Ho to program STM32F7 using open source, cross-platform tools only?

Demo with graphics using STM32F769 Discovery Kit

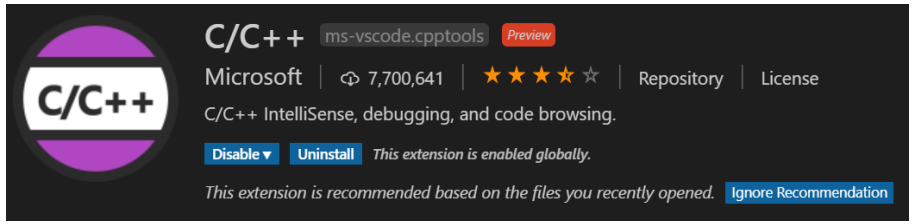
by Tomasz Jastrzębski, November 2019 (revised March 2020)

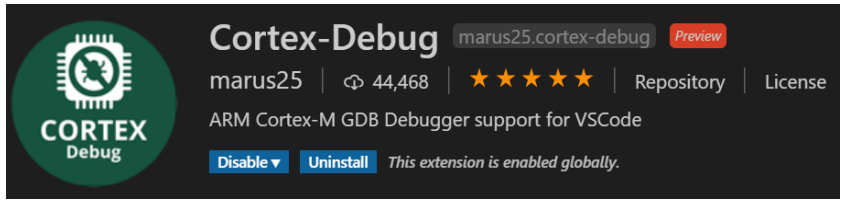
source code available at:

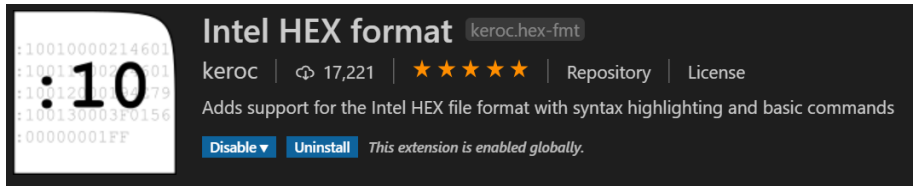
https://github.com/tdjastrzebski/DISCO-F769NI_LCD_demo

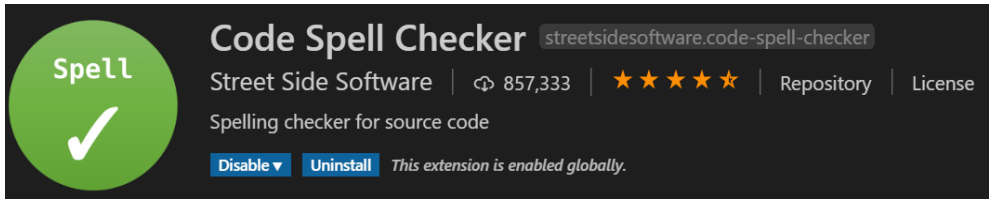
VS Code Installation

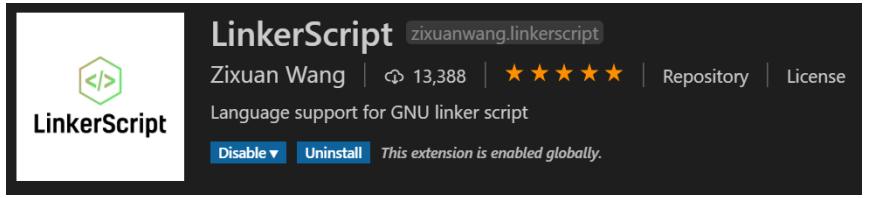
- Install VS Code https://code.visualstudio.com/
- Install VS Code Extensions:
  - C/C++ VS
  - Cortex-Debug
  - Intel HEX format
  - LinkerScript
  - Code Spell Checker











GNU Arm Embedded Toolchain Installation

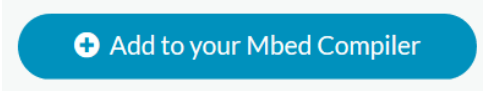
1. Download and install **GNU Arm Embedded Toolchain** installer, version **9 2019-q4-major**
   https://developer.arm.com/tools-and-software/open-source-software/developer-tools/gnu-toolchain/gnu-rm/downloads
2. During the installation check “Add path to environment variable”

Alternatively:

1. Download zip package, unpack it to selected folder, e.g.
   C:/Program Files (x86)/GNU Tools ARM Embedded/9 2019-q4-major
   - this is the default location if you use installer, it contains white space but that’s OK
2. Add **bin** folder to the **PATH** system environment variable
   Example: **C:/Program Files (x86)/GNU Tools ARM Embedded/9 2019-q4-major/bin**

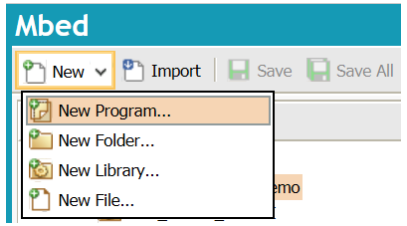
Sample Source Code

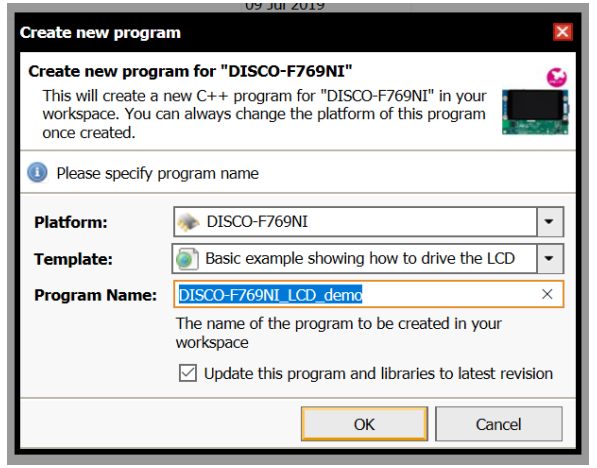
- Login to https://www.mbed.com/
  - you need to create an account first
- Go to Hardware/Boards website menu,
  find **DISCO-F769NI** board (STM32F769I-DISCO),
  select "**Add to your Mbed Compiler** option in the right panel



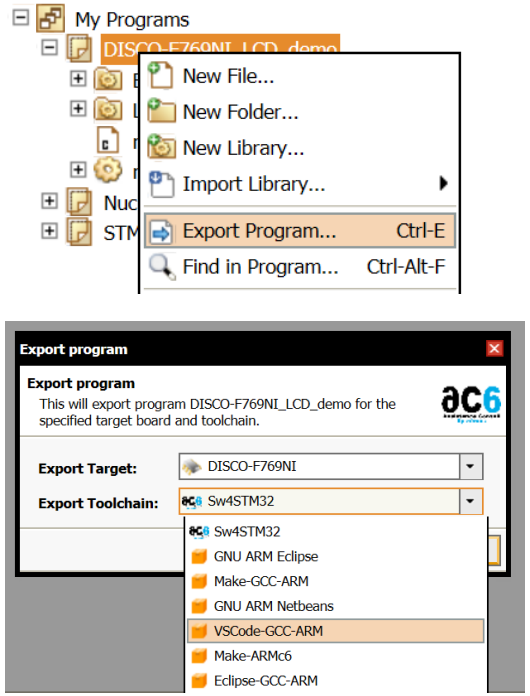
- Go to Compiler →

- Select **New/New Program** menu option.
  In the config form select your board and
  Basic example showing how to drive the LCD template





- Right-click your new program, select **Export Program** option
- Select **VSCode-GCC-ARM** export toolchain
- Save generated ZIP file locally, unzip to preferred location



Git source control

1. Download and install **Git**
   https://git-scm.com/downloads

2. On Windows we need not only source control but some convenient Unix commands available in Bash shell installed with Git.
   Namely: **find** and **rm**

Git

1. Add **.gitignore** file with the following content:

```
/BUILD
*.state.json
```

1. From the terminal window issue commands:
   - `git config --global user.email "your@email.here.com"`
   - `git init`
   - `git add .`
   - `git commit -m "initial version"`

GNU **make**

Obtain GNU Make build tool

https://www.gnu.org/software/make/

There many sources available.

Example:

1. Download **gnumake-4.2.1-x64.exe** or **gnumake-4.2.1.exe** from https://github.com/mbuilov/gnumake-windows
2. Rename downloaded file to **make.exe**
3. Place it where it will be easily accessible, e.g. **C:/Windows/System32**

modify **c_cpp_properties.json**

1. Leave only one configuration, name it “**GCC**”
   - we do not need separate configurations for Mac, Linux and Windows since build is not OS specific but compiler specific

2. `"compilerPath": "arm-none-eabi-g++"`

3. ```
   "includePath": [
      "/usr/src/mbed-sdk/",
      "BSP_DISCO_F769NI/**",
      "LCD_DISCO_F769NI/**",
      "mbed/**"
   ]
   ```
   ```

recreate **tasks.json**

Supplied **tasks.json** file uses old syntax version 0.1.0

Create new content:

```
{
    "version": "2.0.0",
    "tasks": [
    ]
}
```

recreate **tasks.json**

Add **Build** task

```
{
    "label": "Build",
    "type": "shell",
    "command": "make",
    "args": [
        "-j8",
        "-output-sync=recurse",
        "all",
        "OPT=-O0 -g"
    ],
    "options": {
        "cwd": "${workspaceRoot}"
    },
    "presentation": {
        "clear": true
    },
    "problemMatcher": ["$gcc"],
    "group": {
        "kind": "build",
        "isDefault": true
    }
}
```

recreate **tasks.json**

Add **Clean** task to **tasks.json** file:

```
{
    "label": "Clean",
    "type": "shell",
    "command": "make",
    "args": [
        "clean"
    ],
    "options": {
        "cwd": "${workspaceRoot}"
    },
    "group": {
        "kind": "build",
        "isDefault": true
    },
    "problemMatcher": [],
    "presentation": {
        "clear": true
    }
}
```

For **debug** build modify **Makefile**

- In line 35 before **VPATH** variable add **OPT** variable definition:

```
# optimization params for RELEASE, change to [-O0 -g] for DEBUG version
OPT = -Os -g1
```

- In **C_FLAGS**, **CXX_FLAGS** and **ASM_FLAGS** replace **-Os** and **-g** flags with **OPT** variable, e.g. change:

```
C_FLAGS += -Os
C_FLAGS += -g
```

to:

```
C_FLAGS += $(OPT)
```

- Fix **mbed_config.h** path in **ASM_FLAGS**

Run build

At this stage you should be able to build your project.

Press Ctrl+Shift+B, select **Build** task.

After the build is finished, BUILD bolder should contain

DISCO-F769NI_LCD_demo.bin output file.

Run build

Note: on some systems you may get the following “unexpected EOF” error in Makefile around line **530**

```
/usr/bin/sh: -c: line 0: unexpected EOF while looking for matching `"'
/usr/bin/sh: -c: line 1: syntax error: unexpected end of file
make[1]: *** [h:/DISCO-F769NI_LCD_demo/Makefile:530: DISCO-F769NI_LCD_demo.elf] Error 1
make: *** [Makefile:26: all] Error 2
The terminal process terminated with exit code: 2
```

While I was unable to determine the root cause, it seems the problem is related to shell command length limits.
On Windows you may try to use cmd.exe or PowerShell.

The above problem does not occur if you use **Build++**. Continue reading.

get **stlink** utility

https://github.com/texane/stlink/

1. Download **stlink** version 1.3.0 (Windows & Mac)
   https://github.com/texane/stlink/releases/tag/1.3.0
2. Windows:
   1. Extract content to **C:/Program Files/StLink**
   2. Add **C:/Program Files/StLink/bin** to the system **PATH** environment variable
   3. Download libusb from https://libusb.info/
   4. Copy files from **MS64/dll** folder to **C:/Program Files/StLink/bin**
      - 7Zip utility needed from http://www.7-zip.org

Note: the latest version 1.6.0 and Linux executables are not available from author's Git repo – you have to build them yourself.

Executable **stlink** version 1.6.0 for Windows is available from my repo:
https://github.com/tdjastrzebski/DISCO-F769NI_LCD_demo

Linux: build latest **stlink** utility

1. Download source code for the latest stable version as zip package from https://github.com/texane/stlink/releases

2. Follow build steps
https://github.com/texane/stlink/blob/master/doc/compiling.md

create **Deploy** task

Add **Deploy** task definition to **tasks.json** file:

```
{
    "label": "Deploy",
    "type": "shell",
    "command": "st-flash",
    "args": [
        "write",
        "${workspaceRoot}/BUILD/${workspaceRootFolderName}.bin",
        "0x08000000"
    ],
    "group": {
        "kind": "build",
        "isDefault": true
    },
    "problemMatcher": [],
    "presentation": {
        "clear": true
    }
}
```

At this point you should be able to deploy your program – run **Deploy** task

Debug

1. Obtain **STM32F7x9.svd** file from https://github.com/posborne/cmsis-svd/tree/master/data/STMicro and place it in the project root folder
2. Replace **launch.json** file content with:

```
{
    "version":"0.2.0",
    "configurations": [
        {
            "name": "Debug (ST-Util)",
            "type": "cortex-debug",
            "request": "launch",
            "servertype": "stutil",
            "cwd": "${workspaceRoot}",
            "executable": "./BUILD/${workspaceRootFolderName}.elf",
            "device": "STM32F769NI",
            "v1": false,
            "svdFile": "${workspaceRoot}/STM32F7x9.svd",
            "preLaunchTask": "Build & Deploy"
        }
    ]
}
```

Debug – cont’d

3. Add **Build & Deploy** task to **tasks.json** file:

```
{
    "label": "Build & Deploy",
    "dependsOn": ["Build", "Deploy"],
    "dependsOrder": "sequence",
    "group": {
        "kind": "build",
        "isDefault": true
    },
    "problemMatcher": []
}
```

Finally, set breakpoint within **main.cpp** file, press **F5** to build, deploy and start

Build++

1. Install **Node.js** from https://nodejs.org/en/download/
2. Install **CppBuild**: `npm install cppbuild -g`
3. You should be able to build your project from VS terminal command line:

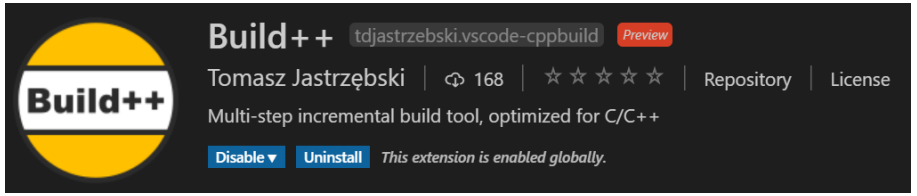
   ```
   cppbuild gcc debug -w
   ```

   note:
   - use Bash shell,
   - run “cbbpulid --help” for more options
4. Install **Build++** VS Code extension
5. Add **Build++** task to **tasks.json** file:

```
{
    "label": "Build++",
    "type": "shell",
    "command": "cppbuild",
    "args": ["gcc", "debug", "-w" ],
    "presentation": {
        "clear": true
    },
    "problemMatcher": ["$gcc"],
    "group": {
        "kind": "build",
        "isDefault": true
    }
}
```

5. Modify **lunch.json** file:

```
"executable": "./BUILD/debug/${workspaceRootFolderName}.elf",
"preLaunchTask": "Build++"
```

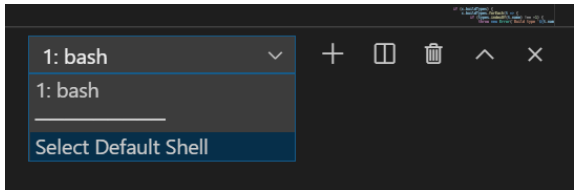


6. Add **c_cpp_build.json** file to **.vscode** folder

Do NOT just copy-paste this code. Very likely some characters (-) will be missing.
Get this code from: https://github.com/tdjastrzebski/DISCO-F769NI_LCD_demo

```
{
  "version": 1,
  "params": {
    "buildDir": "BUILD",
    "buildOutput": "${buildDir}/${buildTypeName}"
  },
  "configurations": [
    {
      "name": "gcc",
      "problemMatchers": ["$gcc"],
      "buildTypes": [
        {
          "name": "debug",
          "params": { "buildTypeParams": "-O0 -g" }
        },
        {
          "name": "release",
          "params": { "buildTypeParams": "-Os -g1" }
        }
      ],
      "buildSteps": [
        {
          "name": "C Compile",
          "filePattern": "**/*.c",
          "outputFile": "${buildOutput}/${fileDirectory}/${fileName}.o",
          "trimIncludePaths": true,
          "params": {
            "flags": "-fdata-sections -ffunction-sections -fmessage-length=0 -fno-delete-null-pointer-checks -fno-exceptions -fomit-frame-pointer -funsigned-char -mcpu=cortex-m7 -mfloat-abi=softfp -mfpu=fpv5-d16 -MMD -mthumb -Wall -Wextra -Wno-missing-field-initializers -Wno-unused-parameter"},
          "command": "arm-none-eabi-gcc -std=gnu11 -c ${buildTypeParams} ${flags} (-I[$${includePath}]) (-D$${defines}) (-include [$${forcedInclude}]) [${filePath}] -o [${outputFile}]"
        },
        {
          "name": "C++ Compile",
          "filePattern": "**/*.cpp",
          "outputFile": "${buildOutput}/${fileDirectory}/${fileName}.o",
          "trimIncludePaths": true,
          "params": {
            "flags": "-fdata-sections -ffunction-sections -fmessage-length=0 -fno-delete-null-pointer-checks -fno-exceptions -fno-rtti -fomit-frame-pointer -funsigned-char -mcpu=cortex-m7 -mfloat-abi=softfp -mfpu=fpv5-d16 -MMD -mthumb -Wall -Wextra -Wno-missing-field-initializers -Wno-unused-
parameter -Wvla"},
          "command": "arm-none-eabi-g++ -std=gnu++14 -c ${buildTypeParams} ${flags} (-I[$${includePath}]) (-D$${defines}) (-include [$${forcedInclude}]) [${filePath}] -o [${outputFile}]"
        },
        {
          "name": "Build link script",
          "params": {
            "flags": "-E -P -Wl,--gc-sections -Wl,--wrap,main -Wl,--wrap,_malloc_r -Wl,--wrap,_free_r -Wl,--wrap,_realloc_r -Wl,--wrap,_memalign_r -Wl,--wrap,_calloc_r -Wl,--wrap,exit -Wl,--wrap,atexit -Wl,-n -mcpu=cortex-m7 -mthumb -mfpu=fpv5-d16 -mfloat-abi=softfp",
            "memDefines": "-DMBED_ROM_START=0x8000000 -DMBED_ROM_SIZE=0x200000 -DMBED_ROM1_START=0x200000 -DMBED_ROM1_SIZE=0x200000 -DMBED_RAM_START=0x20020000 -DMBED_RAM_SIZE=0x60000 -DMBED_RAM1_START=0x20000000 -DMBED_RAM1_SIZE=0x20000 -DMBED_BOOT_STACK_SIZE=4096"
          },
          "command": "arm-none-eabi-cpp ${flags} ${memDefines} [mbed/TARGET_DISCO_F769NI/TOOLCHAIN_GCC_ARM/STM32F769xI.ld] -o [${buildOutput}/${workspaceRootFolderName}.link_script.ld]"
        },
        {
          "name": "Build object list 1",
          "command": "find [${buildOutput}] -type f -name '*.o' > [${buildOutput}/objects.txt]"
        },
        {
          "name": "Build object list 2",
          "command": "find mbed -type f -name '*.o' >> [${buildOutput}/objects.txt]"
        },
        {
          "name": "Link to elf",
          "params": {
            "flags": "-Wl,--gc-sections -Wl,--wrap,main -Wl,--wrap,_malloc_r -Wl,--wrap,_free_r -Wl,--wrap,_realloc_r -Wl,--wrap,_memalign_r -Wl,--wrap,_calloc_r -Wl,--wrap,exit -Wl,--wrap,atexit -Wl,-n -mcpu=cortex-m7 -mthumb -mfpu=fpv5-d16 -mfloat-abi=softfp",
            "memDefines": "-DMBED_ROM_START=0x8000000 -DMBED_ROM_SIZE=0x200000 -DMBED_ROM1_START=0x200000 -DMBED_ROM1_SIZE=0x200000 -DMBED_RAM_START=0x20020000 -DMBED_RAM_SIZE=0x60000 -DMBED_RAM1_START=0x20000000 -DMBED_RAM1_SIZE=0x20000 -DMBED_BOOT_STACK_SIZE=4096",
            "sysLibs": "-lmbed -Wl,--start-group -lstdc++ -lsupc++ -lm -lc -lgcc -lnosys -lmbed -Wl,--end-group"
          },
          "command": "arm-none-eabi-gcc ${flags} ${memDefines} -T [${buildOutput}/${workspaceRootFolderName}.link_script.ld] -L[mbed/TARGET_DISCO_F769NI/TOOLCHAIN_GCC_ARM] -o [${buildOutput}/${workspaceRootFolderName}.elf] @[${buildOutput}/objects.txt] ${sysLibs}"
        },
        {
          "name": "elf -> bin",
          "command": "arm-none-eabi-objcopy -O binary [${buildOutput}/${workspaceRootFolderName}.elf] [$${buildOutput}/${workspaceRootFolderName}.bin]"
        },
        {
          "name": "elf -> hex",
          "command": "arm-none-eabi-objcopy -O ihex [${buildOutput}/${workspaceRootFolderName}.elf] [${buildOutput}/${workspaceRootFolderName}.hex]"
        },
        {
          "name": "Deploy",
          "command": "st-flash write [${buildOutput}/${workspaceRootFolderName}.bin] 0x08000000"
        }
      ]
    }
  ]
}
```

Build++ cont’d



Set your default VS Code default shell to Bash.

Press **F5**. Your project should build, deploy and start in debug mode.

Note: make sure your current VS Code terminal shell supports Unix-style “find” command used in Build++ file. Use Git Bash or similar, do NOT use Windows Command Prompt or PowerShell.

Happy coding ☺

Tomasz Jastrzębski

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