phyCORE-AT91M55800A

QuickStart Instructions

Using Keil's ULINK and the Keil ARM7/µVision3 Software Development Tool Chain

Note: The PHYTEC Spectrum CD includes the electronic version of the English phyCORE-AT91M55800A Hardware Manual

Edition: July 2005

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1 Introduction to the Rapid Development Kit

This QuickStart provides:

- general information on the PHYTEC phyCORE-AT91M55800A Single Board Computer (SBC),
- an overview of Keil's ARM7/µVision3 software development tool chain evaluation version, and
- instructions on how to run example programs on the phyCORE-AT91M55800A , mounted on the PHYTEC phyCORE Development Board HD200, in conjunction with the Keil ULINK and software tools

Please refer to the phyCORE-AT91M55800A Hardware Manual for specific information on such board-level features as jumper configuration, memory mapping and pin layout. Selecting the links on the electronic version of this document links to the applicable section of the phyCORE-AT91M55800A Hardware Manual.

1.1 Rapid Development Kit Documentation

This "Rapid Development Kit" (RDK) includes the following electronic documentation on the enclosed "PHYTEC Spectrum CD-ROM":

- the PHYTEC phyCORE-AT91M55800A Hardware Manual
- controller User's Manuals and Data Sheets
- this QuickStart Instruction with general "Rapid Development Kit" description, software installation hints and three example programs enabling quick out-of-the box start-up of the phyCORE-AT91M55800A in conjunction with the Keil ARM7/µVision3 software development tool chain

1.2 Overview of this QuickStart Instruction

This QuickStart Instruction gives a general "Rapid Development Kit" description, as well as software installation hints and three example programs enabling quick out-of-the box start-up of the phyCORE-AT91M55800A in conjunction with the Keil ULINK and ARM7/µVision3 software tools. It is structured as follows:

1) The *"Getting Started"* section uses two example programs: *Blinky* and *Hello* to demonstrate the download of user code to the Flash device using the Keil ULINK and ARM7/µVision3 software tools
2) The *"Getting More Involved"* section provides step-by-step instructions on how to modify both examples, create and build new projects and generate and download output files to the phyCORE-AT91M55800A using the Keil tools.
3) The *"Debugging"* section provides a third example program - "Debug" - to demonstrate simple debug functions using the Keil µVision3 debug environment.

In addition to dedicated data for this Rapid Development Kit, the PHYTEC Spectrum CD-ROM contains supplemental information on embedded microcontroller design and development.

1.3 System Requirements

Use of this "Rapid Development Kit" requires:

- the PHYTEC phyCORE-AT91M55800A
- the phyCORE Development Board HD200 with the included DB-9 serial cable and AC adapter supplying 5 VDC /min. 500 mA
- the Keil ULINK JTAG-USB adapter, **not** included in the standard Rapid Development Kit version[1]
- the PHYTEC Spectrum CD for ARM7
- an IBM-compatible host-PC (486 or higher running at least Windows95/NT)

For more information and example updates, please refer to the following sources:

http://www.phytec.com - or - http://www.phytec.de
support@phytec.com - or - support@phytec.de

http://www.keil.com
support@keil.com

[1]: The Keil ULINK is included in the Rapid Development Kit version with the part number KPCM-014-SK-Keil.

1.4 The PHYTEC phyCORE-AT91M55800A

The phyCORE-AT91M55800A represents an affordable yet highly functional Single Board Computer (SBC) solution in sub-miniature dimensions (60 x 53 mm). The standard module is populated with an Atmel AT91M55800A controller.

All applicable data/address lines and signals extend from the underlying logic devices to two high-density Molex SMT pin header connectors (pin width is 0.635 mm/25 mil) lining the circuit board edges. This enables the phyCORE-AT91M55800A to be plugged like a "big chip" into target hardware.

The standard module runs at a 32 MHz internal clock speed (delivering 31.25 ns instruction cycle) and offers 512 kByte (up to 8 MByte) SRAM and 1 MByte (up to 16 MByte) Flash on-board for DATA and CODE storage.

The module communicates by means of three RS-232 transceivers, two CAN bus interfaces, and a CS8900A 10Base-T Ethernet controller which enables implementation of the module in embedded Internet applications. The phyCORE-AT91M55800A operates within a standard temperature range of 0 to +70°C and requires only a 220 mA power source.

The Keil ARM/µVision3 software tools, in conjunction with the Keil ULINK adapter, enables easy on-board download of user programs.

The phyCORE-AT91M55800A offers the following features:

- subminiature Single Board Computer (60 x 53 mm) achieved through modern SMD technology
- populated with the Atmel AT91M55800A microcontroller (BGA-176 package)
- improved interference safety achieved through multi-layer PCB technology and dedicated Ground pins
- controller signals and ports extend to two 100-pin high-density (0.635 mm) Molex connectors aligning two sides of the board, enabling it to be plugged like a “big chip” into target application
- 16-bit, de-multiplexed bus mode
- 32 MHz clock frequency (31.25 ns instruction cycle)
- 128 MByte address space
- 1 MByte (up to 16 MByte) on-board Flash[1]
- on-board Flash programming, no dedicated Flash programming voltage required through use of 3.3 V Flash devices
- 512 kByte (up to 8 MByte) RAM on-board, max. 2 MByte at 0 wait states[1]
- RS-232 transceiver for three serial interfaces
- CS8900A Ethernet controller with EEPROM
- 2 kByte (up to 8 kByte) SPI-EEPROM[1]
- up to 6 free Chip Select signals for easy connection of peripherals
- one operating voltage for core & peripherals, 3.3 V, typ. <150 mA

[1] : Please contact PHYTEC for more information about additional module configurations.

The phyCORE Development Board HD200, in EURO-card dimensions (160 x 100 mm) is fully equipped with all mechanical and electrical components necessary for the speedy and secure insertion and subsequent programming of most PHYTEC phyCORE high-density series Single Board Computers. Simple jumper configuration readies the Development Board's connection to the phyCORE-AT91M55800A, which plugs into the receptacle contact strips mounted on the Development Board HD200.

phyCORE Development Board HD200 Technical Highlights

- low voltage socket for supply with regulated input voltage 5 VDC
- additional supply voltages 3.3 VDC or 2.5 VDC
- two DB-9 sockets (P1A, P1B) configurable as RS-232 interfaces
- two additional DB-9 plugs (P2A, P2B) configurable as CAN interfaces
- simple jumper configuration allowing use of the phyCORE Development Board HD200 with various PHYTEC phyCORE high-density SBC's
- socket for RJ45 Ethernet transformer module
- one control LED D3 for quick testing of user software
- 2 x 160-pin Molex connector (X2) enabling easy connectivity to expansion boards (e.g. PHYTEC GPIO Expansion Board)

1.5 The Keil ARM7/µVision3 Software Development Tool Chain

Keil Software development tools for the ARM7 TDMI Architecture support every level of developer from the professional applications engineer to the student just learning about embedded software development. The Keil ARM7 compiler supports all ARM7-compatible devices including the Atmel AT91xxxx devices. For a complete list of supported ARM7 derivatives go to:

http://www.keil.com/dd/arm7chips.asp

µVision3, the latest version of Keil's popular IDE, combines project management, source code editing, program debugging, and Flash programming in a single, powerful environment. This QuickStart provides an overview of the most commonly used µVision3 features including:

- Project management, device setup, and tool configuration
- Integrates Keil ARM development tools in a single graphical user interface (GUI)
- Editor facilities for creating, modifying, and correcting programs
- JTAG/target debugging or CPU & peripheral simulation

Once installed, the default destination location for all ARM7 tools; executables; include, header and example files; as well as online help and documentation is the ***C:\Keil\Arm*** folder, while the µVision3 IDE is located at ***C:\Keil\Uv3***. You can start Keil µVision3 by selecting it from the *Programs* menu using the Windows *Start* button. The Keil µVision3 icon will also be placed on your desktop for easy startup of the development tools.

The new µVision3 editor offers many standard and advanced software editing features like:

- **Incremental Find** positions the cursor while you type the search phrase.
- **Active Brace Checking** shows nesting and highlights mismatches while entering parentheses, braces, or brackets.
- **Text Block Functions** that comment, indent, uppercase, tabify, and remove whitespace from text blocks.
- **Document-Selective Settings** for tab spacing and syntax coloring in Assembler, C, and other file types.
- Detailed **Syntax Highlighting** that allows you to define a user keyword list. Colors are used in printed output.
- Document **Outlining** that provides a quick overview of complex source files.

The ARM7 evaluation version, as provided on the PHYTEC Spectrum CD, has the following limitations:

- The µVision Debugger is limited to 16 kBytes.
- You may not use the Evaluation Version of the µVision IDE/Debugger to create commercial products.
- The GNU ARM tools (compiler, assembler, and so on) that are provided are not limited or restricted in any way.

The full DKARM Developer's Kit can be purchased through PHYTEC. Please contact our sales representatives for a quote.

For more information on Keil ARM7/µVision3 tools visit their website at:

http://www.keil.com/arm/

2 Getting Started

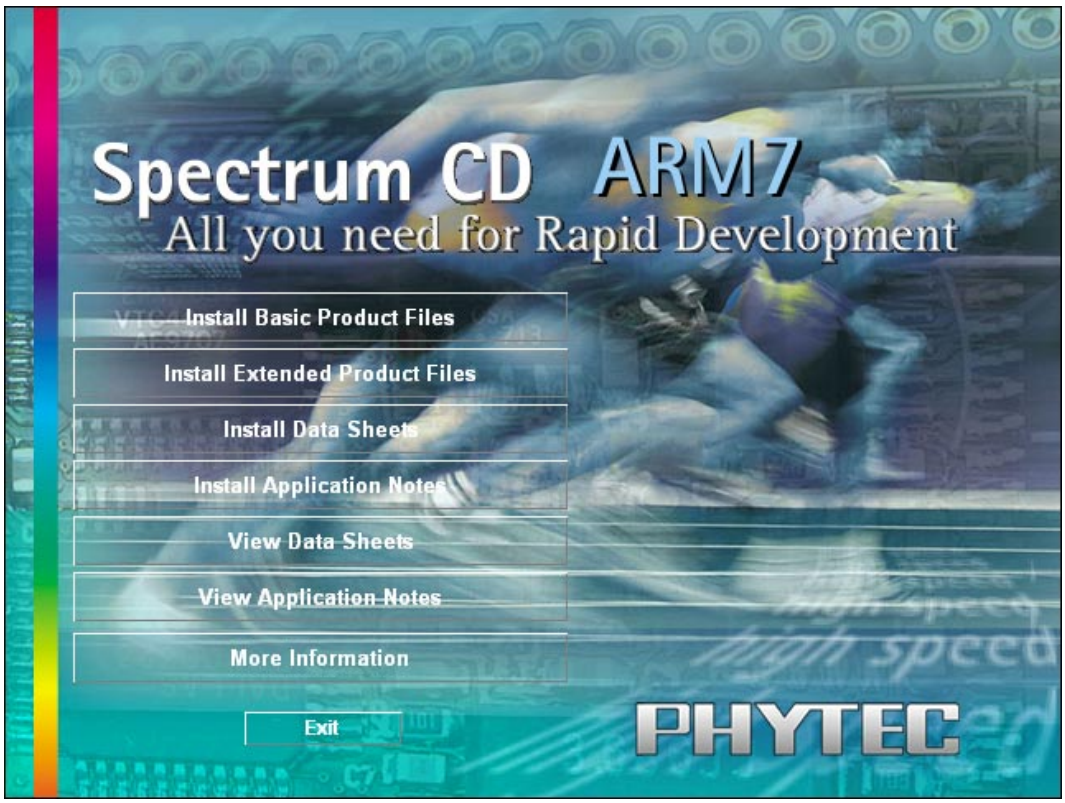
What you will learn with this Getting Started example:

- installing Rapid Development Kit software
- interfacing the phyCORE-AT91M55800A, mounted on the Development Board, to a host-PC using the Keil ULINK
- downloading example machine readable user code from a host-PC to the external Flash memory using ARM7/µVision3 tools

2.1 Installing Rapid Development Kit Software

When you insert the PHYTEC Spectrum CD into the CD-ROM drive of your host-PC, the PHYTEC Spectrum CD should automatically launch a setup program that installs the software required for the Rapid Development Kit as specified by the user. Otherwise the setup program ***start.exe*** can be manually executed from the root directory of the PHYTEC Spectrum CD.

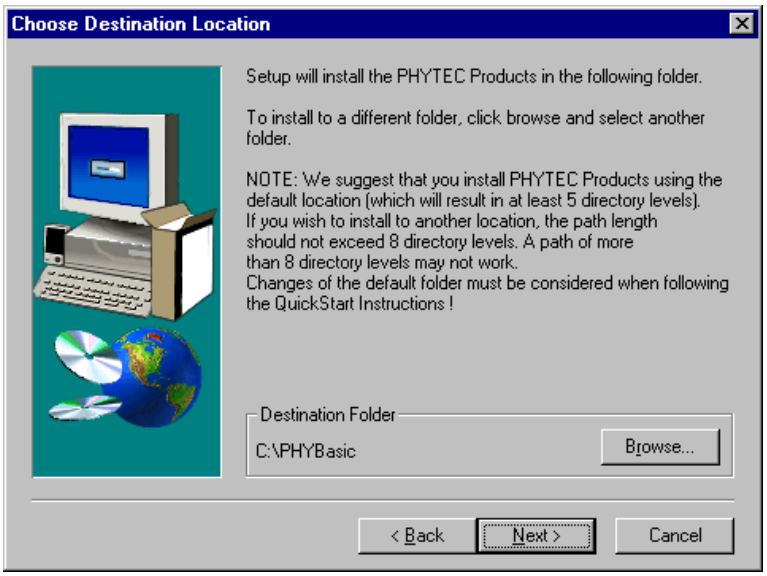
The following window appears:



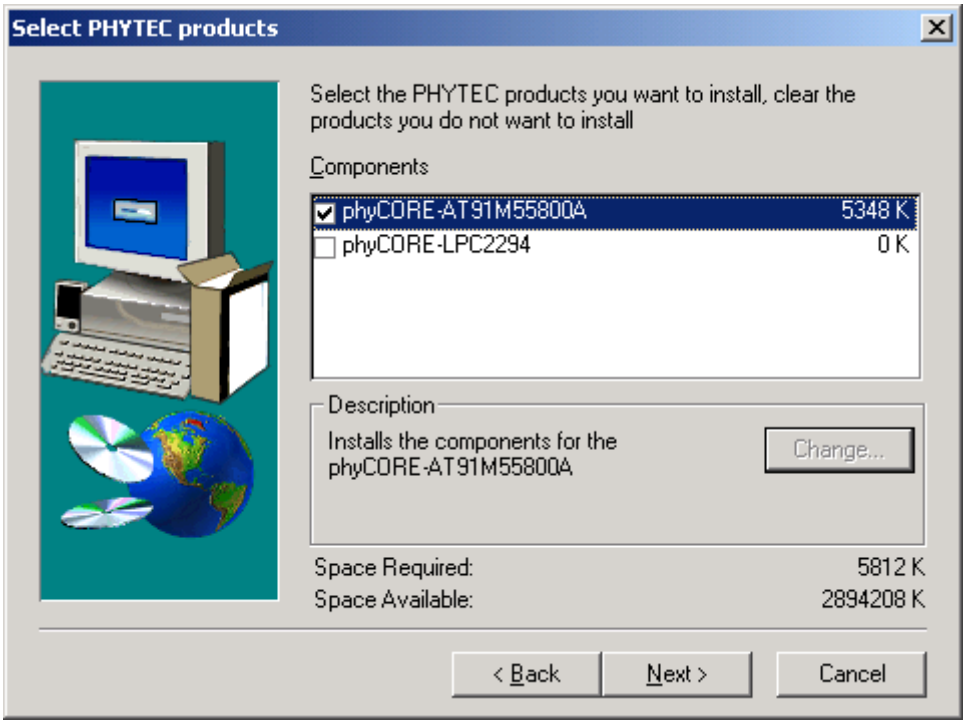
- Choose *Install Basic Product Files* Button.
- After accepting the *Welcome* window and license agreement select the destination location for installation of Rapid Development Kit software and documentation.

The default destination location is ***C:\PHYBasic***. All path and file statements within this QuickStart Instruction are based on the assumption that you accept the default install paths and drives. If you decide to individually choose different paths and/or drives you must consider this for all further file and path statements.

We recommend that you accept the default destination location.



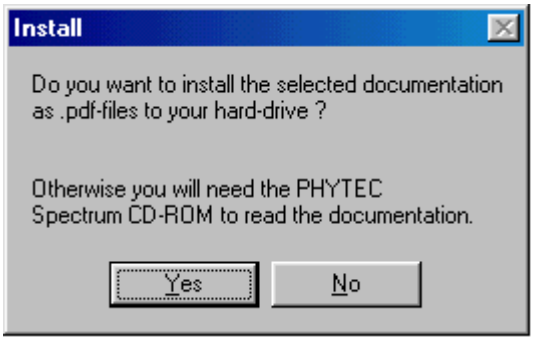
- In the next window select your Rapid Development Kit of choice from the list of available products.



All Kit-specific content will be installed to a Kit-specific subdirectory of the Rapid Development Kit root directory that you have specified at the beginning of the installation process.

All software and tools for this phyCORE-AT91M55800A RDK will be installed to the ***\PHYBasic*** directory on your hard-drive.

- In the next dialog you must choose whether to copy the selected documentation as ***.pdf** files to your hard drive or to install a link to the file on the Spectrum CD.

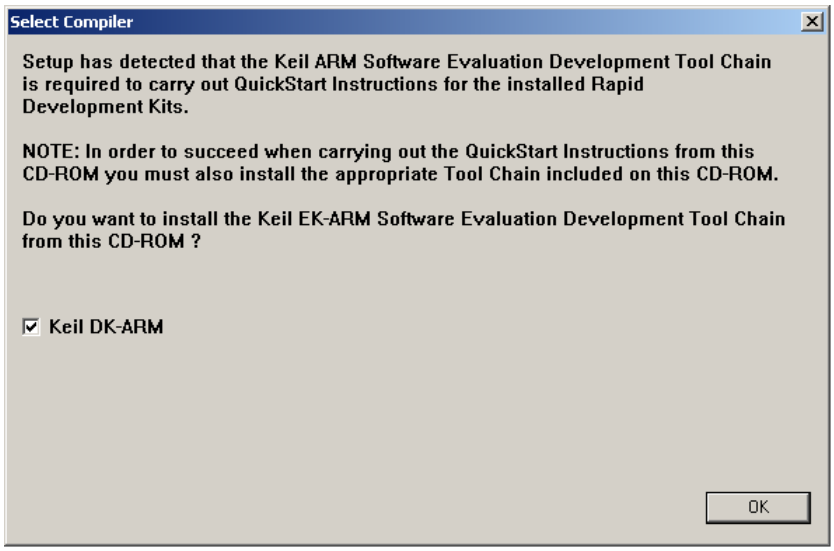


If you decide **not** to copy the documentation to your hard-drive you will need the PHYTEC Spectrum CD-ROM each time you want to access these documents. The installed links will refer to your CD-ROM drive in this case.

If you decide to copy the electronic documentation to your hard-drive, the documentation for this phyCORE-AT91M55800A Kit will also be installed to the Kit-specific subdirectory.

- Setup will now add program icons to the program folder, named *PHYTEC*.

- In the next window, choose the Keil ARM7/µVision3 Software Development Tool Chain.



The applicable Keil tool chain must be installed to ensure successful completion of this QuickStart Instruction. Failure to install the proper software could lead to possible version conflicts, resulting in functional problems.

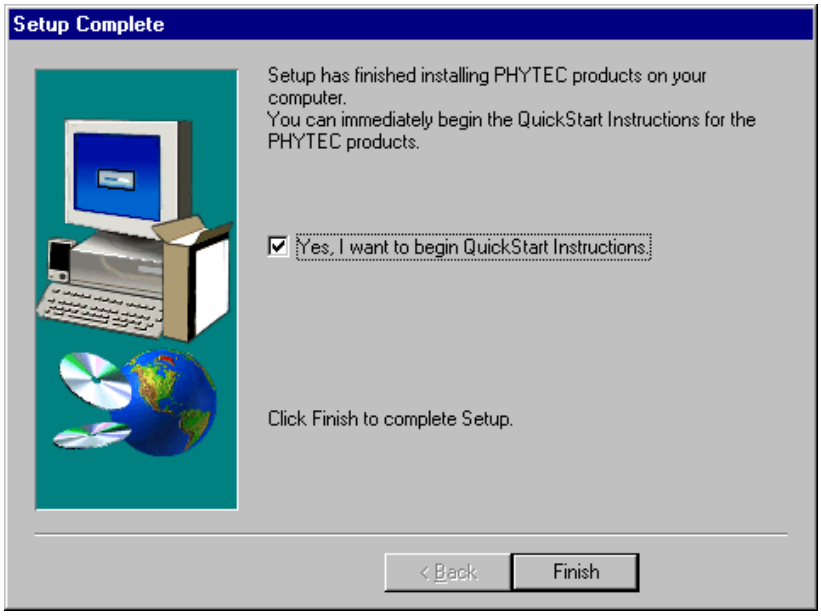
We recommend that you install the Keil ARM7 tools resp. µVision3 from the Spectrum CD-ROM even if other versions of µVision3 are already installed on your system. These QuickStart Instructions and the demo software included on the CD-ROM have been specifically tailored for use with one another[1].

[1] : **Note:** If you have a full version of the Keil ARM7 tools already installed on your host-PC we recommend installing this evaluation version on a different desktop or laptop computer. If this is not possible we recommend to use the same version of the Keil ARM7 tools that we use in this QuickStart manual. PHYTEC can not guarantee successful completion of these QuickStart instructions if a different version of the Keil ARM7 tools is used.

- After accepting the *Welcome* window and license agreement select the destination location for installation of the Development Tool Chain.

The applicable Keil ARM7/µVision3 evaluation development tool chain will be installed to your hard-drive. Additional software, such as Adobe Acrobat Reader, will also be offered for installation.

- Decide if you want to begin the QuickStart Instruction immediately by selecting the appropriate checkbox and click on *Finish* to complete the installation.



2.2 Interfacing the phyCORE-AT91M55800A to a Host-PC

Connecting the phyCORE-AT91M55800A, mounted on the phyCORE Development Board HD200, to your computer is simple.

- Ensure proper jumper settings on the phyCORE Development Board as shown in *Figure 1*.

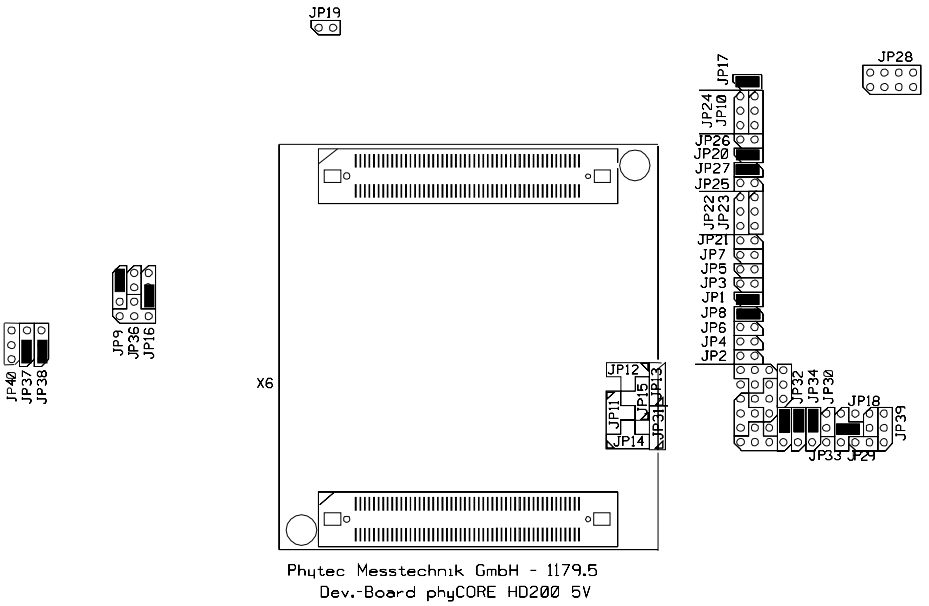


Figure 1: Default Jumper Settings of the phyCORE Development Board HD200 with phyCORE-AT91M55800A

- The ULINK JTAG adapter comes with various flat-band cables. In order to connect this device to the phyCORE-AT91M55800A module you need to connect the flat-band cable with a 2.0 mm connector. If such a cable is not already connected to your ULINK, open the enclosure and connect the correct 2.0 mm cable to the applicable header connector inside the ULINK. Make sure that pin #1 on the cable (black wire) matches pin #1 on the connector.

- Connect the other 2.0 mm cable connector onto pin header rows X2 on the phyCORE module. Make sure that pin #1 on the ULINK cable (black wire) is correctly connected to pin #1 on the JTAG connector X2 (located on the connector side of the PCB) of the phyCORE-AT91M55800A *(refer to Figure 2)*.

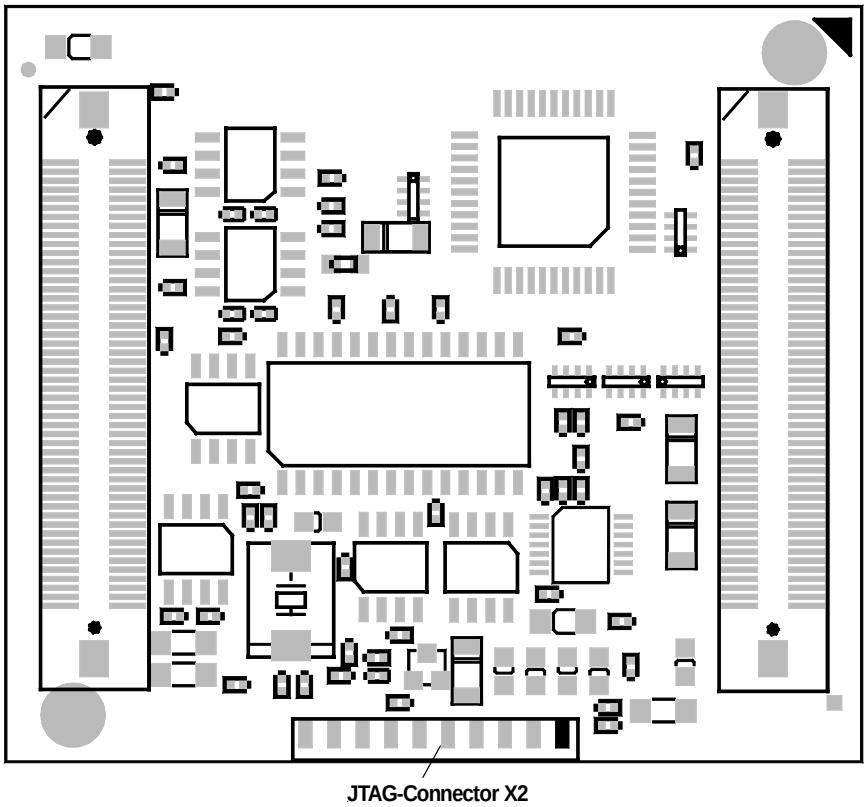


Figure 2: JTAG Connector X2 on the phyCORE-AT91M55800A (Bottom View)

- Mount the phyCORE module onto the Development Board's receptacle footprint (X6) as shown in *Figure 3* below. Ensure that pin 1 of the module, designated by the hash stencil mark, matches pin 1 of the receptacle on the Development Board.

Ensure that there is a solid connection between the module's pins and the Development Board receptacle. Also take precautions not to damage the connectors when the phyCORE is removed from and inserted onto the Development Board.

Figure 3: ULINK and JA-002 Connected to the phyCORE Module

- Connect the USB end of the ULINK JTAG adapter to the USB port of your host-PC using the included USB cable.
- Connect the RS-232 interface of your computer to the DB-9 RS-232 interface on the phyCORE Development Board HD200 (P1A = bottom) using the included serial cable.
- Using the included 5V DC power adapter, connect the power socket X1 on the phyCORE module to a power supply (*refer to Figure 4 for the correct polarity*).

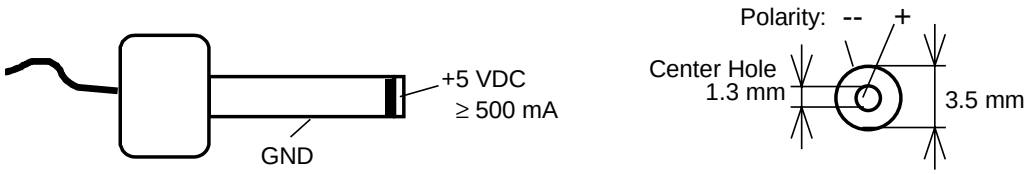


Figure 4: Power Connector

- The red power LED D2, located next to the power socket at X1, should light. This indicates that proper voltage is supplied to the phyCORE Development Board combination (which is also referred to as "target hardware" within this document).
- The phyCORE-AT91M55800A should now be properly connected via the Development Board and ULINK to a host-PC and power supply. You are now ready to use the Keil ARM7/µVision3 tools to establish communication between the host-PC and target hardware.

2.3 Downloading Example Code with µVision3

The µVision3 evaluation software development tool chain should have been installed during the install of the PHYTEC Rapid Development Kit Software from the Spectrum CD, as described in *section 2.1*.

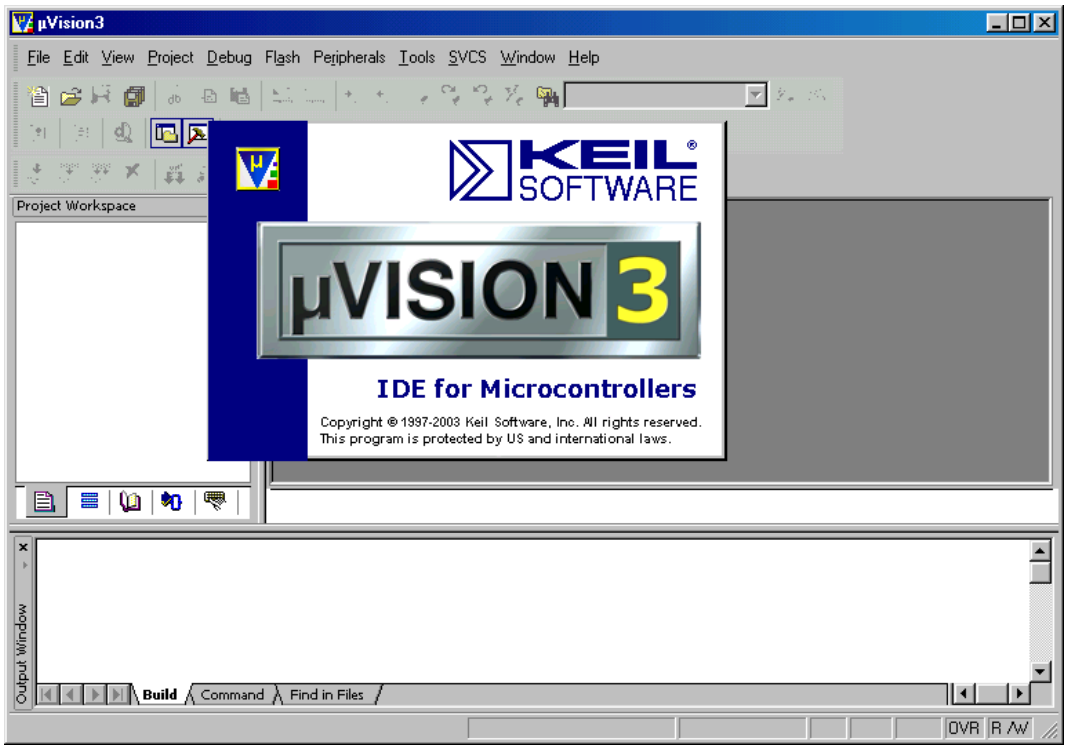
You can also manually install the ARM7/µVision3 tools by executing ***KARM220.EXE*** from within the ***\Software\Keil\Arm*** directory of your PHYTEC Spectrum CD. Follow the instructions displayed by the setup program for manual installation.

Note:
It is recommended to use the Keil tool chain provided on the accompanying Spectrum CD in order to complete this QuickStart Instruction successfully. Use of a different version could lead to possible version conflicts, resulting in functional problems[1].

Start the tool chain by selecting Keil µVision3 from within the programs group: *Start\Programs\Keil µVision3* or by double-clicking on the Keil µVision3 icon on your desktop.

[1] : **Note:** If you have a full version of the Keil ARM7 tools already installed on your host-PC we recommend installing this evaluation version on a different desktop or laptop computer. If this is not possible we recommend to use the same version of the Keil DK-ARM tools that we use in this QuickStart manual. PHYTEC can not guarantee successful completion of these QuickStart instructions if a different version of the Keil DK-ARM tools is used.

After you start µVision3, the window shown below appears. From this window you can create projects, edit files, configure tools, assemble, link and start the debugger. Close all projects that might be open by selecting *Project / Close Project.*

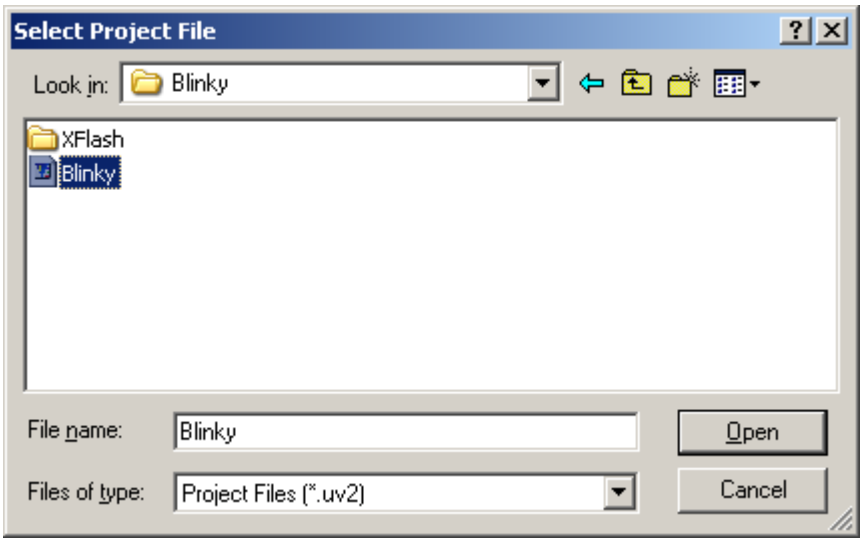


2.3.1 "Blinky"

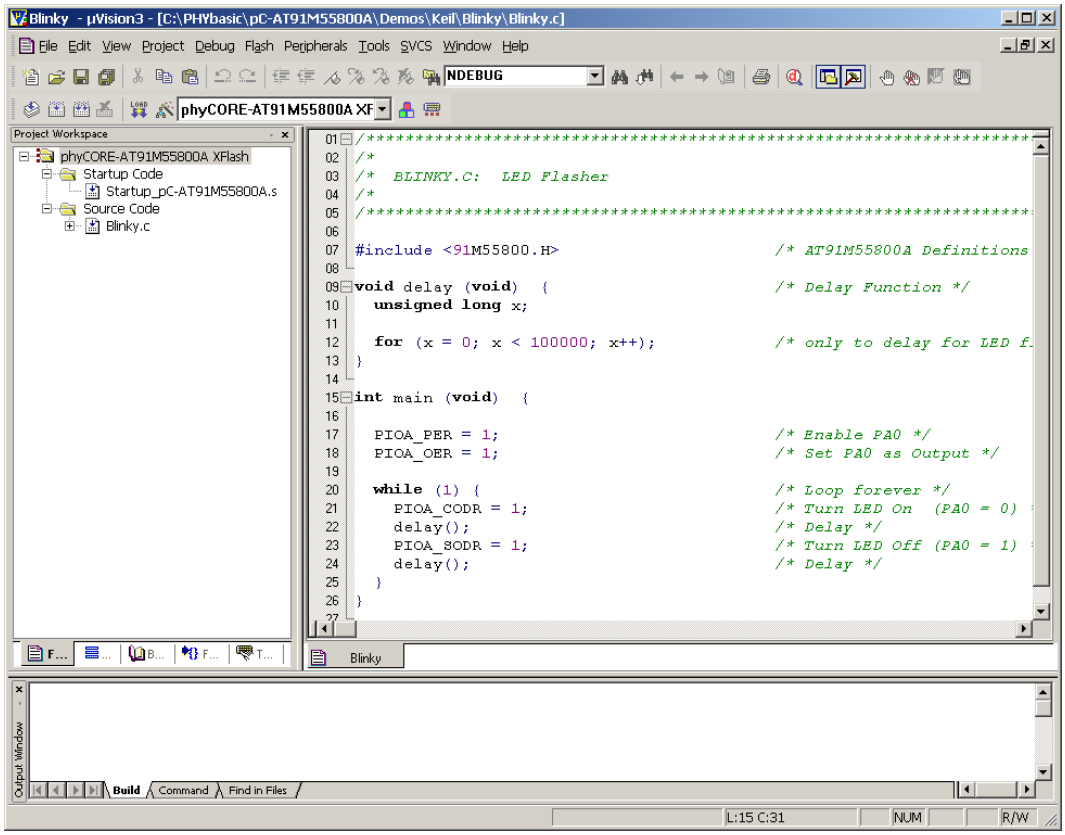
The "Blinky" example downloads a program to external Flash that, when executed, manipulates the LED D3 on the phyCORE Development Board HD200.

- Open the ***Blinky*** project from the µVision3 menu *Project / Open Project.*
- Browse to ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Blinky***.

- Select the ***Blinky*** project.

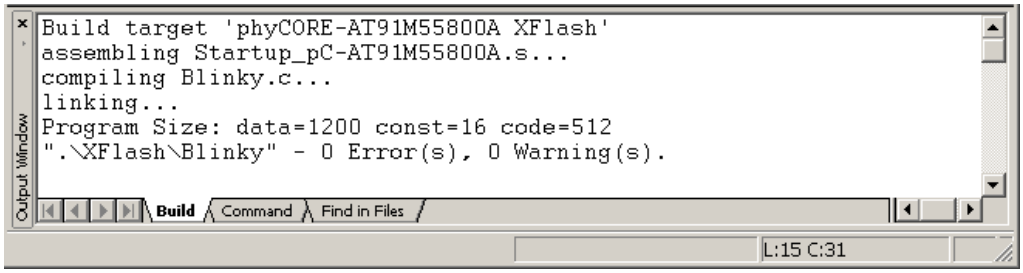


- Click *Open*.
- In the **Select Target** pull down menu be sure that the *phyCORE-AT91M55800A XFlash* target is selected.



Build the Project

- Build the target by either selecting the *Build Target* icon  on the build toolbar or in the main menu bar select *Project / Build target.*
- If any source file of the project contains any errors, they will be shown in the **Output Window - Build** tab. Use the editor to correct the error(s) in the source code, save the file and repeat the build.
- If there are no erorrs, the code is ready to be downloaded into the external Flash memory.



Download to Flash

- Download the code into Flash memory by either selecting the *Download to Flash Memory* icon  on the build toolbar or in the main menu bar select *Flash / Download.*
- The individual steps of the Flash download procedure can be viewed at the bottom of the µVision3 **Output Window - Build** tab.
- Wait until the programming is complete. This is indicated by the **"Verify OK"** message. The download utility will perform a reset and the code will execute without further user interaction.

Successful execution of the program will flash the LED D3 with equal on and off duration.

Erase Flash

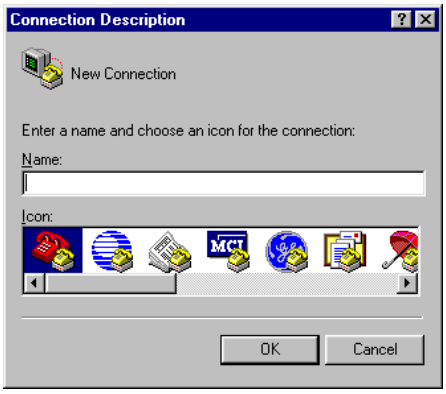
- Erase Flash by selecting *Flash / Erase* in the main uVision menu bar.

2.3.2 "Hello"

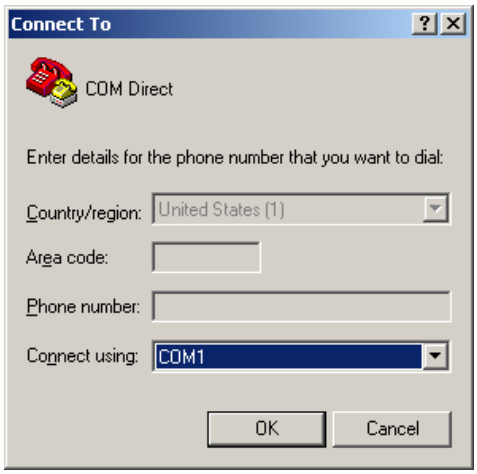
The "Hello" example downloads a program to the external Flash that, when executed, sends a character string from the target hardware back to the host-PC. The character string can be viewed with a terminal emulation program. This example program provides a review of the Flash download procedure using the Keil ULINK and µVision3.

Monitoring the execution of the Hello demo requires use of a terminal program, such as the HyperTerminal program included within Windows.

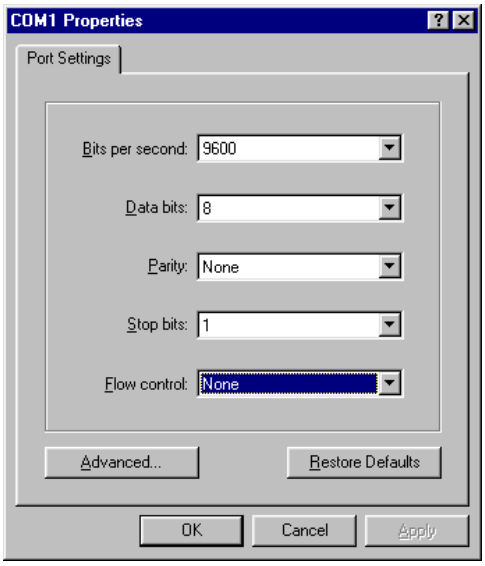
- Start the HyperTerminal program within the *Programs /Accessories/Communications* bar.
- The Connection Description window will now appear. Enter "COM Direct" in the *Name* text field.



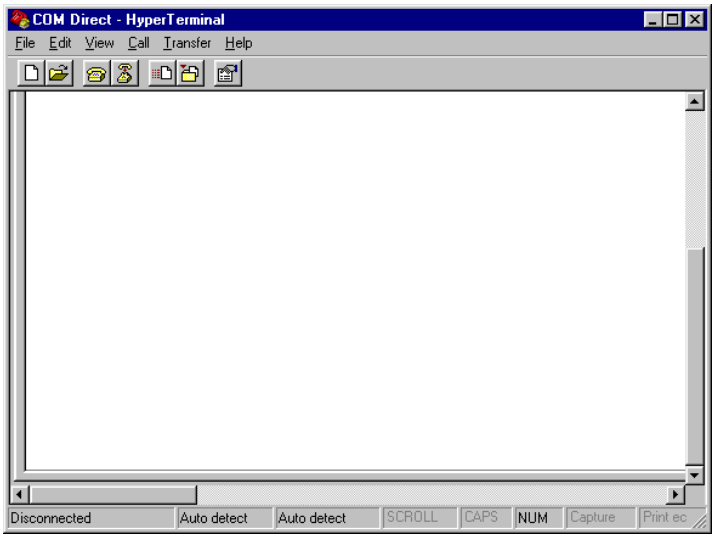
- Next click on *OK*. This creates a new HyperTerminal session named "COM Direct" and advances you to the next HyperTerminal window. Specify *COM1* under the *Connect Using* pull-down menu (be sure to indicate the correct COM setting for your system).



- Click *OK* to advance to the next window (*COM1 Properties*).
- Then set the following COM parameters: Bits per second = *9,600*; Data bits = *8*; Parity = *None*; Stop Bits = *1*; Flow Control = *None*.

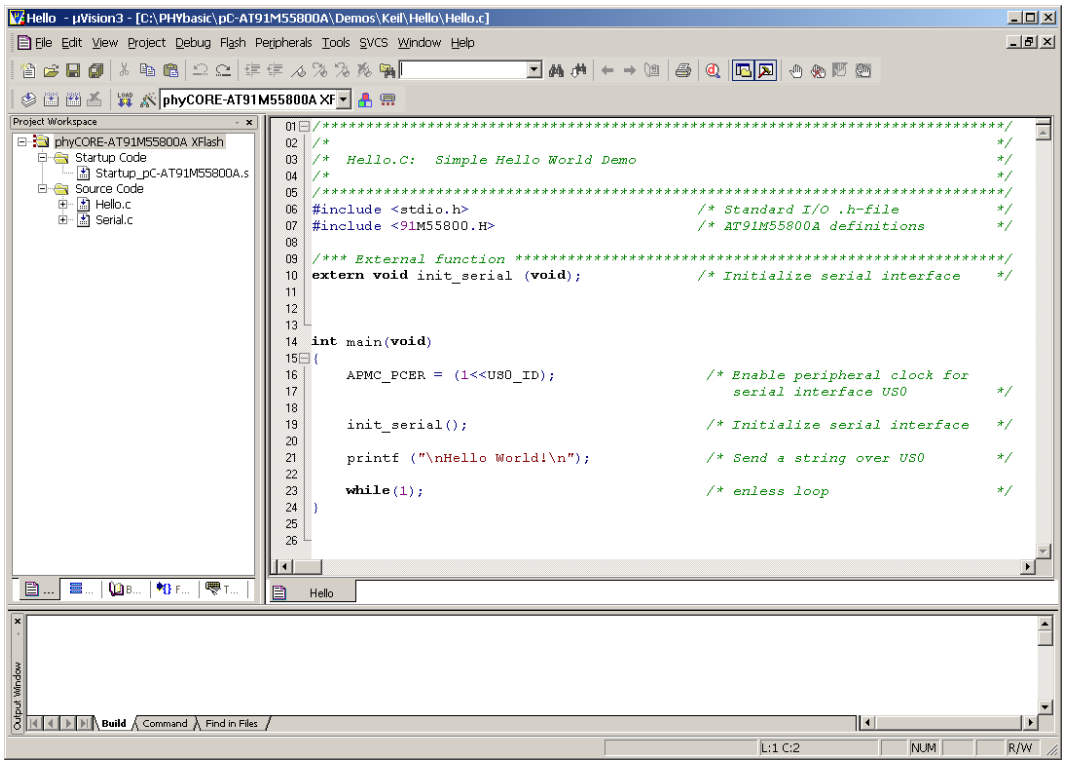


- Selecting *OK* advances you to the *COM Direct–HyperTerminal* monitoring window. Notice the connection status report in the lower left corner of the window.



- Ensure that the target hardware is properly connected to the host-PC via the ULINK and serial cable as well as a power supply.

- Open the ***Hello*** project from the µVision3 menu *Project / Open Project.*
- Browse to the correct drive and path for the phyCORE-AT91M55800A demo folder (default location ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Hello***) and click *Open.*



- In the **Select Target** pull down menu be sure that the *phyCORE-AT91M55800A XFlash* target is selected.

Build the Project

- Click on the *Build Target* icon  on the build toolbar to build the target.
- If any source file of the project contains any errors, they will be shown in the **Output Window - Build** tab. Use the editor to correct the error(s) in the source code, save the file and repeat the build.
- If there are no erorrs, the code is ready to be downloaded into the Flash memory.

Download to Flash

- Click on the *Download to Flash Memory* icon  in the build toolbar to download the code into Flash memory.
- Wait until the programming is complete. This is indicated by the **"Verify OK"** message. The download utility will perform a reset and the code will execute without further user interaction.
- Successful program execution will send the character string "*Hello World*" from the target hardware to the HyperTerminal window.
- If no output appears in the HyperTerminal window check the power supply, the COM parameters and the RS-232 connection.

The code within the demo application ***Hello*** initializes the serial port of your phyCORE-AT91M55800A to 9600 baud. The initialization values are based on the assumption that the microcontroller runs at a 32 MHz internal clock frequency. If your phyCORE-AT91M55800A is equipped with a different speed oscillator, the demo application might transmit using another baud rate. This may lead to incoherent characters appearing in the HyperTerminal window following execution of code.

- Click the disconnect icon  in HyperTerminal toolbar and exit HyperTerminal.

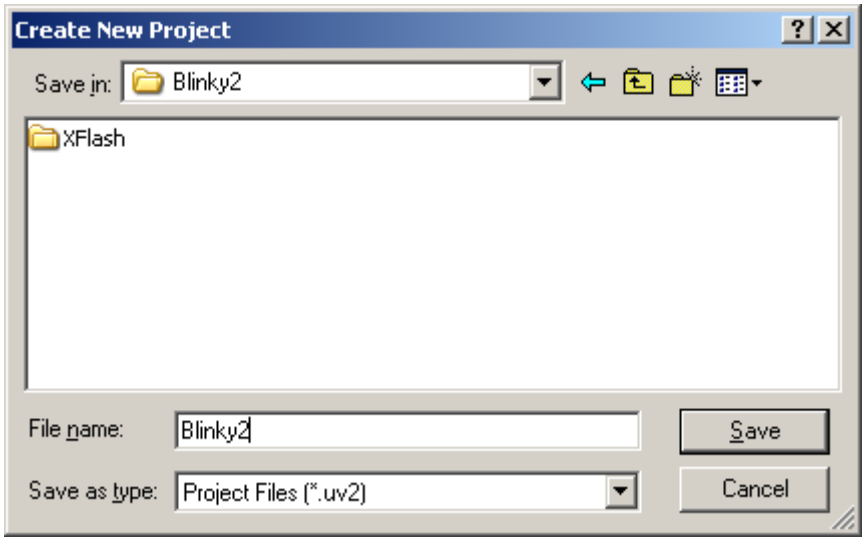
3 Getting More Involved

What you will learn with this example:

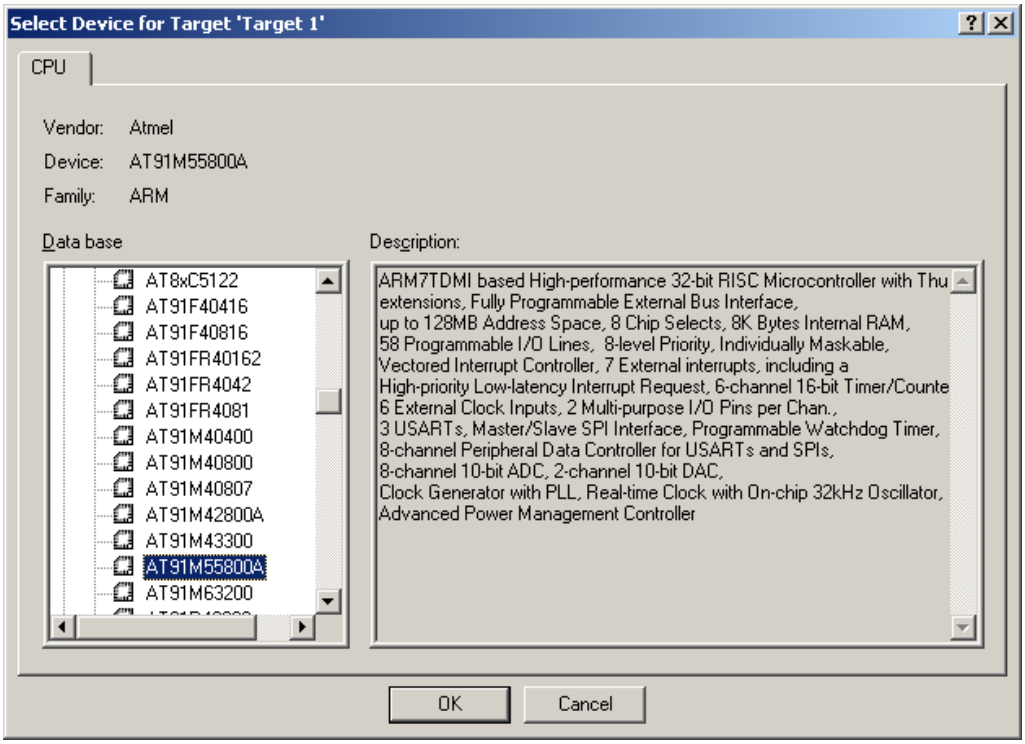
- how to configure the µVision3 IDE (Integrated Development Environment)
- how to modify the source code from our examples, create a new project and build and download a machine readable file to the target hardware

3.1 Creating a New Project and Adding an Existing Source File

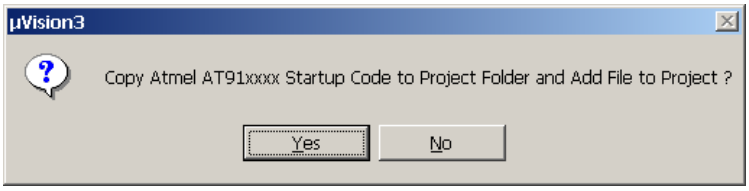
- To create a new project file select from the µVision3 menu ***Project*|*New Project….*** This opens a standard Windows dialog that asks you for the new project file name.
- Change to the project directory created by the installation procedure (default location ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Blinky2***).
- In the text field *'File name'*, enter the file name of the project as ***Blinky2.uv2*** and click on *Save*.



- The **Select Device for Target 'Target1'** will automatically appear. Select **Atmel** as manufacturer for the CPU. The phyCORE-AT91M55800A is populated with an AT91M55800A *CPU*. Choose the controller type from the list as shown below. This selection sets necessary tool options for the AT91M55800A device and simplifies in this way the tool configuration.



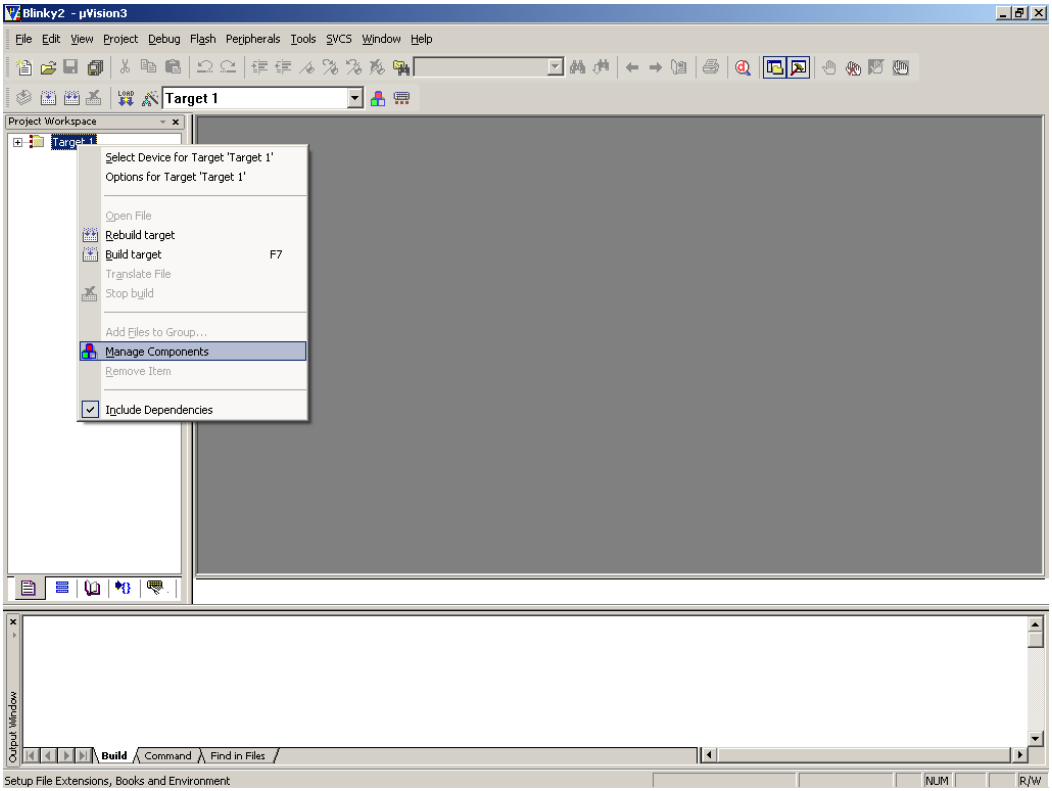
- Click on *OK* to save the settings.
- The uVision3 dialog box *"Copy Atmel AT91xxxx Startup Code to Project Folder and Add File to Project?"* will appear.



- Click on *No* to not include this default startup code! The default startup code provided by Keil does not match the phyCORE-AT91M55800A hardware properties. The correct startup file ***startup_pC-AT91M55800A.s*** will be added to the project later.

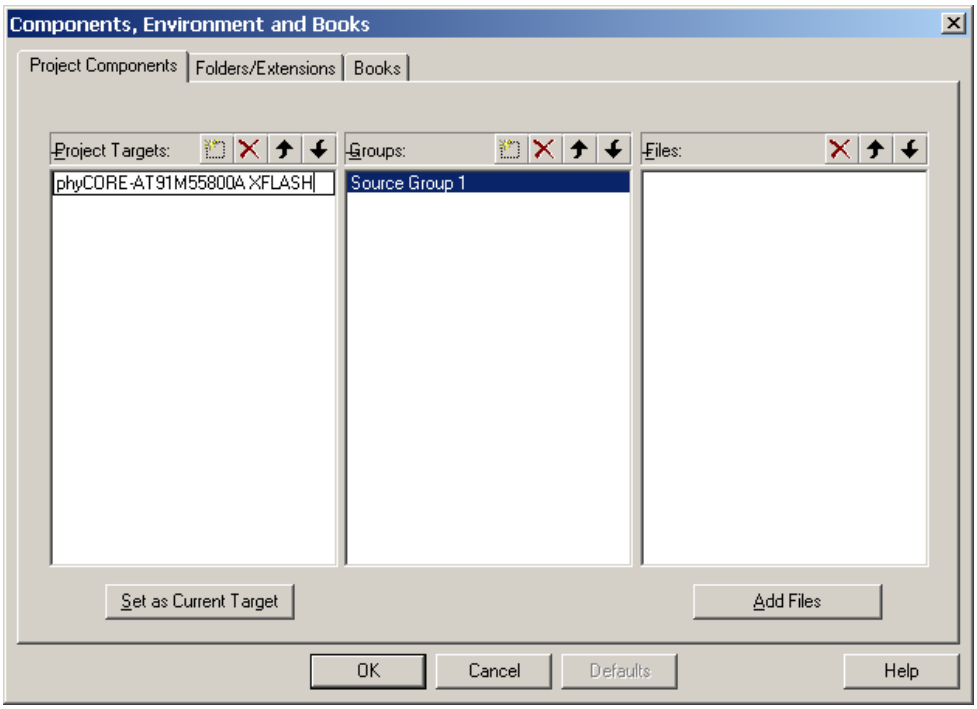
3.1.1 Configure the Project Components

- To configure the target click on the  icon in the build toolbar or right-click on the target, *'Target 1'* in the **Project Workspace** window and select *Manage Components*.

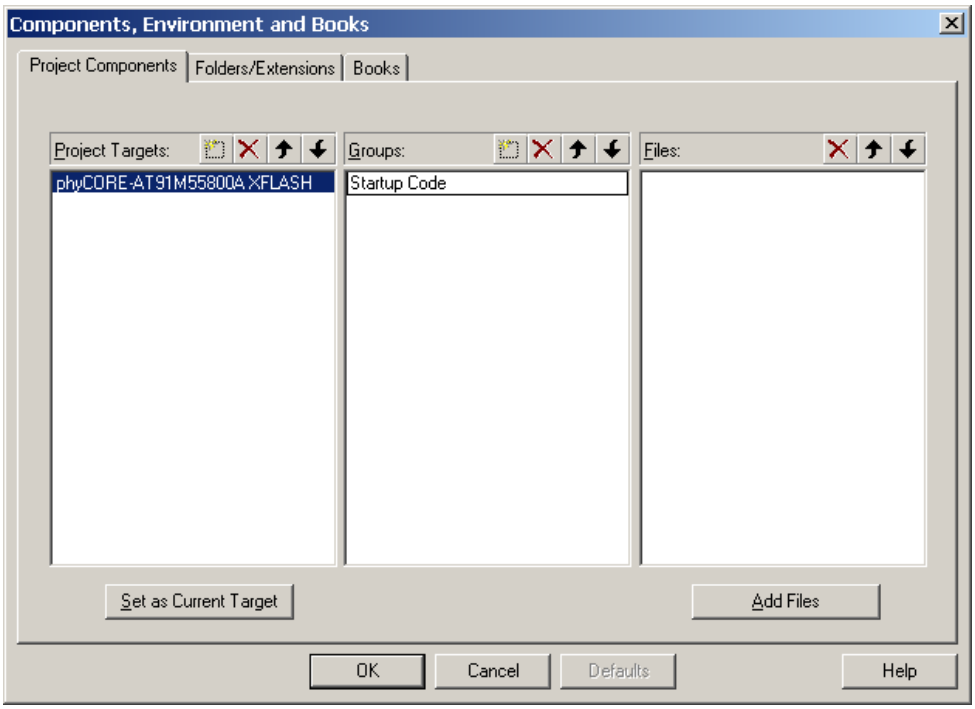


- The **Components, Environments, and Books** window will appear.

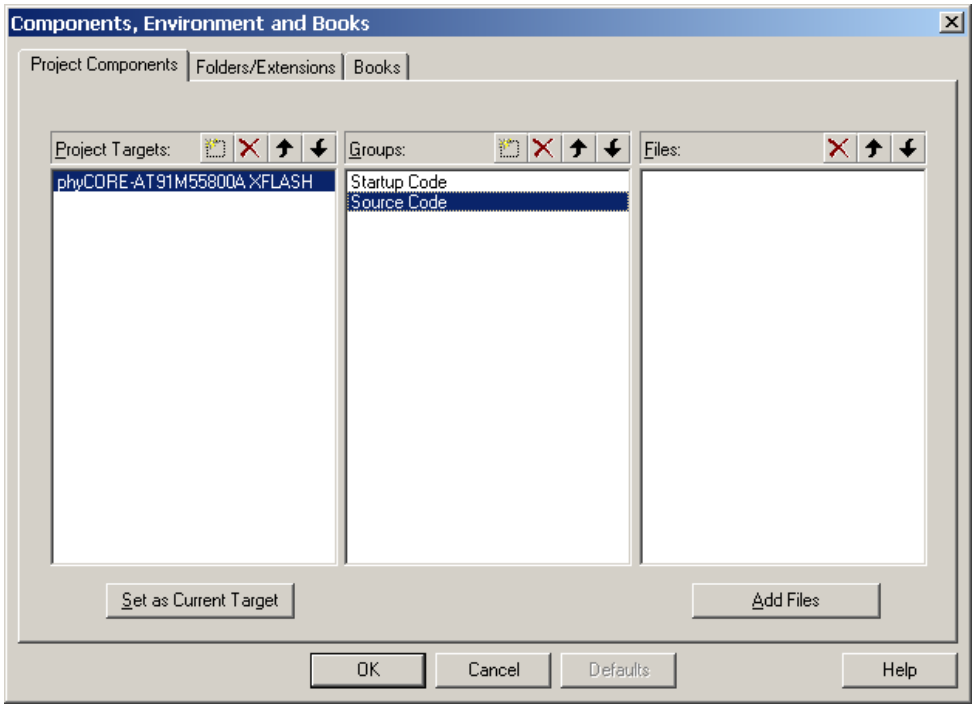
- In the **Project Components** tab, double-click on *Target 1*. Change the name of the target to *phyCORE-AT91M55800A XFLASH*.



- Double-click on *Source Group 1*, in the **Groups** window, and change the name of the group to *Startup Code.*

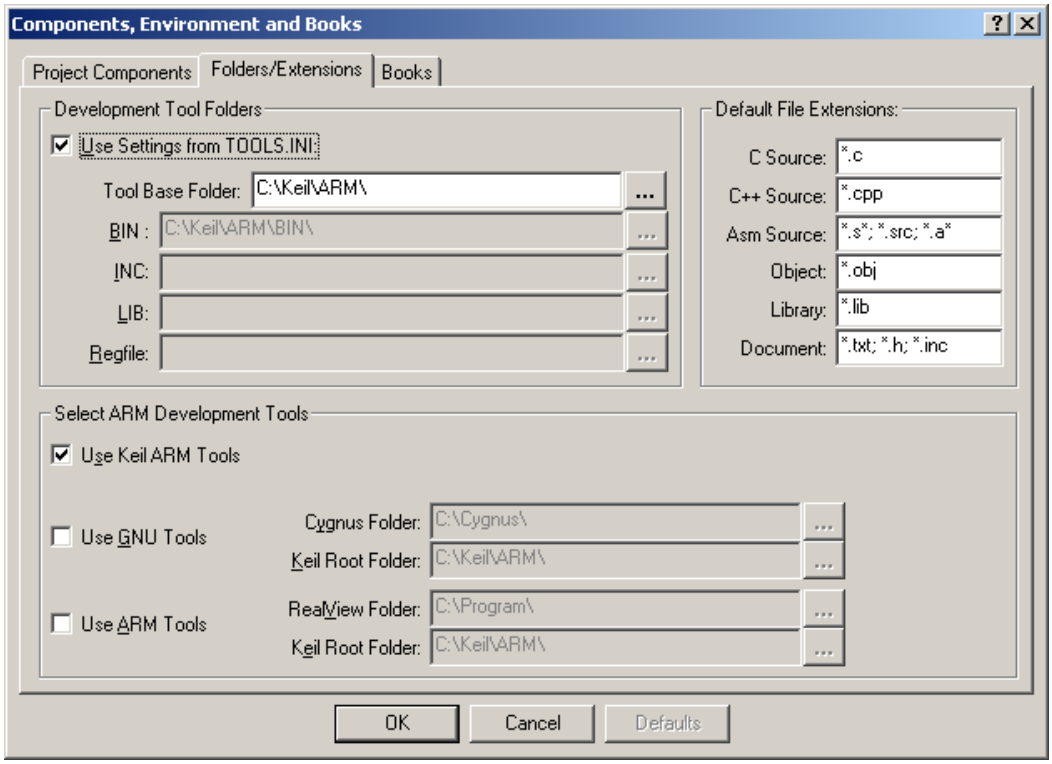


- Add another group by selecting the *New(Insert)* icon  in the **Groups** window. Name the new group *Source Code.*



- Select the **Folders/Extensions** tab.

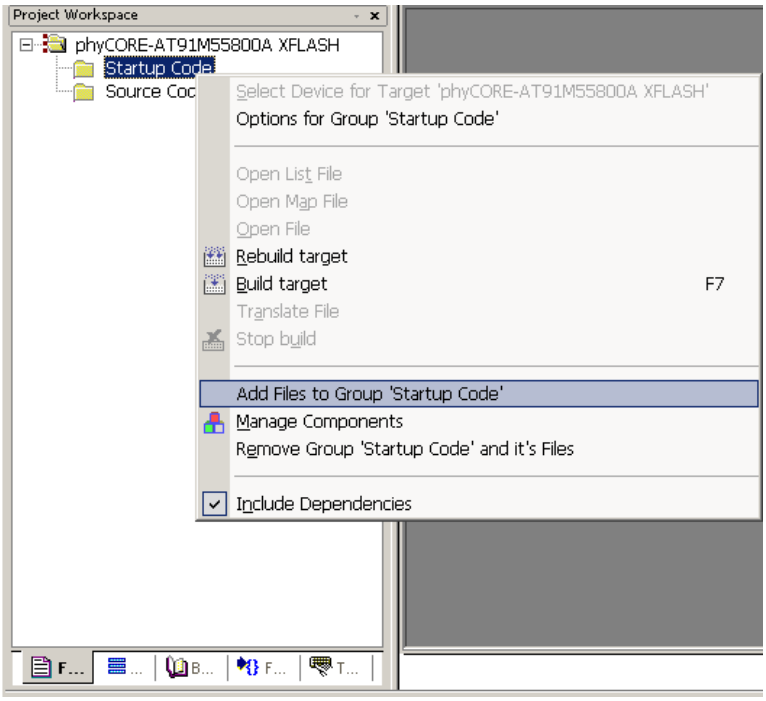
- Be sure that *Use Settings from TOOLS.INI* is checked and the path for the *Tool Based Folder* is *C:\Keil\ARM*
- Be sure that the *Use Keil ARM Tools* ARM Development Tools is selected.



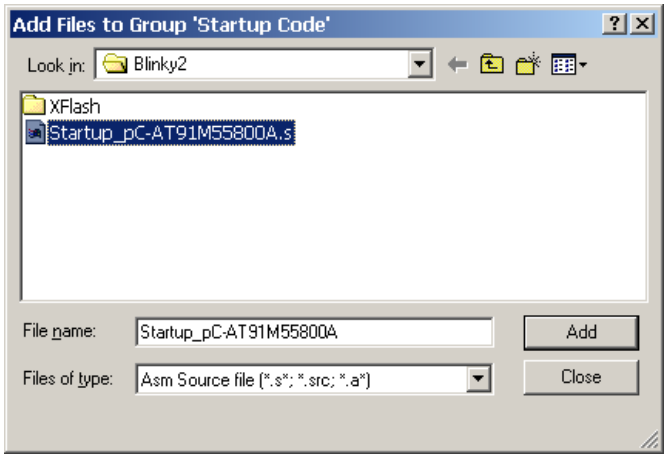
- Click *OK*. This brings you back to the **Project Workspace** window.
- You are now ready to add source files to the project. Make sure the files in the **Project Workspace** window are expanded. Right-click on *Startup Code* and select *Add Files to Group 'Startup Code'*.

3.1.2 Adding Source Files to the Project

- In the **Project Workspace** window - **Files** tab right-click on *Startup Code* and select *Add Files to Group 'Startup Code'*.

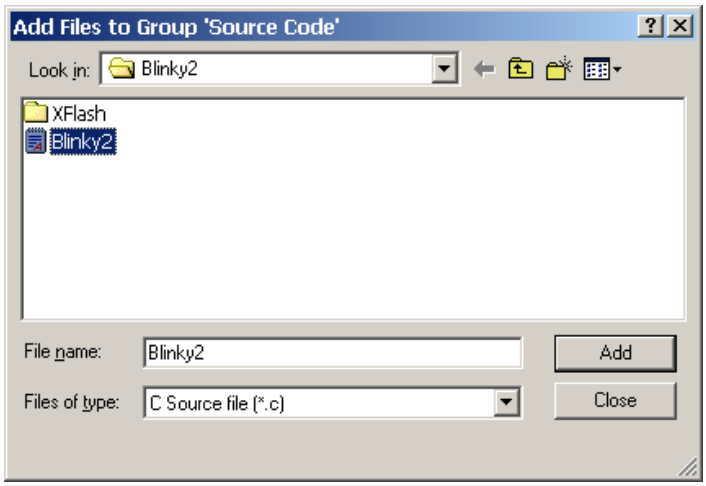


- In the *File of type* pull-down menu, select: "***Asm Source file (*.s*; *.src*; .a*)***". Browse to ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Blinky2*** and select ***Startup_pC-AT91M55800A.s***.



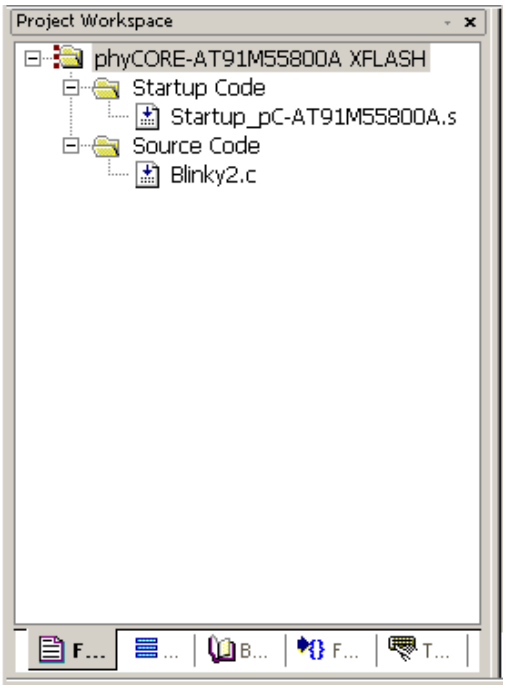
- Click on the *Add* button and then click *Close*.

- In the **Project Workspace** window right-click on the *Source Code* group.
- Select *Add Files to Group 'Source Code'.*
- Browse to ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Blinky2*** and select ***Blinky2.c.***



- Click on the *Add* button and then click *Close*.

- The **Project Workspace** window should appear as follows:

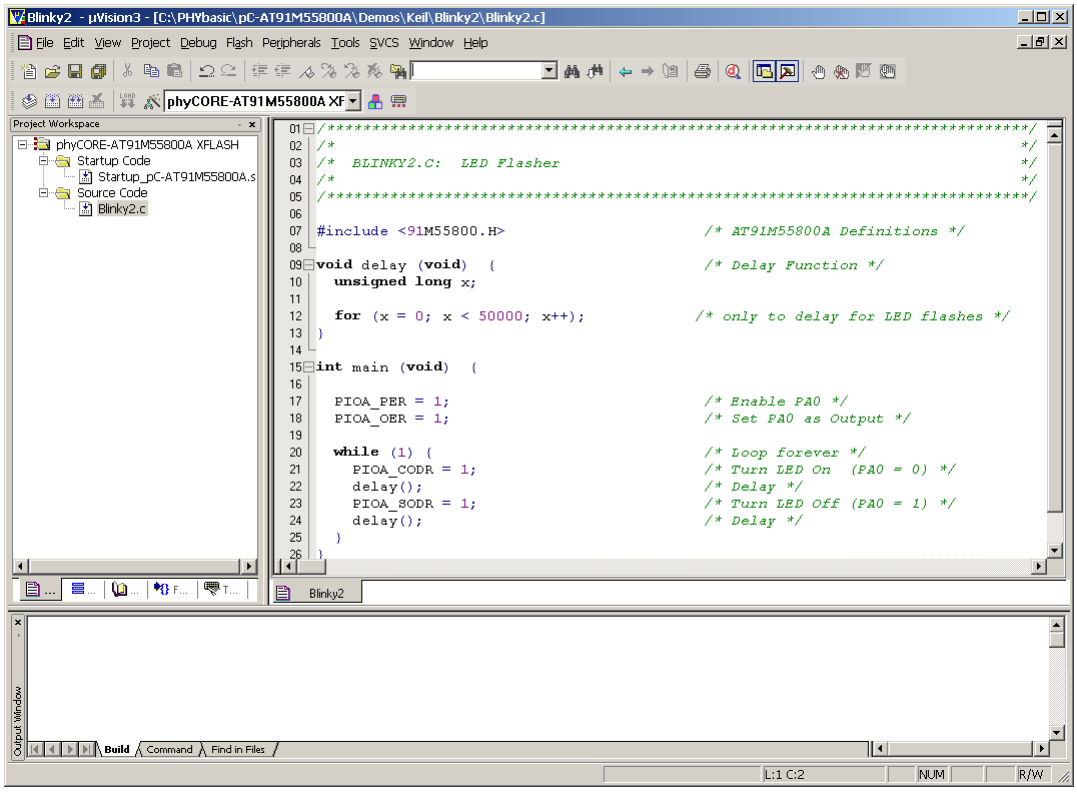


At this point you have created a project called ***Blinky2.uv2*** and added an existing C source file called ***Blinky2.c*** and an existing assembly source file called ***Startup_pC-AT91M55800A.s***. The next step is to modify the C source file before building your project. This includes compiling, linking, locating and creating the machine-readable file.

Note:
Always use the ***Startup_pC-AT91M55800A.s*** file provided by PHYTEC in your application project. This startup file contains the correct controller setting for access to external memory and other on-board components. Using other startup code, e.g. the default Keil startup code that is offered when creating a new project will lead to functional problems and may cause your application code to not execute as desired.

3.2 Modifying the Source Code

- Double-click on ***Blinky2.c*** in the **Project Workspace** window to open the file in the source code editor.



- Locate the following code section and modify the delay for LED Flashes from the original **`50000`** to **`200000`**.

```
for (x = 0; x < 50000; x++);   /* only to delay for LED Flashes */
```

- Save the modified file by choosing *File / Save* or by clicking the floppy disk  icon.

3.3 Setting Options for Flash Target

Keil includes a Make utility that can control compiling and linking source files in several programming languages. Before building your project you must configure the target options. Most of the options are set when specifying the target device for the project.

Enter the changes as indicated below and leave all other options set to their default values. µVision3 allows you to set various options with mouse clicks and these are all saved in your project ****.opt*** file.

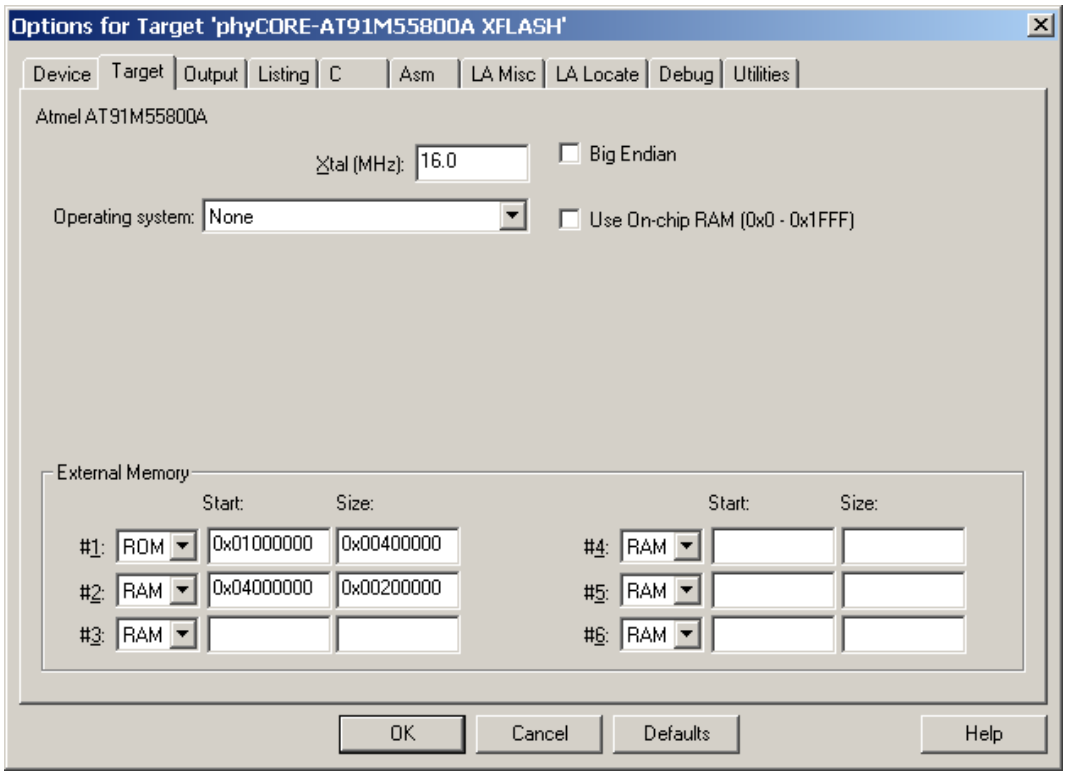
- Configure options for target by selecting the *Options for Target* icon  on the build toolbar or right-click on the *phyCORE-AT91M55800A XFLASH* target in the **Project Workspace** window and select *Options for Target 'phyCORE-AT91M55800A XFLASH'*.

Configure the Target Options

- In the **Target** tab be sure that the *Xtal* is set to **16 MHz** and *Use One-chip RAM(0x0-0x1FFF)* is not checked. Set the *External Memory #1 to* **ROM** and *#2 to* **RAM** and set the *Start* and *Size* as follows:

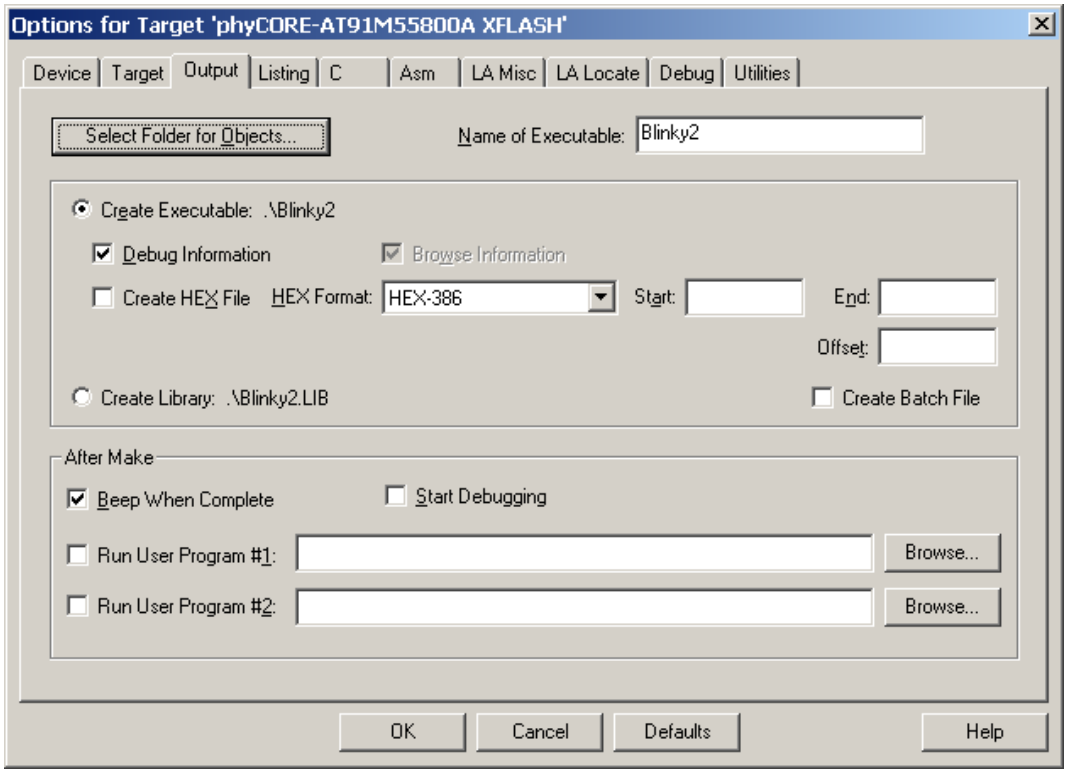
  ROM: **0x0100 0000** (Start) **0x0040 0000** (Size)

  RAM: **0x0400 0000** (Start) **0x0020 0000** (Size)



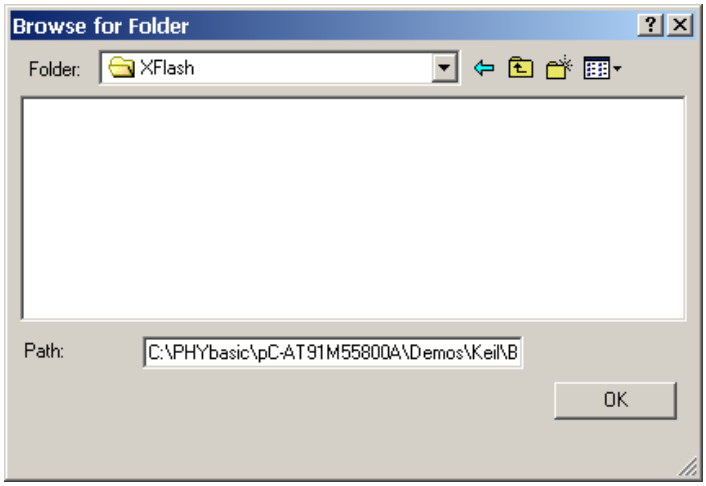
Configure the Output Options

- In the **Output** tab be sure that *Create Executable*, *Debug Information* and *Beep When Complete* options are selected.



- Click on the *Select Folder for Objects* button.

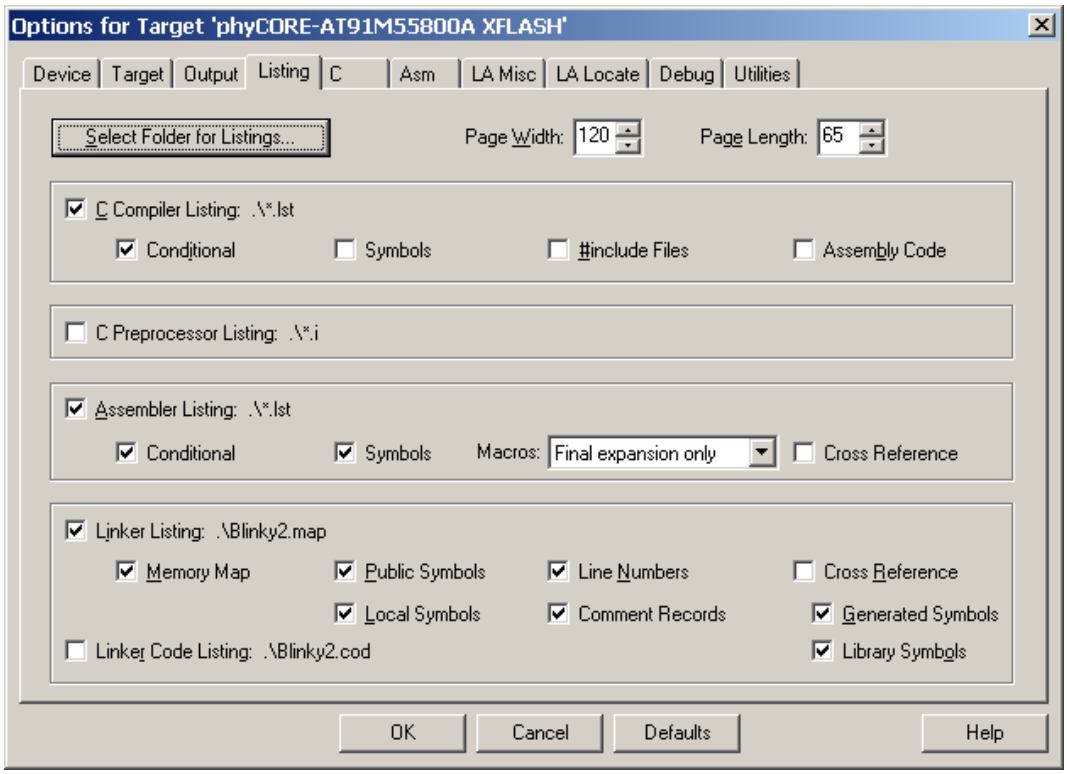
- Browse to the folder:
  C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Blinky2\XFlash.



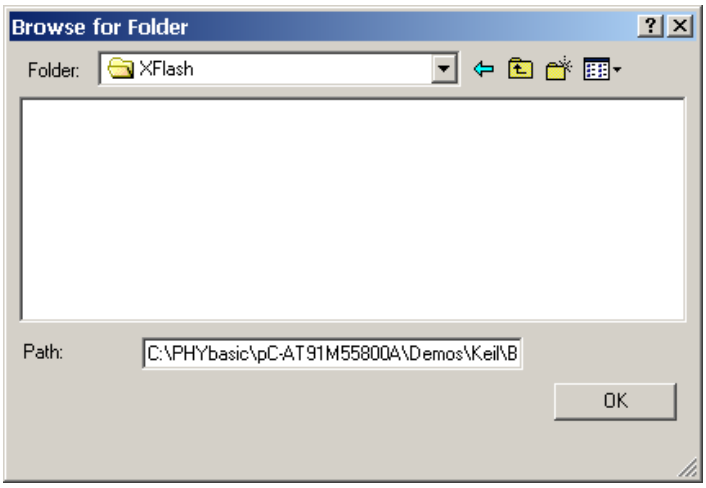
- Click *Ok*. This takes you back to the *Options for Target* window.

Configure the Listing Options

- In the **Listing** tab, leave the default settings as follows.



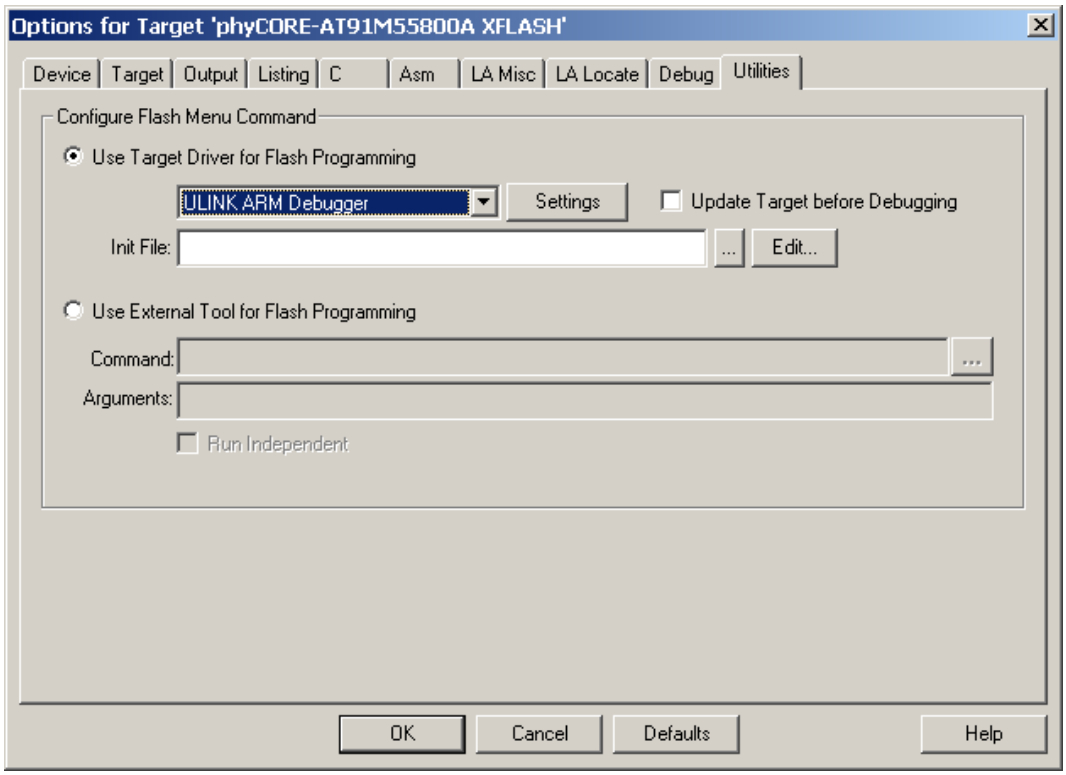
- Click on the *Select Folder for Listing* button.
- Browse to the folder: ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Blinky2\XFlash***.



- Click *OK*. This takes you back to the *Options for Target* window.

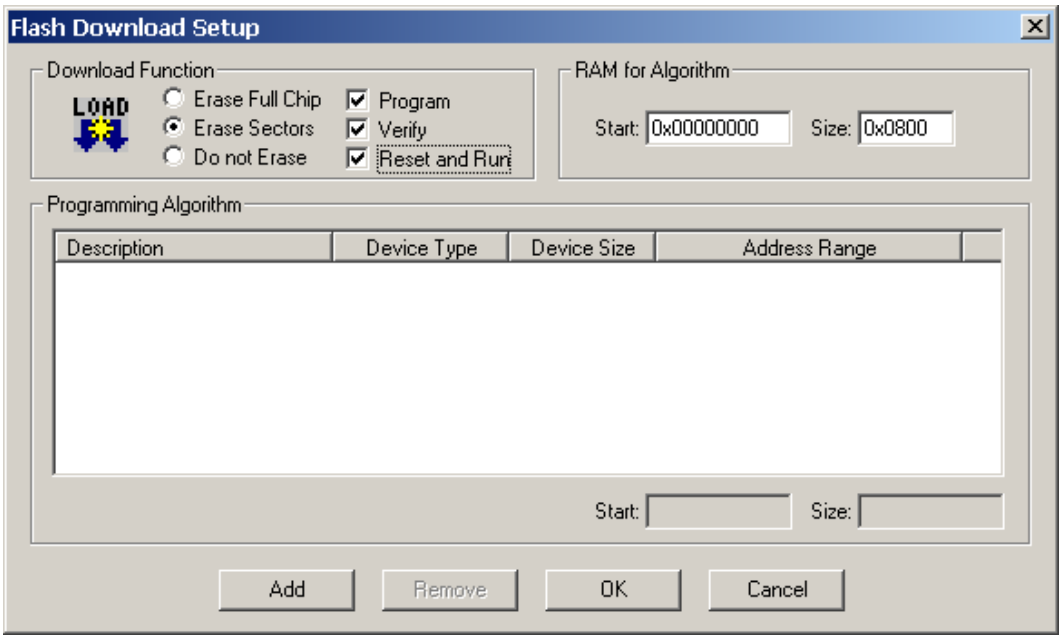
Configure the Utilities Options

- Select the **Utilities** tab.
- Select the *Use Target Driver for Flash Programming* option.
- In the pull-down menu select *ULINK ARM Debugger*.



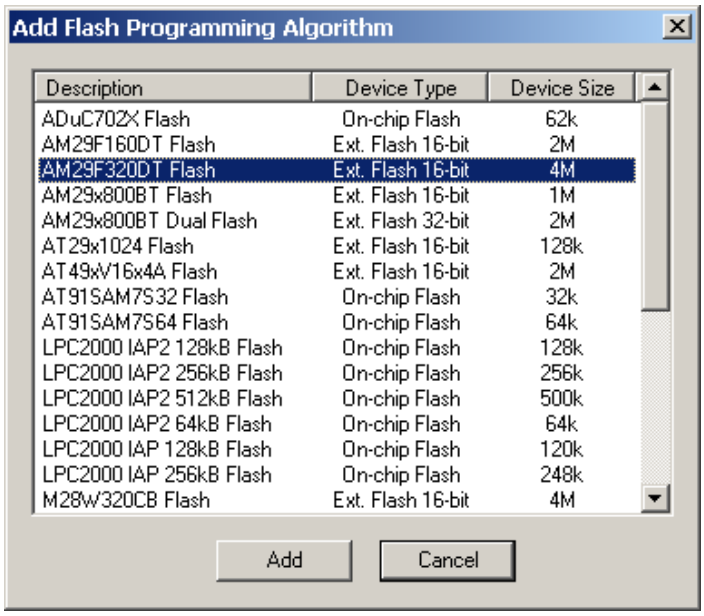
- Click the *Settings* button.

- In the **Flash Download Setup** window be sure that the following *Download Function* options are selected: *Erase Sectors*, *Program*, *Verify*, and the *Reset and Run*. Checking the *Reset and Run* box will execute the downloaded ***Blinky2*** code at the end of the Flash programming sequence without having to push the Reset button (S_2) on the Development Board.



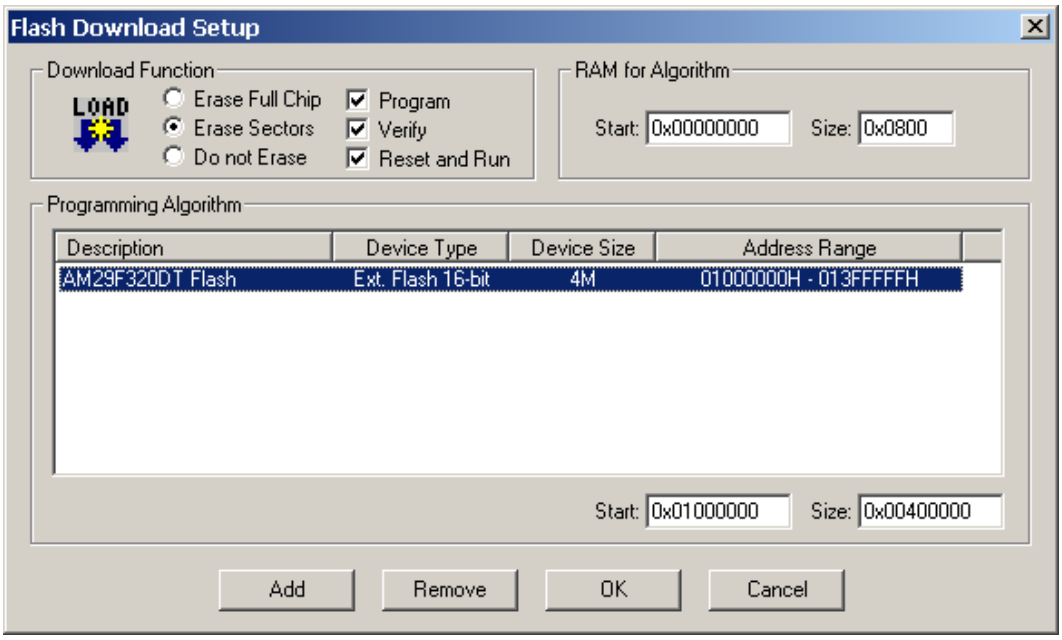
- Click on *Add* to add a *Programming Algorithm*.

- In the **Add Programming Algorithm** window, select *AM29F320DT Flash* and click *Add*. The AM29F320DT device is the external Flash memory populating the phyCORE-AT91M55800A module.



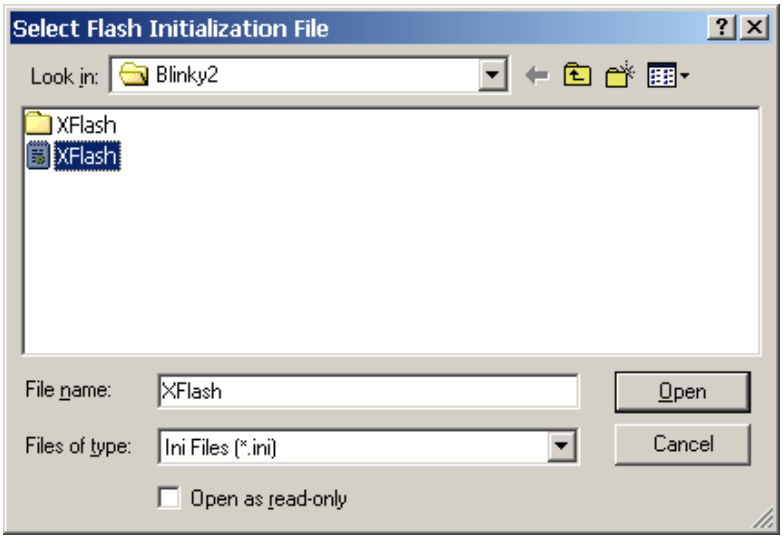
- Click *Add*.

- In the *RAM for Algorithm* section, set the *Start* address to **0x00000000** and address *Size* to **0x0800** as shown below.
- In the *Programming Algorithm* window click on the *AM29F320DT Flash* device and set the *Start* address to **0x01000000** and *Size* to **0x00400000** as shown below and click *OK*.



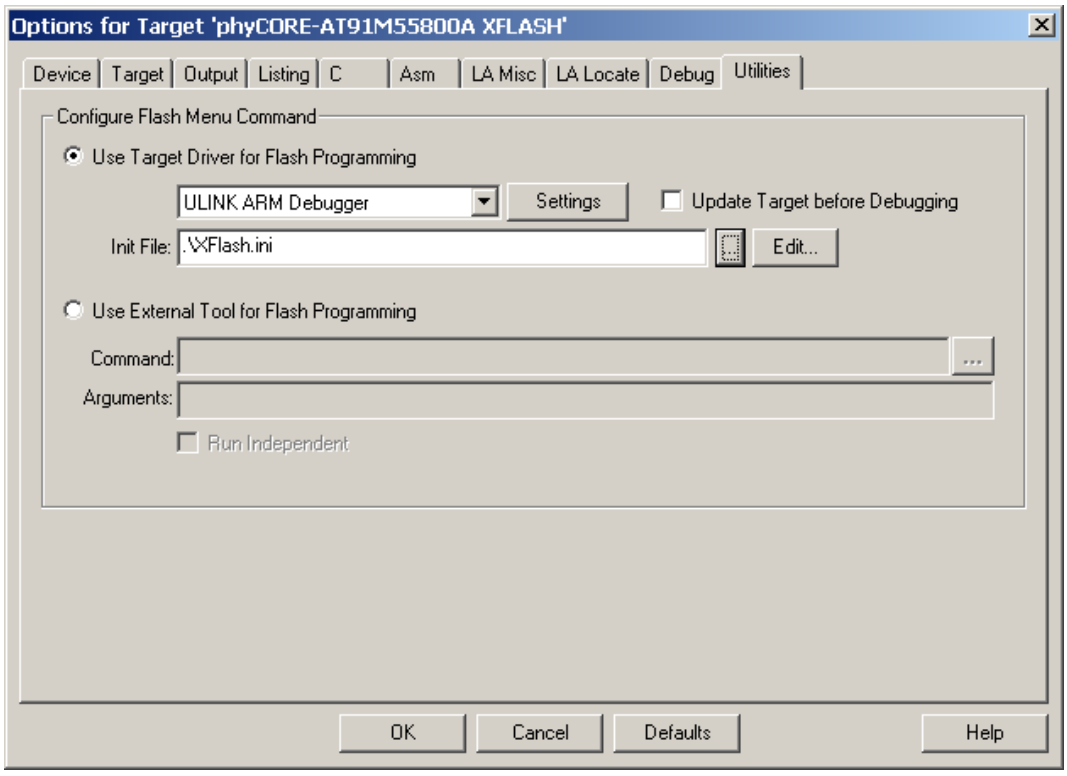
- Back in the **Utilities** tab, select the browse button  in the *Init File:* line to add the Flash initialization file.

- In the **Select Flash Initialization File** pop-up window browse to ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Blinky2*** and select the ***XFlash.ini*** file.



- Click the *Open* button.

- The **Utilities** tab should appear as follows:



- Click *OK.*
- In the main µVision3 menu select *File / Save All.*

3.4 Building the Project

You are now ready to run the compiler and linker using the Make utility.

- Build the desired target by either selecting the build icon  on the build toolbar or in the main menu select *Project / Build target.*

If any source file of the project contains any errors, they will be shown in the **Output Window - Build** tab. Use the editor to correct the error(s) in the source code and save the file and repeat the build.

If there are no errors, the code is ready to be downloaded into the Flash memory.

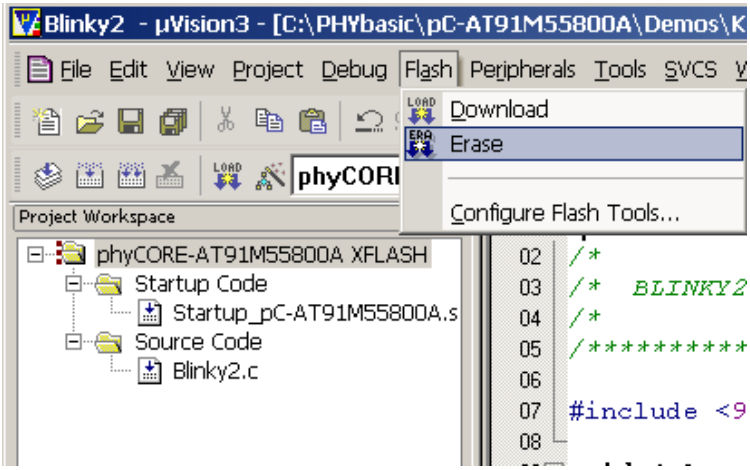
3.5 Downloading Code into Flash Memory

- In the **Select Target** pull down menu be sure that the *phyCORE-AT91M55800A XFLASH* target is selected.
- Download the code into Flash memory by either selecting the *Download to Flash Memory* icon  on the build toolbar or in the main menu select *Flash / Download.*
- Wait until the programming is complete. This is indicated by the **"Verify OK"** message. The download utility will perform a reset and the code will execute without further user interaction.

Successful execution of the program will flash the LED D3 with equal on and off duration but with longer cycles compared to the original ***Blinky*** demo.

You have now modified source code, recompiled the code, created a downloadable file, and successfully executed this modified code.

- If you wish to erase the external Flash select *Flash /Erase* in the main µVision3 menu:



- The Flash erase status will be displayed at the bottom of the µVision3 window and take a few seconds.

4 Debugging

This Debugging section provides a basic introduction to the debug functions included in the Keil ARM7/µVision3 evaluation tool chain. Using an existing example, the more important features are described. For a more detailed description of the debugging features, *please refer to the appropriate manuals provided by Keil.*

The µVision3 Debugger offers two operating modes that can be selected in the ***Project|Options for Target phyCORE-AT91M55800A*** dialog:

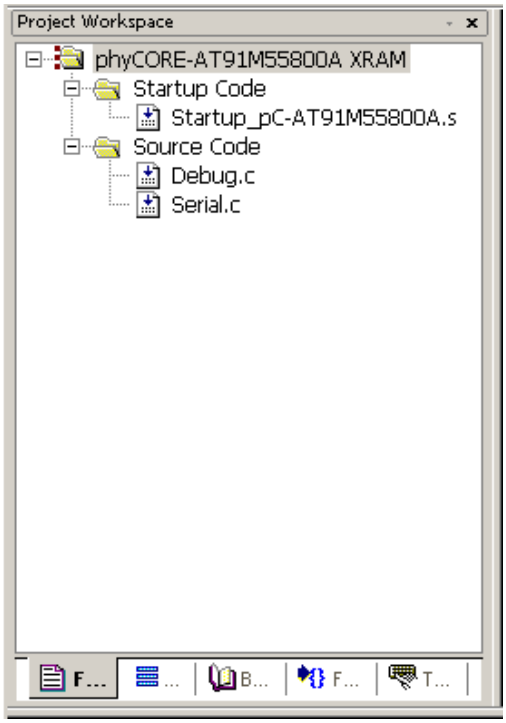
- The **Simulator** allows PC-based simulation of most features of the AT91M55800A microcontroller without actually having target hardware. You can test and debug your embedded application before the hardware is ready. µVision3 simulates a wide variety of peripherals, including external I/O and timers. The peripheral set is configured when you select a CPU from the device database for your target.
- USB-JTAG debugging interface adapters like the **Keil ULINK**, allow target-based debugging. With the ULINK interface you may connect directly to the target hardware using the JTAG interface. Debugging on the target hardware also enables testing peripheral components of the application and real-time program execution.

The following examples utilize the **ULINK ARM Debugger** environment.

4.1 Creating a Debug Project and Preparing the Debugger

4.1.1 Creating a New Project

- Start the Keil µVision3 environment and close all projects that might be open.
- Open the **Project** menu and create a **New Project** called ***Debug.uv2*** within the existing project directory ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Debug*** (default location) on your hard drive. Select the *Atmel AT91M55800A* in the CPU vendor data base list.
- Rename the target of your project within the **Project Workspace** window **- Files** tab into *phyCORE-AT91M55800A XRAM*.
- Rename the file group *Source Group 1* as *Startup Code* and add one additional file group named *Source Code*.
- Add ***Startup_pC-AT91M55800A.s*** to the file group *Startup Code*, and the files ***Debug.c*** and ***Serial.c*** to the file group *Source Code* from within the **Project Workspace**.
- Your project should now appear as follows:



- Go to **Project / Components, Environment, Books…** from the menu or select the  icon on the toolbar. Select the **Folders/Extensions** tab and be sure that *Use Keil ARM Tools* under *Select ARM Development Tools* box is selected.
- Save the project.
- Double-click on the ***Debug.c*** file to open the source code window.

At this point you have created a project called ***Debug.uv2,*** consisting of the C source files called ***Debug.c*** and ***Serial.c*** and the assembler file ***Startup_pC-AT91M55800A.s***.

4.1.2 Setting Options for Target

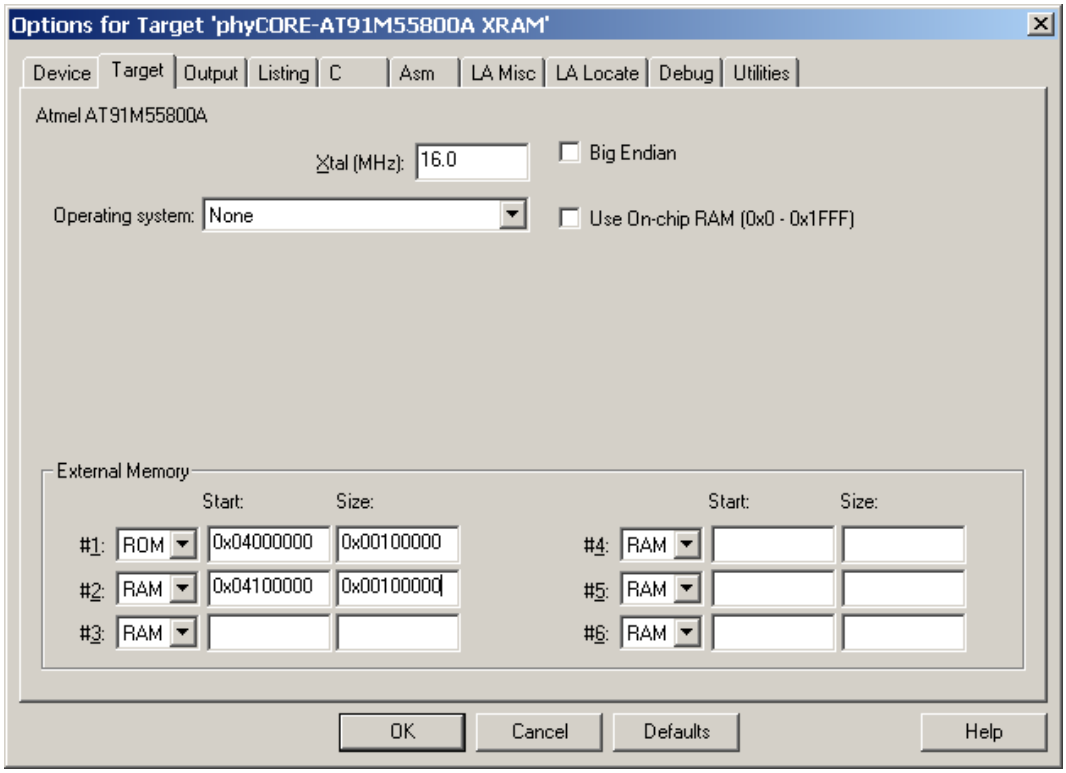
- In the **Select Target** pull down menu make sure the *phyCORE-AT91M55800A XRAM* target is selected.
- Configure options for target by selecting the *Options for Target* icon  on the build toolbar or right-click on the *phyCORE-AT91M55800A XRAM* target in the **Project Workspace** window and select *Options for Target 'phyCORE-AT91M55800A XRAM'.*

Configure the Target Options

- In the **Target** tab be sure that *Xtal* is set to **16 MHz** and *Use On-chip RAM(0x0-0x1FFF)* is not checked. Set the *External Memory #1 to* **ROM** and *#2 to* **RAM** and set the *Start* and *Size* as follows:

  ROM: **0x0400 0000** (Start) **0x0010 0000** (Size)

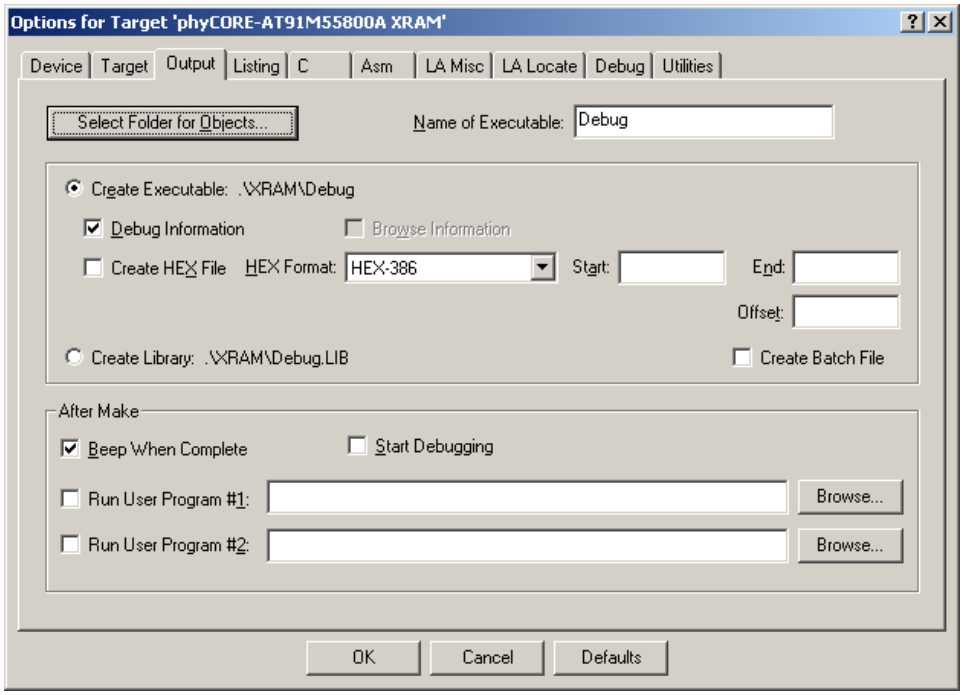
  RAM: **0x0410 0000** (Start) **0x0010 0000** (Size)



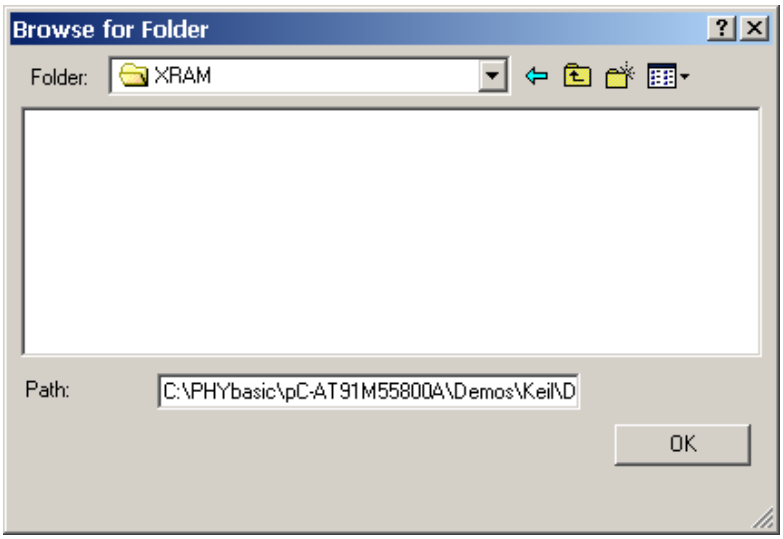
It is necessary to configure the External Memory *Start* and *Size* settings so that the combined user code and data does not exceed the physical size of the RAM. The phyCORE®-AT91M55800A standard version features 2 MByte of external SRAM.

Configure the Output Options

- In the **Output** tab be sure that *Create Executable*, *Debug Information* and *Beep When Complete* options are selected.



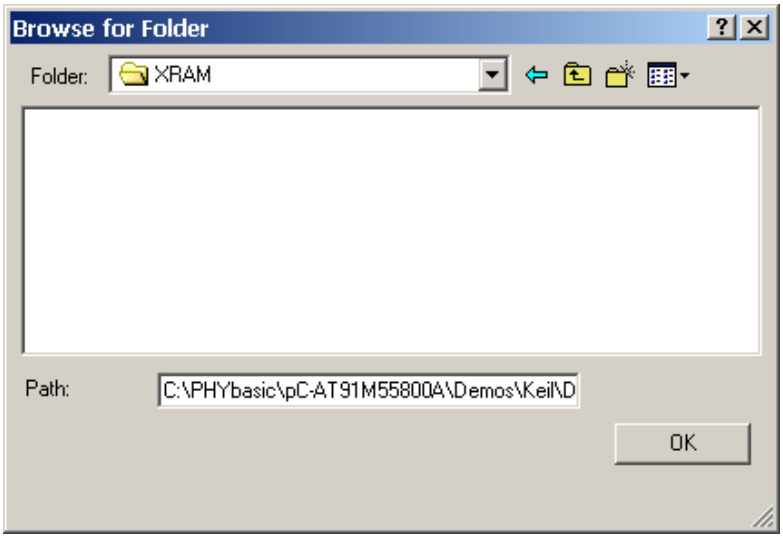
- Click on the *Select Folder for Objects* button.
- Browse to the folder: ***C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Debug\XRAM***.



- Click *OK*.

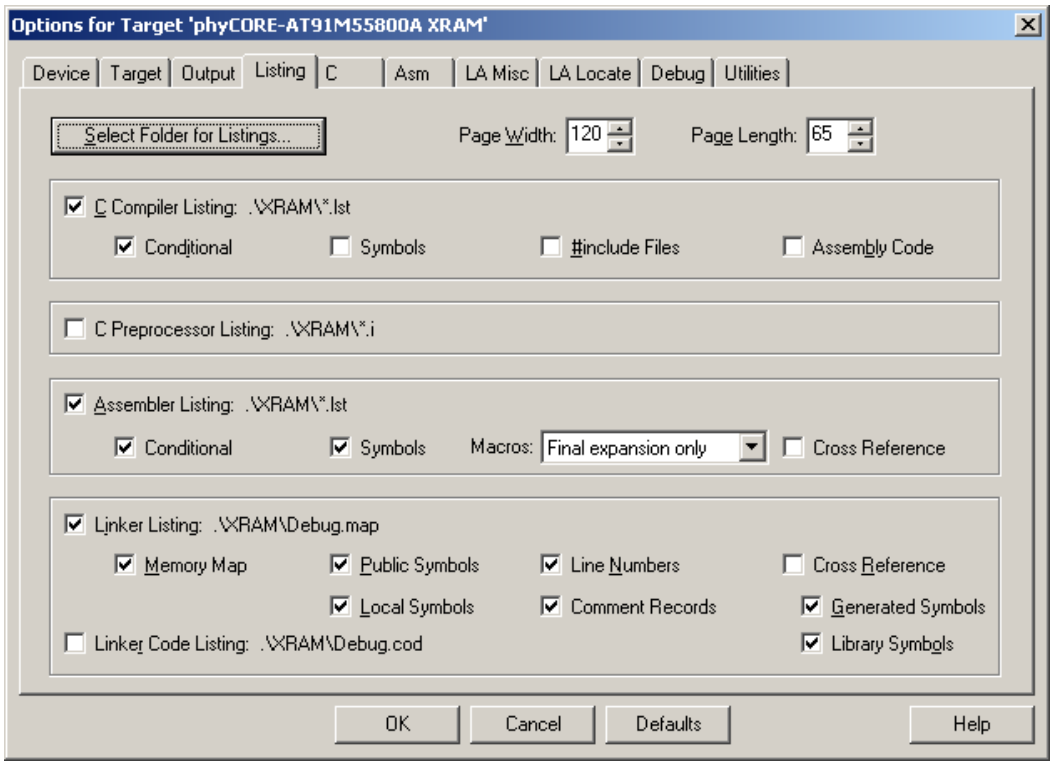
Configure the Listing Options

- In the **Listing** tab, leave the default settings are set.
- Click on the *Select Folder for Listing* button.
- Browse to the folder:
  C:\PHYBasic\pC-AT91M55800A\Demos\Keil\Debug\XRAM.



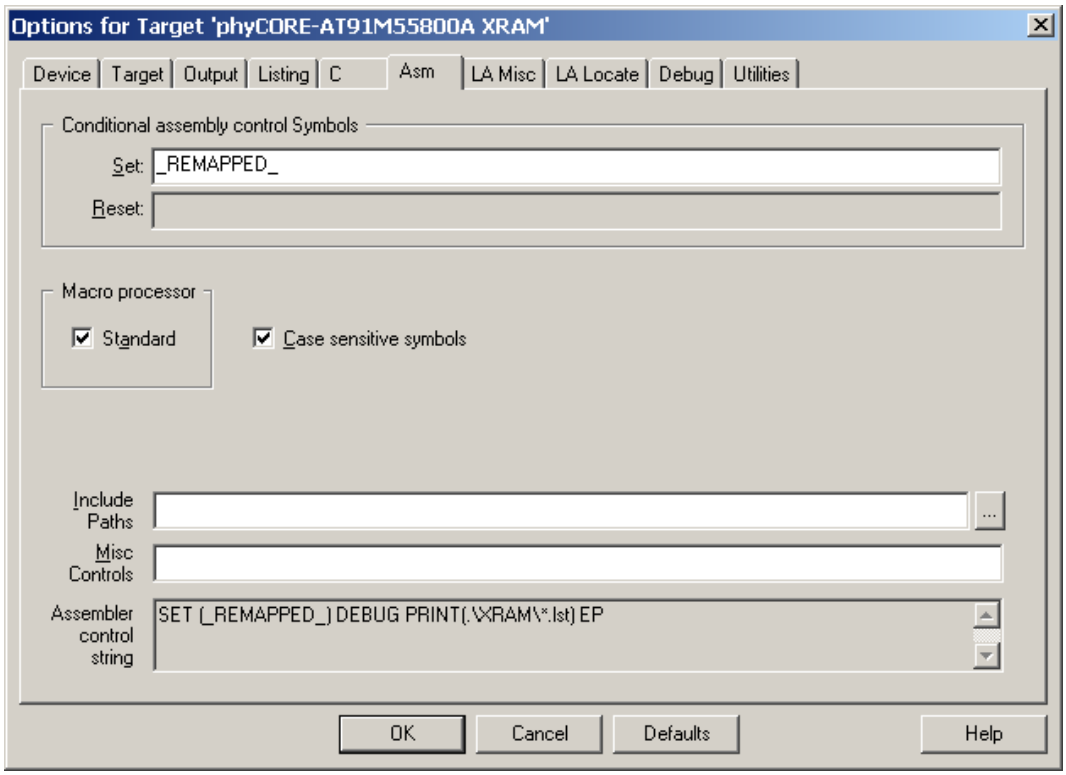
- Click *OK*.

- The **Listing** tab should appear as follows:



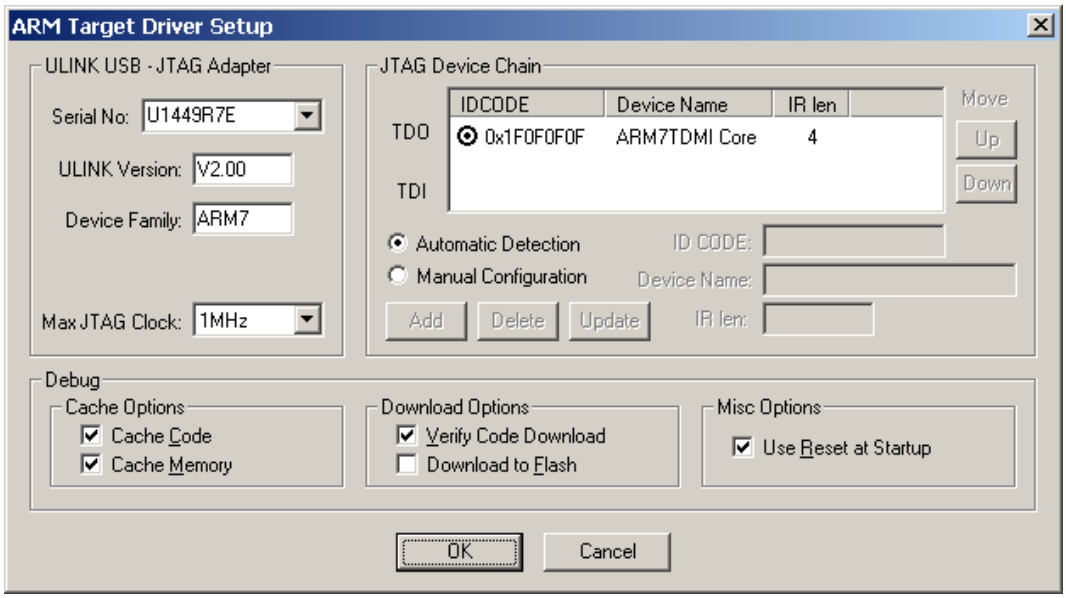
Configure the Asm Options

- Change to the **Asm** tab. In the *Conditional assembly control Symbols, Set* field, type: **_REMAPPED_**. This will make sure the correct code base address is used when compiling and linking the project.



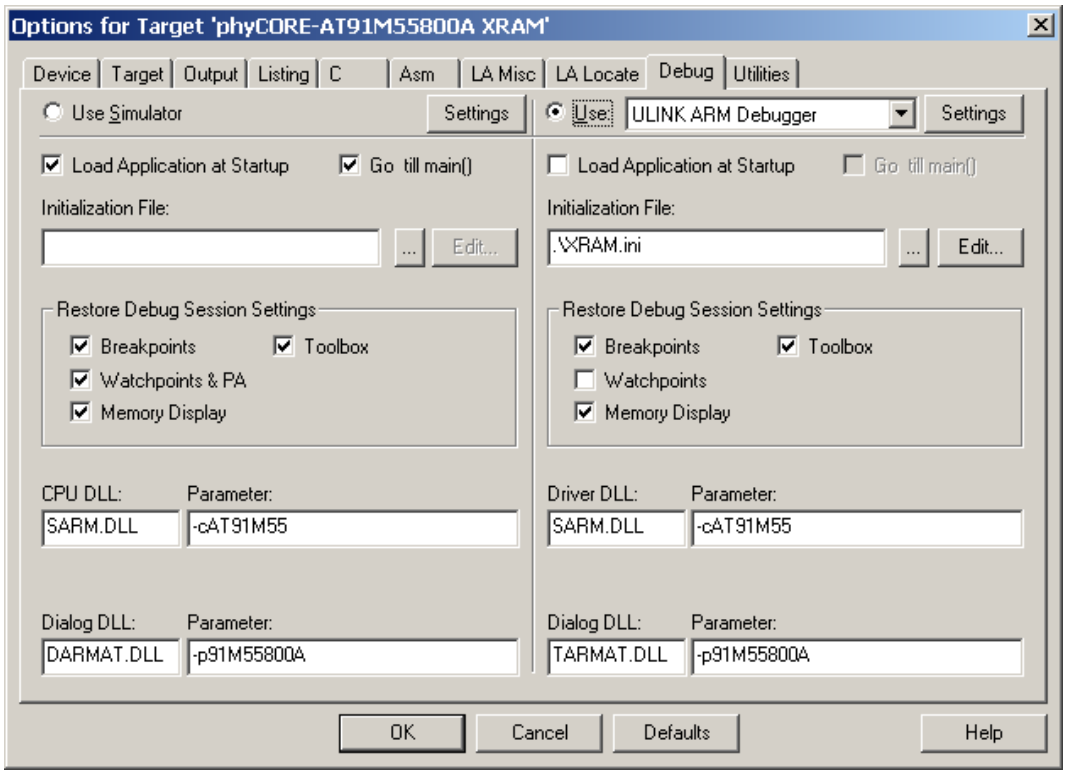
Configure the Debug Options

- In the **Debug** tab, check the *Use: ULINK ARM Debugger* option.
- Configure the *ARM Target Driver Setup* by clicking the *Settings* button. The *ARM Target Driver Setup* settings should be as follows:



- Click *OK* to return to the *Options for Target* window.
- Be sure that the *Load Application at Startup*, under the ULINK ARM Debugger setting, is **NOT** checked. Loading the application code and the go till main function are executed by the ***XRAM.ini*** file *(see below)*.
- Add the correct *Initialization File* by clicking the browse button  and select ***XRAM.ini.***

- The ***Debug*** tab should now appear as follows:



- Click *OK* to save all the settings.
- In the main µVision3 menu select *File / Save All.*

You are now ready to run the compiler and linker using the Make utility.

- Build the target by either selecting the build icon  on the build toolbar or in the main menu select *Project / Build target.*

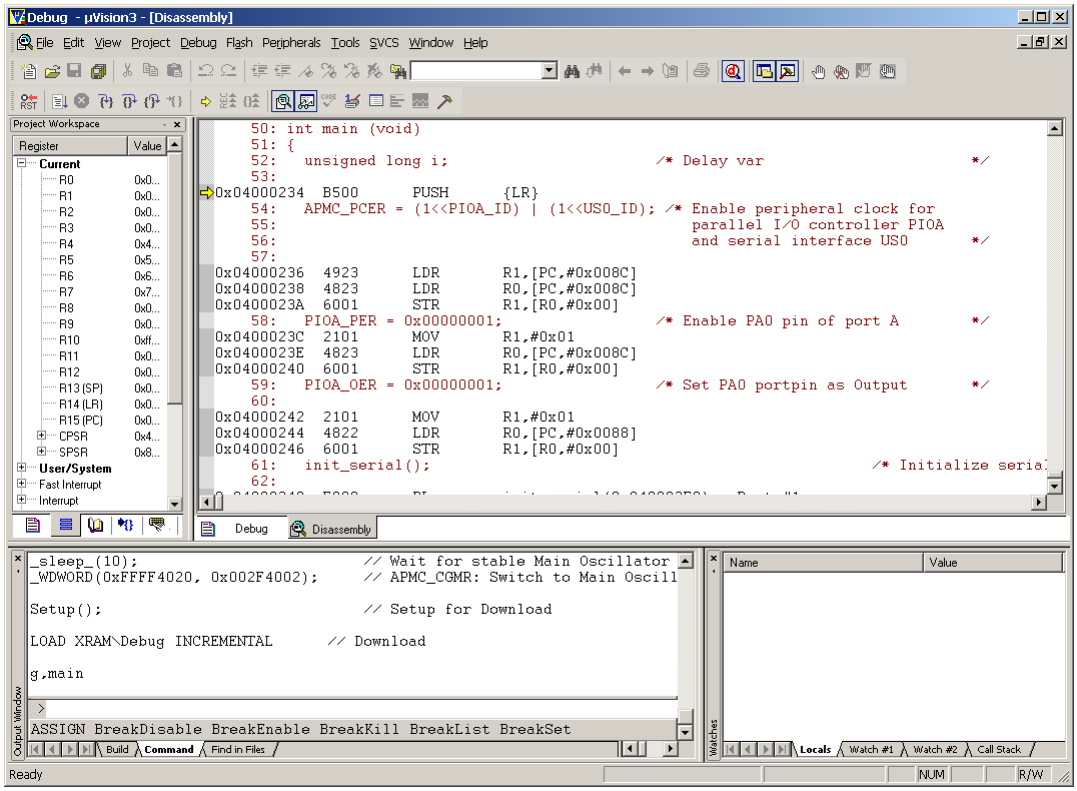
If there are no errors, the code is ready to be downloaded into the external SRAM for further debugging steps. Before starting the debugger first open HyperTerminal again using the same settings as described in *section 2.3.2*. This allows you to monitor the `printf` outputs over the serial RS-232 port.

4.2 Starting the Debugger

- To start the ARM7/µVision3 debug environment, click on the debugger icon  on the µVision3 toolbar.
- You will see a blue status bar from left to right at the bottom of your screen indicating the download process of the debug program.

If a problem occurs during data transfer, an error message will be displayed. If this should occur, make sure the target hardware is properly connected to a power supply and the host-PC using the Keil ULINK device (*refer to section 2.2*).

If the data transfer was successful, a screen similar to the one shown below will appear. The ***Project*** window changed to the ***Register*** page and the main page has changed to the **Disassembly**. The debug toolbar is also displayed. In the lower part of the debug screen you will see the ***Command*** and ***Watch*** windows.



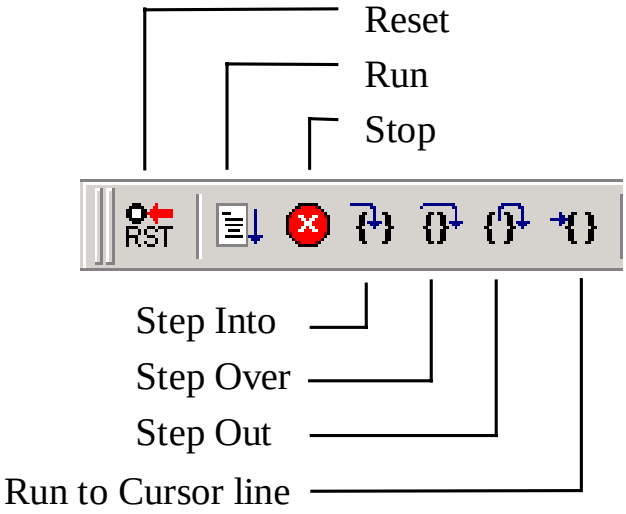
You may need to open, resize and /or move some windows to make your screen look similar to the screen capture. You can open inactive windows by choosing the desired window from the ***View*** pull-down menu.

- Change to the *Debug.c* source window by clicking on the corresponding tab.

The debugger will run to the *'main'* function and stop automatically. Notice the yellow arrow pointing to the first command in the *'main'* function. Also notice the program counter (**PC $**) within the **Project Window – Register** page showing the start address of the *'main'* function.

4.3 Keil µVision3 Debug Features

- The ***Debugger*** window toolbar gives access to the following debug commands: *Reset*, *Run*, *Stop*, *Step Into*, *Step Over*, *Step Out* and *Run to Cursor line*.



- The first button on the debugger toolbar is the *Reset*  button.

  The *Reset* command sets the program counter to 0.

- The button to the right of the *Reset* button starts the *Run*  command.

  Clicking this button runs the program without active debug functions. To stop program execution at a desired point, a breakpoint can be placed before the *Run* button is pushed.

- The next button on the debugger toolbar is the *Stop*  button.

  The *Stop* button interrupts and stops the running program at an undetermined location.

- The first button allowing exact control of the program execution is the *Step Into* button.

  The *Step Into* command performs the execution of the command line to which the *Current-Statement Arrow* points. This can be a C command line or a single assembler line, depending on the current display mode. If the command line is a function call, *Step Into* jumps to the C function or subroutine, enabling you to explore the code contained in the accessed subroutine.

- The *Step Over* button is next on the debugger toolbar.

  The *Step Over* command executes the command line, to which the *Current-Statement Arrow* points. This can be a C command line or a single assembler line, depending on the current display mode. If the command line is a function call, the function will be executed without single stepping into the function.

- The next button is the *Step Out* button..

  Step Out is used to exit a function you are currently in. *Step Out* is very useful if you find yourself in a function you are not interested in and need to return quickly to your intended function.

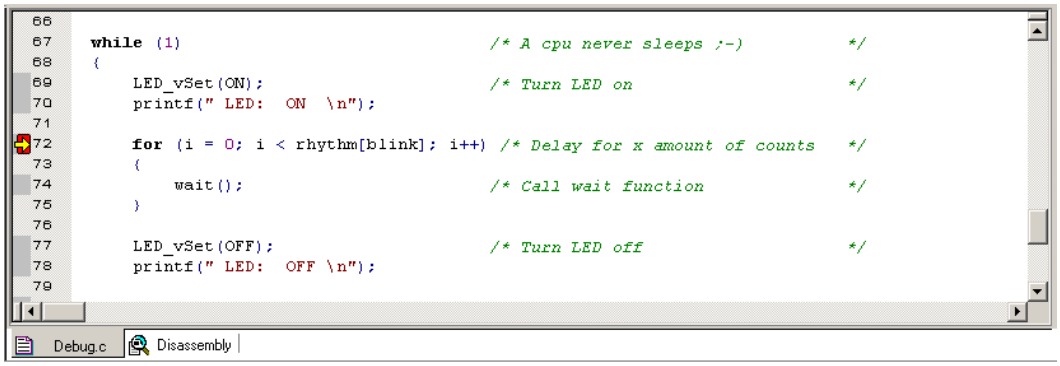
- The last button on the debugger toolbar performs the *Run to Cursor line* command.

  The *Run to Cursor line* command executes the program to the current cursor position within the code window. This allows use of the cursor line as a temporary breakpoint.

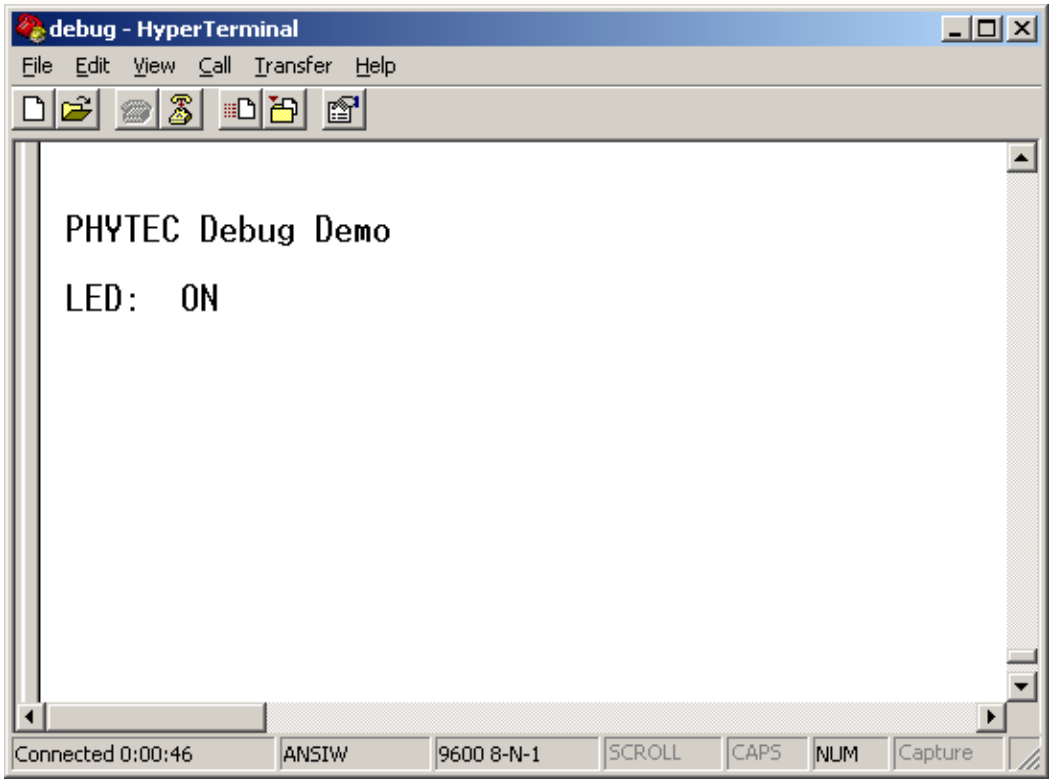
4.4 Using the Keil µVision3 Debug Features

4.4.1 Breakpoints

- Activate the ***Debug.c*** file by clicking on the ***Debug*** tab.
- Click in the line `for (i = 0; i < rhythm[blink]; i++)`
- Click on *Insert/Remove Breakpoint*  to set a breakpoint here. The red marker on the left-hand side of the selected line indicates the breakpoint. You can also set a breakpoint by double-clicking in the desired code line.



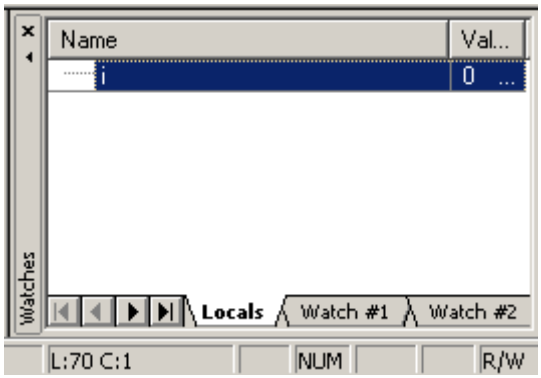
- Click on the *Run*  icon and the program will run and stop at the breakpoint.
- Notice that the LED (D3) on the Development Board now illuminates.
- Also notice the output message in HyperTerminal that comes from the `printf` statement in line # 63 and #70.



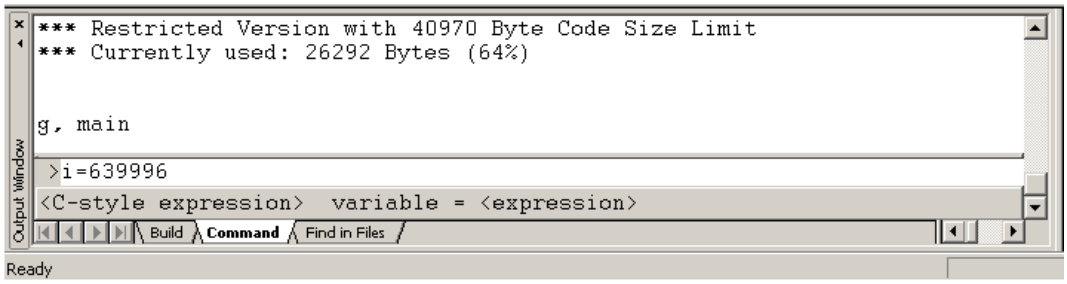
- Click again on *Insert/Remove Breakpoint* to remove the breakpoint.

4.4.2 Single Stepping and Watch Window

- Click on the ***Step Into*** icon to enter the `for{}` loop.
- The **Watch** window – **Locals** tab automatically shows the value of the local variable *i*. Change the number base from hexadecimal to decimal by right-clicking on the variable.

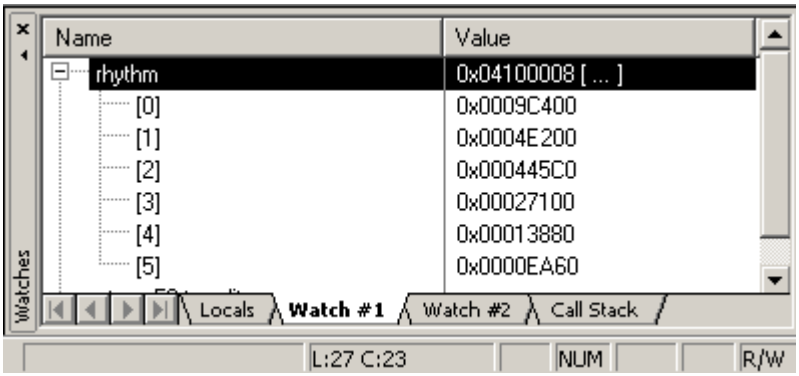


- Click ***Step Over*** several times and watch the value of *i* count up.
- As you can see in the source code, the `for{}` loop will end if *i* becomes equal to the first element of the constant field *rhythm[]* which has the value of **640,000**. To leave the *wait* function, change the value of *i* by typing i=***639996*** in the command line and pressing <Enter>. Now repeat clicking on ***Step Over*** until you leave the wait function.



- Click in the source code line *blink++* and choose ***Run to Cursor line*** from the debug toolbar. Your program will be executed until it reaches this line.
- Notice that the LED D3 on the Development Board is off now and the output message appearing in the HyperTerminal window indicates LED: OFF.

- As a last example, the constant "**rhythm[]**" will be evaluated. Go to the source code line where the constant "**rhythm[]**" is declared. Right-click on "**rhythm[]**" and choose the **"ADD rhythm to watch window" -> #1** option. Select the "**Watch #1**" tab at the bottom of the watch window. The constant is shown with its address and a small ⊞ sign in front which indicates that "**rhythm[]**" is an array with a group of array elements. Click the ⊞ sign to expand the view and to see all array elements of "**rhythm[]**".



4.5 Running, Stopping and Resetting

- To run your program without stopping at any time, delete all breakpoints by clicking on the button.
- Click the ***Run*** button.

The LED now blinks at changing on/off intervals.

You can use of the ***Stop*** button to stop program execution at any time.

4.6 Changing Target Settings for the "Executable Version"

After successfully debugging the program, next change the project and the target settings in order to create an executable file that can then be downloaded to and executed out of the Flash memory on the phyCORE- AT91M55800A.

- Exit the current debug session by selecting ***Debug*|*Start*|*Stop Debug Session***.
- We recommend adding a new target to the debug project. This allows you to use the same C source files but different target settings to be used for debugging (*XRAM*) and Flash download (*XFLASH*).
- Click on the  icon in the build toolbar.
- Add another target by selecting the *New(Insert)* icon  in the **Project targets** window. Name the new target *phyCORE-AT91M55800A XFLASH.*
- Click *OK* to return to the µVision3 window.
- In the **Select Target** pull down menu select *phyCORE-AT91M55800A XFLASH*.
- Configure options for target by selecting the *Options for Target* icon  on the build toolbar.
- Set all target options as described in *section 3.3* and build the project.
- Download the created ***Debug*** file to the external Flash memory. For general download procedure information refer to *section 3.5*.
- Start the HyperTerminal program as described in *section 2.3.2*.
- The ***Debug*** code will start automatically at the end of the download.

Now you can watch your final debug example execute. The HyperTerminal will display the status of the LED.

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Document number: **L-659e_3, July 2005**

How would you improve this manual?

Did you find any mistakes in this manual? page

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