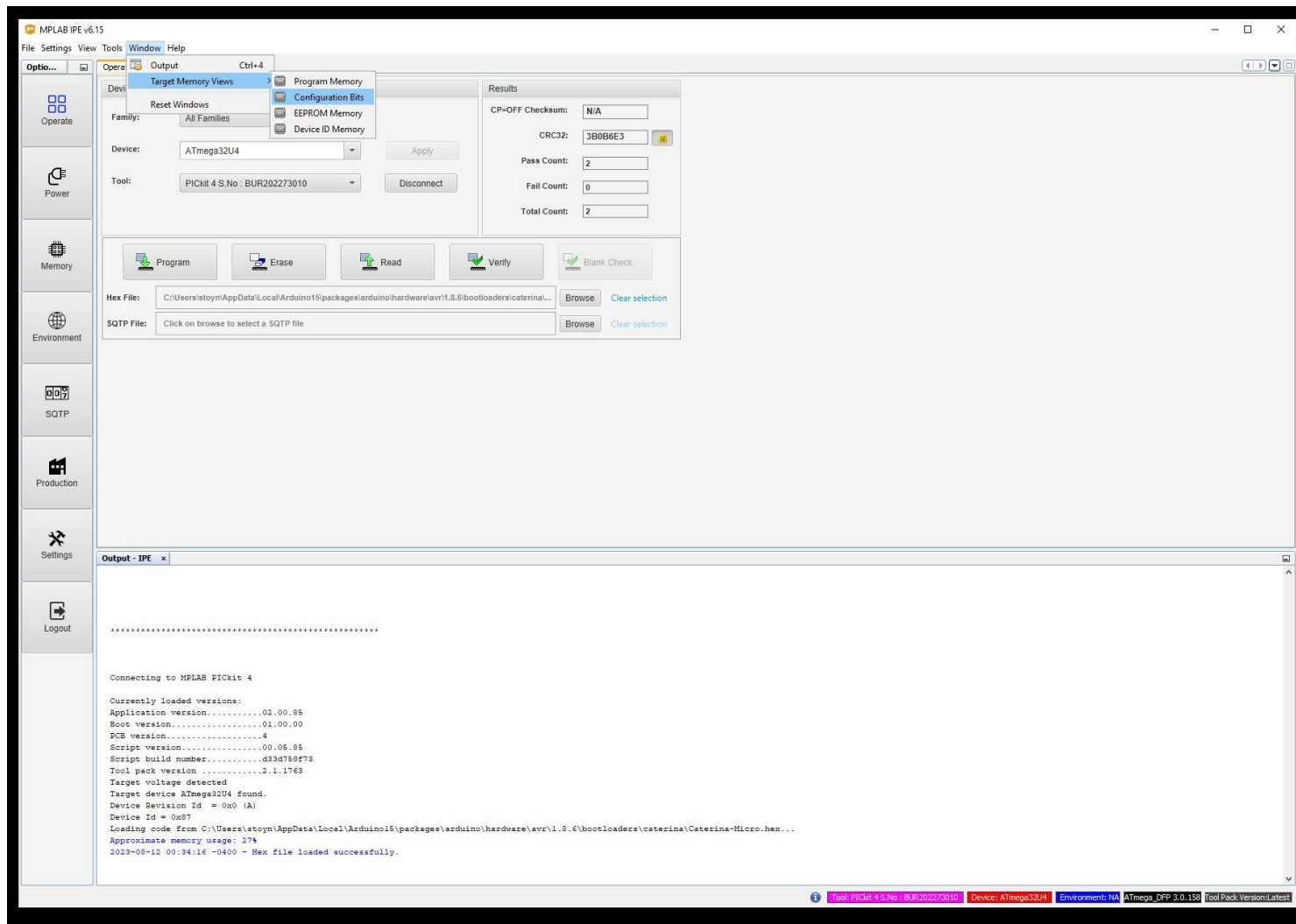
Name	Date
Caterina-Circuitplay32u4.hex	5/26
Caterina-Esplora.hex	5/26
Caterina-Industrial101.hex	5/26
Caterina-Leonardo.hex	5/26
Caterina-LeonardoEthernet.hex	5/26
Caterina-LininoOne.hex	5/26
Caterina-Micro.hex	5/26
Caterina-Yun.hex	5/26
Caterina-YunMini.hex	5/26
Caterina-Yun-noblink.hex	5/26
Esplora-prod-firmware-2012-12-10.hex	5/26
Leonardo-prod-firmware-2012-04-26.hex	5/26
Leonardo-prod-firmware-2012-12-10.hex	5/26
Micro-prod-firmware-2012-11-23.hex	5/26
Micro-prod-firmware-2012-12-10.hex	5/26

The 'File name' field in the dialog is set to 'Caterina-Micro.hex' and the file type is 'HEX File (*.HEX;*.hex)'. The 'Open' button is highlighted.

The background 'Output - IPE' window shows the following log output:

```
.....  
Connecting to MPLAB PICkit 4  
Currently loaded versions:  
Application version.....02.00.85  
Boot version.....01.00.00  
PCB version.....4  
Script version.....00.05.85  
Script build number.....d33d758f73  
Tool pack version.....2.1.1763  
Target voltage detected  
Target device ATmega32U4 found.  
Device Revision Id = 0x0 (A)  
Device Id = 0x87
```

- 11. You may program the HEX to the chip, but the board will not work until you load the proper configuration words.
- 12. Go to Windows / Target Memory / Configuration Bits



You should be able to see the configuration bits tab

The screenshot shows the MPLAB IDE v6.15 interface. The 'Settings' tab is active, displaying device and tool selection options. The 'Device and Tool Selection' section shows:

- Family: All Families
- Device: ATmega32U4
- Tool: PICkit 4 S.No : BUR202273010

 The 'Results' section shows:

- CP-OFF Checksum: N/A
- CRC32: 3B0B6E3
- Pass Count: 2
- Fail Count: 0
- Total Count: 2

 Below these are buttons for Program, Erase, Read, Verify, and Blank Check. The 'Hex File' and 'SQTP File' fields are also visible.

The 'Output - IPE' window is open to the 'Configuration Bits' tab, displaying a table of configuration bits:

Address	Name	Value	Field	Option	Category	Setting	
820000	LOW	52	SUT_CRSEL	INTRCOSC 6CK 4MS1	Select Clock Source	Int. RC Osc.: Start-up time: 6 CK + 4.1 ms	
			CRDUT	CLEAR	Clock output on PORC7	CLEAR	
			CRDIV8	SET	Divide clock by 8 internally	SET	
	820001	HIGH	99	BOOTRST	CLEAR	Boot Reset vector Enabled	CLEAR
				BOOTSZ	2048W_3800	Select Boot Size	Boot Flash size=2048 words start address=43800
			EESAVE	CLEAR	Preserve EEPROM through the Chip Erase cycle	CLEAR	
		WDTON	CLEAR	Watchdog timer always on	CLEAR		
		SPIEN	SET	Serial program downloading (SPI) enabled	SET		
		JTAGEN	SET	JTAG Interface Enabled	SET		
		OCDEN	CLEAR	On-Chip Debug Enabled	CLEAR		
820002	EXTENDED	FB	BODLEVEL	2V6	Brown-out Detector trigger level	Brown-out detection at VCC=2.6 V	
			HWBDE	CLEAR	Hardware Boot Enable	CLEAR	
830000	LOCKBIT	FF	LB	NO_LOCK	Memory Lock	No memory lock features enabled	
			BLBO	NO_LOCK	Boot Loader Protection Mode	No lock on SPM and LPM in Application Section	
			BLBI	NO_LOCK	Boot Loader Protection Mode	No lock on SPM and LPM in Boot Section	

At the bottom of the window, a status bar shows:

- Tool: PICkit 4 S.No : BUR202273010
- Device: ATmega32U4
- Environment: NA
- ATmega_DFP 3.0.158
- Tool Pack Version: Latest

13. Read the configuration word from the target device – the upper green arrow

The screenshot shows the MPLAB IPE v6.15 interface. The 'Device and Tool Selection' section is configured with Family: All Families, Device: ATmega32U4, and Tool: PICKit 4 S.No : BUR202273010. The 'Results' section shows CP=OFF Checksum: N/A, CRC32: 3B0B6E3, Pass Count: 2, Fail Count: 0, and Total Count: 2. The 'Read' button is highlighted with a green arrow. The 'Output - IPE' window shows the 'Read Configuration Bits' table.

Address	Name	Value	Field	Option	Category	Setting
Read Configuration Bits						
	SUI_CKSEL	FF	EXTXOSC	8MHZ XX 16KCK 65MS	Select Clock Source	Ext. Crystal Osc. 8.0- MHz; Start-up time: 16K CK +...
	CKOUT		CLEAR		Clock output on PORTC7	CLEAR
	CKDIV8		CLEAR		Divide clock by 8 internally	CLEAR
020001	HIGH	D8	BOOTRST	SET	Boot Reset vector Enabled	SET
	BOOTSZ		2048W_3800		Select Boot Size	Boot Flash size=2048 words start address=3800
	EESAVE		CLEAR		Preserve EEPROM through the Chip Erase cycle	CLEAR
	WDTON		CLEAR		Watchdog timer always on	CLEAR
	SPIEN		SET		Serial program downloading (SPI) enabled	SET
	JTAGEN		CLEAR		JTAG Interface Enabled	CLEAR
	OCDEN		CLEAR		On-Chip Debug Enabled	CLEAR
020002	EXTENDED	F4	BODLEVEL	2V4	Brown-out Detector trigger level	Brown-out detection at VCC=2.4 V
	HWBE		SET		Hardware Boot Enable	SET
030000	LOCKBIT	FF	LB	NO_LOCK	Memory Lock	No memory lock features enabled
	BLB0		NO_LOCK		Boot Loader Protection Mode	No lock on SPM and LPM in Application Section
	BLB1		NO_LOCK		Boot Loader Protection Mode	No lock on SPM and LPM in Boot Section

14. Once loaded from the target you will be able to change the configuration bits.

The screenshot shows the MPLAB IDE v6.15 interface. The 'Settings' window is open, displaying the 'Configuration Bits' tab. The 'Device and Tool Selection' section shows the device is set to ATmega32U4 and the tool is PICKit 4 S.No : BUR202273010. The 'Results' section shows the CP=OFF Checksum as N/A, CRC32 as 3B0B6E3, Pass Count as 2, Fail Count as 0, and Total Count as 2. The 'Output - IPE' window at the bottom displays a table of configuration bits.

Address	Name	Value	Field	Option	Category	Setting
820000	LOW	FF	SUT_CKSEL	EXTOSC 8MHZ XX 16KCK 65MS	Select Clock Source	Ext. Crystal Osc. 8.0- MHz; Start-up time: 16K CK +...
			CKOUT	CLEAR	Clock output on PORTC7	CLEAR
			CKDIV8	CLEAR	Divide clock by 8 internally	CLEAR
820001	HIGH	D8	BOOTRST	SET	Boot Reset vector Enabled	SET
			BOOTSZ	2048W_3800	Select Boot Size	Boot Flash size=2048 words start address=3800
			EESAVE	CLEAR	Preserve EEPROM through the Chip Erase cycle	CLEAR
			WDTON	CLEAR	Watchdog timer always on	CLEAR
			SPIEN	SET	Serial program downloading (SPI) enabled	SET
			JTAGEN	CLEAR	JTAG Interface Enabled	CLEAR
			OCDEN	CLEAR	On-Chip Debug Enabled	CLEAR
820002	EXTENDED	F4	BODLEVEL	2V4	Brown-out Detector trigger level	Brown-out detection at VCC=2.4 V
			HWBDE	SET	Hardware Boot Enable	SET
830000	LOCKBIT	FF	LB	NO_LOCK	Memory Lock	No memory lock features enabled
			BLB0	NO_LOCK	Boot Loader Protection Mode	No lock on SPM and LPM in Application Section
			BLB1	NO_LOCK	Boot Loader Protection Mode	No lock on SPM and LPM in Boot Section

Unfortunately you can't change the whole byte as a hex value, but need to change the options themselves to match your configuration bytes.

Keep on mind that the active /set is equal 0. Programmed = active=set = 0, unprogrammed = not active = disabled = 1.

15. Load the new configuration bytes to the target device clicking on the lower green arrow.

You are done, now the host should recognize the board as Arduino Micro and a serial port should appear in your device manager.