Objectives

In this lab, you will learn:

- How to verify Kconfig settings for a Zephyr application
- How to modify Kconfigs for an application
- How to open the *guiconfig* tool, and explore or search for Kconfig settings and details
- How to create board-specific Kconfig files in an application
- How to change the compiler optimization Kconfigs
- How to increase Kconfigs for stack sizes

Kconfig Lab

The software used to build Zephyr applications can be configured at build time to adapt for specific application and platform needs. Configuration is handled through Kernel Config (Kconfig), which is the same configuration system used by the Linux kernel. The goal is to support configuration without having to change any source code.

Configuration options (often called symbols) are defined in Kconfig files, which also specify dependencies between symbols that determine what configurations are valid. Kconfig definitions and settings come from many sources in the Zephyr tree, including:

- Application-specifc Kconfigs, like samples/basic/blinky/prj.conf
- board-specific Kconfigs, like boards/nxp/frdm_mcxn947/frdm_mcxn947_mcxn947_cpu0_defconfig
- SOC-specific Kconfigs, like soc/nxp/mcx/mcxnx4x/Kconfig.soc
- SOC family Kconfigs, like soc/nxp/mcx/Kconfig
- Kernel Kconfigs, like kernel/Kconfig
- Driver Kconfigs, like drivers/gpio/Kconfig
- Subsystem Kconfigs, like subsys/console/Kconfig
- Kconfigs for other open-source modules, like modules/mbedtls/Kconfig

The outputs from Kconfig are build-time generated files for the application. One text file *.config* is the final merged Kconfig symbols from all Kconfig sources used by the application. Another file *autoconf.h* is a C header file with macros that can be tested at build time. These lab steps will demonstrate how these files are useful, to confirm the Kconfig settings used during the most recent build of the application.

Kconfigs can be defined as different types. In this lab, we will explore 3 different types: boolean, integer, and choice Kconfigs. The lab steps will modify the following Kconfigs, and demonstrate how they configure the application:

- `CONFIG_CONSOLE` : (type boolean) selects if Zephyr's Console subsystem is included in the application
- `CONFIG_COMPILER_OPTIMIZATIONS` : (type choice) selects which compiler optimization setting is used when the application is built
- `CONFIG_MAIN_STACK_SIZE` : (type integer) sets the stack size in bytes for the Main thread

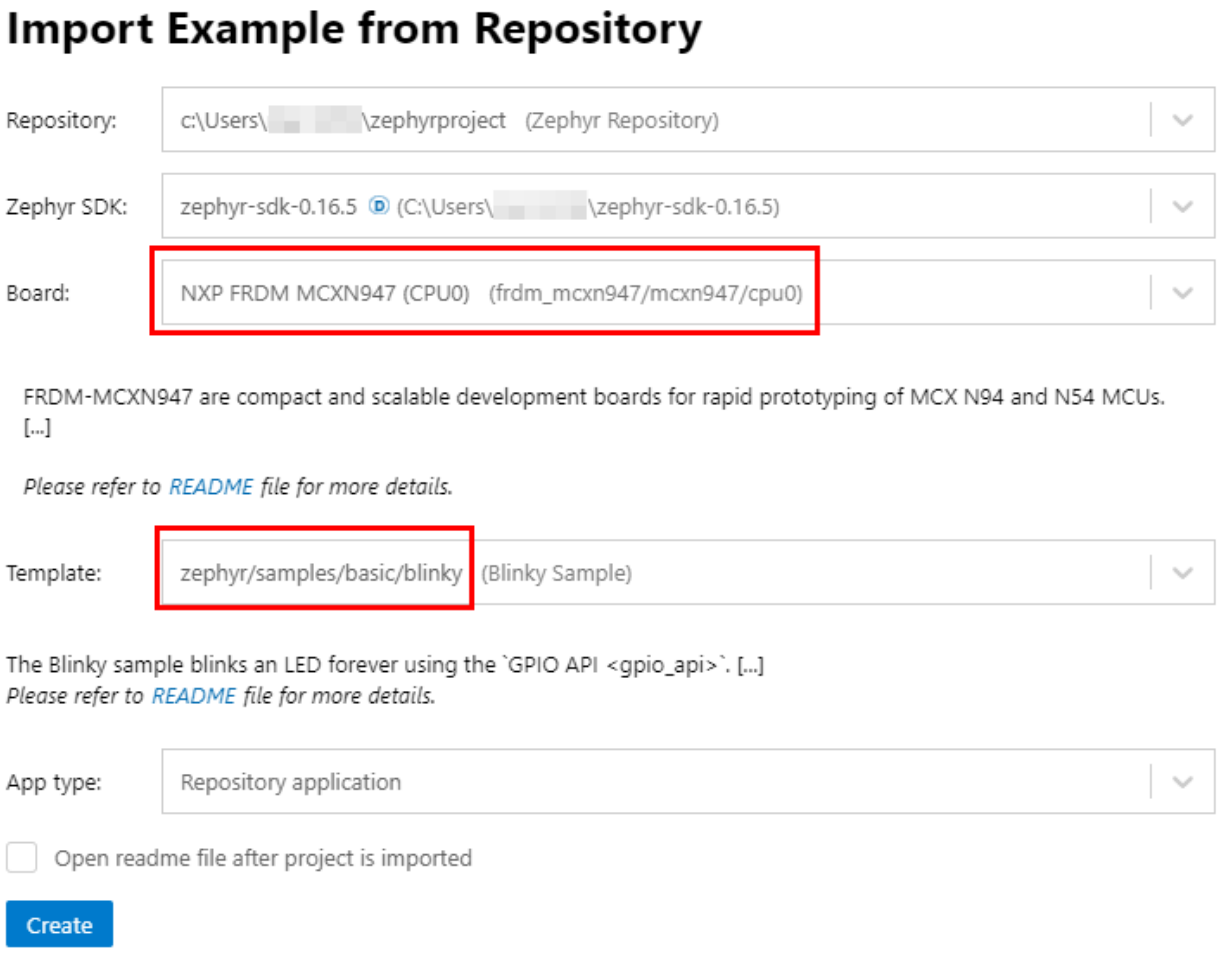
For Zephyr application development, typically Kconfig options are set at the application level. This lab will give some simple examples to get familiar with how Kconfigs are modified for applications. These lab sections include modifying the *prj.conf* file, which is the Kconfig file at the application level. And also create a new board-specific Kconfig file, which configures the app when it is built for a specific board.

1. Changing a Kconfig symbol for an application

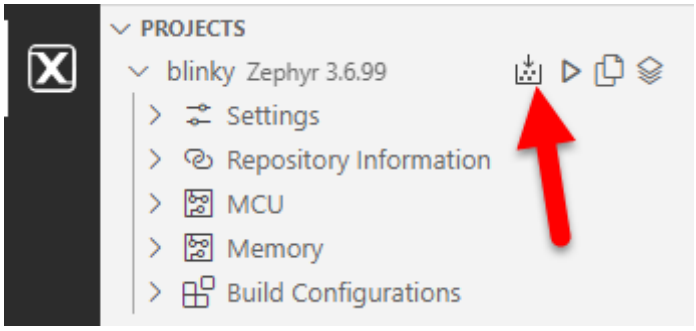
First we will import a Zephyr sample application into VS Code, build it, explore the existing Kconfig symbols, and make a simple Kconfig change. This section uses the *blinky* application, and will modify the application Kconfig in prj.conf.

1. Open VS Code. In the Quickstart Panel, click **Import Example from Repository**. If needed, the steps to import an example, build, and debug it are included in [[Zephyr Lab MCXN947 Hello World]].

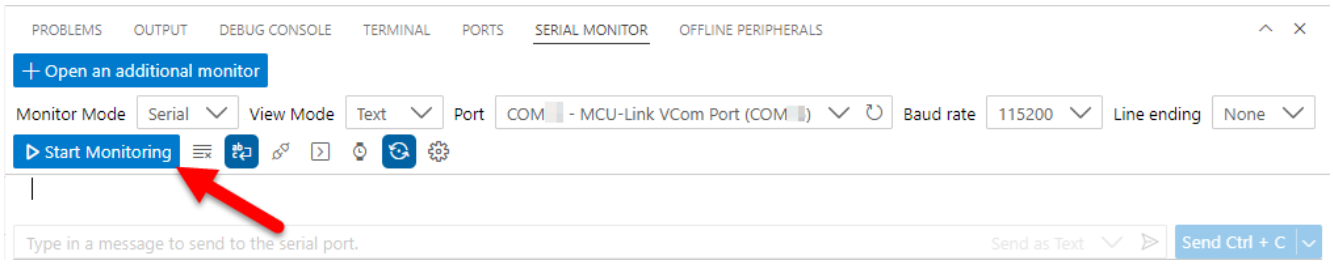
2. Import the *blinky* sample with the following settings:
    - For the board, you can type **n947** to filter the board target **frdm_mcxn947/mcxn947/cpu0**. Be sure this board target ends with `cpu0`.
    - For the example template, type **blinky** to filter the app **zephyr/samples/basic/blinky**
    - For Application type, select **Repository Application**
    - Click **Create**



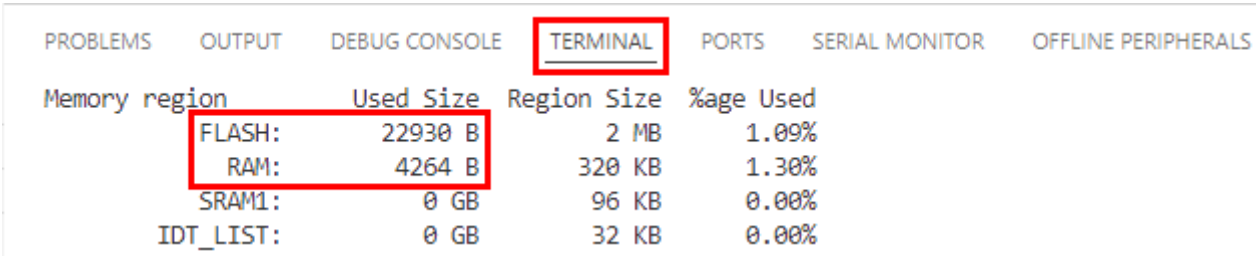
3. Build the *blinky* project



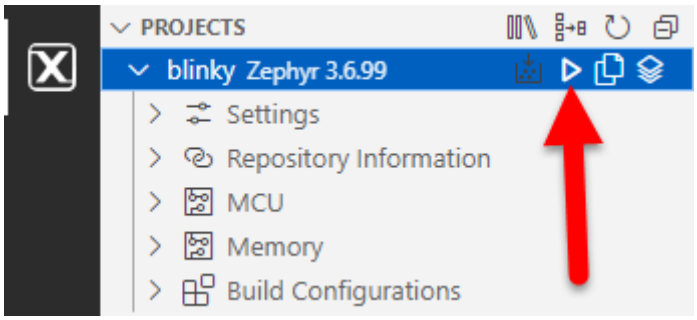
4. If not already connected to the board, connect the USB Type-C cable to J17, to power and debug the board. In VS Code, connect the Serial Monitor to the board's COM port, and click **Start Monitoring**.



5. When the build completes, take note of the memory sizes. We will refer back to this memory usage in the later steps in this lab. In VS Code, this is found in the **Terminal view** after the build completes.



6. Debug the blinky project.

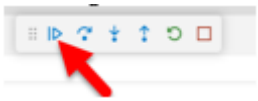


7. In the Serial Monitor view, you will see the app prints the boot banner during the startup code, before main() is reached. It also prints the Zephyr version used during the build:

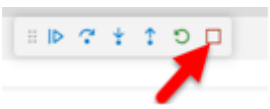
   Blinky boot banner in Serial Monitor:

```
*** Booting Zephyr OS build v3.6.0-3471-gaa72e8178cea ***
```

8. **Continue** executing the application. The red LED D2 should be blinking.

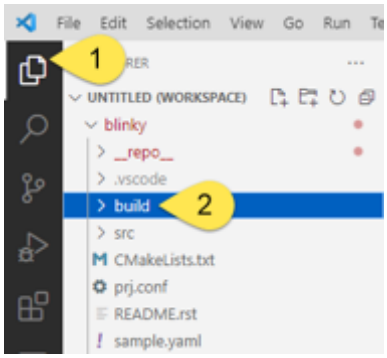


9. Stop the debugger

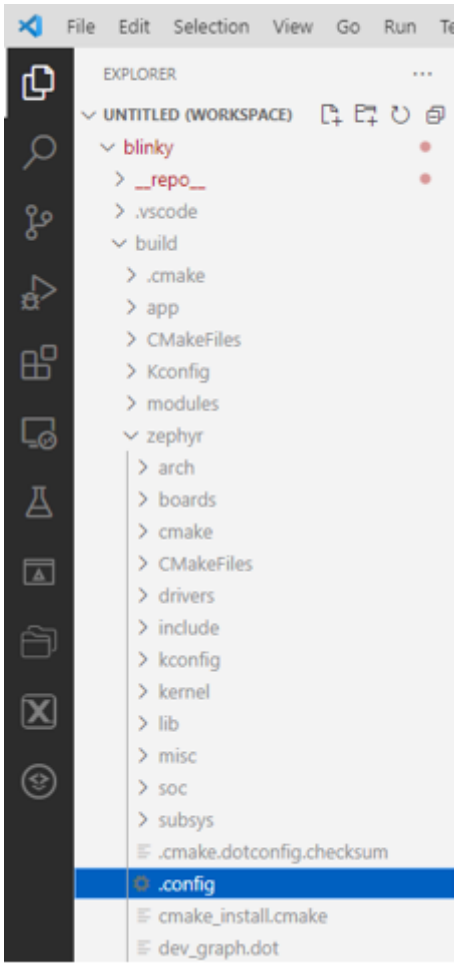


Now that we have the default *blinky* sample working, we will explore some Kconfig settings, and make some simple changes.

10. In the Explorer view, find the **build folder** under the *blinky* project. This is a generated folder created when building the *blinky* project. Every Zephyr application has a build folder after it is built. It contains all the generated files from the build tools, like the object code from the compiler, and the linker outputs.



11. In the build folder, open the file **zephyr/.config**.



The *.config* file is the final merged Kconfig settings for the application, generated when the application is built. It is a helpful resource to use to confirm the Kconfig settings used by the application. The Kconfig settings can come from many different source files during the build. They can also have dependencies on other Kconfigs. Sometimes a Kconfig setting can be confusing when reviewing the sources. Verifying the Kconfig in the *.config* file confirms the setting used during the build. And these lab steps demonstrate, after making Kconfig changes, it is helpful to review the generated *.config* file to confirm those changes were used during the build.

Another good tip is to review the *.config* file to optimize your application. You may find there are features/drivers/subsystems enabled that you do not need in your application, and you can make changes to

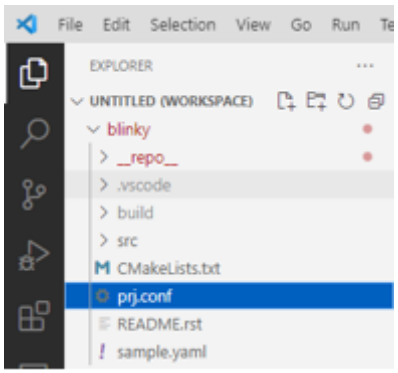
remove them. Or the *.config* file may reveal settings that are not ideal for your application, and you can change them.

Because the *.config* file is generated during the build, it is important to understand what happens when changing this file. Any modifications to this file can be reverted if the *.config* file is re-generated again during a build. For Kconfig changes to be retained, it is best to make the change in a Kconfig source file. In this lab section, we will demonstrate modifying the application's *prj.conf* file, and then confirming the modification in the *.config* file.

12. In the *.config* file, search for the symbol `CONFIG_CONSOLE`. This is a boolean Kconfig, and shows as "=y". Booleans use `y` for Yes and `n` for No. Here "=y" means the symbol is selected, or enabled. Symbols that are not selected (or disabled) are commented out. In this example *.config* file below, we see that `CONFIG_CONSOLE` is selected by default in the *blinky* sample, and `CONFIG_POWER_DOMAIN` is not selected.

```
# CONFIG_POWER_DOMAIN is not set
CONFIG_CONSOLE=y
```

13. In the Explorer view, open the **prj.conf** file under the *blinky* project.



14. Modify the ***prj.conf*** file, by **adding the line highlighted below** for `CONFIG_CONSOLE`. This will disable the Console subsystem, and it will be removed from the application. Save the *prj.conf* file (Ctrl-S)

```
CONFIG_GPIO=y
```

```
CONFIG_CONSOLE=n # Add this line
```

Notice after saving this file, the build tools are run immediately. It does not build the application image or run the C compiler. But it does run the Kconfig tools, and re-generates the *.config* file with this change.

15. Go back to the **.config** file already open in the editor. Notice that `CONFIG_CONSOLE` is no longer set in this generated file.

```
# CONFIG_CONSOLE is not set
```

16. **Rebuild the blinky application**. When the build finishes, the memory usage in the *Output view* shows a slight reduction in the flash size, since the Console subsystem has been removed from the application:

    CONFIG_CONSOLE = y

Memory region	Used Size	%age Used
FLASH:	22930 B	1.09%
RAM:	4264 B	1.30%

    CONFIG_CONSOLE = n

Memory region	Used Size	%age Used
FLASH:	22806 B	1.09%
RAM:	4264 B	1.30%

17. If you debug the *blinky* application now with the Serial Monitor connected, you will find the app no longer prints the boot banner with the Console removed. You can see the application still executes correctly with the LED blinking.

2. *guiconfig* tool to explore Kconfig symbols

In this section, we will introduce a tool integrated with Zephyr called *guiconfig*. This is an interactive tool to explore and configure Kconfig symbols. *Guiconfig* can be helpful to search for Kconfig symbols, see the different options, understand the dependencies with other symbols, and find where the symbols are located in the source files.

Zephyr offers two similar tools for this, the other is called *menuconfig*. The difference is *menuconfig* is text-based for CLI, while *guiconfig* opens a new window and works with the mouse. The MCUXpresso extension enables opening *guiconfig* for a project directly in VS Code.

18. In VS Code, return to the **.config file** already opened in the editor.

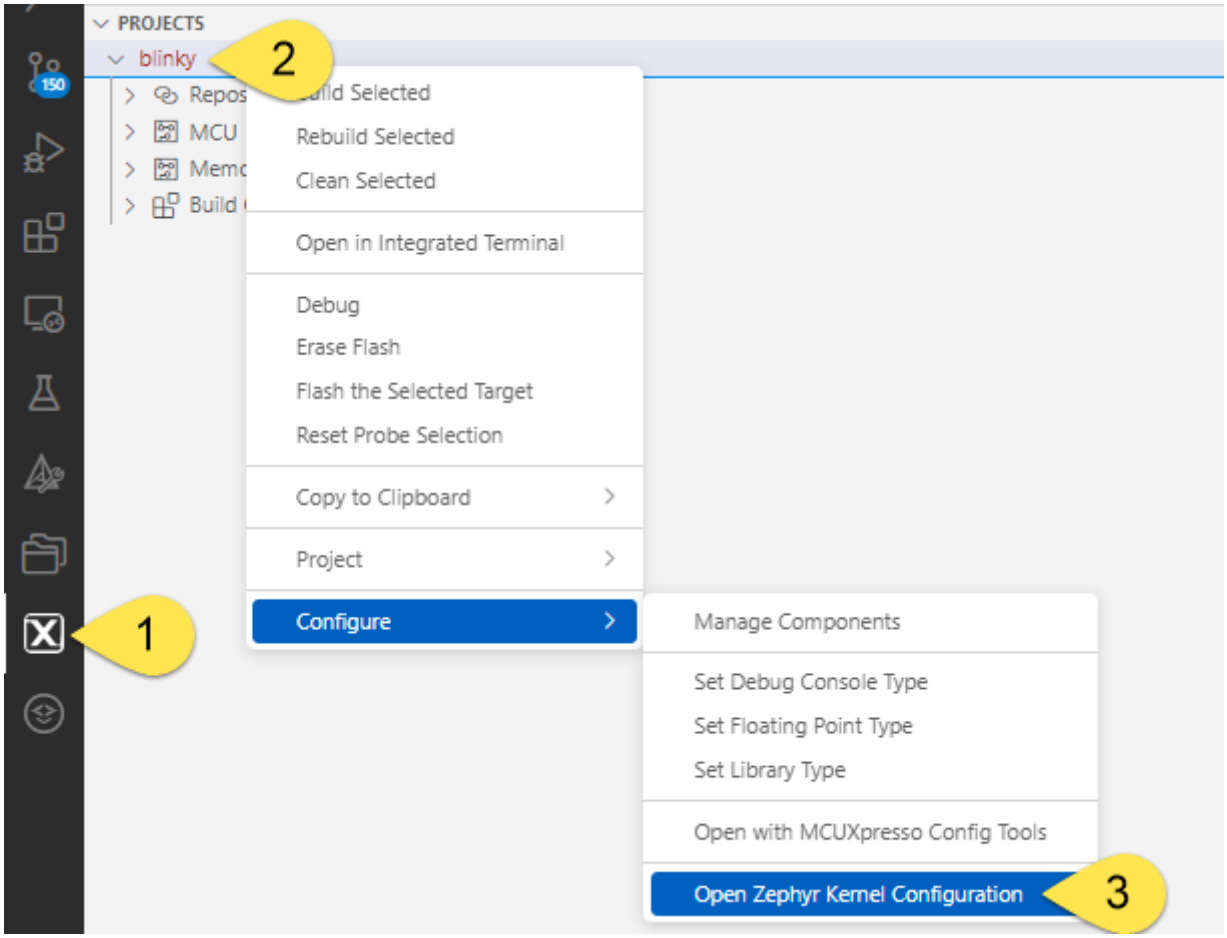
19. Search for the word **OPTIMIZATIONS**. You will find these symbols:

```
CONFIG_SIZE_OPTIMIZATIONS=y
# CONFIG_SPEED_OPTIMIZATIONS is not set
# CONFIG_DEBUG_OPTIMIZATIONS is not set
# CONFIG_NO_OPTIMIZATIONS is not set
```

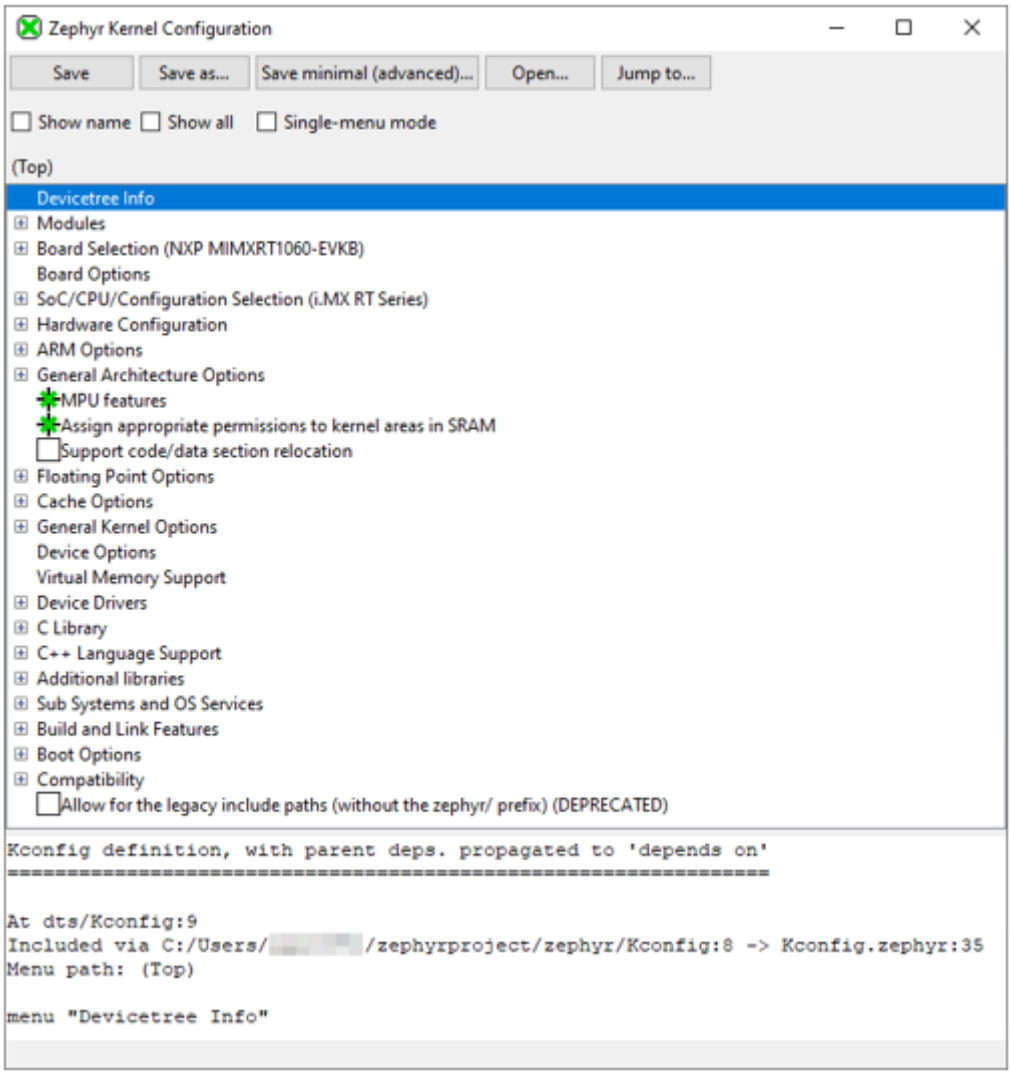
These Kconfig symbols are for the compiler optimizations. When debugging an application and stepping through code, it is helpful to disable optimizations. You can see Zephyr offers an optimization setting for debugging. But we prefer to disable all optimizations when single-stepping or setting breakpoints.

But how does one find that these Kconfigs exist, or how to use them? One option we will use for this is *guiconfig*.

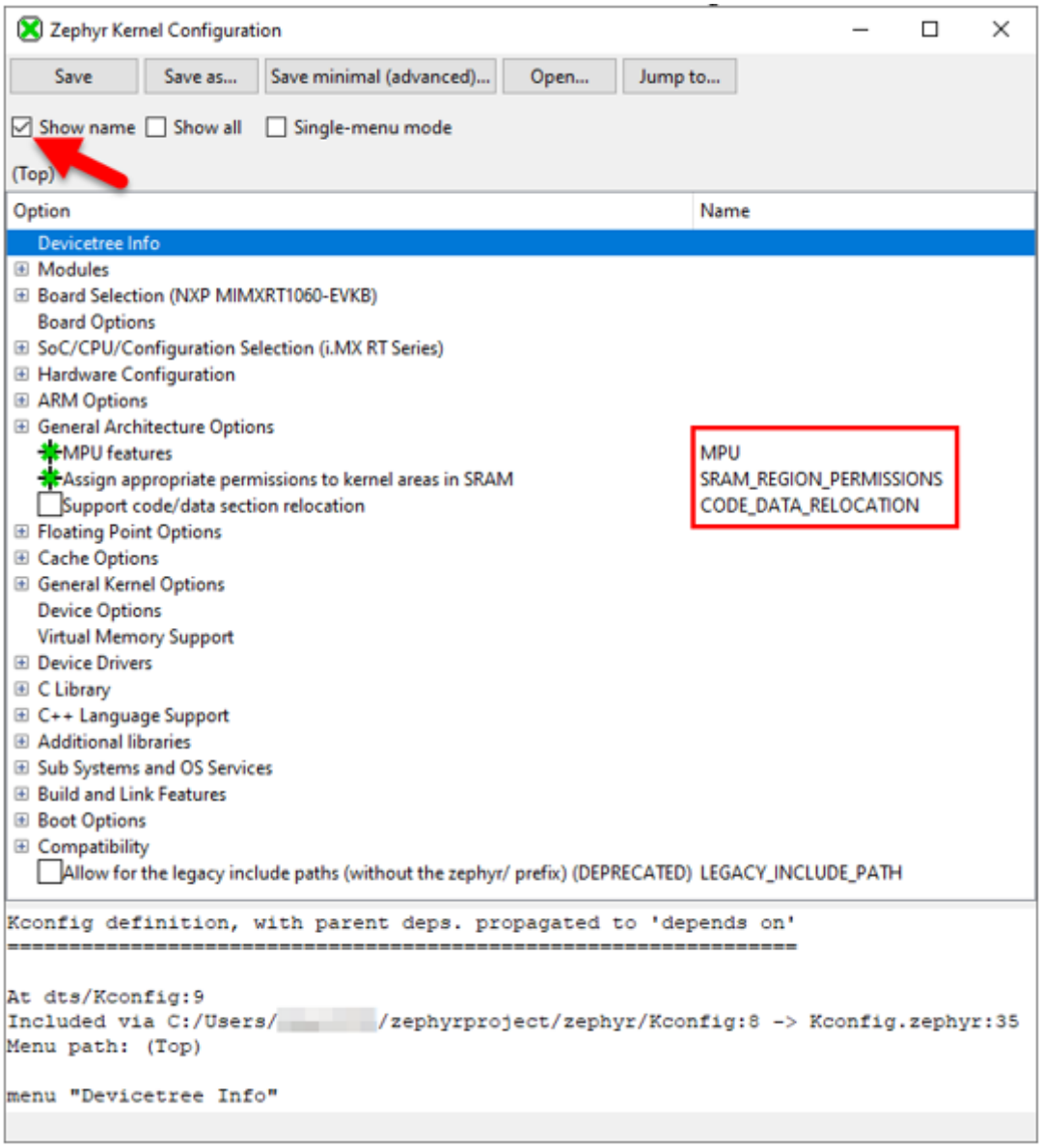
20. To open *guiconfig*, click the MCUXpresso view, **Right-Click the *blinky* project**, and select **Open Zephyr Kernel Configuration**.



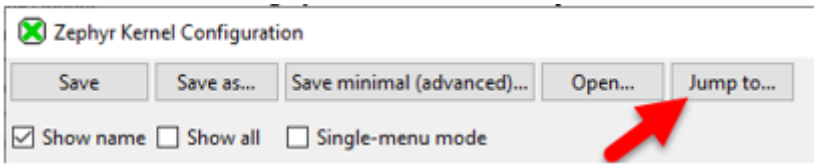
VS Code needs some time to open the tool. Then the *guiconfig* window will open.



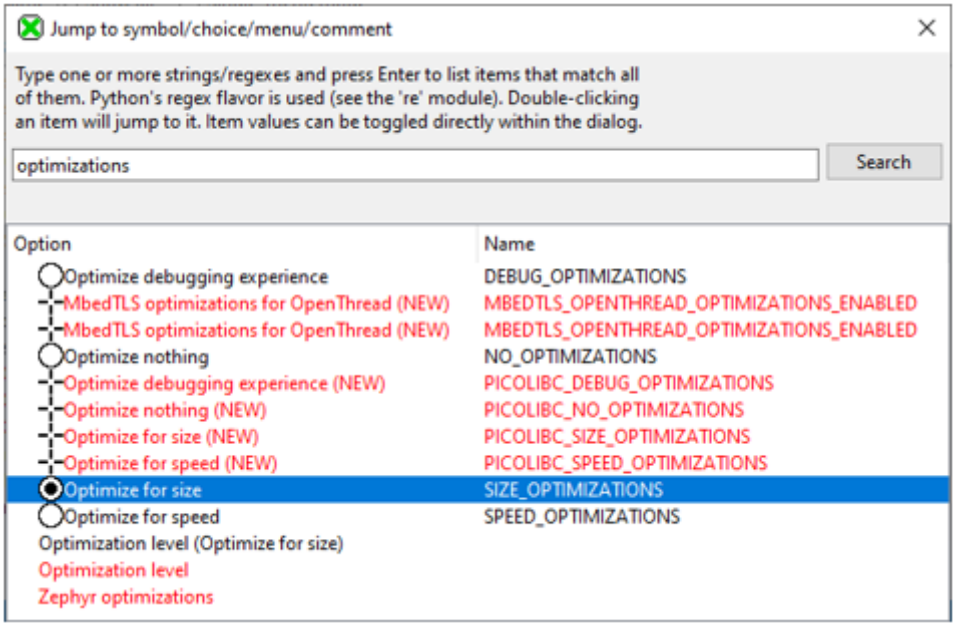
21. Check the **“Show name” box**. This adds a column on the right with the name of the Kconfig symbols.



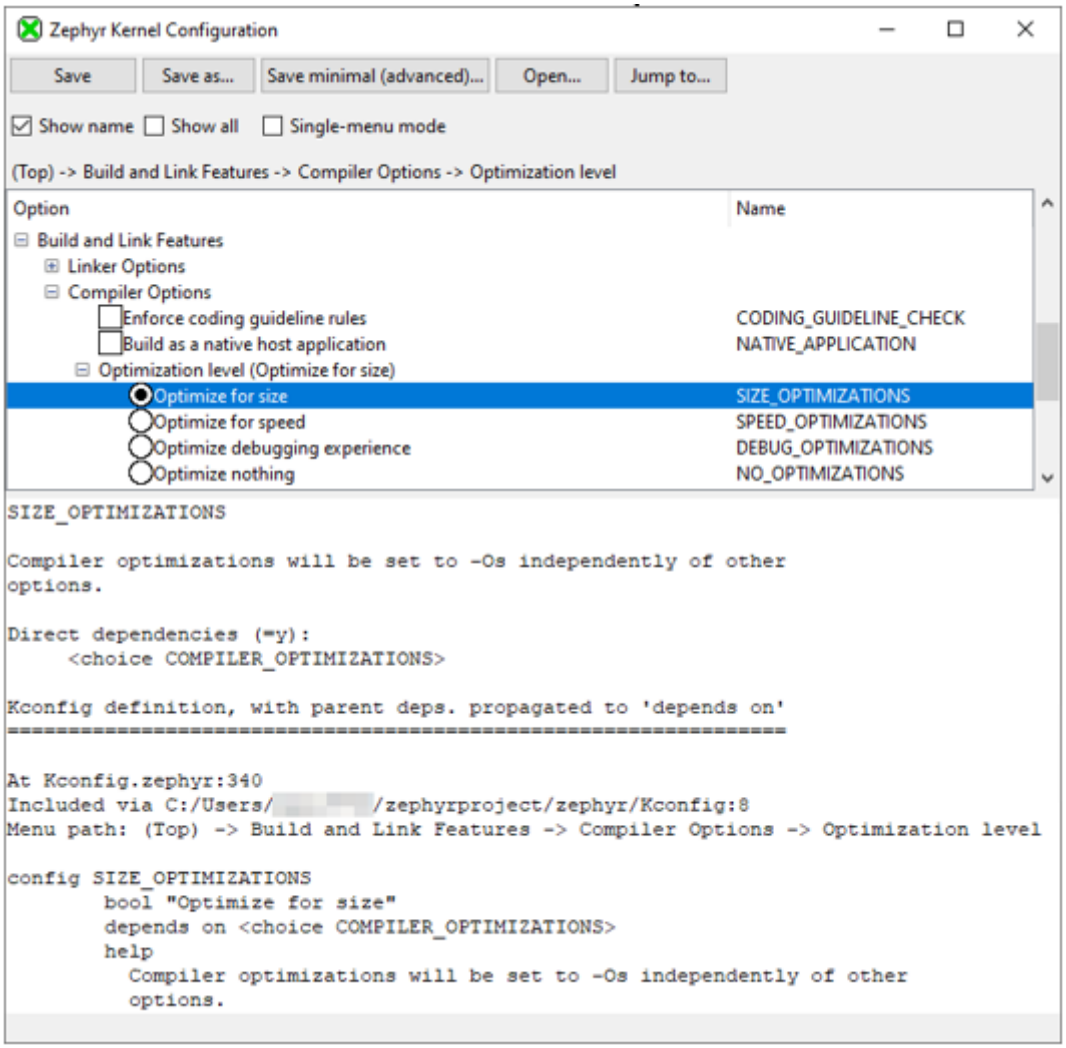
22. To search for a Kconfig symbol, click the **Jump to button**.



23. Search for the word **OPTIMIZATIONS**. The results below are found.



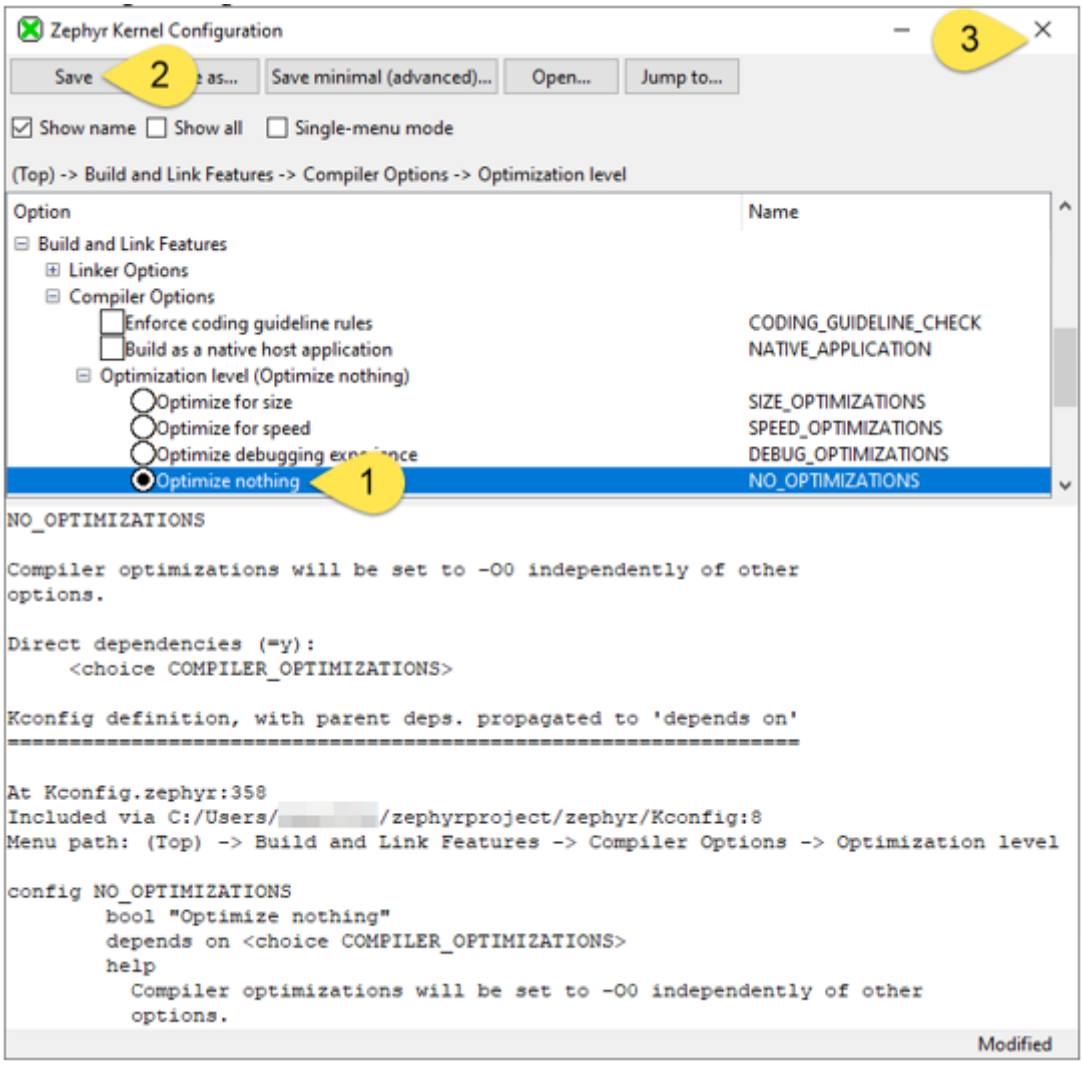
24. To see a more intuitive view, **double-click on the "optimize for size"** result.



Guiconfig helps illustrate that Kconfigs are like a hierarchical menu. You can use *guiconfig* (or *menuconfig*) to browse through the menu to find all the Kconfig settings, and make changes. We also see here the

`OPTIMIZATIONS` setting is a choice Kconfig. *Guiconfig* uses a radio button for this choice, to pick 1 of the 4 options. The text in the lower window shows details about each symbol, like a description, and the source where this Kconfig is defined.

25. Click the setting **Optimize nothing** to disable compiler optimizations, then click the **Save button**, and close the *guiconfig* window.



26. Back in VS Code, return to the **.config** file already open in the editor. Notice *guiconfig* made changes to the `OPTIMIZATIONS` settings. We saw in *guiconfig*, this `OPTIMIZATIONS` Kconfig is a choice of 4 options. But to select a choice, we select the boolean `CONFIG_NO_OPTIMIZATIONS=y`, which also deselected `CONFIG_SIZE_OPTIMIZATIONS`.

```
# CONFIG_SIZE_OPTIMIZATIONS is not set
# CONFIG_SPEED_OPTIMIZATIONS is not set
# CONFIG_DEBUG_OPTIMIZATIONS is not set
CONFIG_NO_OPTIMIZATIONS=y
```

Guiconfig made this change in the *.config* file. But remember, this is a generated file, and will not retain this change if it is rebuilt. We could build the app with this change right now, and see the change's effect on the app. But to make this change permanent, we should add this Kconfig selection to our app's *prj.conf* file.

27. Return to the **prj.conf** file already open in the editor. **Add the highlighted line below** for `CONFIG_NO_OPTIMIZATIONS`, and save the file.

```
CONFIG_GPIO=y
CONFIG_CONSOLE=n
```

```
CONFIG_NO_OPTIMIZATIONS=y # Add this line
```

28. In the MCUXpresso view, rebuild the *blinky* application. At the end of the build, the memory usage shows a large increase in flash usage after optimizations are disabled. But this change can also make the app much easier to debug.

CONFIG_SIZE_OPTIMIZATIONS=y

Memory region	Used Size	%age Used
FLASH:	22806 B	1.09%
RAM:	4264 B	1.30%

CONFIG_NO_OPTIMIZATIONS=y

Memory region	Used Size	%age Used
FLASH:	46730 B	2.23%
RAM:	4360 B	1.33%

3. Board-specific Kconfigs for an application

The previous sections set application Kconfigs using the app's *prj.conf* file. Kconfigs in the *prj.conf* apply across any hardware platform that app is built on. Another option is to create a board-specific Kconfig file for the application. This is useful when you want the same application to build on multiple boards, and may want different Kconfigs depending on the hardware. This method is frequently used by the sample applications in the Zephyr repository, like tests/drivers/spi/spi_loopback/boards/frdm_mcxn947_mcxn947_cpu0.conf. This lab section will give an example of setting board-specific Kconfigs for an app.

In the last section, the lab steps disabled compiler optimizations to ease debugging. A common consequence of disabling optimizations for an application is that a stack size may need to increase to enable the larger RAM requirement. These steps will first intentionally overflow the existing stack size for the Main thread, and then

increase the Main thread stack size using `CONFIG_MAIN_STACK_SIZE`. Other stack size settings frequently used in Zephyr applications include:

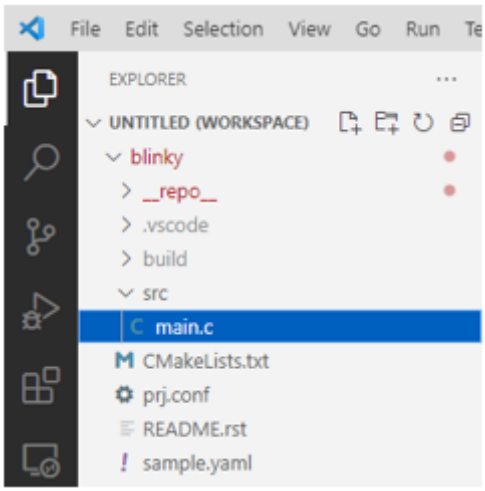
- `CONFIG_IDLE_STACK_SIZE`
- `CONFIG_ISR_STACK_SIZE`
- Plus each thread has an individual stack size

For the first steps, we will confirm the current `CONFIG_MAIN_STACK_SIZE`. And then intentionally overflow this stack size.

29. In VS Code, return to the **.config file** already open in the editor. Search for `CONFIG_MAIN_STACK_SIZE`, and take note of the current size. This is an example of an integer Kconfig, setting the size in bytes:

```
CONFIG_MAIN_STACK_SIZE=1024
```

30. In the Explorer view, **open *main.c***, in the src folder.



31. To overflow the Main thread stack, **copy and add the middle section of code below**, and add to the beginning of `main()` in *main.c*. To overflow the stack, we are declaring an array that is size `1+CONFIG_MAIN_STACK_SIZE`. Save *main.c* (Ctrl-S).

```
void main(void)
{
        int ret;
        bool led_state = true;
```

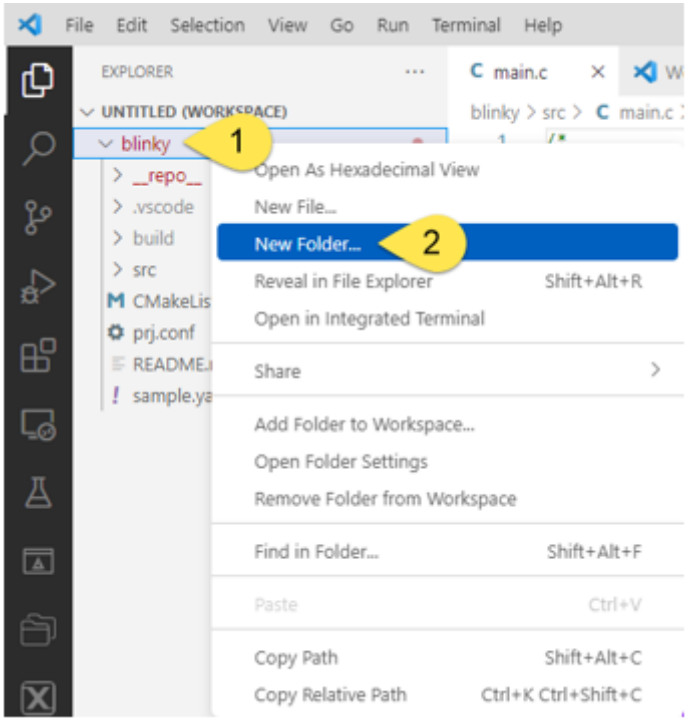
```
        /* Add an array that is too large for the Main thread stack */
        uint8_t large_buf[1025] = {0};
        if(large_buf[0] != 0)    /* to force compiler to keep large array */
                while(1);
```

```
        if (!gpio_is_ready_dt(&led)) {
                return;
        }
```

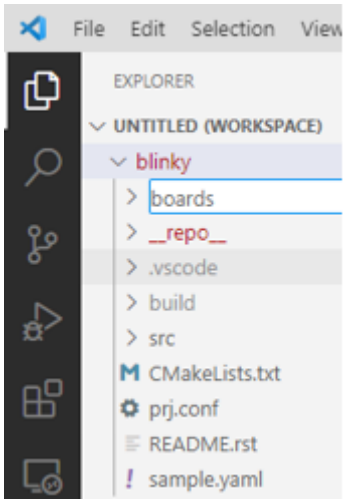
32. Optional, if you build and debug the application now, you will find the app builds, but it no longer blinks the LED, and instead ends up in a fault when the stack overflows.

The next steps will increase the size of `CONFIG_MAIN_STACK_SIZE`, using a board-specific Kconfig file.

33. In the Explorer view, **right-click the blinky project folder**, and **select New Folder**.

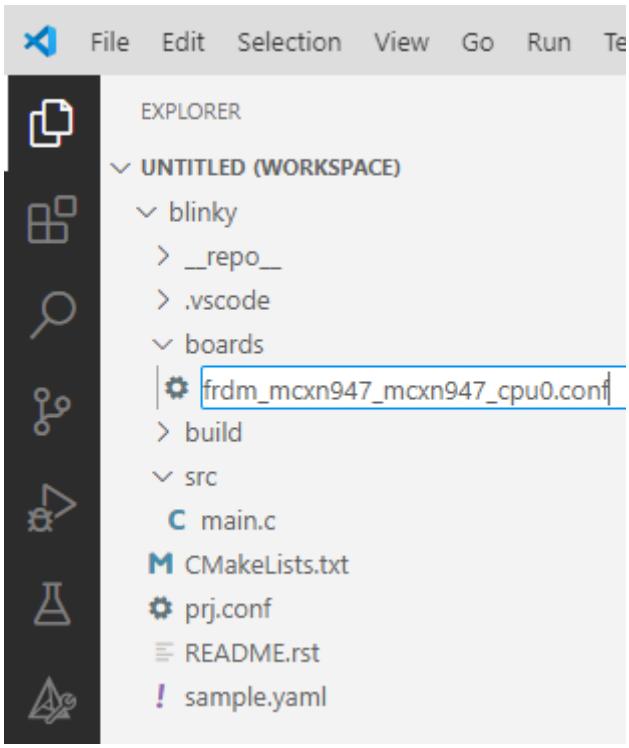


34. Name the new folder **boards**.



35. Right-click the boards folder, and **select New File**.

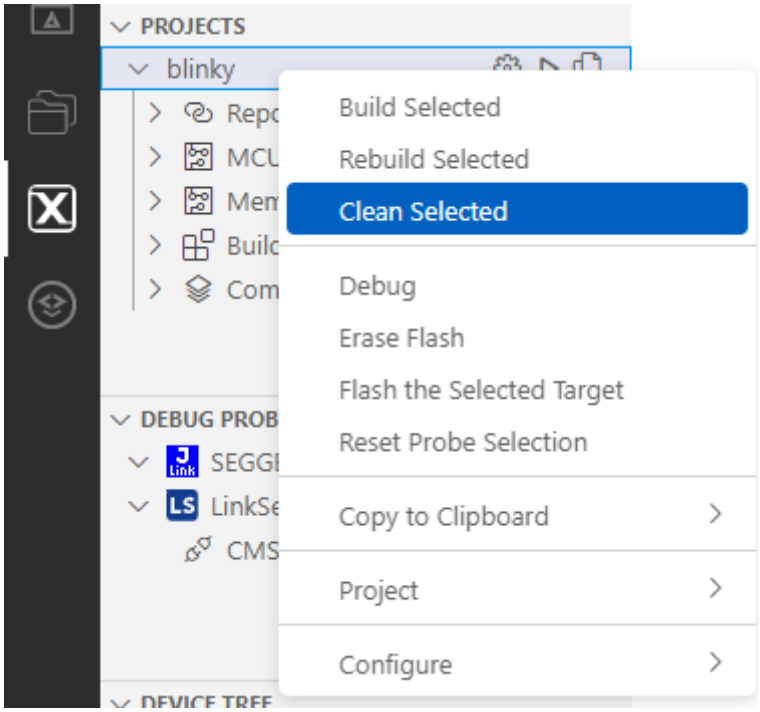
36. The new file must be named after the board target we are building for: ***frdm_mcxn947_mcxn947_cpu0.conf***.



37. **Copy the line below**, and add to the new file. Save *frdm_mcxn947_mcxn947_cpu0.conf* (Ctrl-S).

```
CONFIG_MAIN_STACK_SIZE=2560
```

38. Clean the project. Note that asking VS Code to build the project without cleaning will not work. The build system will not detect that a new Kconfig file was added to the application, so it will think nothing has changed since the last build. To force the build system to include the new file, go to the MCUXpresso view, right-click the *blinky* project, and **select Clean Selected**.



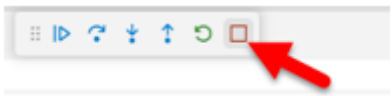
39. **Debug** the *blinky* project, and run on the board. The LED blinks again, now with the larger Main thread stack size.

40. Building the project also processed all the Kconfigs, and re-generated the *.config* file. If you return to *.config* already open in the Editor, `CONFIG_MAIN_STACK_SIZE` has been updated to 2560.

4. Clean up after lab

This Kconfig lab is completed. But the following steps will clean up the VS Code workspace:

41. Stop the Debugger



42. Close all Editor tabs. Right-Click on a tab, and select **Close All**.

43. If this is the last lab and you are done using the board, you should disconnect the Serial Monitor. Find the Serial Monitor view, and click **Stop Monitoring**.

Additional Resources

- Zephyr Kconfig documentation
- guiconfig and menuconfig interactive Kconfig tools
- Sources of Kconfig symbols, and how they are merged
- Webinar with more Kconfig training: Application Portability Made Easy With Zephyr OS and NXP

> Lab completed. Return to the MCXN947 Zephyr Labs Overview [[Training Zephyr Getting Started MCXN947]]