EE 315

MICROPROCESSORS

LABORATORY MANUAL

2019

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Introduction

This document is the laboratory manual for the EE459 Microprocessor-based System Design course. The document includes information on the evaluation kit (EK) and the simulation environment that will be used in the labs.

Lab Rules

• In the laboratory sessions, you are expected to learn to program an ARM based micro-controller using a Texas Tiva C LaunchPad TM4C123G and the Keil µVision **I**ntegrated **D**evelopment **K**it.

• For this purpose, we strongly advise you to install Keil µVision IDE on your PCs.

• There will be quizzes before the labs practice, which will contain questions relating to the experiment to be held on that lab session. Both the quizzes and your lab performance will be graded.

• You will perform your experiments in groups of two.

About the Kit We Will Use

The TM4C123G LaunchPad Evaluation Kit is a low-cost evaluation platform for ARM Cortex-M4F based microcontrollers from Texas Instruments. The design of the TM4C123G LaunchPad highlights the TM4C123GH6PM microcontroller with a USB 2.0 device interface and hibernation module.

The EK-TM4C123GXL also features programmable user buttons and an RGB LED for custom applications. The stackable headers of the TM4C123G LaunchPad BoosterPack™ XL Interface make it easy and simple to expand the functionality of the TM4C123G LaunchPad when interfacing to other peripherals with Texas Instruments MCU BoosterPack.

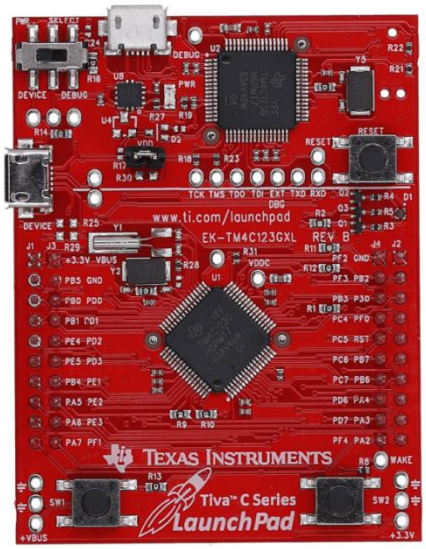


Figure 1 TM4C123G LaunchPad

Features:

The ARM Cortex-M4F Based MCU TM4C123G LaunchPad Evaluation Kit (EK-TM4C123GXL) offers these features:

• High Performance TM4C123GH6PM MCU:

• 80MHz 32-bit ARM Cortex-M4-based microcontrollers CPU

• 256KB Flash, 32KB SRAM, 2KB EEPROM

• Two Controller Area Network (CAN) modules

• USB 2.0 Host/Device/OTG + PHY

• Dual 12-bit 2MSPS ADCs, motion control PWMs

• 8 UART, 6 I2C, 4 SPI

• On-board In-Circuit Debug Interface (ICDI)

It is possible to buy a EK-TM4C123GXL LaunchPad in Turkey. Please check the web for different sellers.

About Keil µvision

Keil µvision is free up to 32kb of code size. The µVision IDE combines project management, run-time environment, build facilities, source code editing, and program debugging in a single powerful environment. µVision supports multiple screens and allows you to create individual window layouts anywhere on the visual surface.

The µVision Debugger provides a single environment in which you may test, verify, and optimize your application code. The debugger includes traditional features like simple and complex breakpoints, watch windows, and execution control and provides full visibility to device peripherals.

µVision Project Manager and Run-Time Environment

With the µVision Project Manager and Run-Time Environment you create software application using pre-build software components and device support from Software Packs. The software components contain libraries, source modules, configuration files, source code templates, and documentation. Software components can be generic to support a wide range of devices and applications.

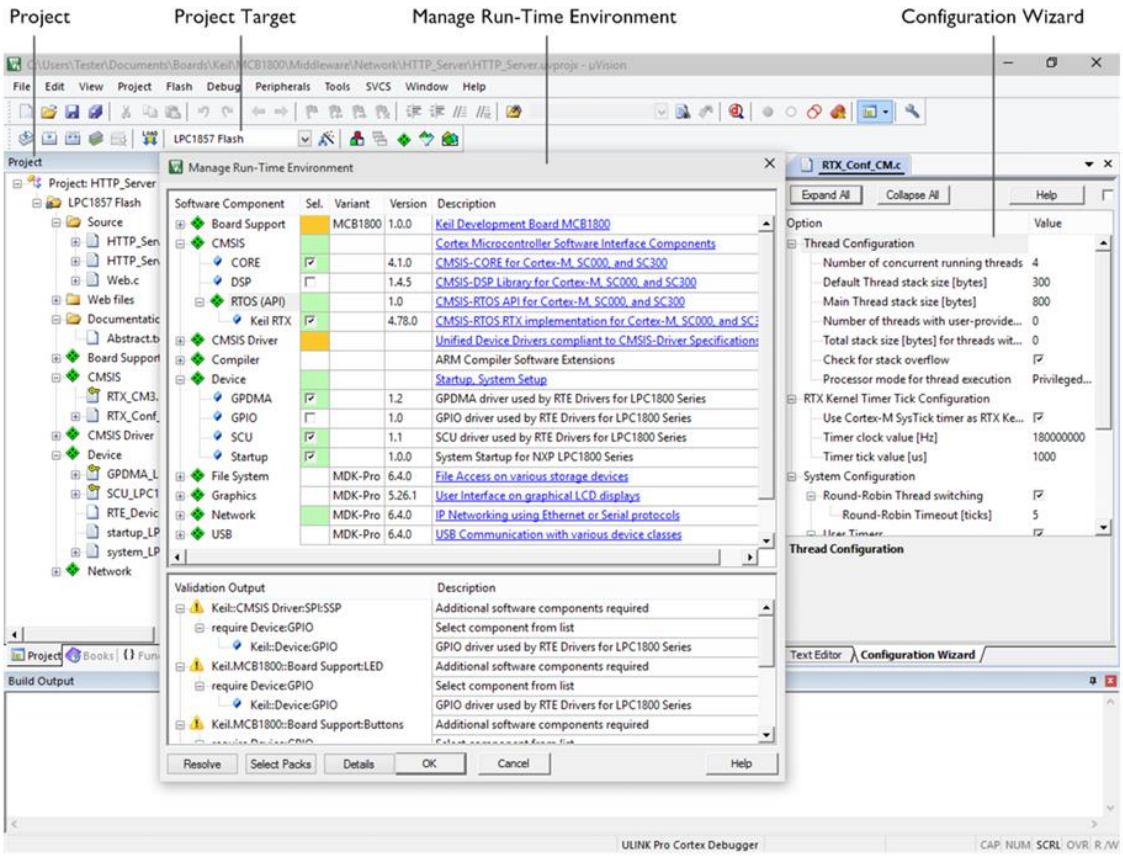


Figure 2

• The Project window shows application source files and selected software components. Below the components you will find corresponding library and configuration files.

• Projects support multiple targets. They ease configuration management and may be used to generate debug and release builds or adoptions for different hardware platforms.

• The Manage Run-Time Environment window shows all software components that are compatible with the selected device. Inter-dependencies of software components are clearly identified with validation messages.

• The Configuration Wizard is an integrated editor utility for generating GUI-like configuration controls in assembler, C/C++, or initialization files.

µVision Editor

The integrated µVision Editor includes all standard features of a modern source code editor and is also available during debugging. Color syntax highlighting, text indentation, and source outlining are optimized for C/C++.

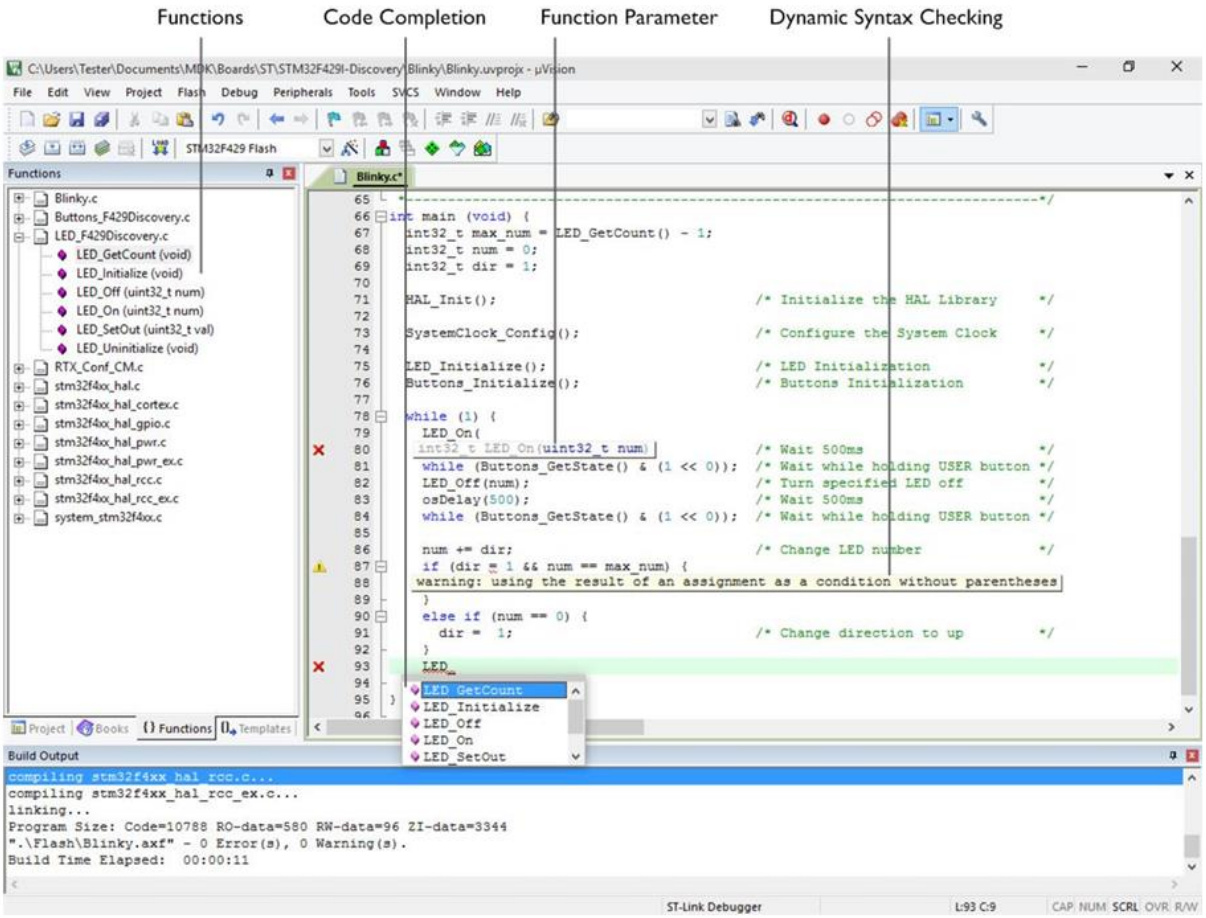


Figure 3

• The Functions window gives fast access to the functions in each C/C++ source code module.

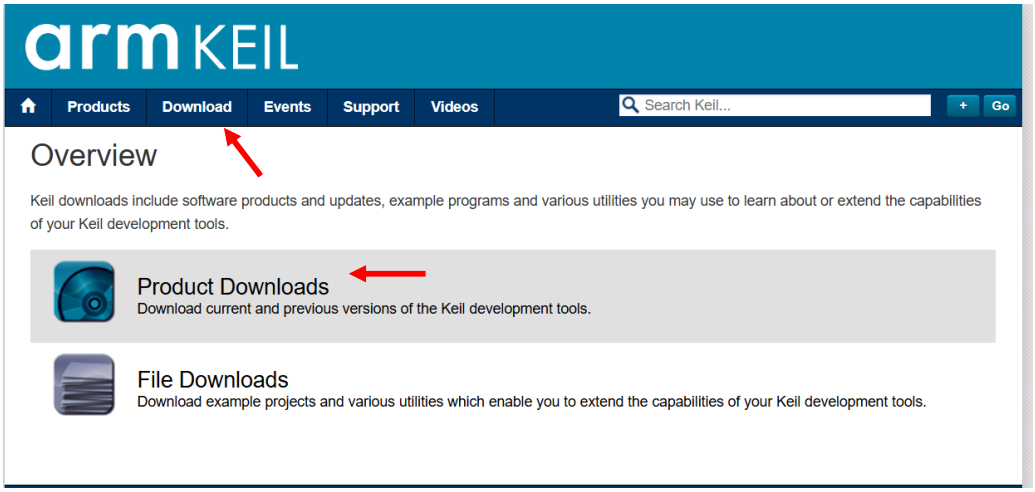
• The Code Completion list and Function Parameter information helps you to keep track of symbols, functions, and parameters.

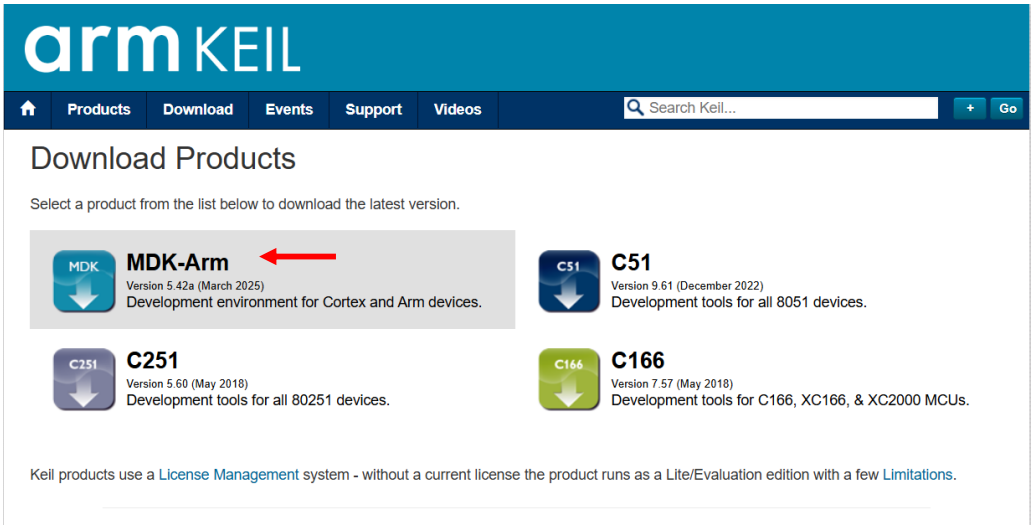
• Dynamic Syntax Checking validates the program syntax while you are typing and provides real-time alerts to potential code violations before compilation.

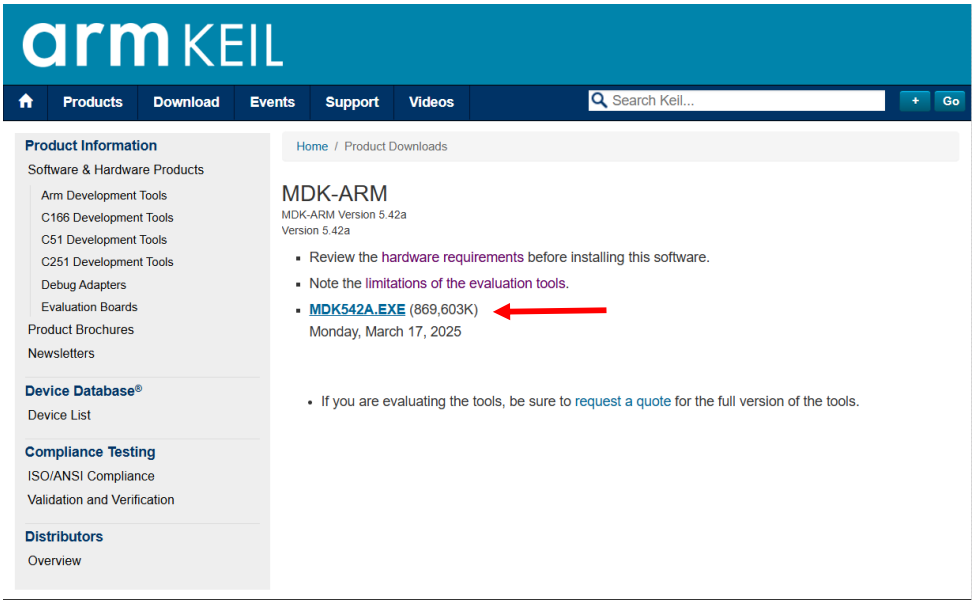
Download Software

First, download the files below using the links:

1. Keil µVision 5 for ARM processors:
   https://www.keil.com/demo/eval/arm.htm (Latest version: MDK542A.EXE)







2. Driver support for the launchpad:
   https://www.ti.com/tool/STELLARIS_ICDI_DRIVERS

3. A useful version (2013) TM4C123GH6PM header file defines the register addresses as mnemonics for C language:
   http://users.ece.utexas.edu/~valvano/Volume1/tm4c123gh6pm.h

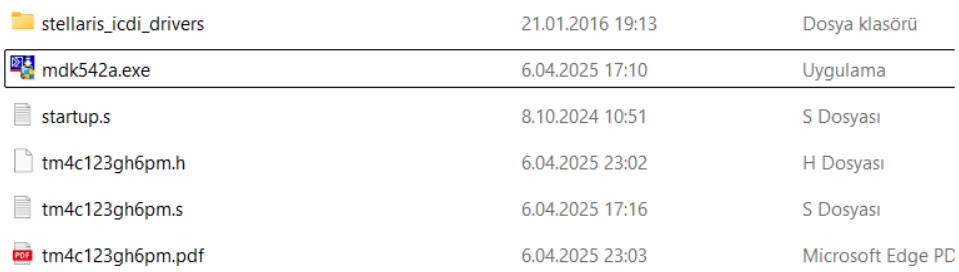
4. A useful version (2013) TM4C123GH6PM header file defines the register addresses as mnemonics for ASSEMBLY language:
   http://users.ece.utexas.edu/~valvano/arm/tm4c123gh6pm.s

5. An old version of ASSEMBLY startup file (startup.s):
   http://ee315.cankaya.edu.tr/uploads/files/startup.s

6. 6. TM4C123GH6PM Datasheet
   http://www.ti.com/lit/ds/symlink/tm4c123gh6pm.pdf

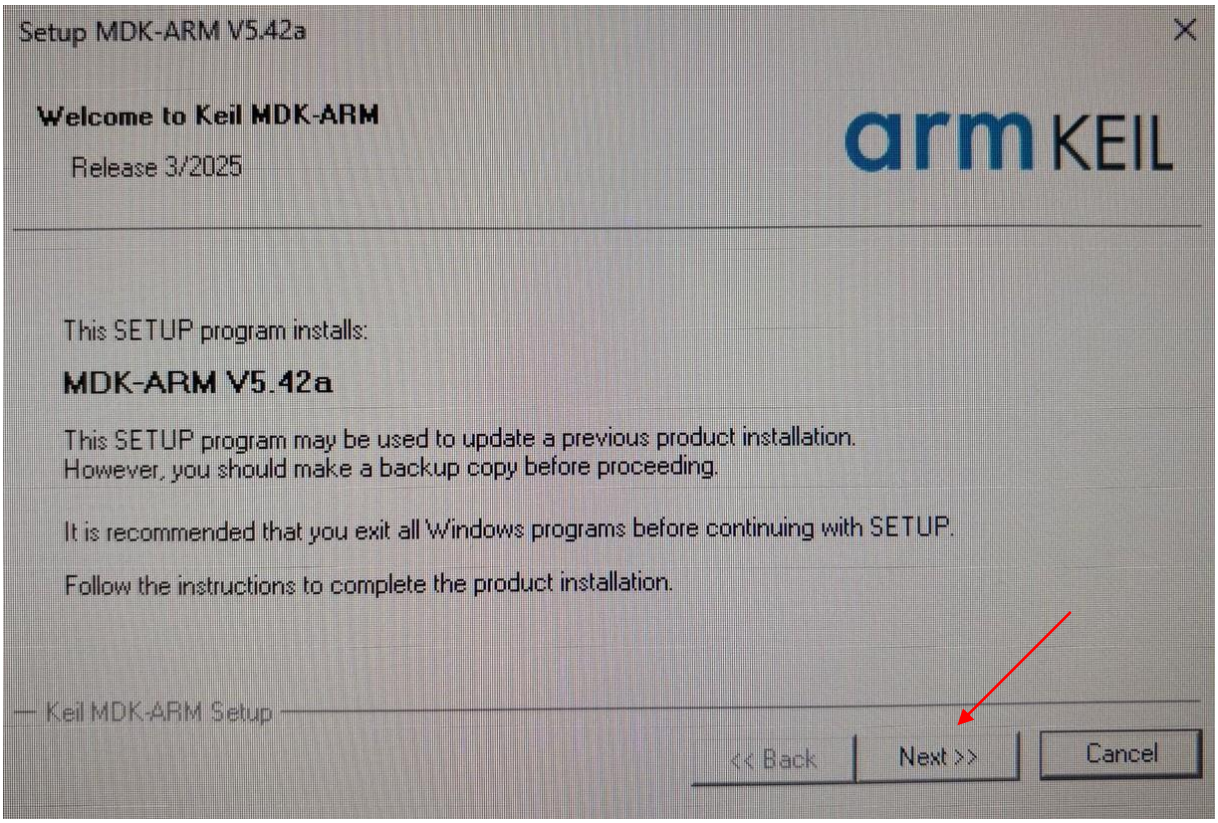
7. If you have any questions, this site may serve as a helpful resource.
   https://developer.arm.com/

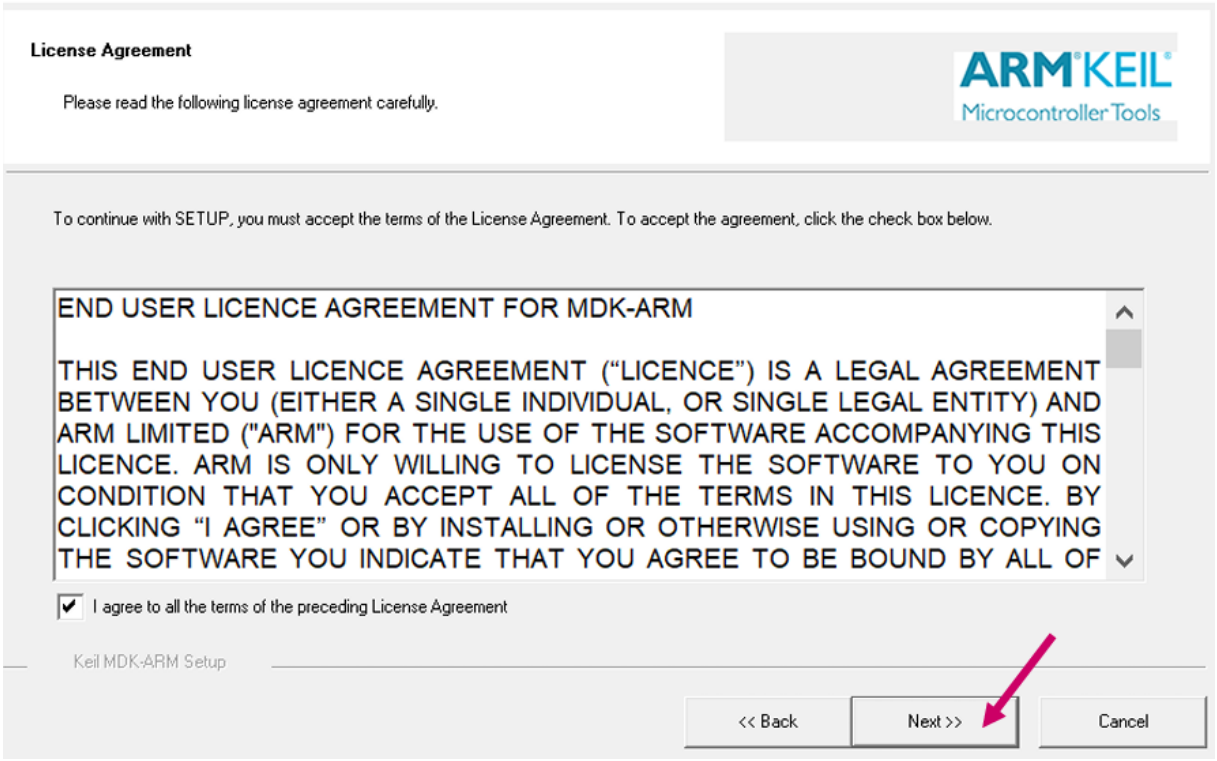
The folder should be like below:

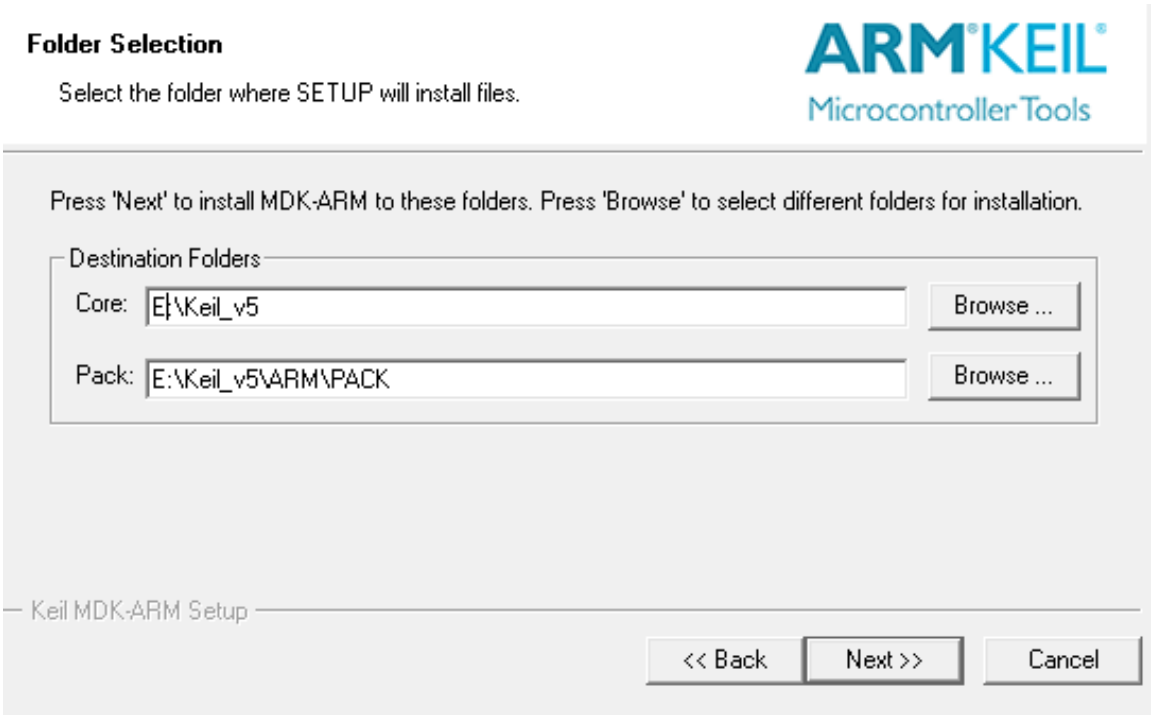


Installation of Software

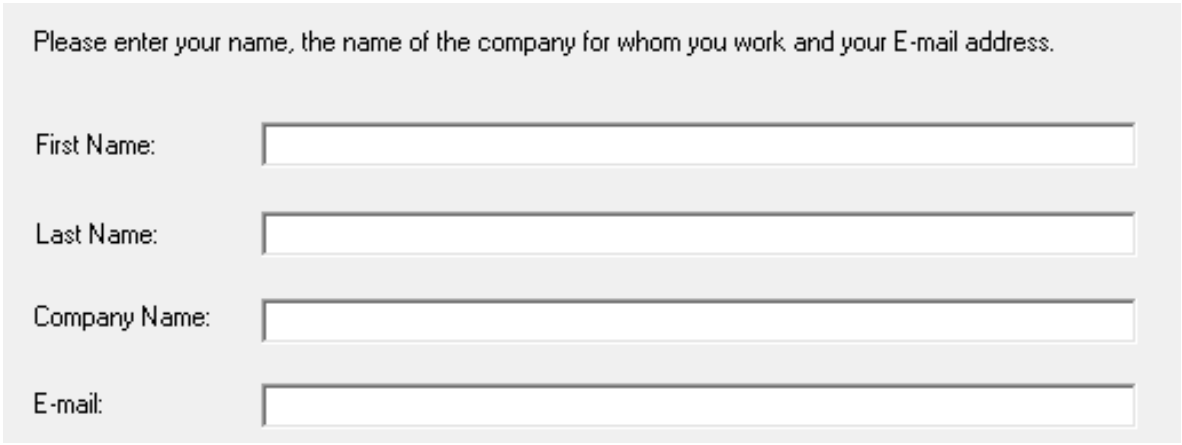
1. First, run MDK542a.exe and follow the instructions below:

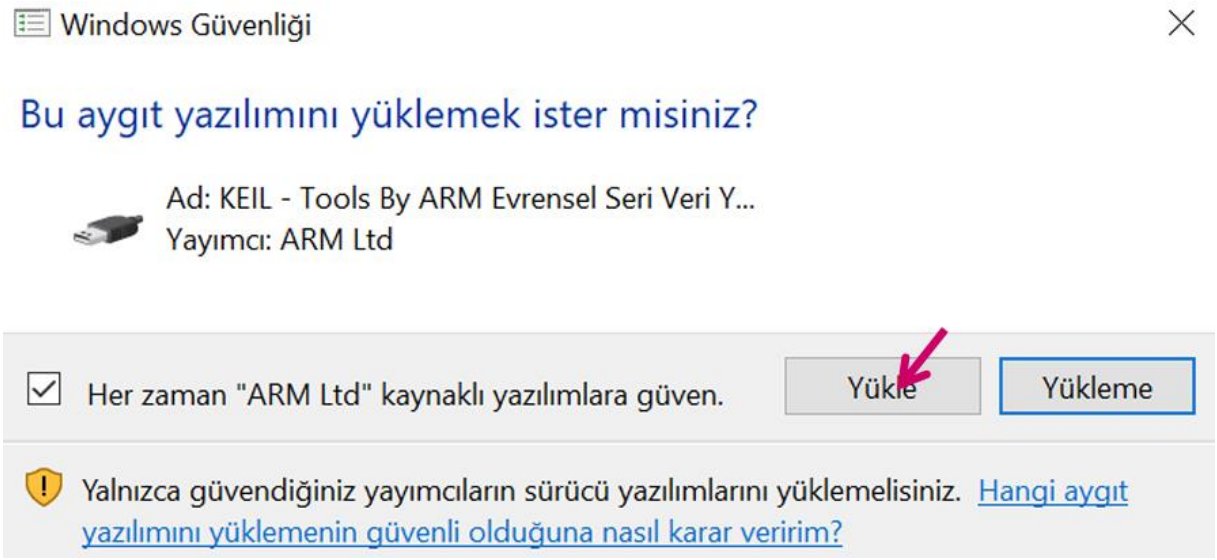


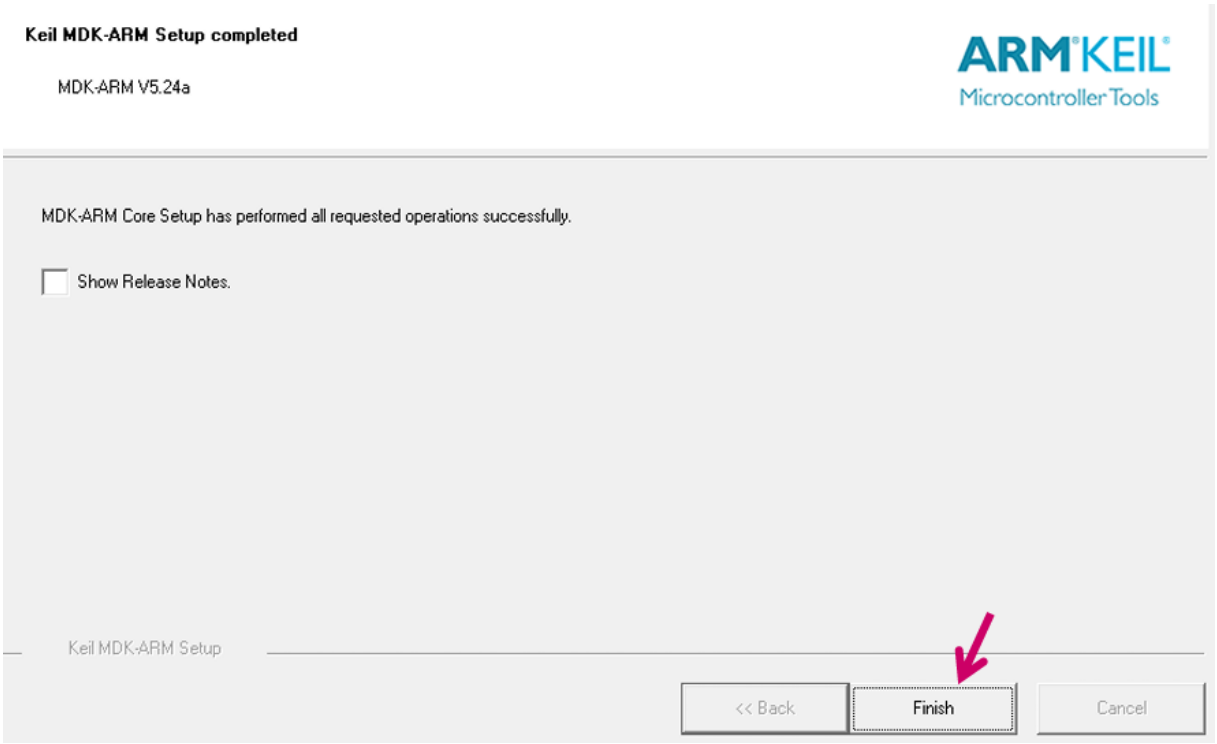

License Agreement
Please read the following license agreement carefully.
ARM KEIL
Microcontroller Tools
To continue with SETUP, you must accept the terms of the License Agreement. To accept the agreement, click the check box below.
END USER LICENCE AGREEMENT FOR MDK-ARM
THIS END USER LICENCE AGREEMENT ("LICENCE") IS A LEGAL AGREEMENT BETWEEN YOU (EITHER A SINGLE INDIVIDUAL, OR SINGLE LEGAL ENTITY) AND ARM LIMITED ("ARM") FOR THE USE OF THE SOFTWARE ACCOMPANYING THIS LICENCE. ARM IS ONLY WILLING TO LICENSE THE SOFTWARE TO YOU ON CONDITION THAT YOU ACCEPT ALL OF THE TERMS IN THIS LICENCE. BY CLICKING "I AGREE" OR BY INSTALLING OR OTHERWISE USING OR COPYING THE SOFTWARE YOU INDICATE THAT YOU AGREE TO BE BOUND BY ALL OF
I agree to all the terms of the preceding License Agreement
Keil MDK-ARM Setup
<< Back
Next >>
Cancel

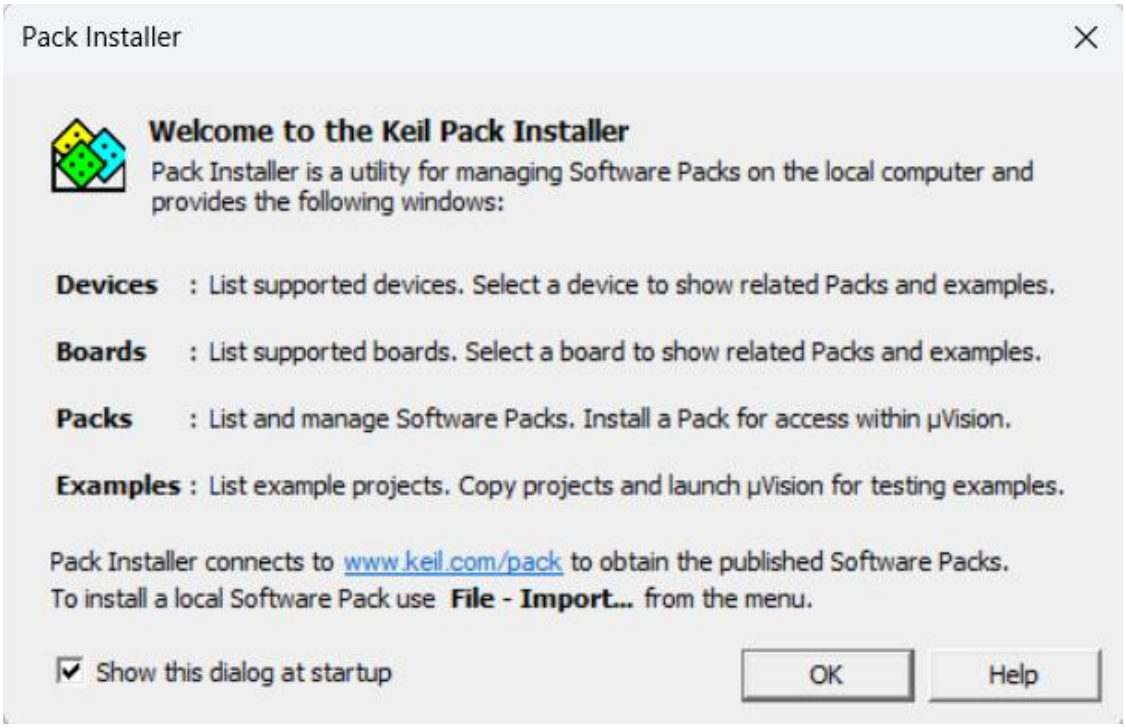

Folder Selection
Select the folder where SETUP will install files.
ARM KEIL
Microcontroller Tools
Press 'Next' to install MDK-ARM to these folders. Press 'Browse' to select different folders for installation.
Destination Folders
Core: E:\Keil_v5
Browse ...
Pack: E:\Keil_v5\ARM\PACK
Browse ...
Keil MDK-ARM Setup
<< Back
Next >>
Cancel

Enter your information:

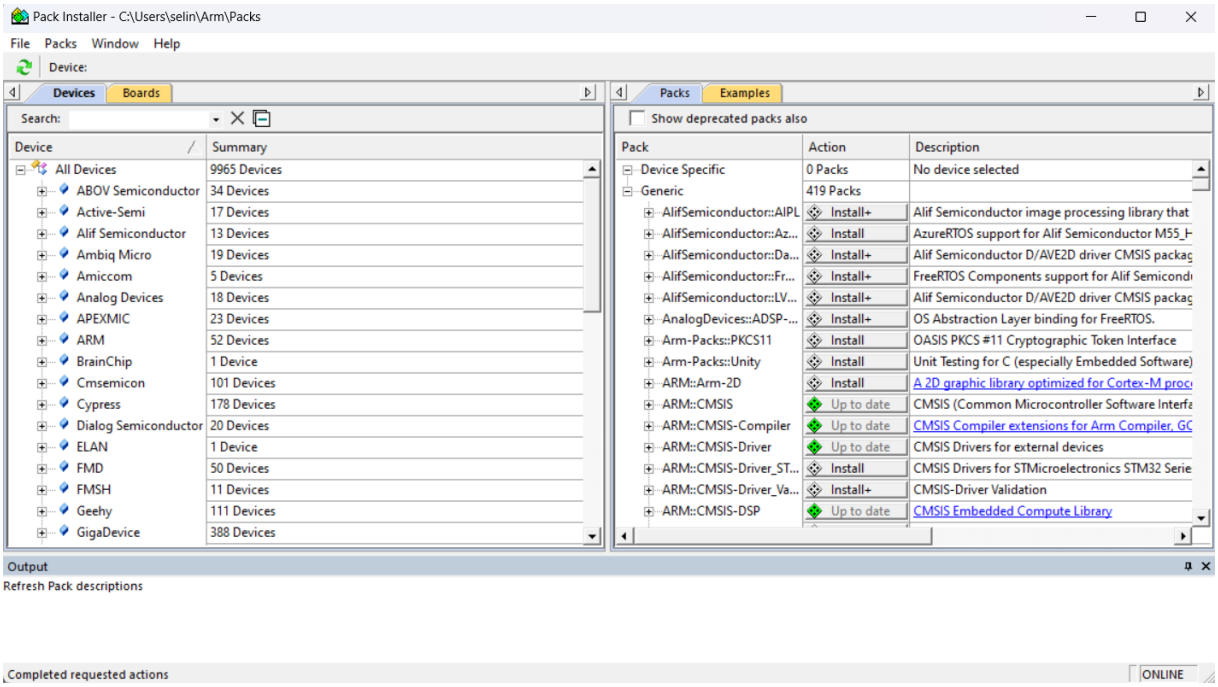




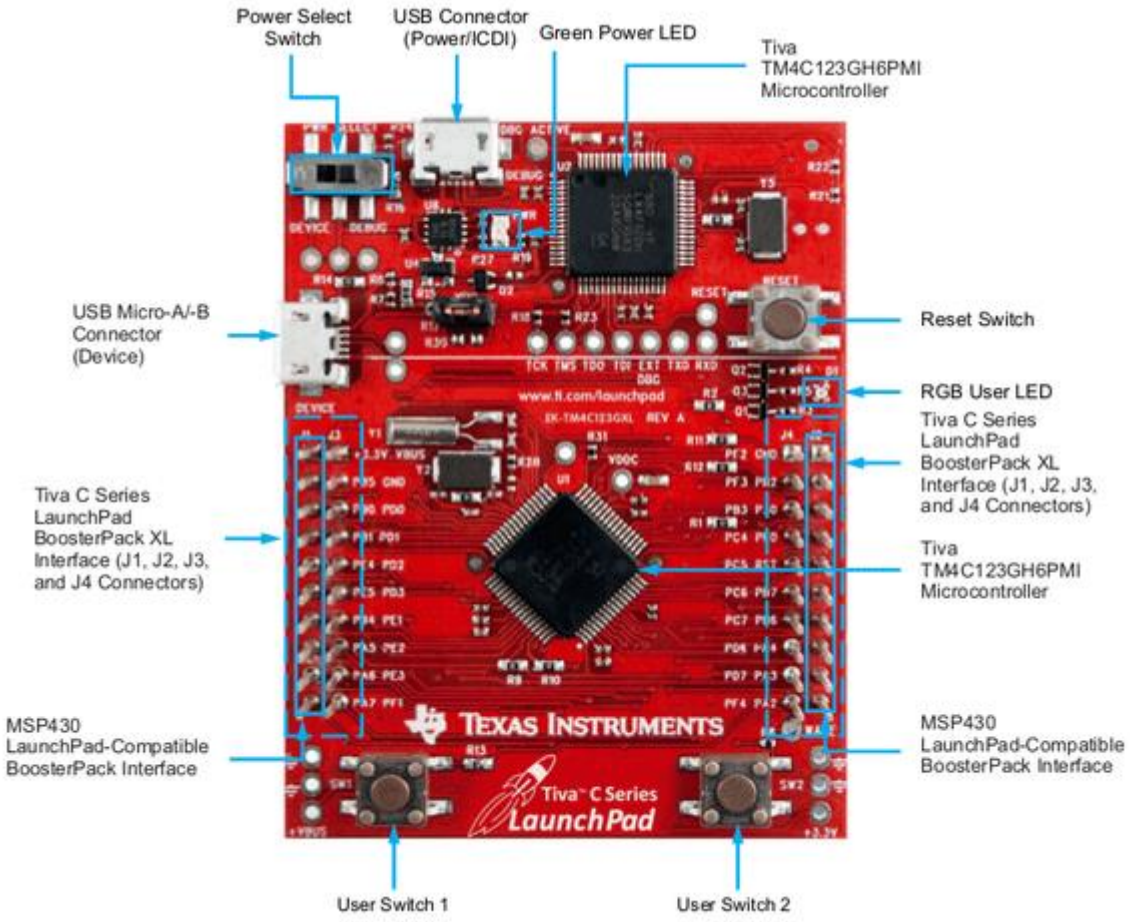

Keil MDK-ARM Setup completed
MDK-ARM V5.24a
ARM KEIL
Microcontroller Tools
MDK-ARM Core Setup has performed all requested operations successfully.
Show Release Notes.
Keil MDK-ARM Setup
<< Back
Finish
Cancel



And let it to update the software by itself:

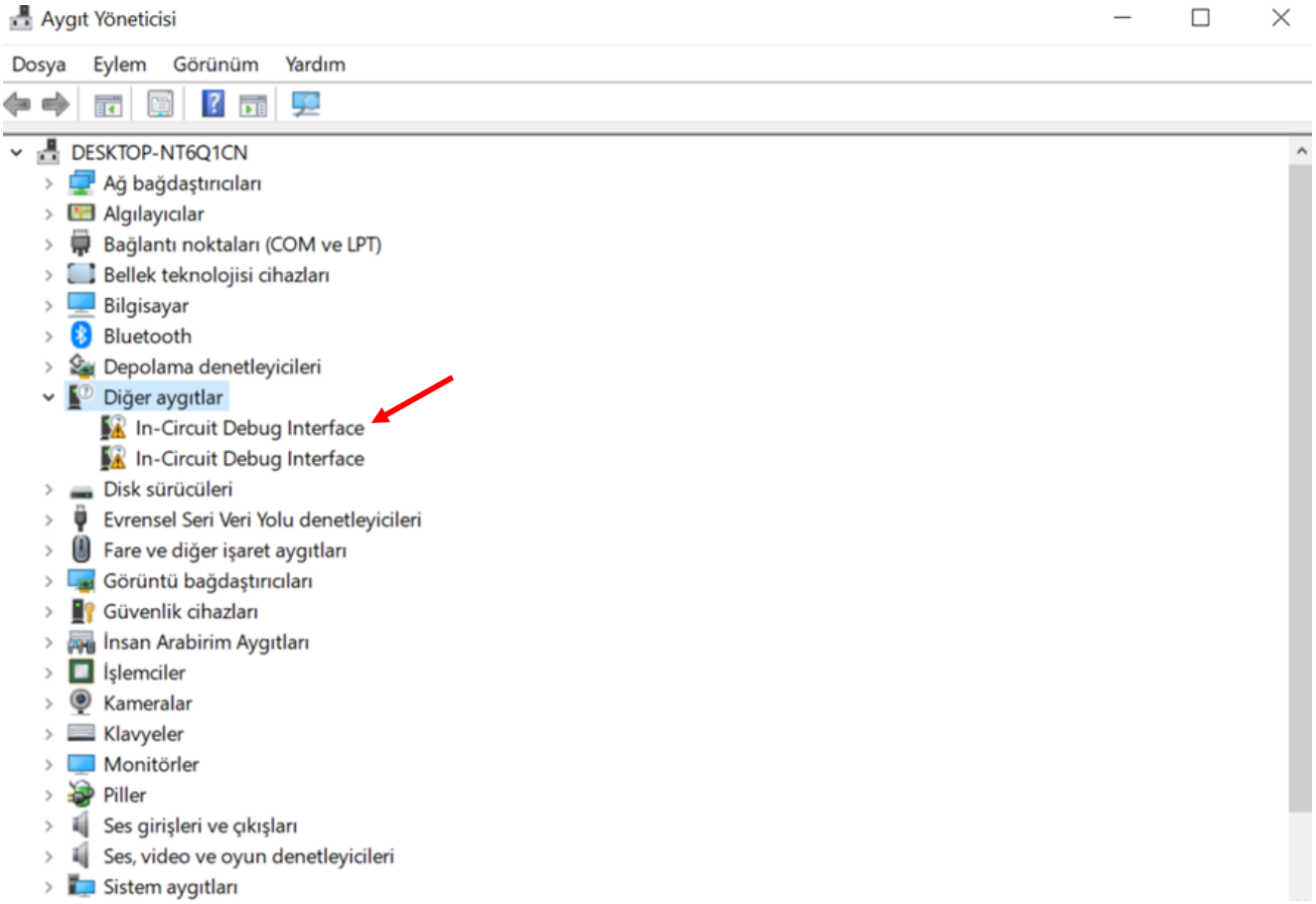


2. Then plug in the USB cable to the “Power/ICDI” port of the microcontroller and select “DEBUG” option using the “Power Select Switch” and then plug it into your computer:

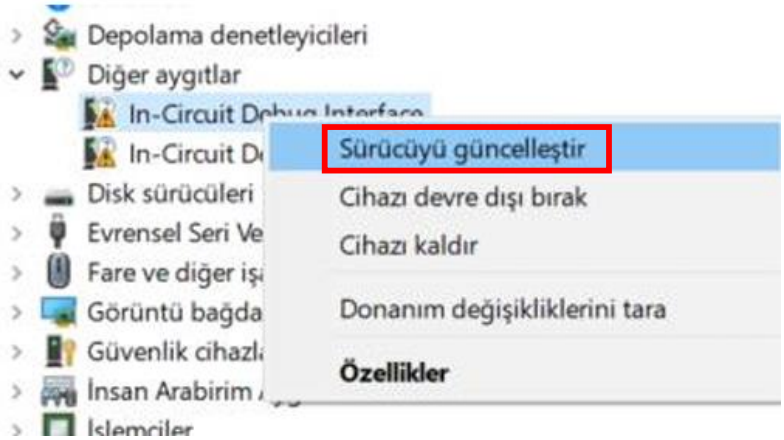


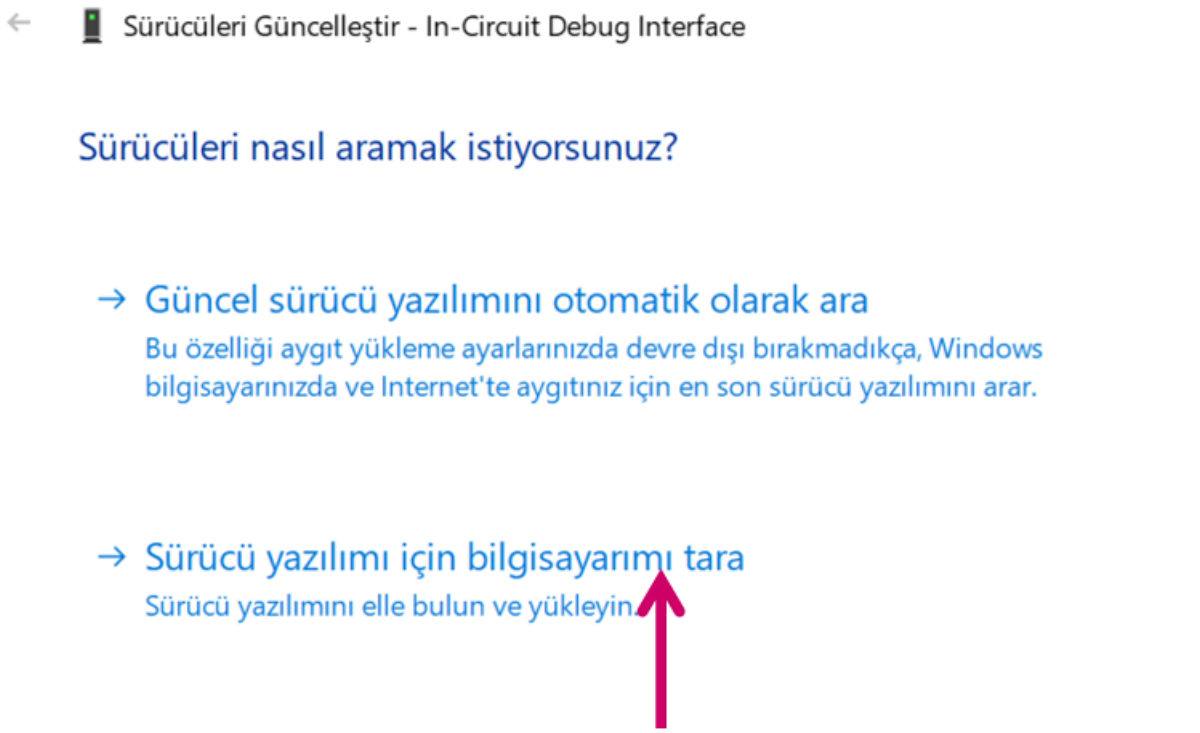
3. The computer should try to recognize the device however, it will fail to detect our hardware.

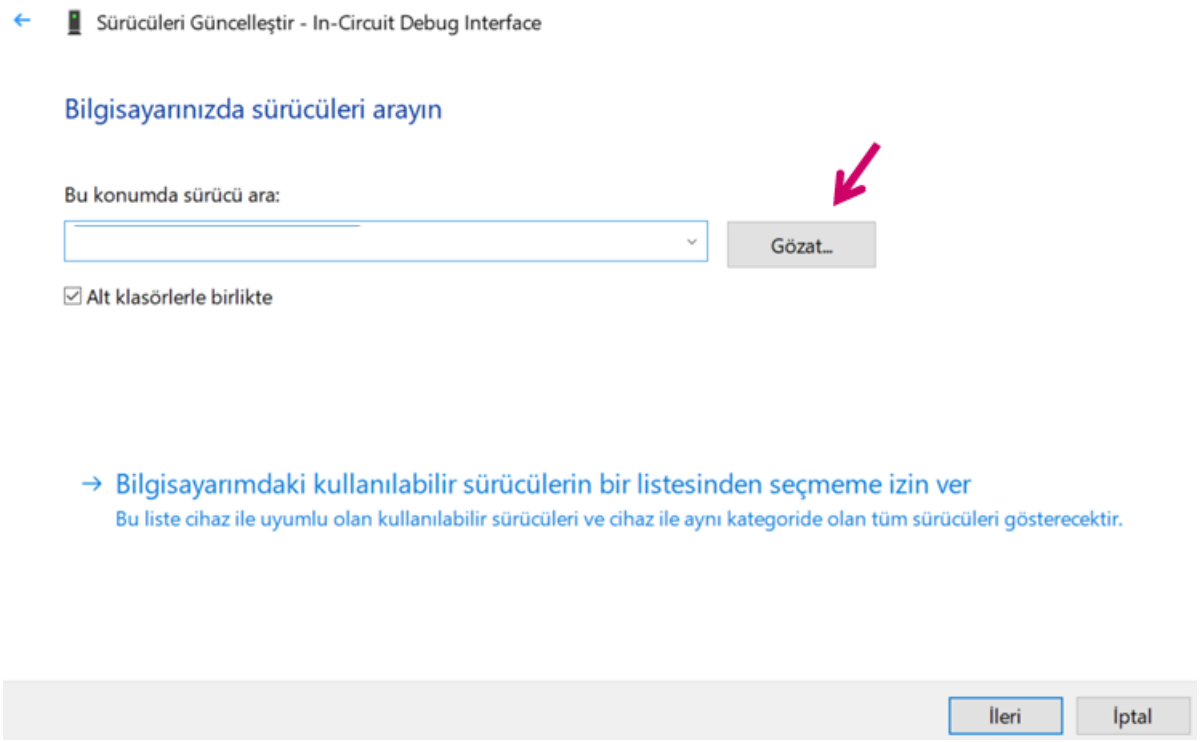
4. Then open the “Device Manager” of Windows OS and follow the pictures below:

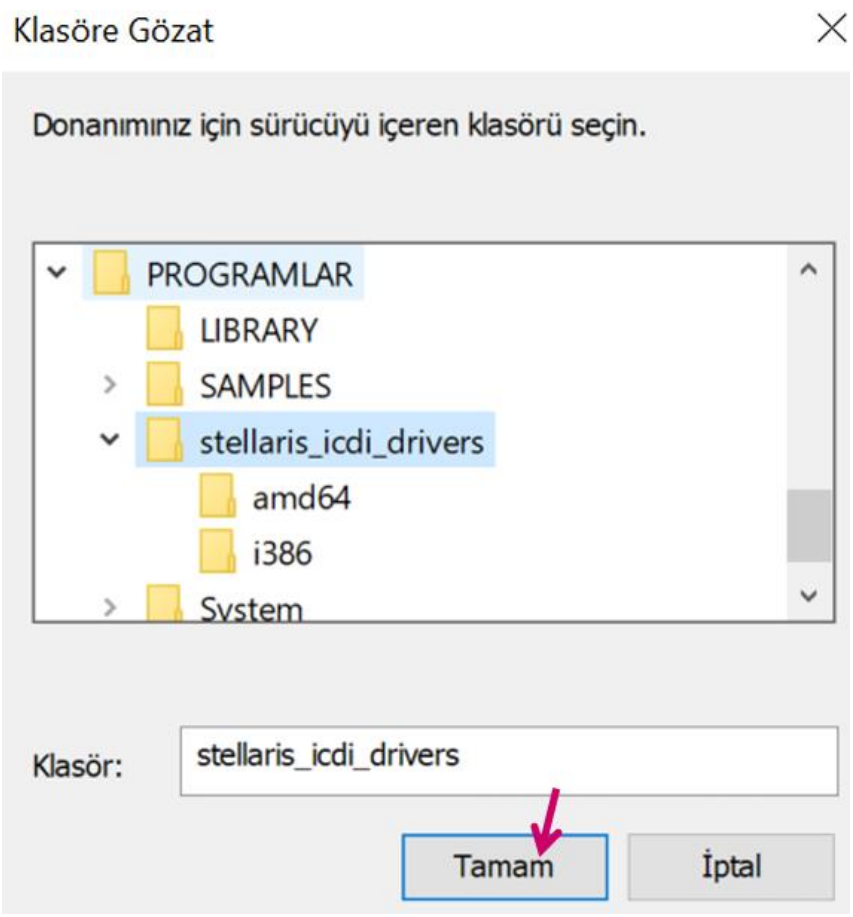


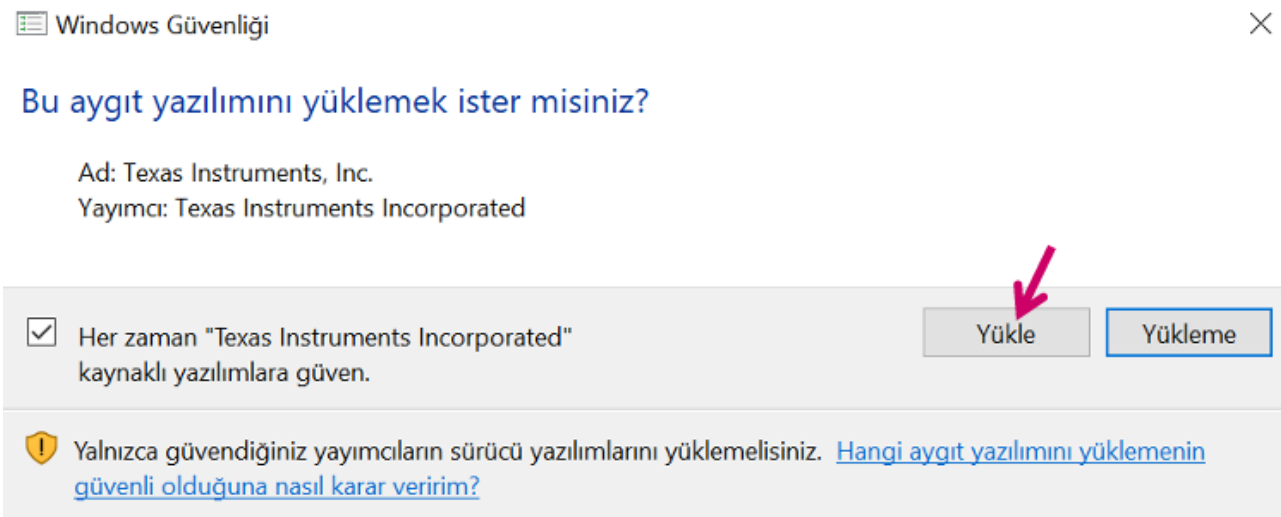
Right-click and select 'Update driver' to proceed with the driver installation.

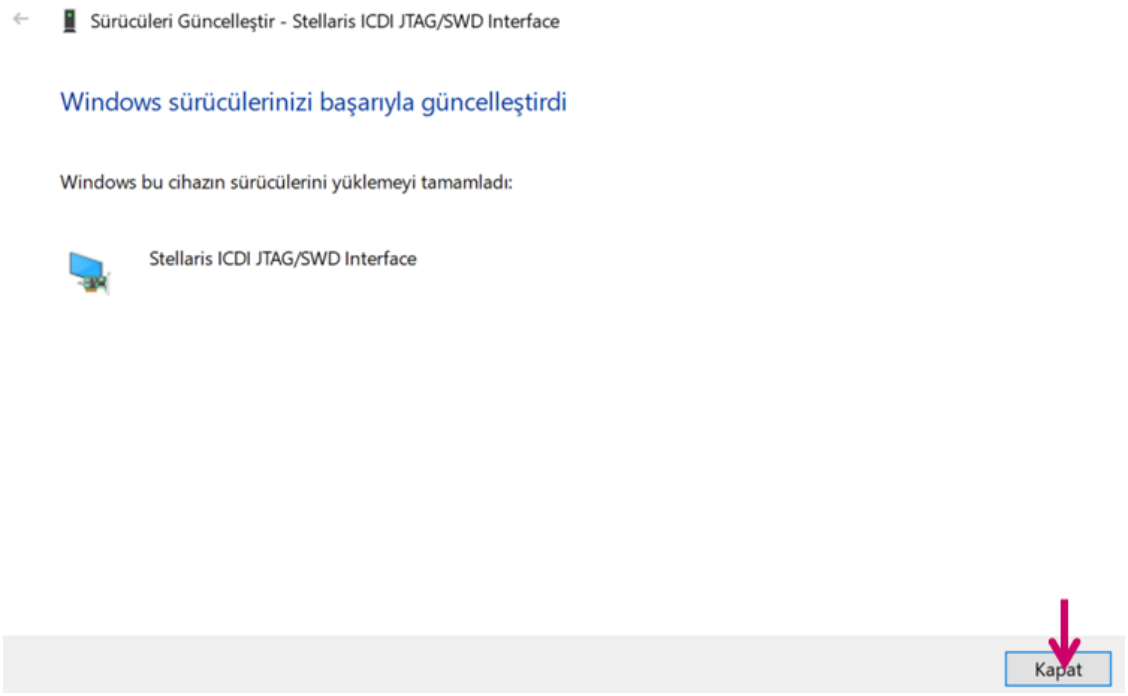



Sürücüleri Güncelleştir - In-Circuit Debug Interface
Sürücüleri nasıl aramak istiyorsunuz?
→ Güncel sürücü yazılımını otomatik olarak ara
Bu özelliği aygıt yükleme ayarlarınızda devre dışı bırakmadıkça, Windows bilgisayarınızda ve Internet'te aygıtınız için en son sürücü yazılımını arar.
→ Sürücü yazılımı için bilgisayarımı tara
Sürücü yazılımını elle bulun ve yükleyin.


Sürücüleri Güncelleştir - In-Circuit Debug Interface
Bilgisayarınızda sürücüleri arayın
Bu konumda sürücü ara:
Gözat...
Alt klasörlerle birlikte
→ Bilgisayarımdaki kullanılabilir sürücülerin bir listesinden seçmeme izin ver
Bu liste cihaz ile uyumlu olan kullanılabilir sürücüleri ve cihaz ile aynı kategoride olan tüm sürücüleri gösterecektir.
İleri
İptal


Klasöre Gözat
Donanımınız için sürücüyü içeren klasörü seçin.
PROGRAMLAR
LIBRARY
SAMPLES
stellaris_icdi_drivers
amd64
i386
System
Klasör:
stellaris_icdi_drivers
Tamam
İptal

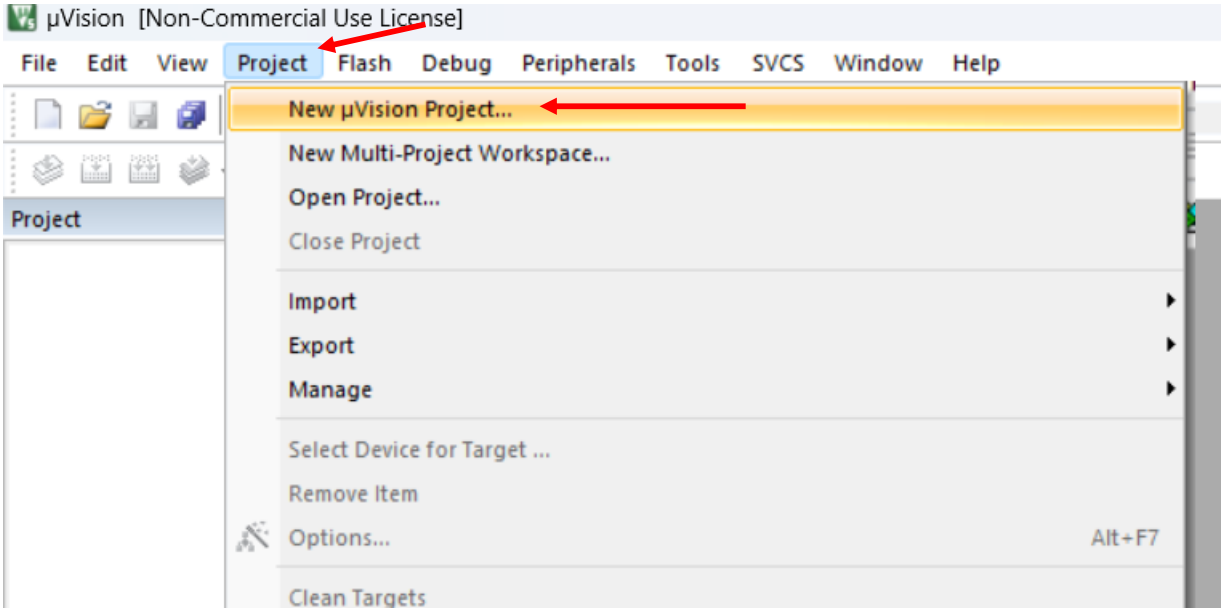

Windows Güvenliği
Bu aygıt yazılımını yüklemek ister misiniz?
Ad: Texas Instruments, Inc.
Yayımcı: Texas Instruments Incorporated
Her zaman "Texas Instruments Incorporated" kaynaklı yazılımlara güven.
Yükle
Yükleme
Yalnızca güvendiğiniz yayımcıların sürücü yazılımlarını yüklemelisiniz. Hangi aygıt yazılımını yüklemenin güvenli olduğuna nasıl karar veririm?

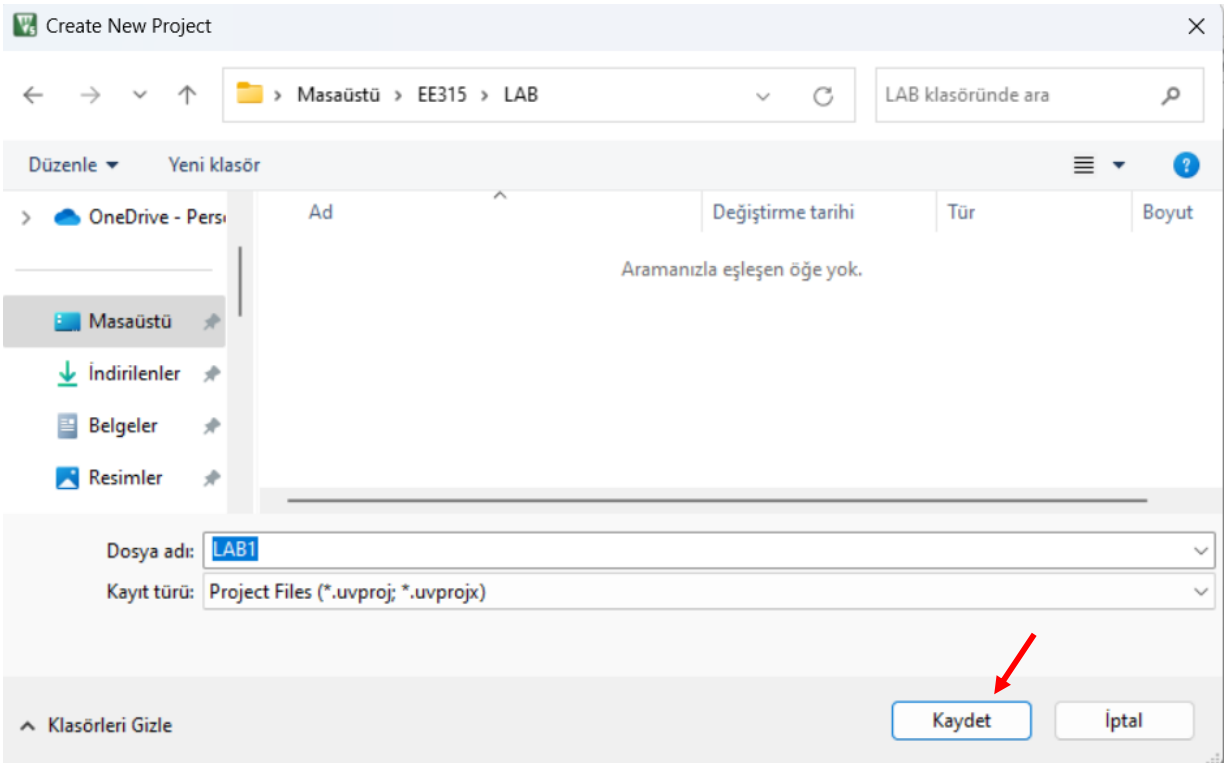


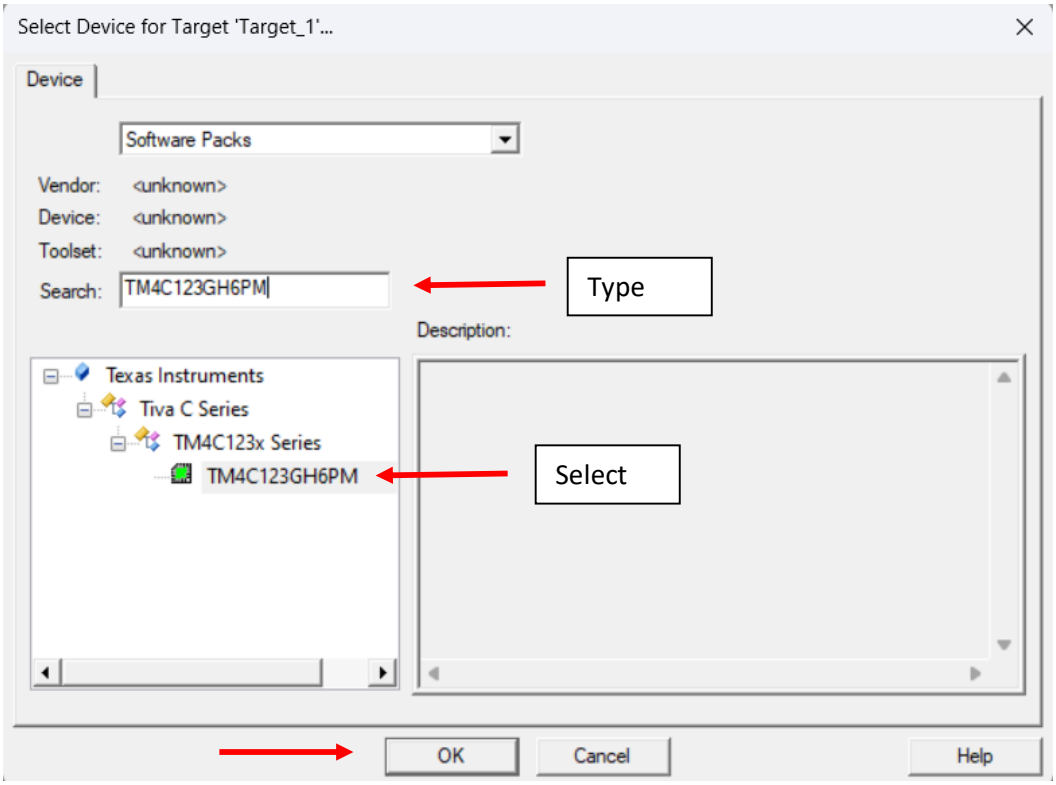
5. Do the same for the remaining device below:

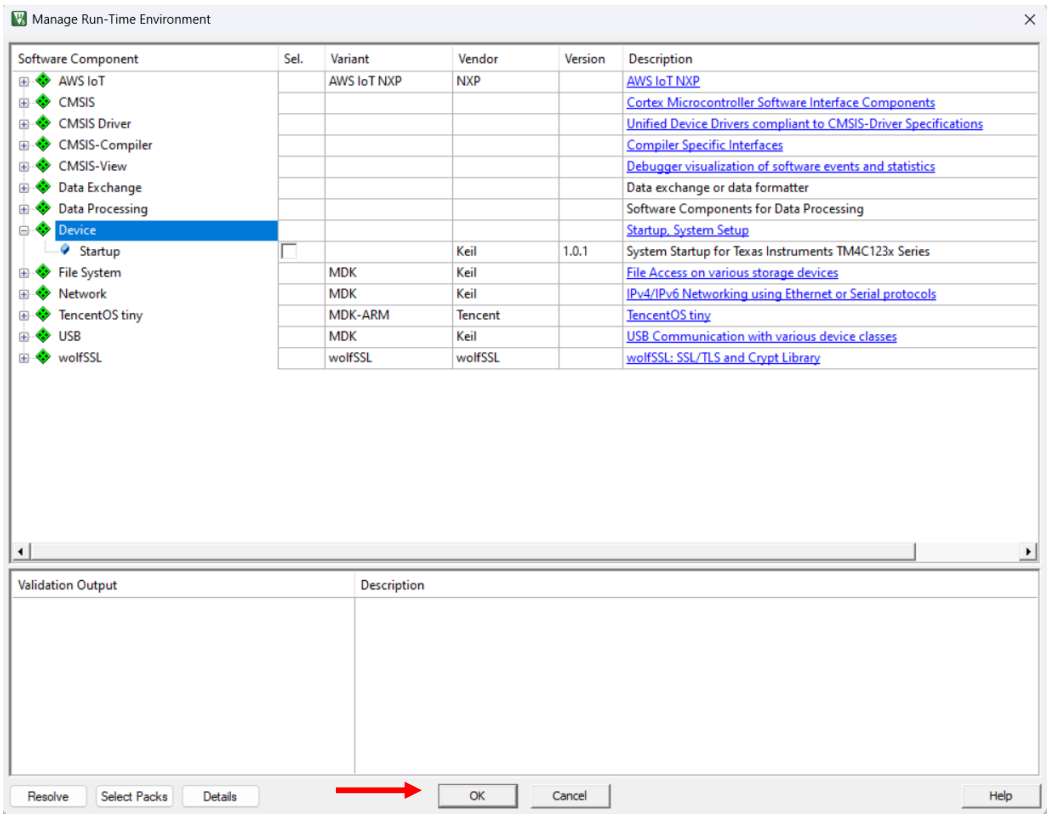
Creating a New Project

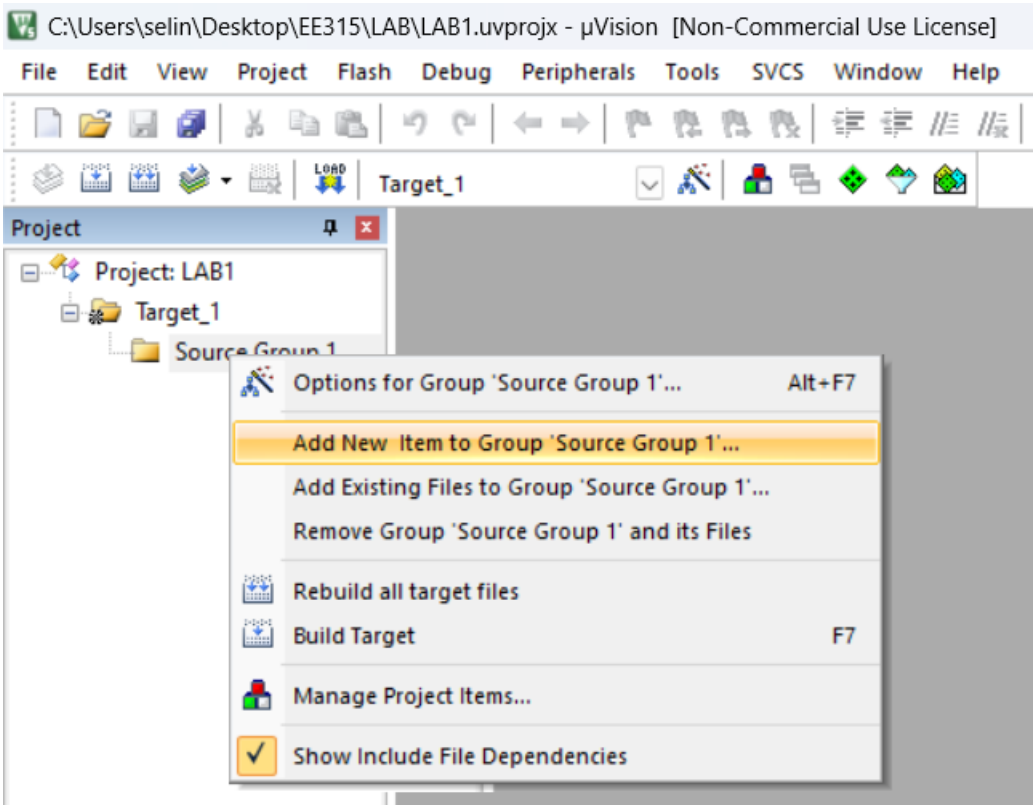
1. Run uVision and follow the instructions below:

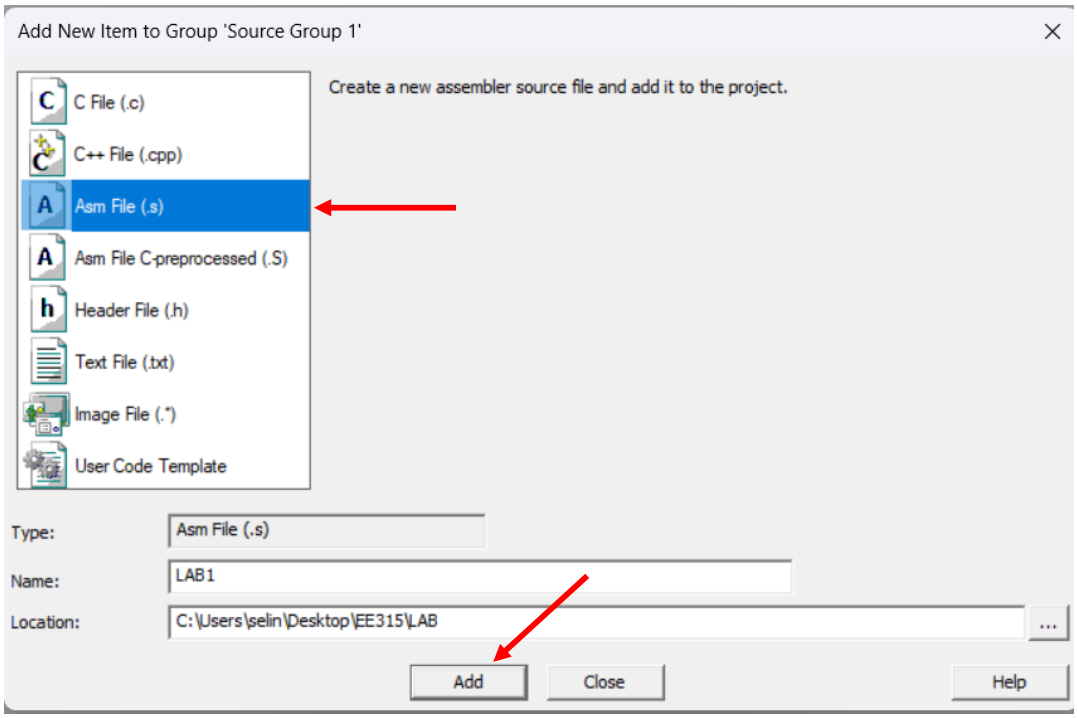


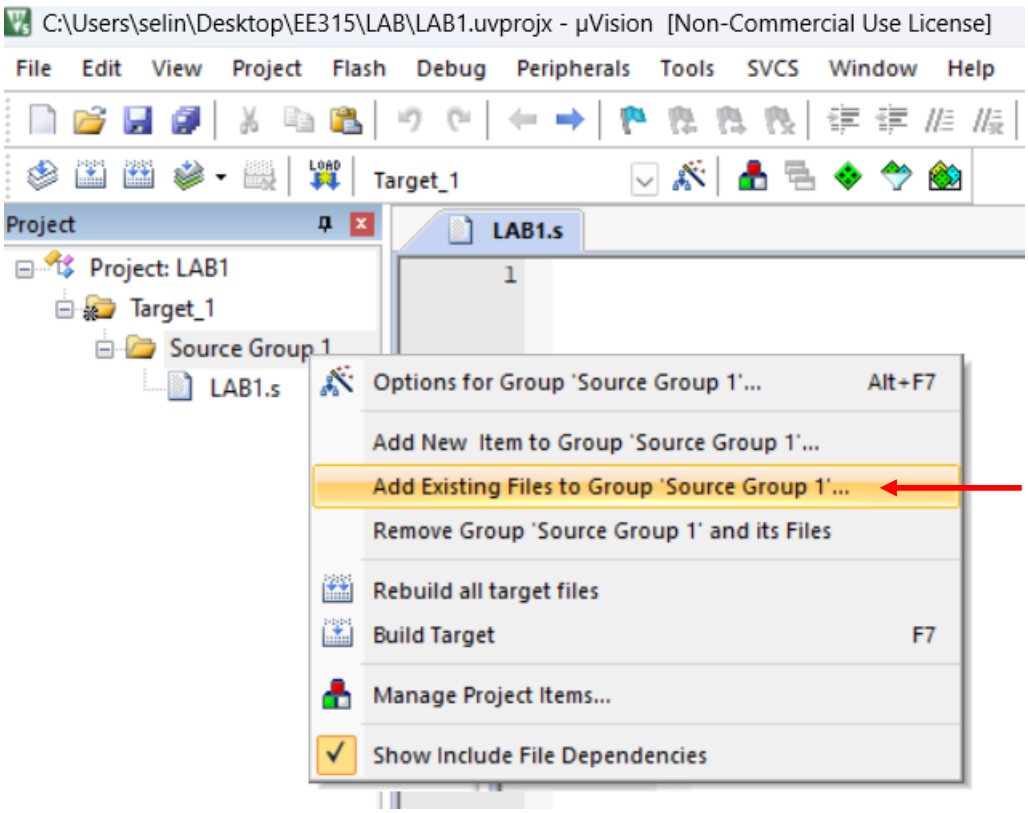


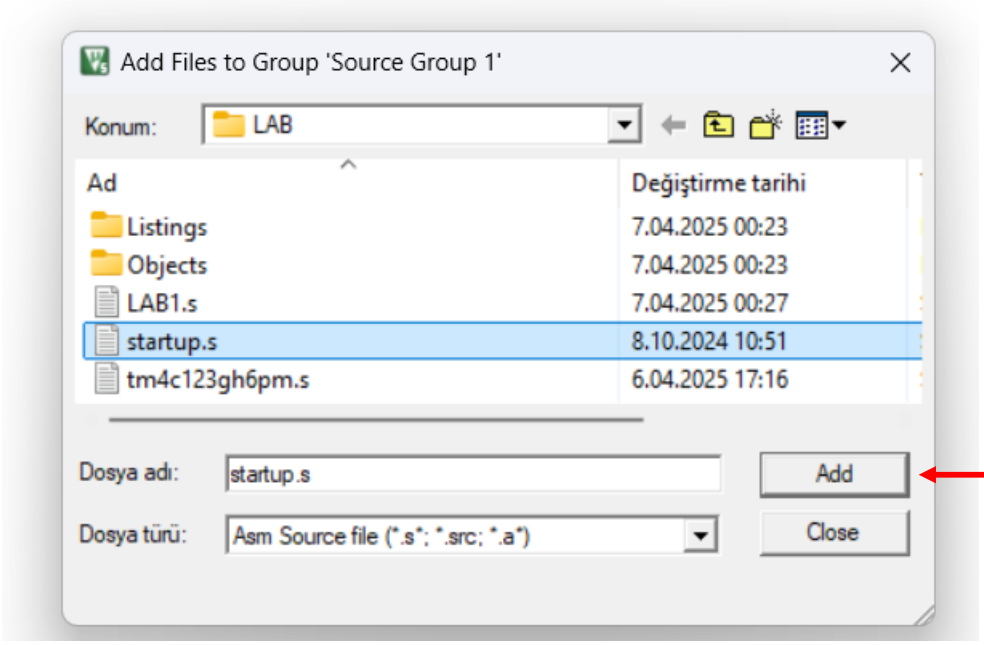

Select Device for Target 'Target_1'...
Device
Software Packs
Vendor: <unknown>
Device: <unknown>
Toolset: <unknown>
Search: TM4C123GH6PM
Type
Description:
Texas Instruments
Tiva C Series
TM4C123x Series
TM4C123GH6PM
Select
OK
Cancel
Help

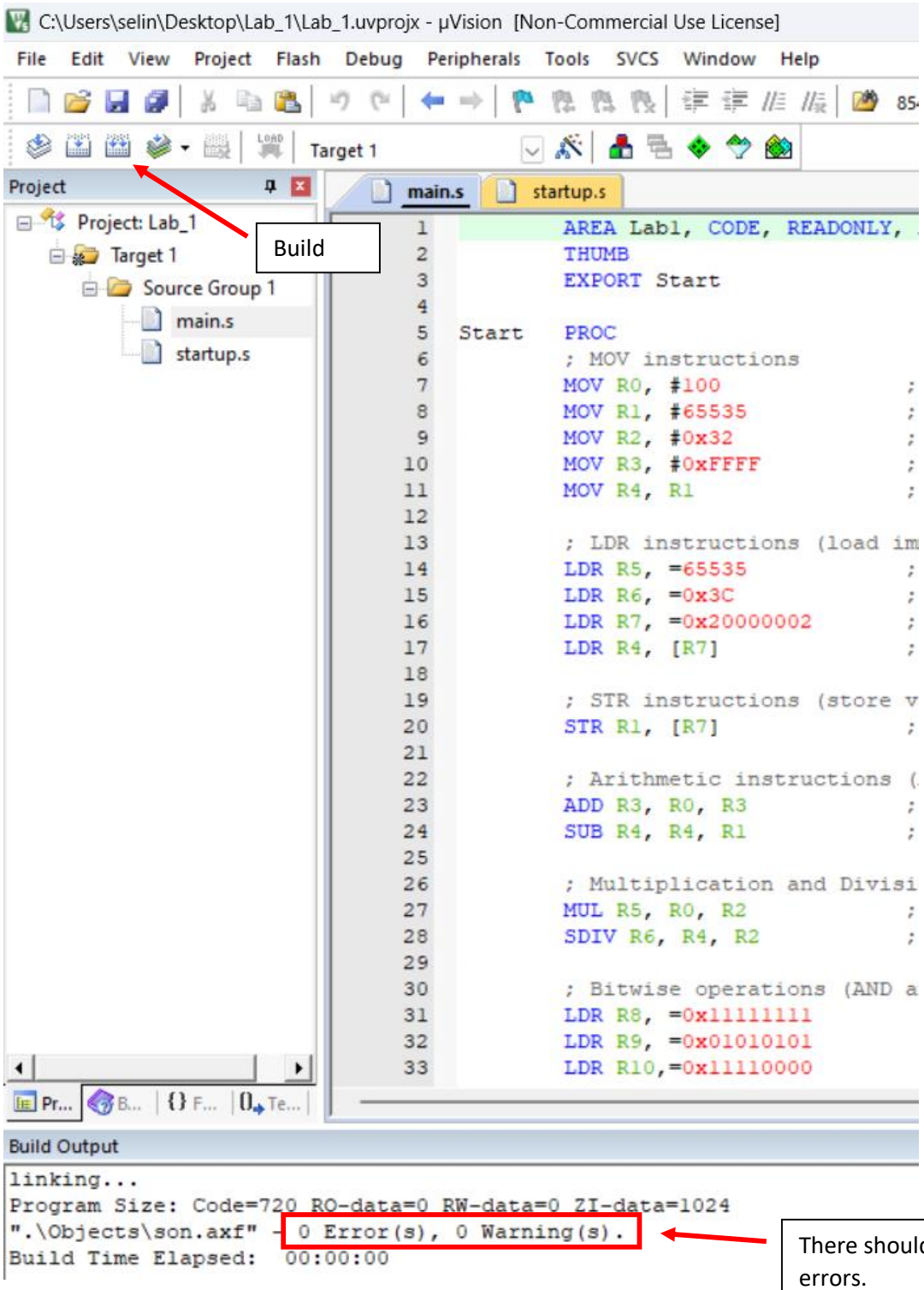

Manage Run-Time Environment
Software Component
Sel.
Variant
Vendor
Version
Description
AWS IoT
AWS IoT NXP
NXP
AWS IoT NXP
CMSIS
Cortex Microcontroller Software Interface Components
CMSIS Driver
Unified Device Drivers compliant to CMSIS-Driver Specifications
CMSIS-Compiler
Compiler Specific Interfaces
CMSIS-View
Debugger visualization of software events and statistics
Data Exchange
Data exchange or data formatter
Data Processing
Software Components for Data Processing
Device
Startup, System Setup
Startup
Keil
1.0.1
System Startup for Texas Instruments TM4C123x Series
File System
MDK
Keil
File Access on various storage devices
Network
MDK
Keil
IPv4/IPv6 Networking using Ethernet or Serial protocols
TencentOS tiny
MDK-ARM
Tencent
TencentOS tiny
USB
MDK
Keil
USB Communication with various device classes
wolfSSL
wolfSSL
wolfSSL
wolfSSL: SSL/TLS and Crypt Library
Validation Output
Description
Resolve
Select Packs
Details
OK
Cancel
Help


C:\Users\selin\Desktop\EE315\LAB\LAB1.uvprojx - µVision [Non-Commercial Use License]
File Edit View Project Flash Debug Peripherals Tools SVCS Window Help
Target_1
Project
Project: LAB1
Target_1
Source Group 1
Options for Group 'Source Group 1'... Alt+F7
Add New Item to Group 'Source Group 1'...
Add Existing Files to Group 'Source Group 1'...
Remove Group 'Source Group 1' and its Files
Rebuild all target files
Build Target F7
Manage Project Items...
Show Include File Dependencies


Add New Item to Group 'Source Group 1'
C File (.c)
C++ File (.cpp)
Asm File (.s)
Asm File C-preprocessed (.S)
Header File (.h)
Text File (.txt)
Image File (.*)
User Code Template
Create a new assembler source file and add it to the project.
Type: Asm File (.s)
Name: LAB1
Location: C:\Users\selin\Desktop\EE315\LAB
Add
Close
Help


C:\Users\selin\Desktop\EE315\LAB\LAB1.uvprojx - µVision [Non-Commercial Use License]
File Edit View Project Flash Debug Peripherals Tools SVCS Window Help
Target_1
Project
Project: LAB1
Target_1
Source Group 1
LAB1.s
LAB1.s
1
Options for Group 'Source Group 1'... Alt+F7
Add New Item to Group 'Source Group 1'...
Add Existing Files to Group 'Source Group 1'...
Remove Group 'Source Group 1' and its Files
Rebuild all target files
Build Target F7
Manage Project Items...
Show Include File Dependencies


Add Files to Group 'Source Group 1'
Konum: LAB
Ad
Değiştirme tarihi
Listings 7.04.2025 00:23
Objects 7.04.2025 00:23
LAB1.s 7.04.2025 00:27
startup.s 8.10.2024 10:51
tm4c123gh6pm.s 6.04.2025 17:16
Dosya adı: startup.s
Add
Dosya türü: Asm Source file (*.s*; *.src; *.a*)
Close



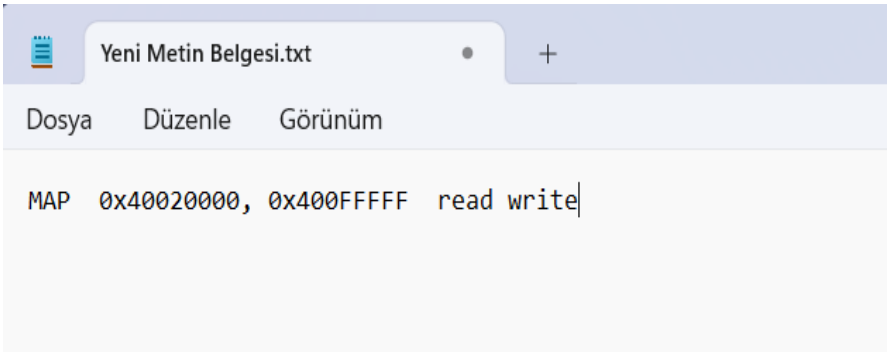
- ✓ If there are some errors, you should check them one by one from the "build output" window and correct them all.

Now, at the desktop, create a txt file.

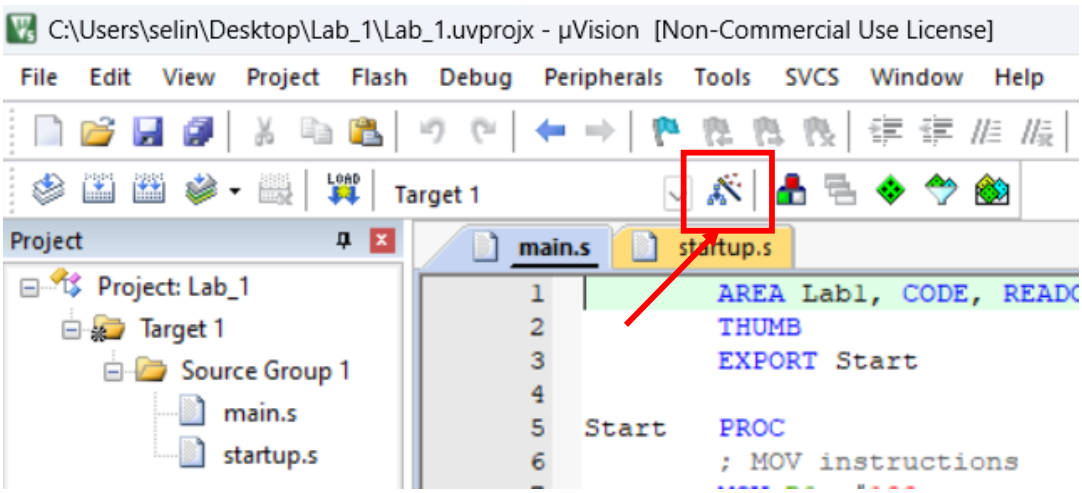
Type :

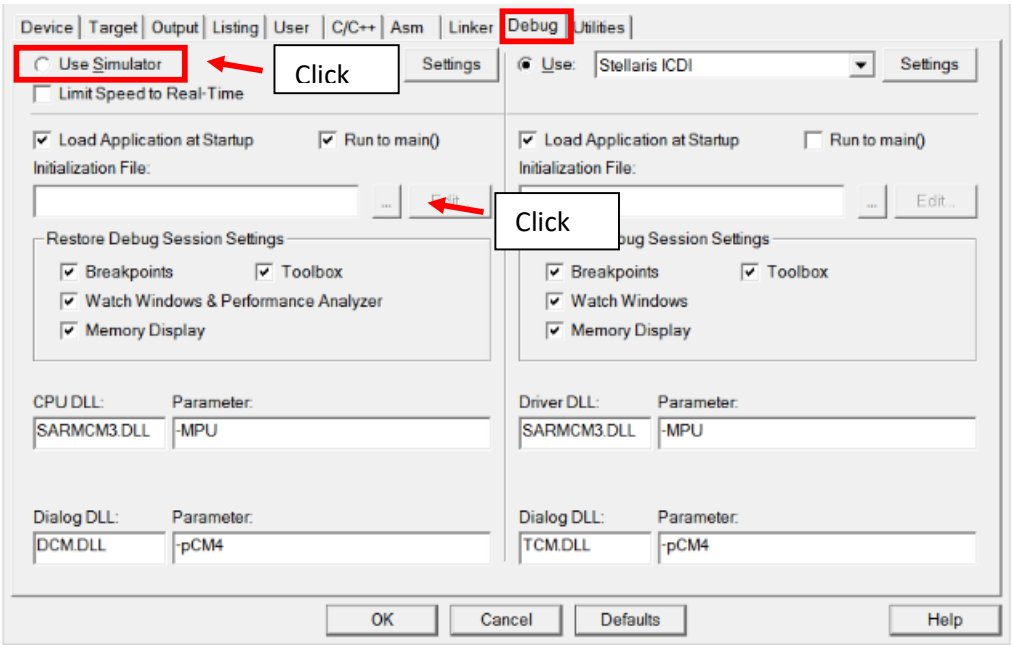
MAP 0x40020000, 0x400FFFFF read write

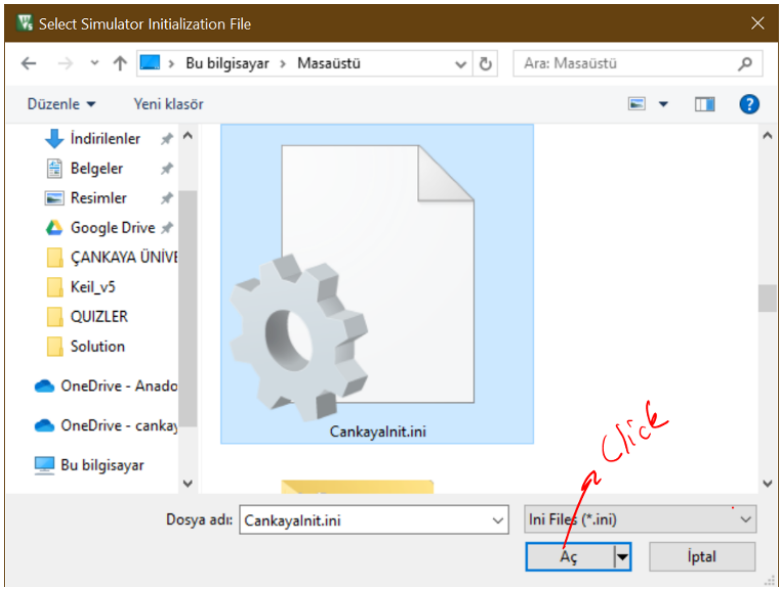
And save this notepad file. Then Don't forget to change file extension into the ".ini"

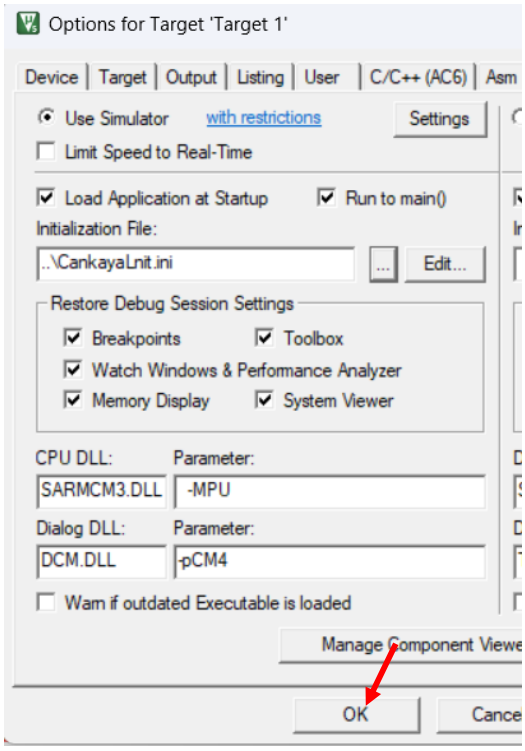


Open Keil and do the followings:




Device
Target
Output
Listing
User
C/C++
Asm
Linker
Debug
Utilities
Use Simulator
Click
Settings
Use:
Stellaris ICDI
Settings
Limit Speed to Real-Time
Load Application at Startup
Run to main()
Initialization File:
Edit...
Click
Restore Debug Session Settings
Breakpoints
Toolbox
Watch Windows & Performance Analyzer
Memory Display
Watch Windows
CPU DLL:
Parameter:
SARMCM3.DLL
-MPU
Driver DLL:
Dialog DLL:
DCM.DLL
-pCM4
TCM.DLL
OK
Cancel
Defaults
Help


Select Simulator Initialization File
Bu bilgisayar
Masaüstü
Ara: Masaüstü
Düzenle
Yeni klasör
İndirilenler
Belgeler
Resimler
Google Drive
ÇANKAYA ÜNİVE
Keil_v5
QUIZLER
Solution
OneDrive - Anado
OneDrive - canka
Bu bilgisayar
Cankayalnit.ini
Click
Dosya adı:
Cankayalnit.ini
Ini Files (*.ini)
Aç
İptal



Now, you will have the permission to write or read into/from this address region.

Debugging Your Code

1. Follow the steps below: