Application Note

AN_325

FT9XX Toolchain Installation Guide

Version 1.07

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This guide documents the tools and methods required for building, programming and debugging the FT9XX series devices from BRTChip.

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1 Introduction

The free FT9XX toolchain is a port from the popular GNU toolchain which includes the following components:

- GCC based compiler
- ft32-elf-gcc (GCC) 8.0.0 20171111 (experimental)GNU Binary Utilities (binutils) based tools, most notably:
  - as - the assembler
  - ld - the linker
  - and some other useful tools such as objdump, ar, ranlib, addr2line, etc.
- GDB based debugger
- In addition, a plugin for the Eclipse IDE is also provided. This 'Bridgetek FT9XX Eclipse plugin' allows the FT9xx toolchain to integrate seamlessly into Eclipse and as a result, greatly simplify the development and debugging of applications for the FT9xx MCUs.

1.1 Compiler: ft32-elf-gcc

The FT9XX compiler is used similarly to standard GCC. It supports most GCC options such as -Wall, -O1, -O2…

Example: To compile a C file into an object file:

ft32-elf-gcc -c -o file.o file.c

1.2 Assembler: ft32-elf-as

The FT9XX assembler functions in the same way as the standard GNU assembler (GAS). The assembly files should be written using the GAS general syntax.

Example: To compile an assembly file into an object file:

ft32-elf-as -o file.o file.s

1.3 Linker: ft32-elf-ld

Typically running behind ft32-elf-gcc, the FT9XX linker performs two tasks. It first links all object files and libraries into a.out and then convert's a.out into an executable file for FT9XX. Similar to the FT9XX compiler and assembler, the FT9xx linker supports most standard GNU linker options.

Example:

- To link various object files / libraries into an .elf file:

  ft32-elf-gcc -nostartfiles file1.o file2.o -L <libfolder> -l lib1 -l lib2 -o file.elf

- To convert file.elf into a FT9xx binary file, which can be programmed into the chips:

  ft32-elf-ld --oformat binary -o file.bin file.elf

1.4 Debugger: ft32-elf-gdb

The Bridgetek programmer/debugger module is needed for the communication between ft32-elf-gdb and the chip. The communication follows the GDB remote protocol. In addition to the debugger module, two software components are needed:

- GDB Bridge: for converting GDB commands into the debugger module commands
- Bootloader: for receiving & executing the debugger module commands

More information on how to use the FT9xx debugger can be found in section 6.1.3 of this document.

1.5 A useful utility: ft32-elf-objdump

ft32-elf-objdump displays various information about object files. Its usage is the same as standard GNU objdump.

Example: To disassemble file.elf into a text file

ft32-elf-objdump -d file.elf > disassembly.txt

2 Setting up the FT9XX Toolchain

2.1 Installing the Toolchain

The toolchain can be installed by running the setup wizard "FT9XX Toolchain Setup_*version*.exe", which can be downloaded from the Bridgetek website. Please follow the steps in the wizard to complete the installation process. It is recommended to use the default settings for simplicity.

Note: all applications should be closed before the installation or a restart may be required.

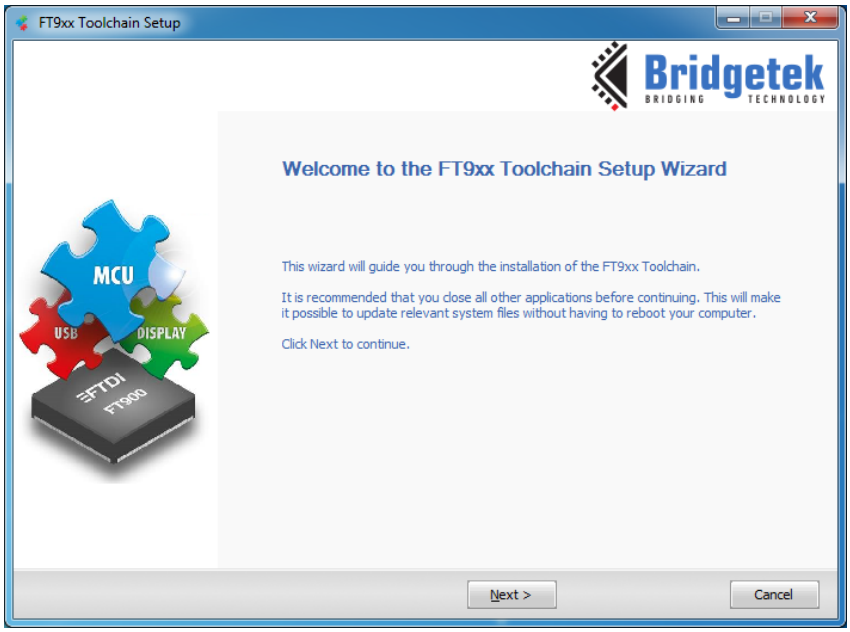


Figure 1 Toolchain Setup Wizard Dialog box

In the License Agreement dialog box, click **I Agree**.

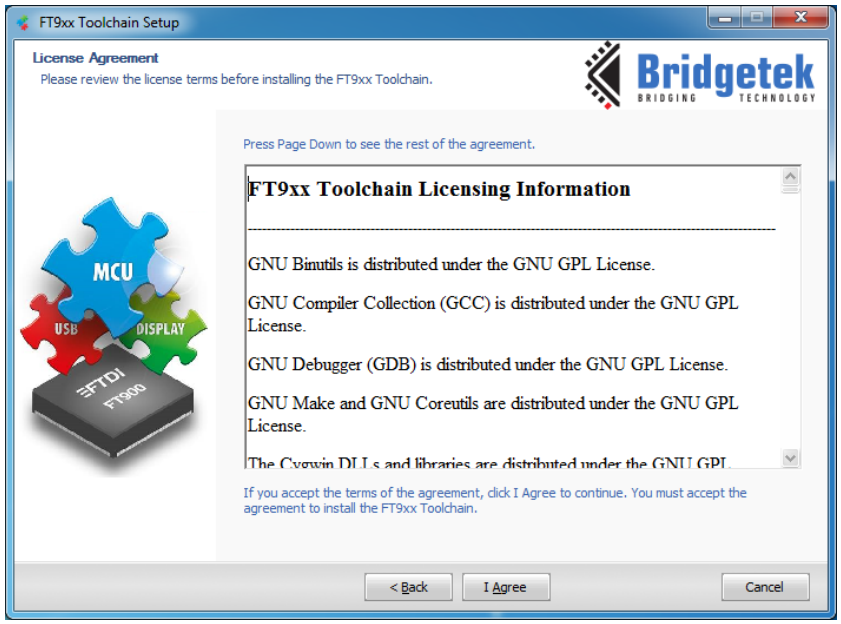


Figure 2 License Agreement Dialog box

Go through the Revision and Release information and click **Next**.

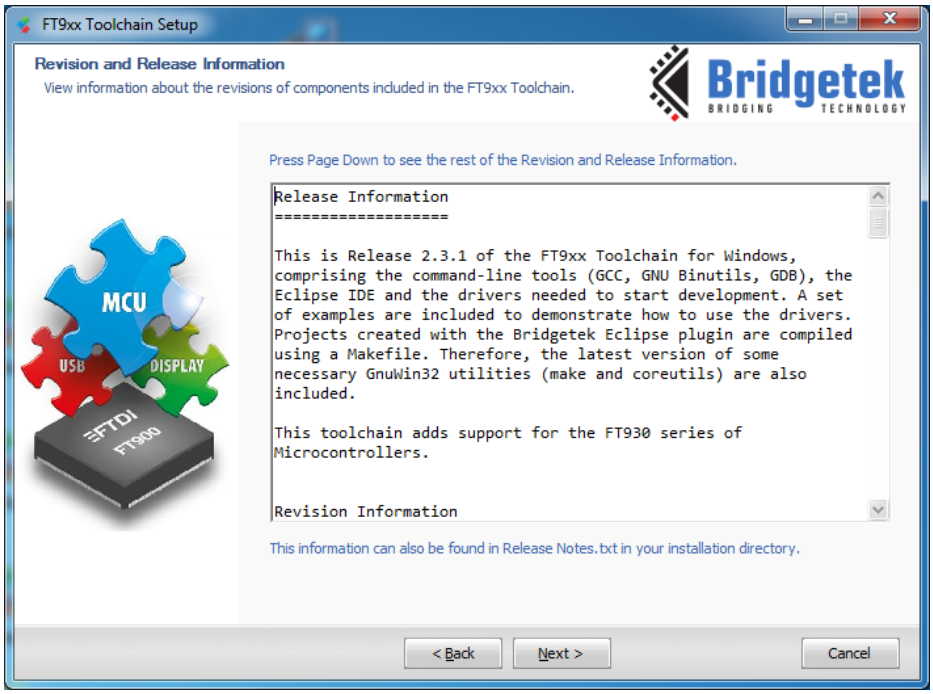


Figure 3 Revision and Release Information Dialog box

Select the Components and click **Next**. The toolchain has an option to install Python 2.7.10 (see Fig 4). You may opt out of the Python installation, if Python 2.7.x or later is present in your system, by unselecting the option for Python 2.7.10 in the Components Dialog box.

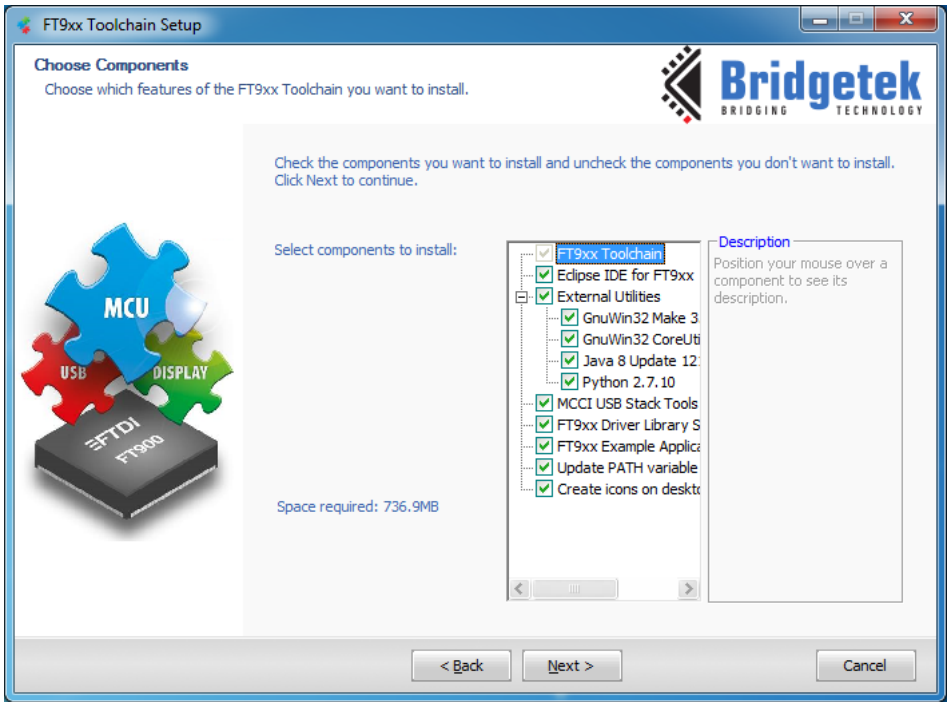


Figure 4 Components Dialog box

Click **Browse** and select a different file path for the FT9XX Toolchain installation. Alternatively, continue installing in the specified folder by clicking **Next**.

The toolchain components like Eclipse IDE, GNU toolchain, programmer utility, FT900 library headers and 3rd party library are installed in the selected path. If the specified path, which is a system path under 'Program Files' or 'Program Files (x86)' is chosen, one has to be aware of Virtual Store folders and files in the section 7.4.

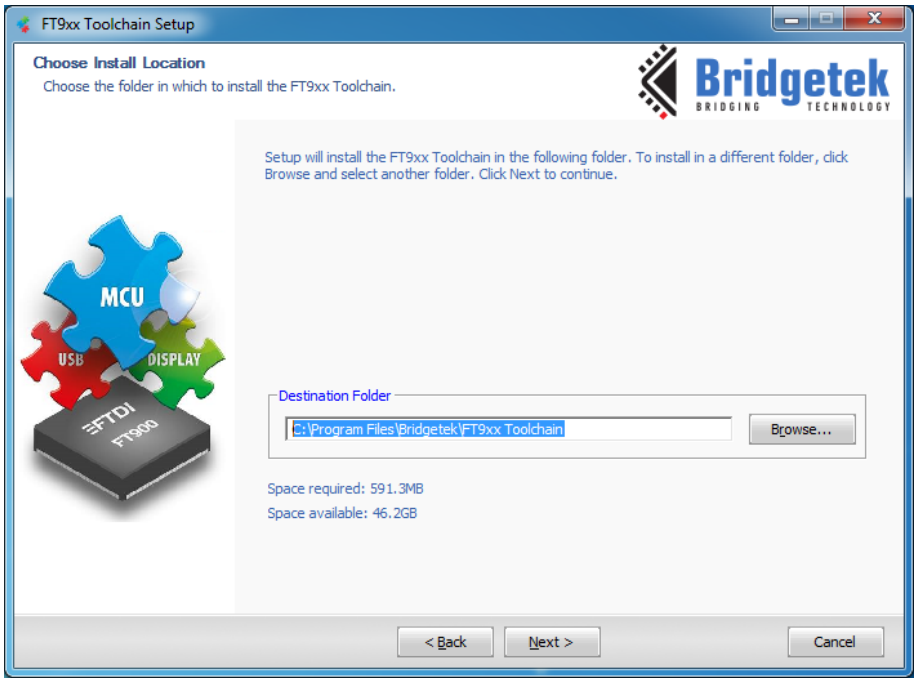


Figure 5 FT9XX Toolchain Install Location Dialog box

Click **Browse** and select a different file path for installing FT9XX examples and documents. Alternatively, continue installing in the specified folder, by clicking **Install**.

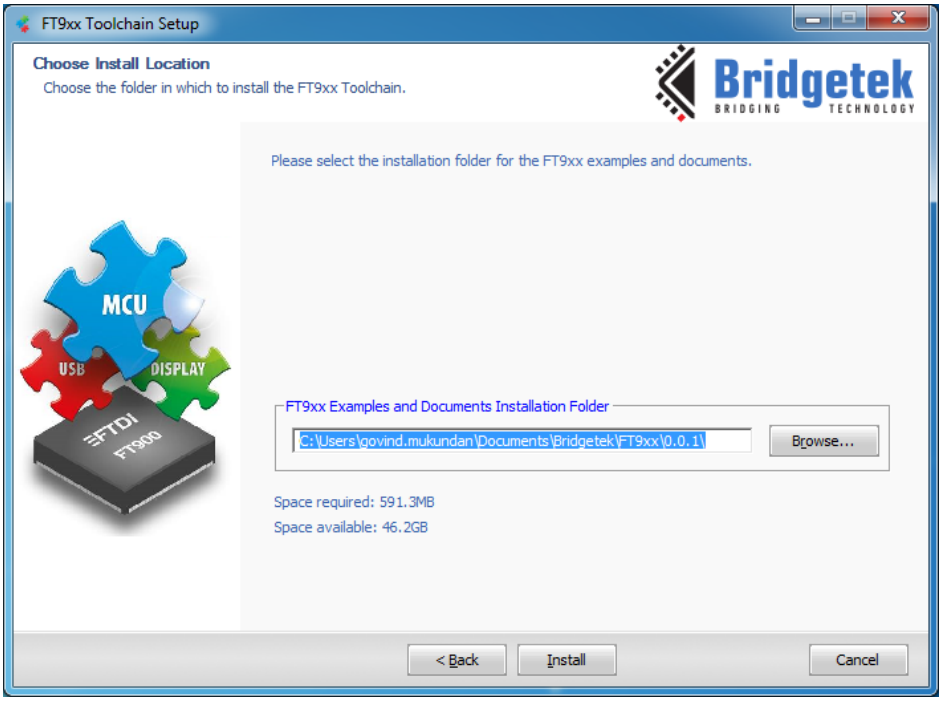


Figure 6 FT9XX Toolchain-Examples & Documents Install Location Dialog box

The FT9XX Toolchain installation progress bar is displayed.

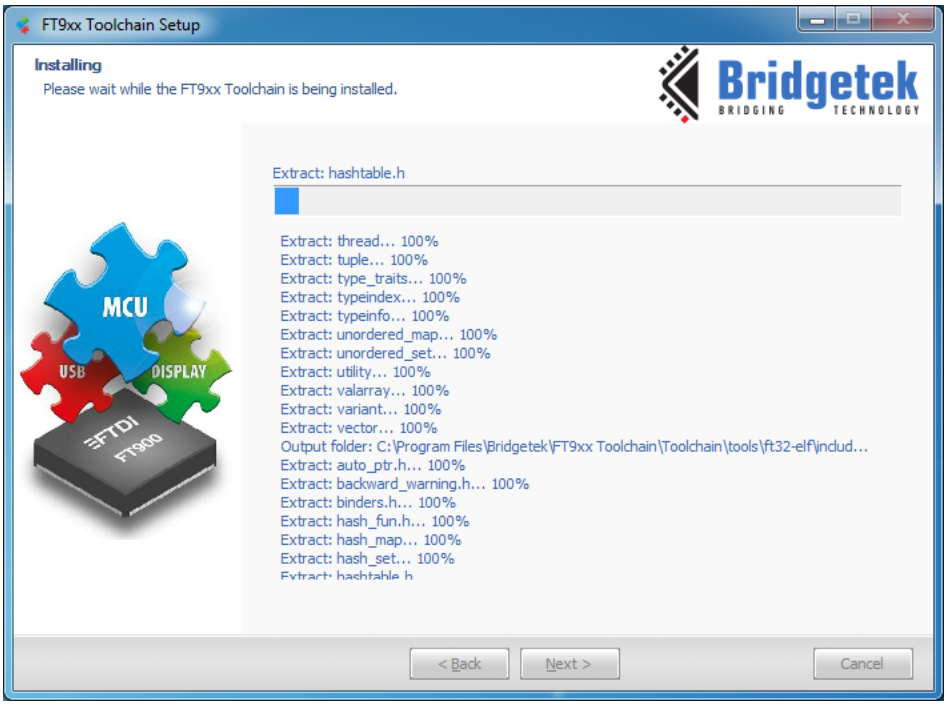


Figure 7 FT9XX Toolchain - Installation Progress Window

If Java is selected for installation, the following message is displayed. Please close any open Java Applications and click **OK**.

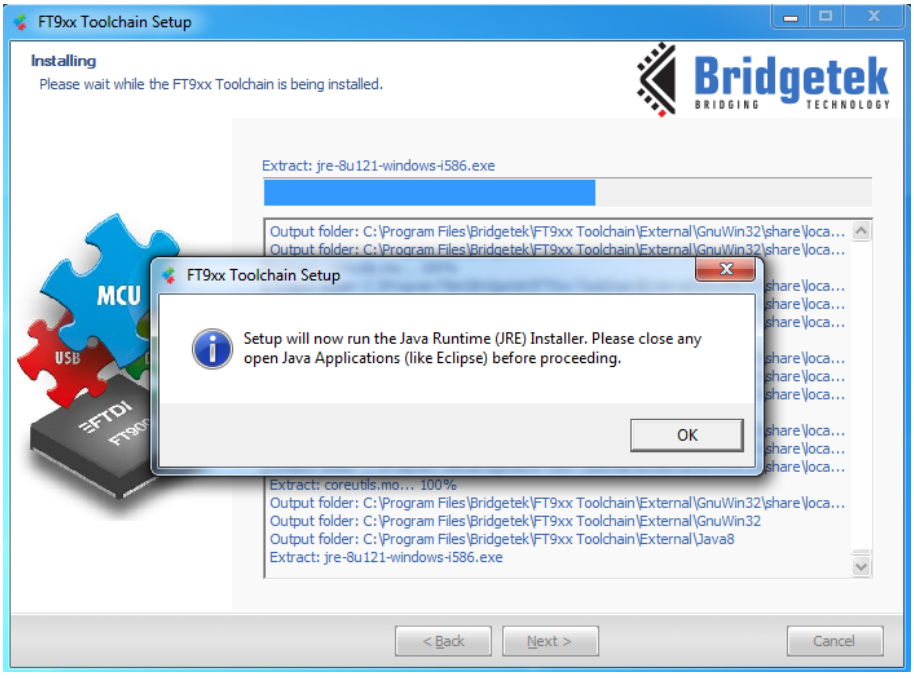


Figure 8 Close any running Java Applications before launching JRE Installer

Setup will then launch the JRE installer and the following window will be displayed.

Figure 9 Java Setup Window

Click **Install** and follow the instructions to install Java on the machine.

Figure 10 Java Setup Progress Window

During installation, if a **Python 2.7.10 Setup** dialog box is displayed, select the appropriate option as required and click **Next**.

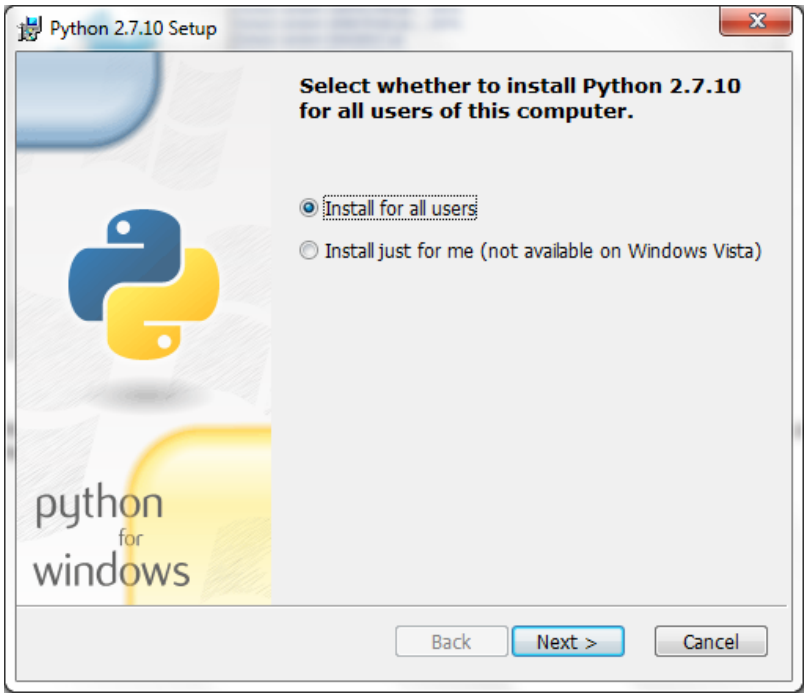


Figure 11 Python Setup Dialog box

Select a different Destination Directory to setup Python. Alternatively, continue installing in the specified folder by clicking **Next**.

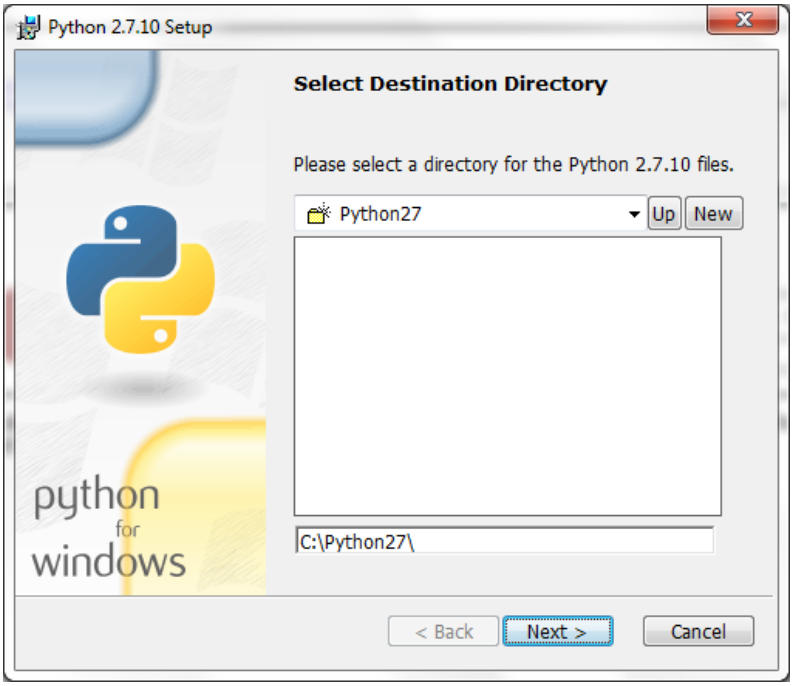


Figure 12 Destination Directory Selection Dialog box for Python Setup

Select the Python features to be installed or continue with the default features and click **Next**.

Figure 13 Python Features Customization Dialog box

Python installation progress bar is displayed.

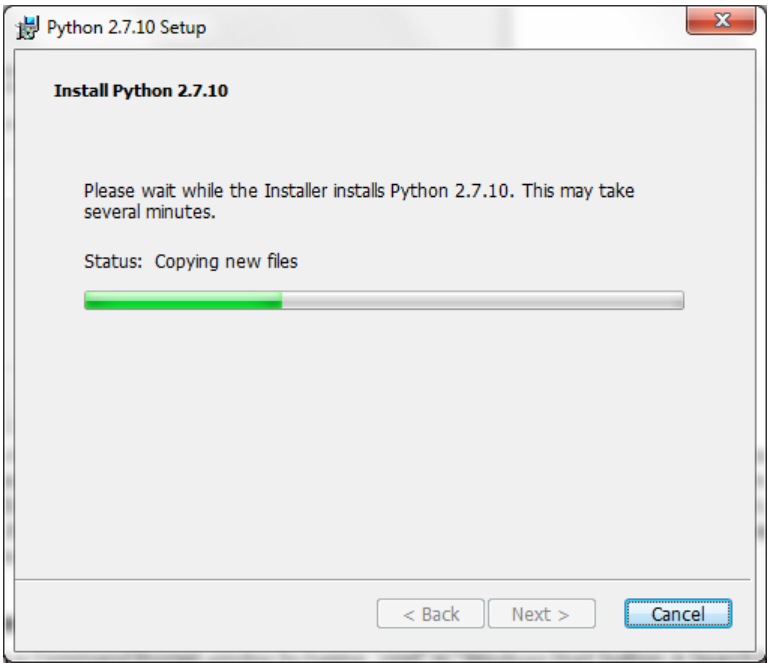


Figure 14 Python Installation Progress Dialog box

Click **Finish** to complete the Python installation.

Figure 15 Python Installation Completion Dialog box

The FT9XX Toolchain installation is continued.

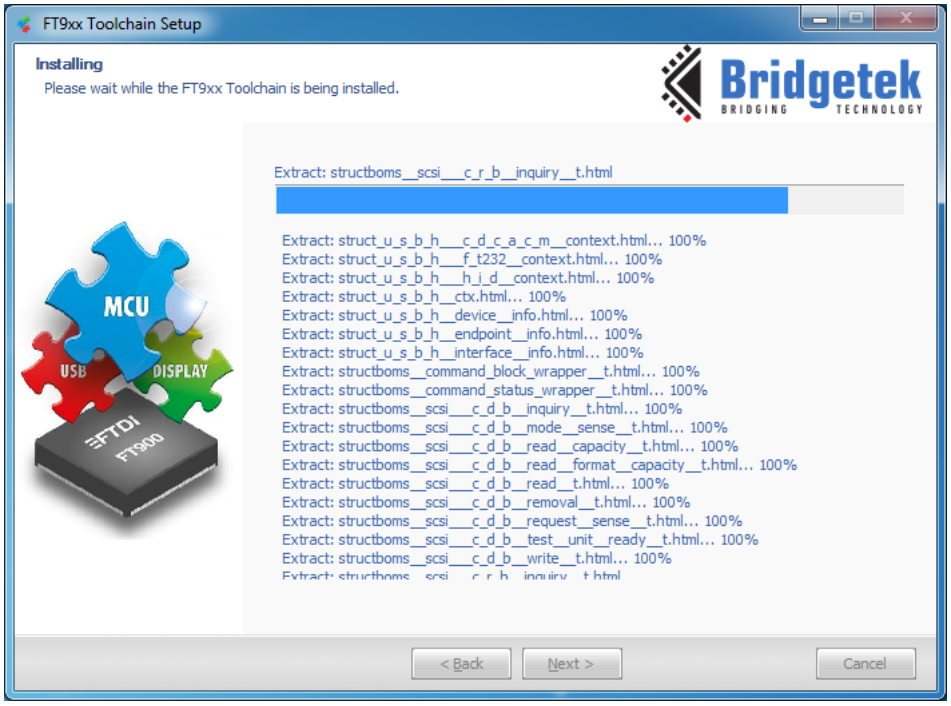


Figure 16 FT9XX Toolchain - Installation Progress Window

Select the **Open AN_325** checkbox to start immediately after closing the Setup Wizard. Else leave it unchecked. Click **Finish** to complete the FT9XX Toolchain Setup.

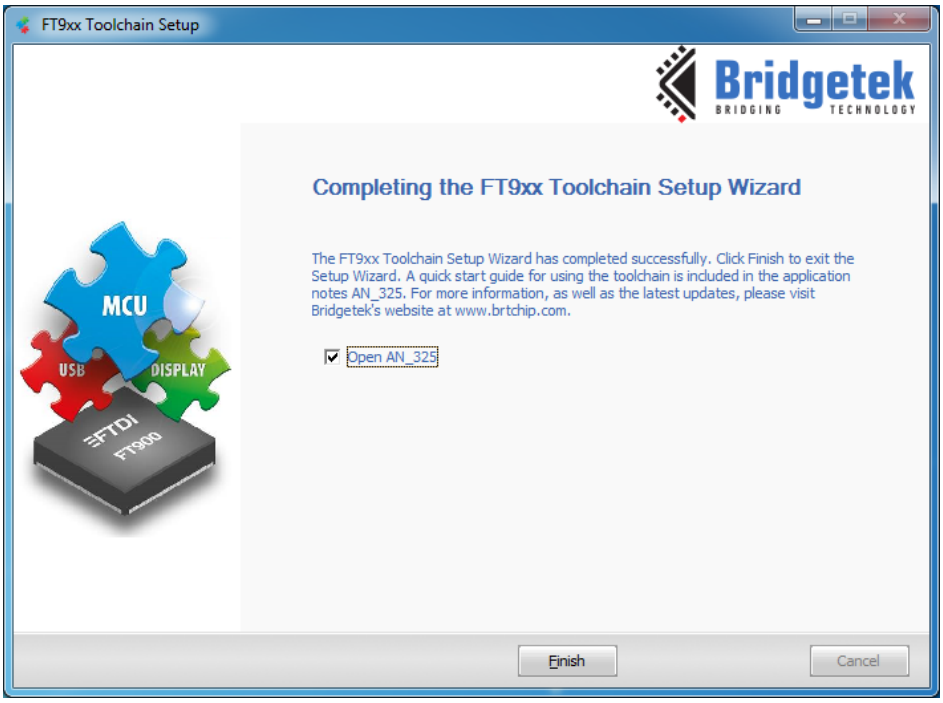


Figure 17 FT9XX Toolchain Setup Completion Dialog box

After the installation, the toolchain can be found in the installation directory. The default location is "C:\Program Files\Bridgetek\FT9XX Toolchain" for 32-bit Windows and "C:\Program Files (x86)\Bridgetek\FT9XX Toolchain" for 64-bit Windows. This directory also contains the external utilities needed. The FT9XX drivers, sample applications and documents (if selected for installation) can be found in "My Documents\Bridgetek\FT9xx".

2.1.1 Installing Java Runtime Environment Manually

The Toolchain requires the Windows MSI Installer (msiexec.exe) while installing the Java Runtime Environment (JRE). The MSI installer can only process one installation at a time. Under some conditions, msiexec.exe may have already been started by another Windows process during automatic Windows Update for example. If the installer detects another instance of msiexec.exe running in the background, the user will be prompted to either wait for the background MSI Installer to complete and retry after 5 seconds or to skip the JRE installation entirely. This is shown in Figure 18.

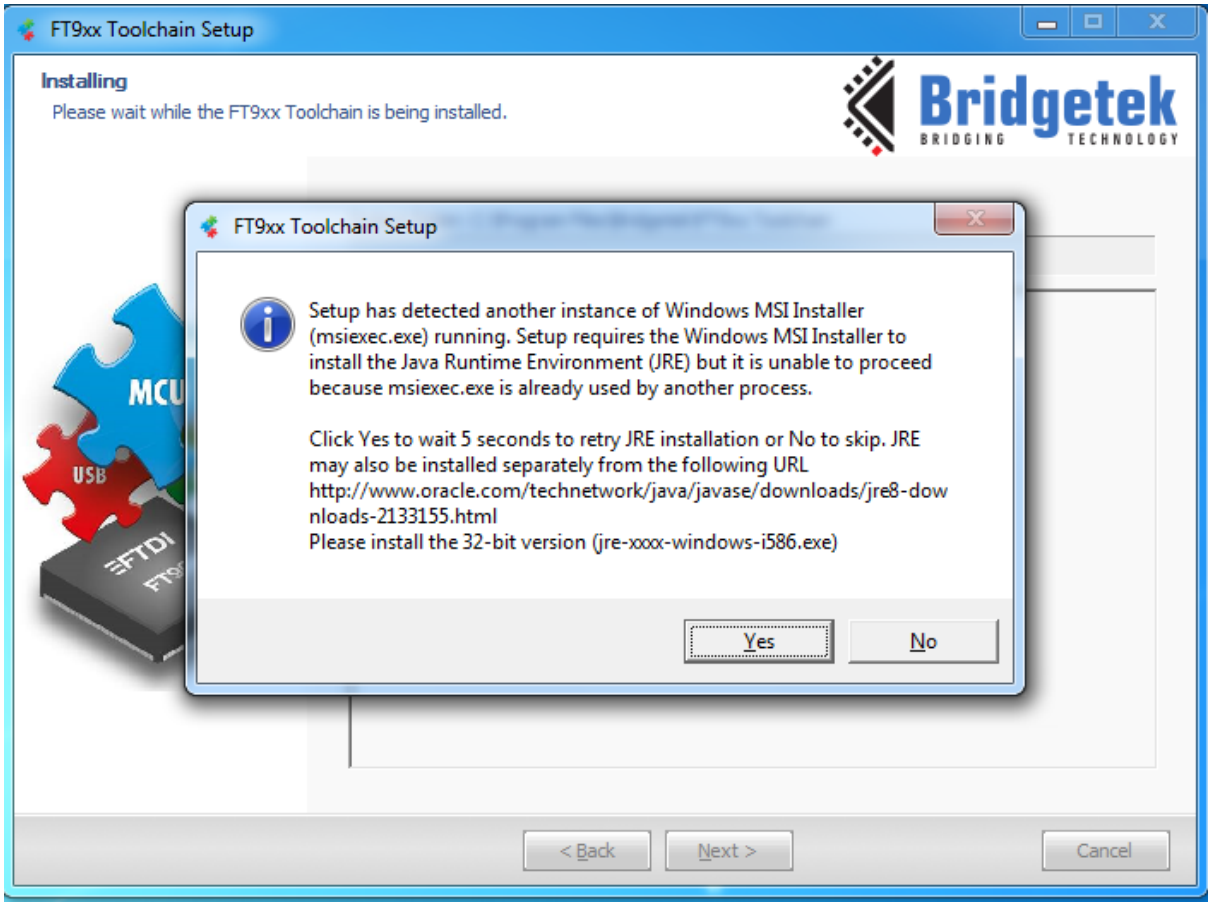


Figure 18 MSI Installer is busy

If the user skips JRE installation, JRE can be installed manually from the Oracle Website (http://www.oracle.com/technetwork/java/javase/downloads/jre8-downloads-2133155.html) or by re-running the FT9xx Toolchain Installer later. Please ensure to install the 32-bit version of JRE (jre-xxx-windows-i586.exe) as the Eclipse installed as part of the FT9xx Toolchain install is 32-bit.

2.2 Verifying the installation

1. Open a Command Prompt window by typing "cmd" in "Windows Start button → Search box".
2. Type "ft32-elf-gcc --version" in the command prompt. It should give the following message:

```
ft32-elf-gcc (GCC) 8.0.0 20171111 (experimental)
Copyright (C) 2017 Free Software Foundation, Inc.
This is free software; see the source for copying conditions.  There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

If this message appears, then the toolchain has been successfully setup.

3 Quick Start Guide: From creating to getting your application to run on the FT9XX MCUs

This Section guides you through the steps to create a new application, compile and program it into the chip. To debug your application, please refer to Section 4 - "Setting up Eclipse for Debugging". For more information about the tools, as well as the advanced features, refer to Section 6 - "Advanced Topics".

3.1 Creating a new project

Double click on the icon "Eclipse for FT9XX" to launch the Eclipse IDE.

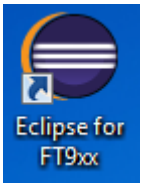


Figure 19 Eclipse for FT9XX Icon

When you run Eclipse for the first time, it will ask you for the location of the workspace. Eclipse will create some files within this directory to manage the projects. Specify a folder of your choice and click OK.

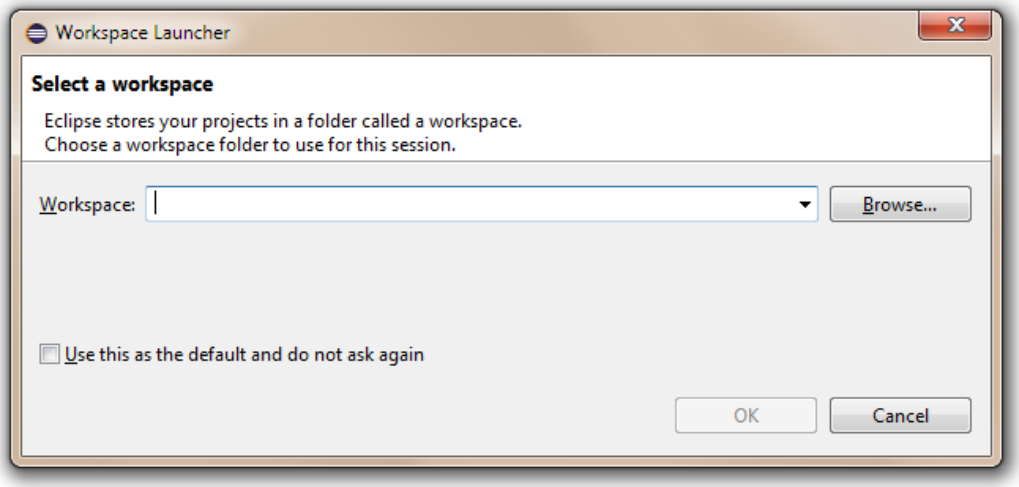


Figure 20 Eclipse Workspace Selection

Note: The following message will be displayed if an existing workspace, which was created by an older version of Eclipse, is specified. As there may be some configurational changes in files related to workspace in the newer version of Eclipse which may cause issues, it is recommended to create a new workspace and import the existing projects to the new workspace.

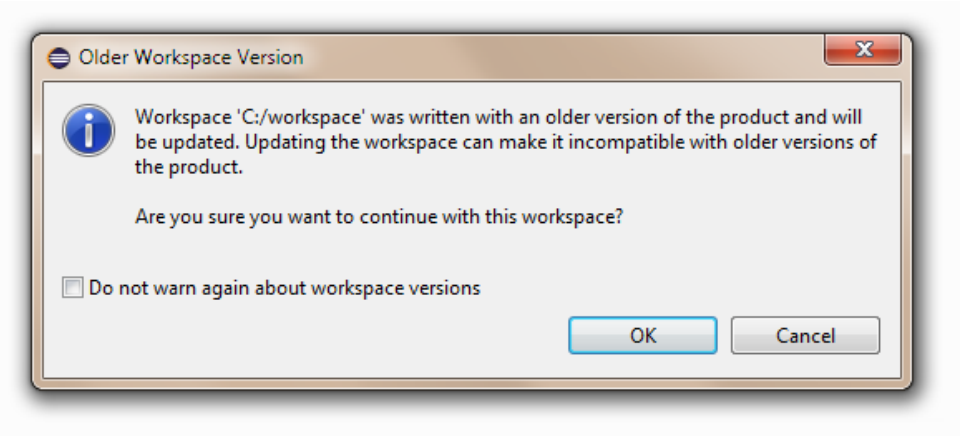


Figure 21 Eclipse Workspace Update

To create a new C project in Eclipse, on the menu bar click **"File → New → C Project"**. The C Project wizard will open.

Give a name to the project, for example "Hello World". By default, the new project will be created inside the workspace you have chosen. If you want to change it, uncheck the box "Use default location" and specify another location. Choose **"Empty Project"** for the project type and **"Bridgetek FT9XX GCC"** for the toolchain. This ensures all the relevant FT9XX include files are part of the project. Click **Next**.

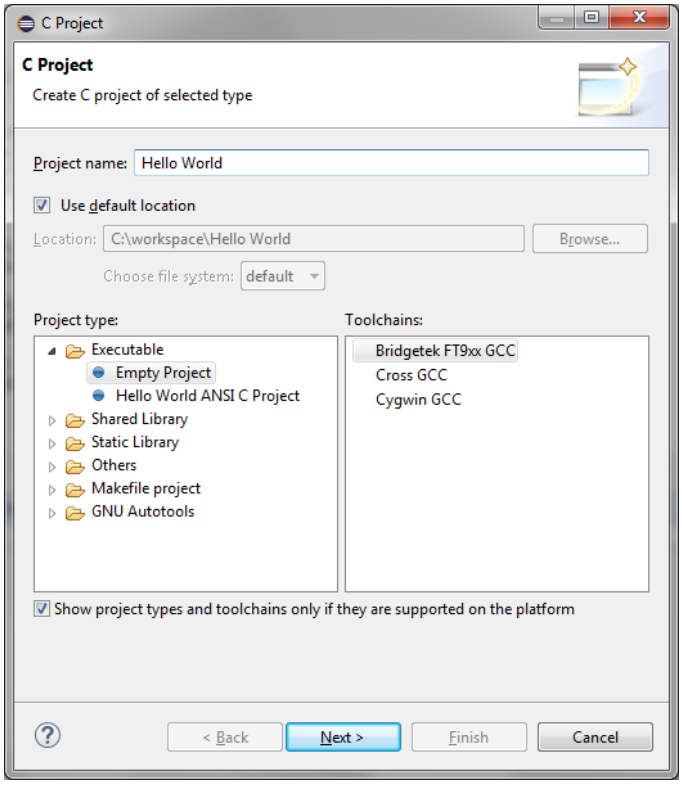


Figure 22 C Project Wizard

In the next window, select FT900 _* configurations if your project is to target FT900 series of MCU or FT930_* to target FT930 series, or both if you wish to target both series and click **Next**.

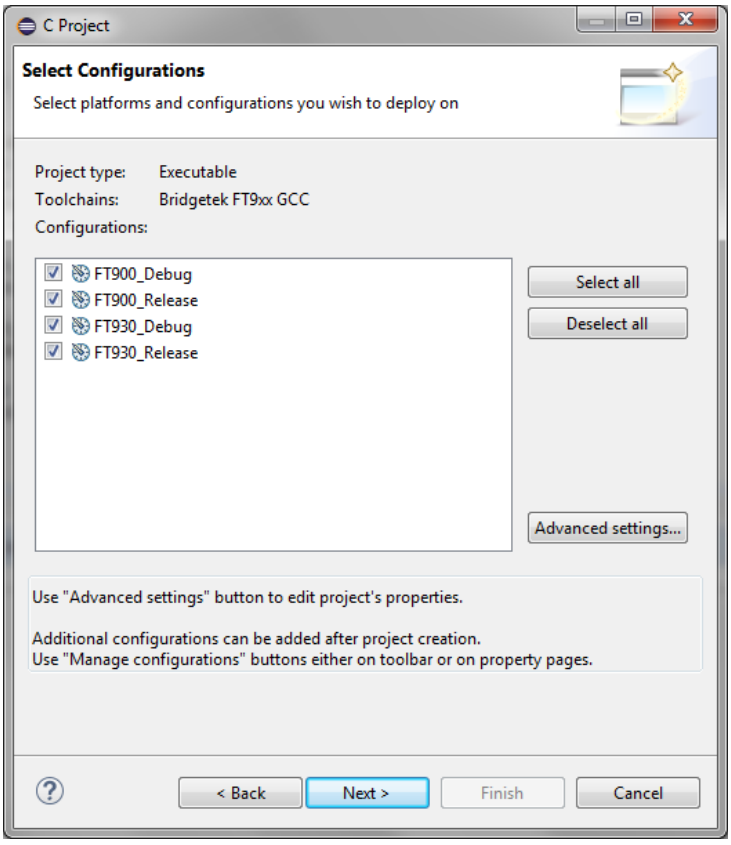


Figure 23 Project Wizard - Build Configurations Selection

The last window is for the toolchain prefix and location. By default, the values will be prefilled as follows.

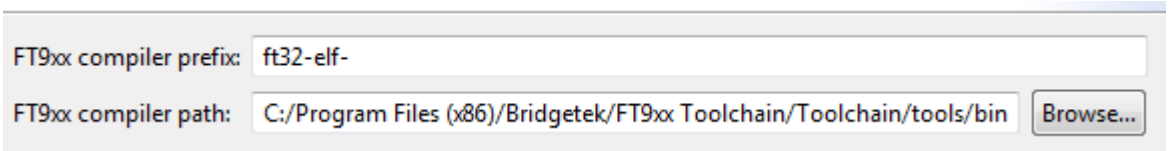


Figure 24 C Project Wizard - Toolchain Details

Click Finish to complete the New Project Wizard. A new FT9XX project will be created in Eclipse.

3.2 Building the project

After the wizard completes, some folders and an empty source file (main.c) will be created.

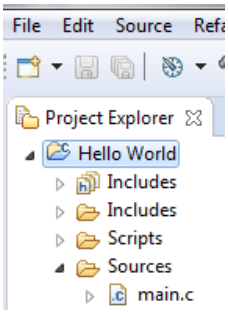


Figure 25 New empty project structure

The main.c contains some default content:

```
#include <stdint.h>
#include <ft900.h>

#if defined(__FT900__)
#define GPIO_UART0_TX     48
#define GPIO_UART0_RX     49
#elif defined(__FT930__)
#define GPIO_UART0_TX     23
#define GPIO_UART0_RX     22
#endif

int main(void){
    /* Enable the UART Device... */
    sys_enable(sys_device_uart0);
    /* Set UART0 GPIO functions to UART0_TXD and UART0_RXD... */
    gpio_function(GPIO_UART0_TX, pad_uart0_txd); /* UART0 TXD */
    gpio_function(GPIO_UART0_RX, pad_uart0_rxd); /* UART0 RXD */
    uart_open(UART0,                    /* Device */
              1,                        /* Prescaler = 1 */
              UART_DIVIDER_19200_BAUD,  /* Divider = 1302 */
              uart_data_bits_8,         /* No. Data Bits */
              uart_parity_none,         /* Parity */
              uart_stop_bits_1);        /* No. Stop Bits */

    /* Print out a welcome message... */
    uart_puts(UART0,
        "---------------------------------------------------------- \r\n"
        "Hello World! \r\n"
        "---------------------------------------------------------- \r\n"
        );
    /* Now keep looping */
    while (1);

    return 0;
}
```

Now select the Build Configuration for either FT90X or FT93X via the project menu:

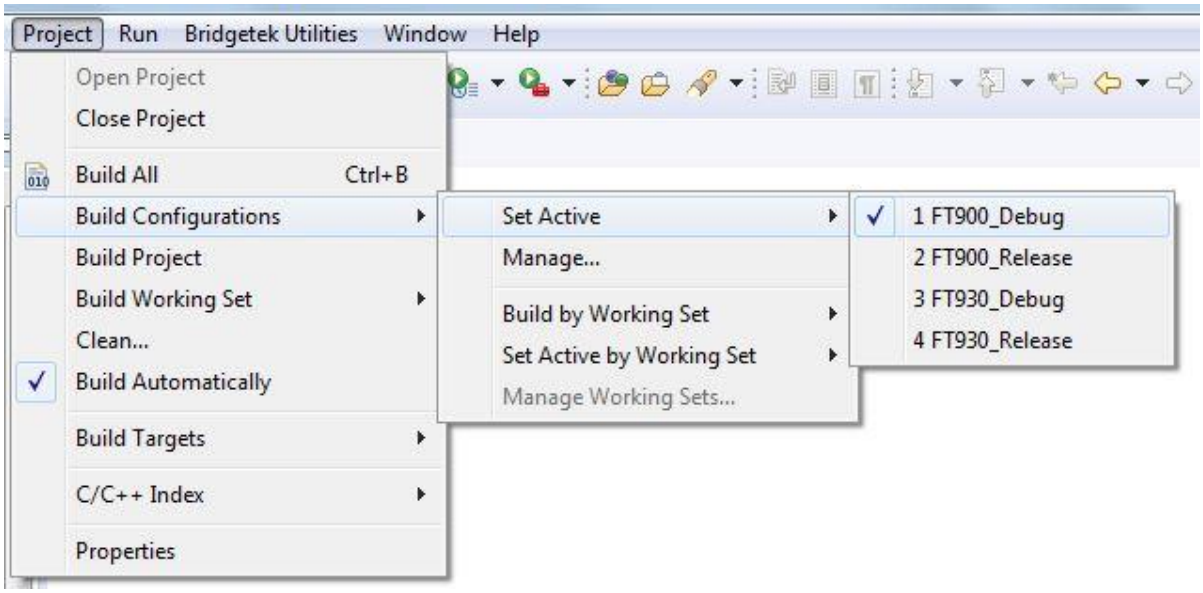


Figure 26 Build Configuration

This can also be done via the Manage Configurations toolbar icon:

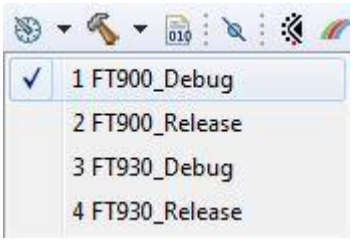


Figure 27 Build Configuration

Now the project can be built by clicking on the menu **Project → Build Project**, but note that there are a few options like right-click on the project → Build Project and the  icon.

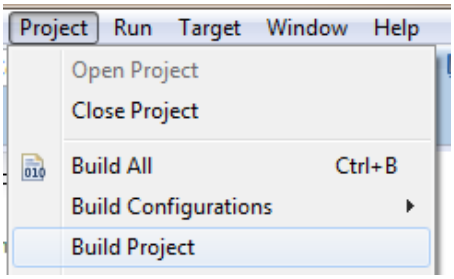


Figure 28 Building the Project

The console window at the bottom of the IDE shows the build status. If the build completes successfully, two files will be created - "Hello World.elf" and "Hello World.bin". The file to be programmed into the chip is "Hello World.bin". The .elf file is used for the debugger, as detailed in the next Section.

```
Problems  Tasks  Console  Properties
CDT Build Console [Hello World]
15:52:13 **** Incremental Build of configuration FT930_Release for project Hello World ****
make all
'Building file: ../Sources/main.c'
'Invoking: FT9xx GCC Compiler'
ft32-elf-gcc -D__FT930__ -I"C:/Program Files/Bridgetek/FT9xx Toolchain/Toolchain/hardware/include" -Os -Wall -c -fmessage-leng
'Finished building: ../Sources/main.c'
' '
'Building target: Hello World.elf'
'Invoking: FT9xx GCC Linker'
ft32-elf-gcc -L"C:/Program Files/Bridgetek/FT9xx Toolchain/Toolchain/hardware/lib/Release" -Wl,--gc-sections -Wl,--entry=_star
'Finished building target: Hello World.elf'
' '
'Invoking: FT9xx Flash File Generator'
ft32-elf-objcopy --output-target binary "Hello World.elf"  "Hello World.bin"
'Finished building: Hello World.bin'
' '
```

Figure 29 Build Status

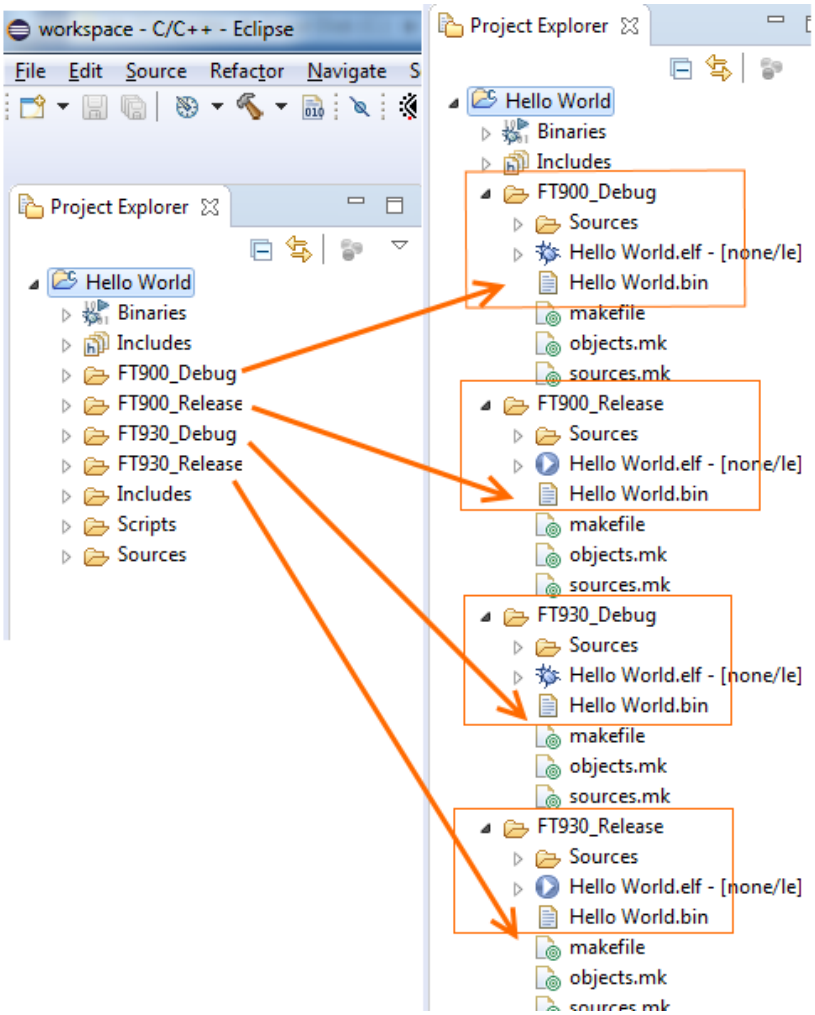


Figure 30 List of Files after building (if all 4 configurations were selected)

For syntax highlighting to work correctly as configurations are switched, the C/C++ Indexer must be configured to "work with the active build configuration". Refer to section 6.3.3 for more details on how to do this.

3.3 Programming the binary file into the chip

There are two ways to program a binary image into the chip.

The debugger may be used to program the binary image into flash or program memory prior to the start of a debug session. Alternatively, if debugging is not required, the FT9XX programmer utility may be used to program the binary image to flash. Unlike the debugger sessions, the programmer utility supports programming to flash memory only.

The programmer utility and Eclipse debugger both use the 1-wire interface to communicate with the FT9xx. Therefore, the utility and debugger shall not be used at the same time.

3.3.1 Eclipse Plugin

The FT9XX toolchain components, including the FT9XX Programmer, have been fully integrated to the Eclipse IDE to allow seamless debugging experience.

To program the compiled binary file into the chip, do the following:

1. On the Menu bar, select **Run → Run Configurations...**
2. In the Run Configurations window, expand the launch configuration type "FT9XX Application Run" and select the default instance "FT9XX RUN".
3. Click on the 'Run' button to start the download. This will internally launch FT9XX Programmer application. The Console window will show the progress of the download.
4. For succeeding run sessions, select **Run → Run Last Launched**.

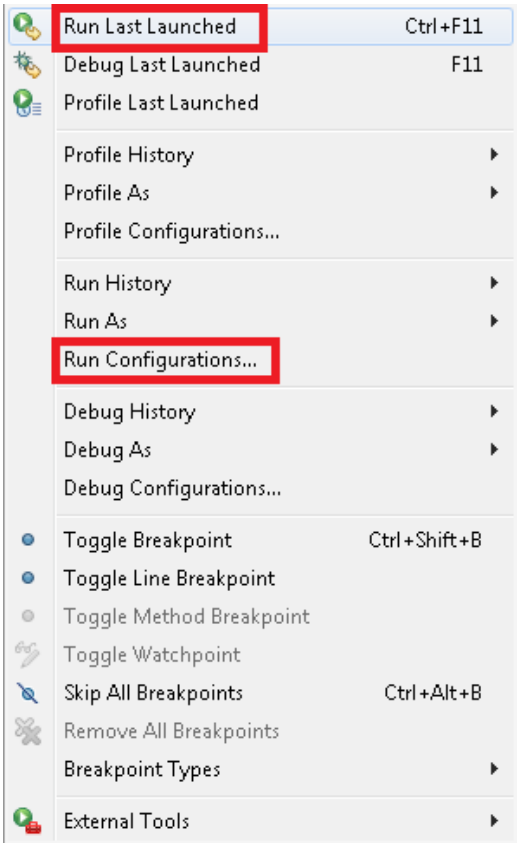


Figure 31 Run menus - Run Configurations and Run Last Launched

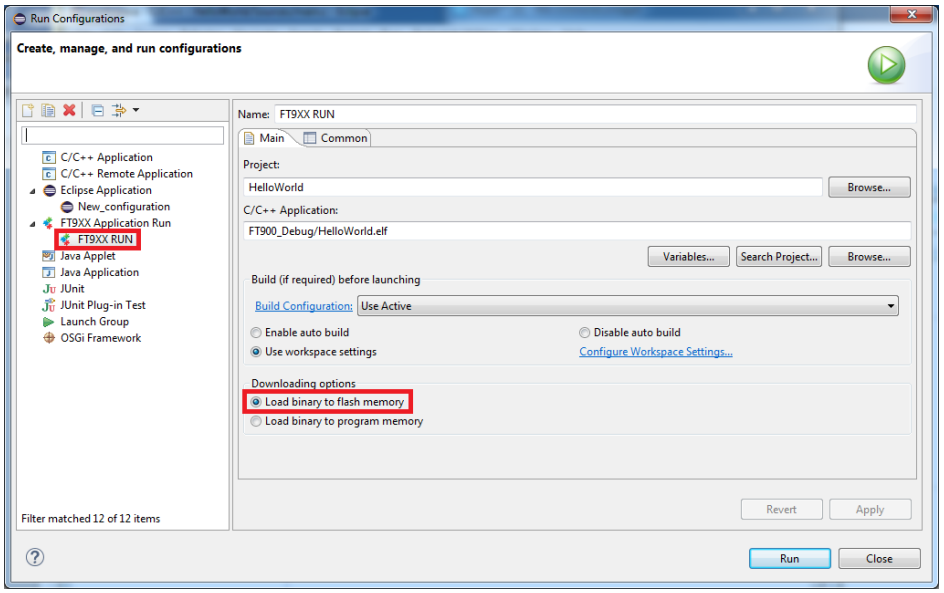


Figure 32 Run Configuration window

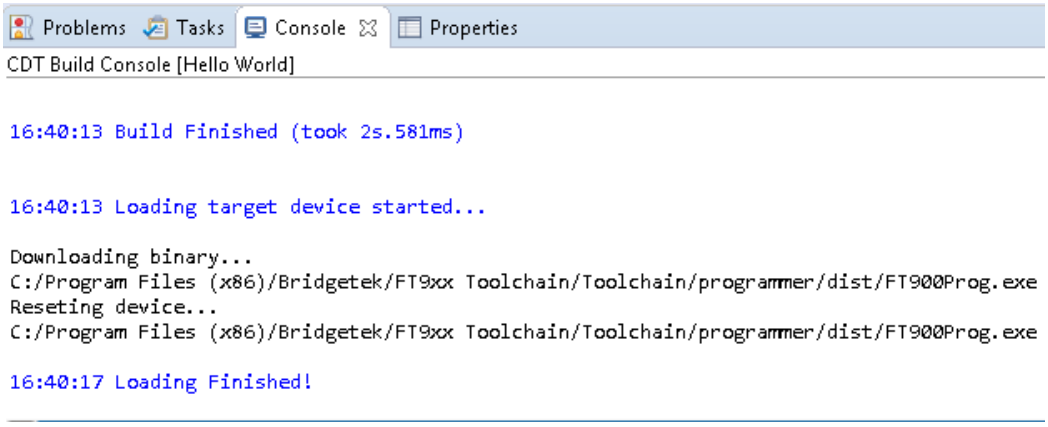


Figure 33 Console window after selecting launch configuration and clicking Run

Alternatively, the FT9XX Programmer can be accessed manually – either the GUI version or the command line version.

3.3.2 GUI Version

To run it, double click on the icon "FT9XX Programming Utility" created on your desktop, if selected during install, otherwise it can be found in:

C:\Program Files (x86)\Bridgetek\FT9xx Toolchain\Toolchain\programmer\dist

Figure 34 FT9XX Programming Utility Icon

You can also open the programming utility from Eclipse by selecting it in the Bridgetek Utilities menu or the toolbar icon as highlighted in Figure 35:

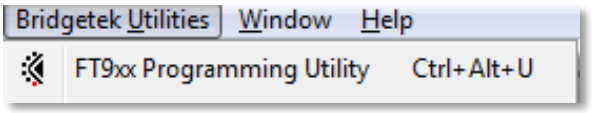


Figure 35 Bridgetek Utilities Menu

After the splash message the following screen will appear.

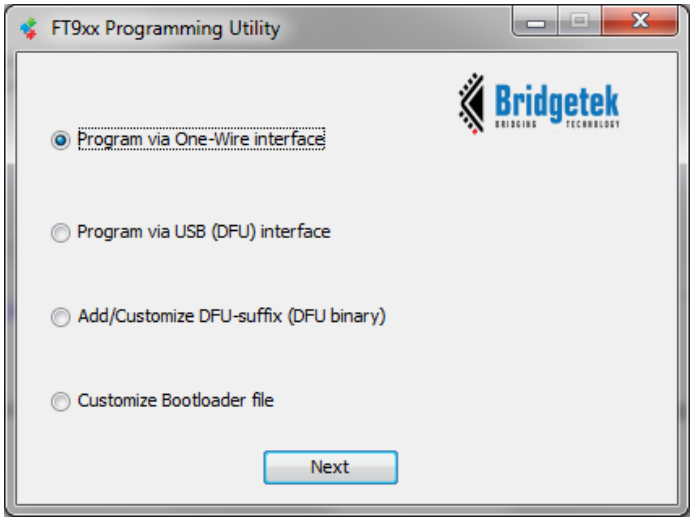


Figure 36 FT9XX Programmer - Work with One-Wire

Only the option 'Program via One-wire interface' in this screen is covered in this section. For information on the remaining options, please refer to the programmer utility help.

Select the "Program via One-wire interface" option and click Next. The next screen shows a list of supported devices that you might wish to program.

When a valid FT9xx and Programmer module are detected, the information will be displayed in the list. Select the device you wish to program and click Next to launch the programmer window.

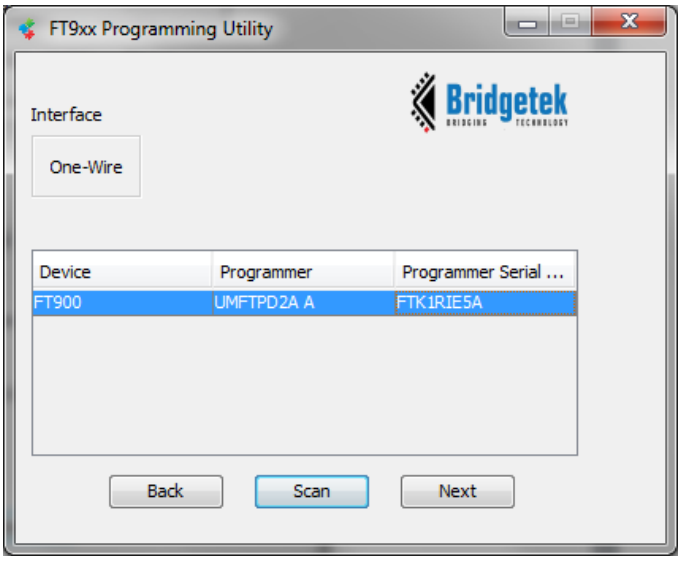


Figure 37 FT9XX Programmer - Device Selection

In the programmer window, leave everything as default. Specify the location of the binary file and click Start. If the Verify check box is selected, an icon will show up next to the status bar to indicate whether the flash memory has been properly programed.

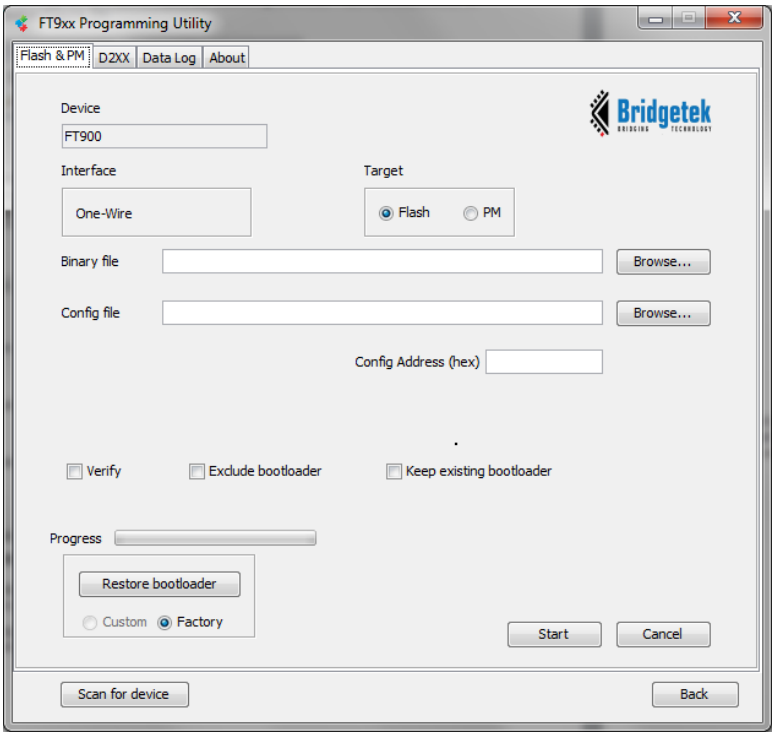


Figure 38 FT9XX Programmer – Flash and PM Screen

More information on the utility can be found in the 'About' tab, then click on Help.

3.3.3 Command Line Version

FT900Prog.exe is available to run at a command prompt. Enter FT900Prog.exe to see the options available. See section 6.1.2 for more details.

This can also be run within Eclipse as an External Tool. See Figure 39 for settings found in Run → External Tools → External Tools Configurations. The argument string is:

```
-f "${project_loc}\${config_name:${project_name}}\${project_name}.bin" -O -v
```

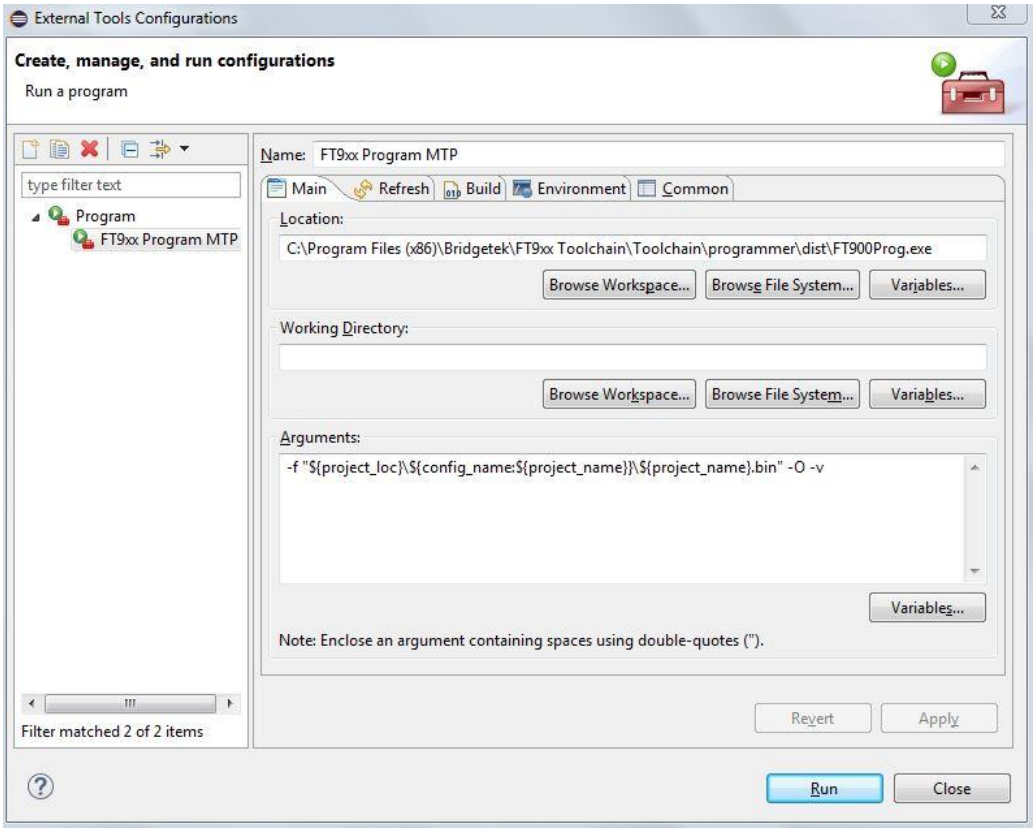


Figure 39 FT9XX Programmer in Eclipse

3.4 "Hello World" in action, and more…

The "Hello World" example above will send a message to a serial terminal via the FT9XX UART0 port. Open a terminal on your computer, for example Tera Term or HyperTerminal. Apply the following settings:

- Baud Rate: 19200
- Parity Bit: None
- Data Bit: 8
- Stop Bit: 1
- Flow Control: None

Now when you reset the MCU, the message will be printed to the terminal.

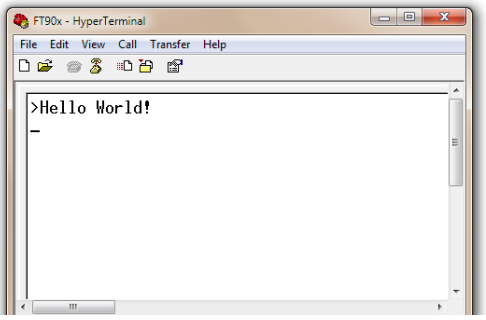


Figure 40 Hello World

Congratulations! You have just completed your first project for FT9XX. The FT9xx toolchain comes with plenty of examples, which demonstrate a variety of features. If you have selected to install them in the Toolchain Installation Wizard, by default they can be found in:

"My Documents\Bridgetek\FT9xx*version*\Examples"

The Eclipse project has already been setup for these examples, as suggested by the presence of two files - ".cproject" and ".project". Instead of creating a new project, you can simply import these projects into the workspace. To do this:

1. On the Menu bar, choose "File → Import"
2. In the Import window, choose "General → Existing Projects into Workspace" and click "Next".
3. In the next window, set the root directory to "My Documents\Bridgetek\FT9xx*version*\Examples". The projects will be detected by Eclipse.
4. Select which projects you wish to import and click Finish to complete the importing process. This is an example of how Eclipse would look like with the sample applications. Refer to AN_360 for more details about these applications.

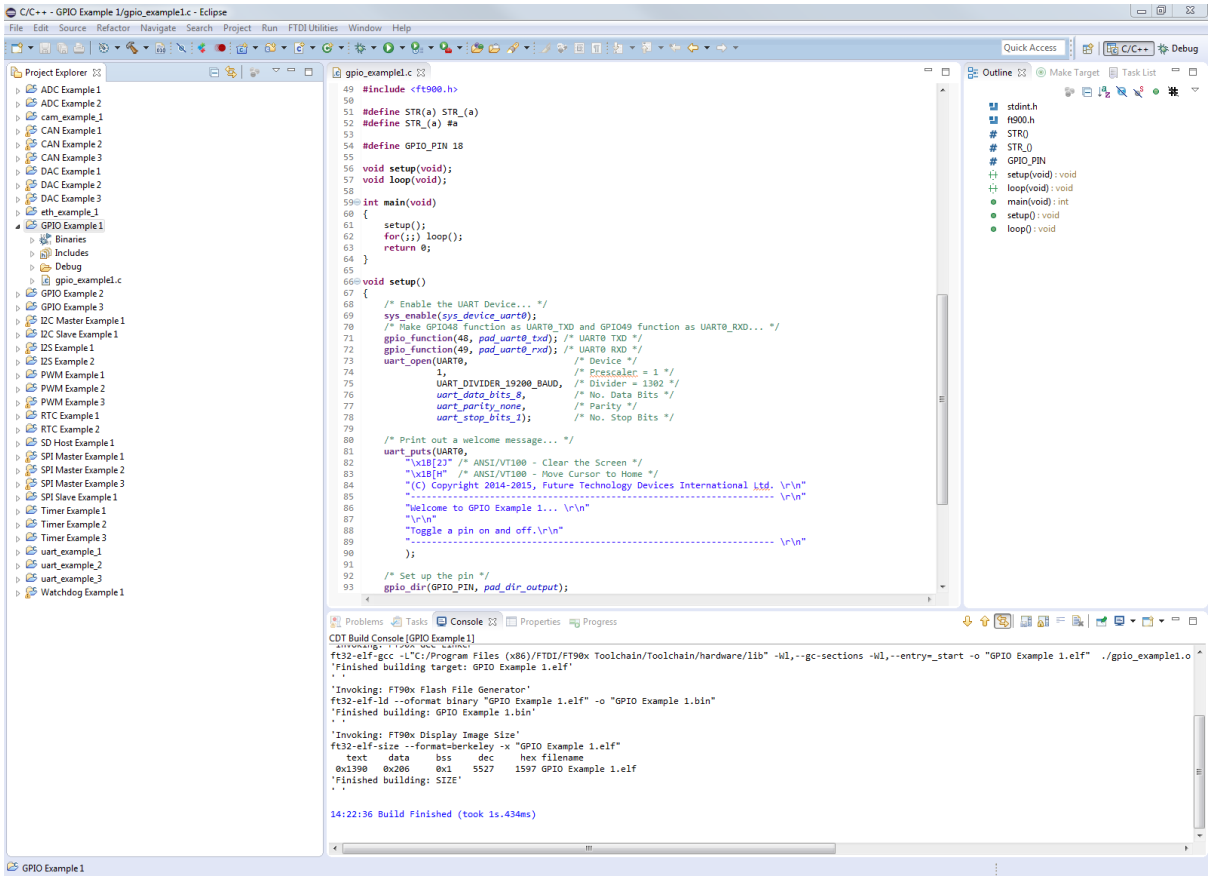


Figure 41 FT9XX Examples

4 Setting up Eclipse for Debugging

Eclipse comes with an intuitive GUI for debugging applications. To enable this feature, Eclipse requires additional information about our debugger. The steps are presented below.

4.1 Build the application using the Debug configuration

The application should be built using the Debug configuration so that the debug information is available. It is the default build configuration but can be verified in the Project menu.

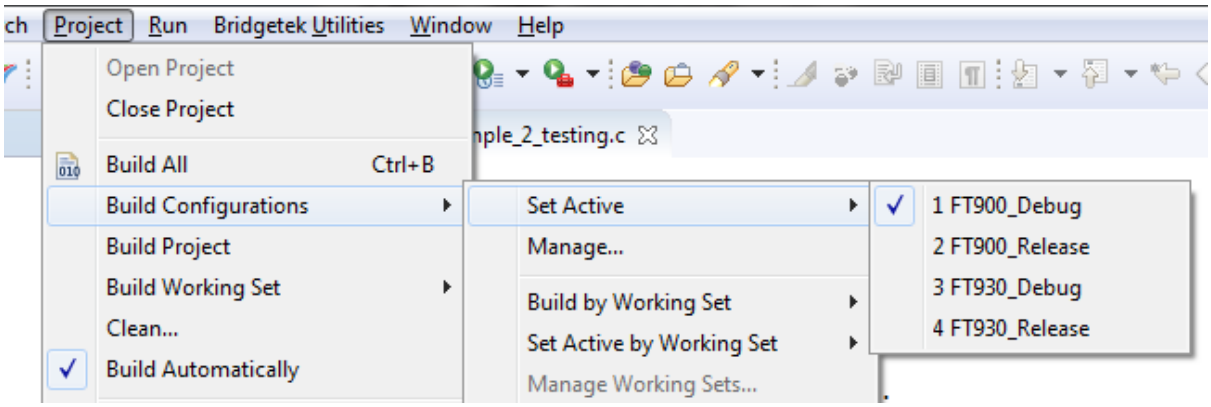


Figure 42 Build Configuration

Please note for FT93X: As of toolchain v2.3.0 it is recommended to disable the `-mcompress` option when using GDB as single stepping does not work properly with `-mcompress`. The option can be disabled in the project settings. See section 6.3.2.1 for more details.

4.2 Starting a debug session

The FT9XX toolchain components, including the FT9XX Programmer and FT9XX GDB Bridge, have been fully integrated to the Eclipse IDE to allow seamless debugging experience.

To program the compiled binary file into the chip and start a debugging session, do the following:

1. On the Menu bar, select **Run → Debug Configurations...**
2. In the Debug Configurations window, expand the launch configuration type "FT9XX Application Debug" and select the default instance "FT9XX DEBUG". This default instance will setup the location of the ft32-elf-gdb.exe, connection type to "TCP", host name to "localhost", port number to "9998" as well as the project name and elf name.

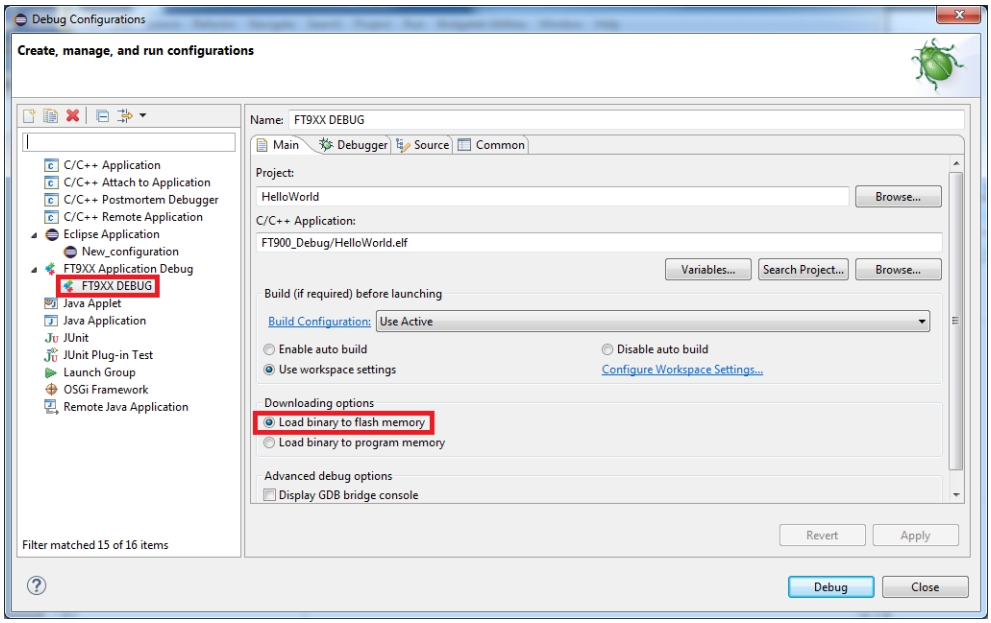


Figure 43 Debug Configuration window

3. Click on the 'Debug' button to start the downloading and debugging. This will internally launch the FT9XX Programmer application to program the binary and then launch the ft32-elf-gdb.exe and FT9XX GDB Bridge to start the debugging session. The Console window will show the progress of the download and debugging.
4. For succeeding debugging sessions, select **Run → Debug Last Launched**.

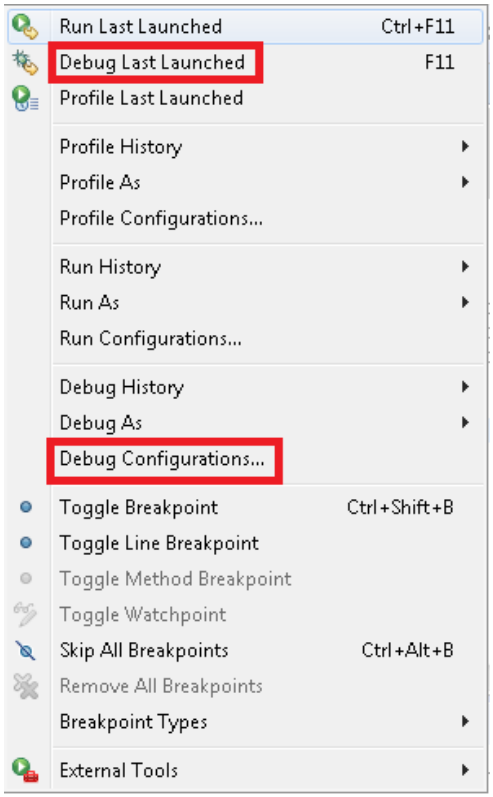


Figure 44 Debug Configurations and Debug Last Launched

```
Problems  Tasks  Console  Properties  Debug
CDT Build Console [Hello World]
17:42:33 Build Finished (took 2s.581ms)


17:42:33 Loading target device started...

Downloading binary...
C:/Program Files (x86)/Bridgetek/FT9xx Toolchain/Toolchain/programmer/dist/FT900Prog.exe --loadflash
Reseting device...
C:/Program Files (x86)/Bridgetek/FT9xx Toolchain/Toolchain/programmer/dist/FT900Prog.exe --chipReset

17:42:38 Loading Finished!


17:42:38 Running GDB started...

Launching Debug Server (GDB Bridge)...
python.exe "C:/Program Files (x86)/Bridgetek/FT9xx Toolchain/Toolchain/utilities/gdb_bridge.py" live
Launching Debug Client (ft32-elf-gdb)...
C:/Program Files (x86)/Bridgetek/FT9xx Toolchain/Toolchain/tools/bin/ft32-elf-gdb.exe
```

Figure 45 Console window after selecting launch configuration and clicking Debug

4.3 Debugging the application in Eclipse

1. Start the debug session as stated in the previous section.
2. The Debug perspective will be opened. The execution will stop at the first line in main(), as shown below. Various debug commands (step into/over, resume, halt, stop, etc.) can now be accessed from the toolbar via buttons. Function variables, setting breakpoints and viewing physical memory in the memory tab, along with some other debug features are also available now.

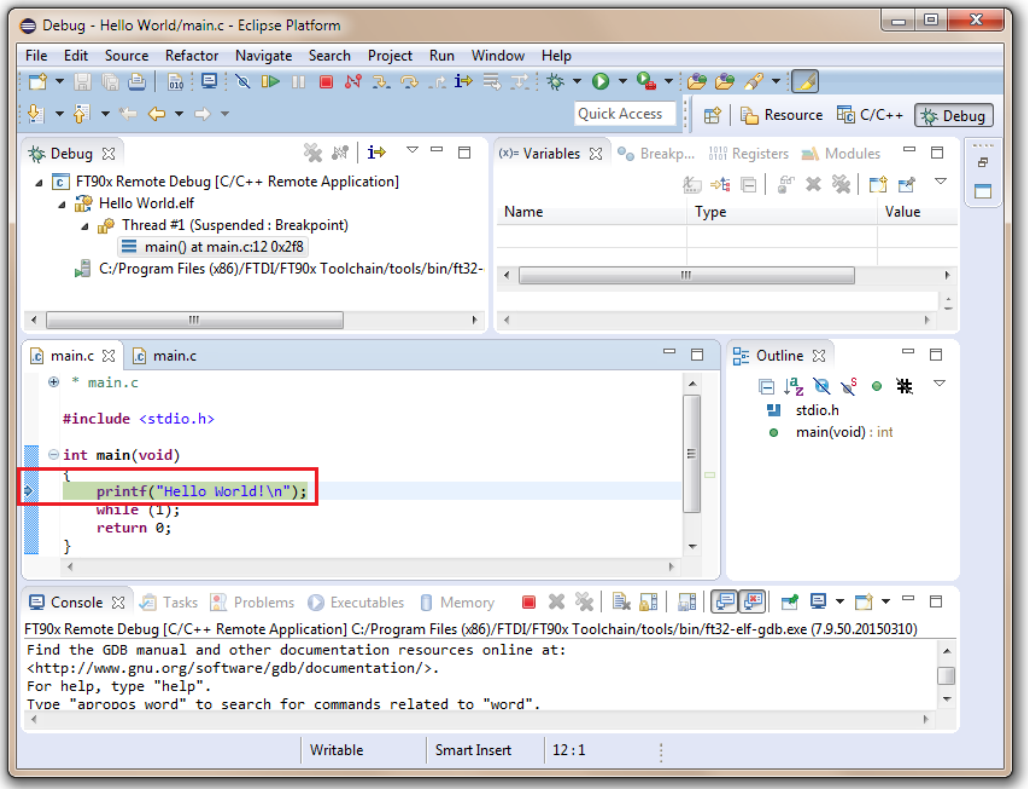


Figure 46 Eclipse Debug Environment

Note: If there is an error message about missing source file as below, locate the source file that contains the main() function using the "Locate file…" button.

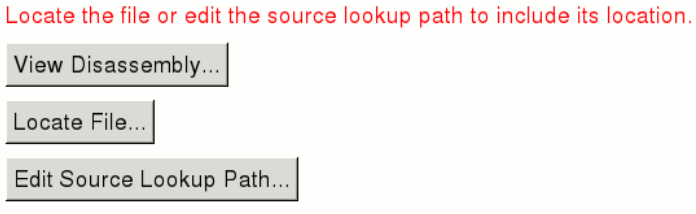


Figure 47 Eclipse Missing Source File

4.3.1 Watch variables in Eclipse Debug Perspective

If the watch variables fail to update or display incorrect values, check that the following flags exist for the debug build (they are present by default in all projects created with Bridgetek Eclipse plugin)

-fvar-tracking -fvar tracking-assignments

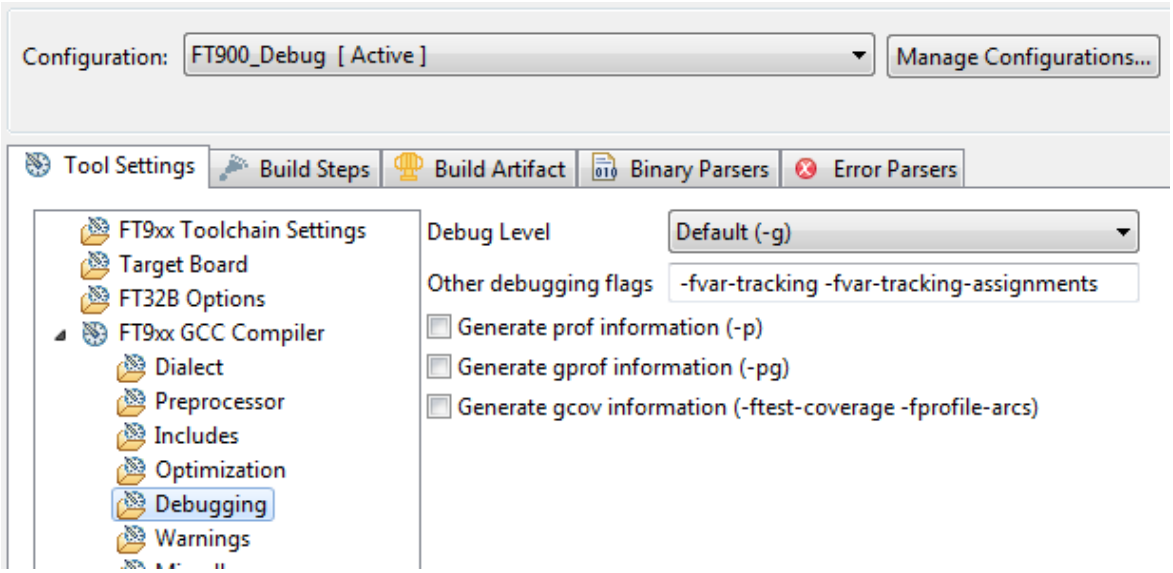


Figure 48 Debug flags

4.3.2 Og Compiler Option when debugging

When compiling a project with no optimization (or –O0) some useful debugging information may not be generated at all, leading to possible unexpected results while debugging. To avoid this, it is recommended to turn on –Og option when no other optimization flags are used. The Bridgetek Eclipse plugin does this automatically.

Note that if multiple optimization options are used, only the last option will be effective.

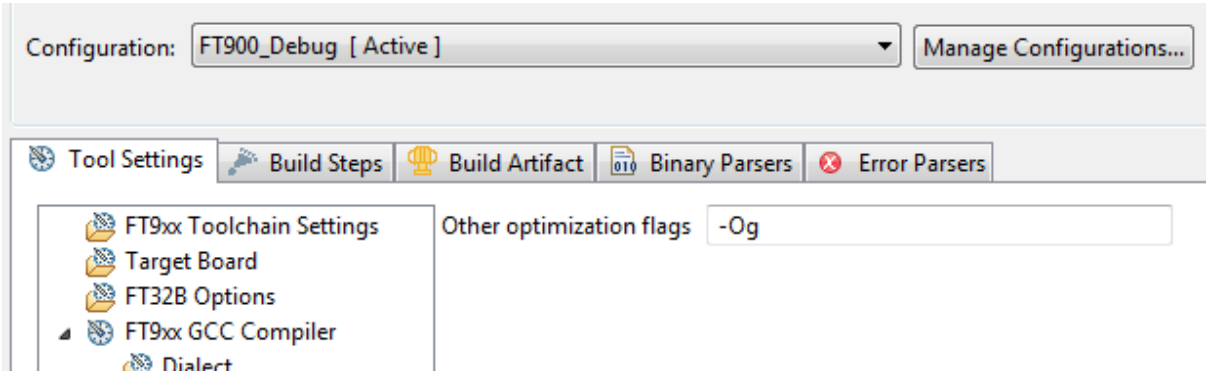


Figure 49 Og compiler optimization option

More information can be found in the GCC documentation - https://gcc.gnu.org/onlinedocs/gcc/Debugging-Options.html and https://gcc.gnu.org/onlinedocs/gcc/Optimize-Options.html

4.4 Eclipse features supported by ft32-elf-gdb

- The features of Eclipse debug perspective, supported through ft32-elf-gdb, are:Breakpoint creation.
- Single stepping/stepping in/stepping out of functions
- Watch variables
- Assembly instruction stepping
- Memory View

5 Bridgetek Projects

Besides the empty project used as the example in Section 3, there are several project types specific to Bridgetek. They can be found under "Others" in the project type selection window. Currently, there are three project types:

- D2XX Project
- Data Log (DLOG) Project
- FreeRTOS Project

For more details about these project types, refer to "AN_360 FT9XX Example Applications", which is included in the toolchain installation.

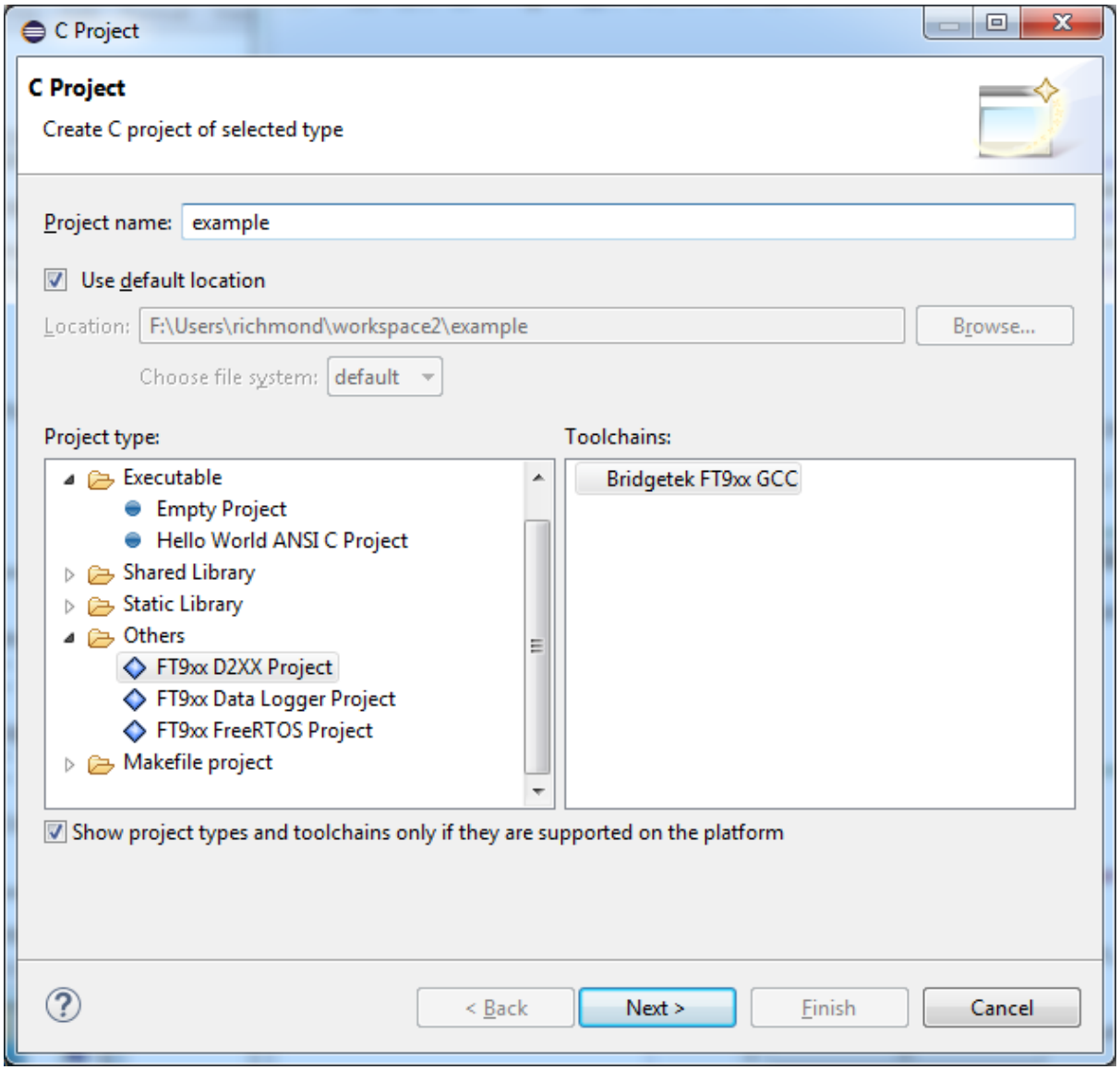


Figure 50 Bridgetek Project Types

The procedure to create a new project is similar to the empty project. When the wizard completes, a template source file will be generated. The template generated for the D2XX project is given below -

main.c main.c

```
127         loop();
128
129
130         /* Event handling */
131         if (D2XXTEST__DfuDetach)
132         {
133             delayms(100);
134             /* DFU detach request had come. Exit D2XX */
135             D2XX_Exit();
136
137             /* Take the system to DFU Mode. Provide timeout in ms to
138              * wait for re-enumeration with the host
139              * */
140             STARTUP_DFU(0);
141             break;
142         }
143
144         /* Suspend mode handling */
145         if (D2XXTEST__Suspend)
146         {
147
148             wkupSource = 0;
149             dbg("Entering Suspend Mode at Master \r\n");
150             delayms(100);
151 #ifdef GPIO_REMOTE_WAKEUP
152             SetRemoteWakeup = 0;
153             if (RemoteWakeupEnable)
154             {
155                 dbg("Configuring GPIO pin to wakeup \r\n");
156                     #if 1
157                         /* Set up the pin */
158                         gpio_dir(GPIO_PIN, pad_dir_input);
159                         gpio_pull(GPIO_PIN, pad_pull_pullup);
160
161                         /* Attach an interrupt */
162                         gpio_interrupt_enable(GPIO_PIN, gpio_int_edge_falling);
163                         interrupt_attach(interrupt_gpio, (uint8_t)interrupt_gpio, ISR_gpio);
164                         dbg("D2XXTEST: GPIO pin setup for interrupt\r\n");
165                     #endif
166             }
167 #endif
```

Figure 51 D2XX Project Template

The template project can be compiled as it is but additional code is needed to customize it according to the user's need.

After selecting the project template, the wizard also allows selection of add-on third-party libraries that have been ported to work on FT9xx (see Figure 52). The source for the libraries are located in <Installation directory>\Toolchain\hardware\3rdparty. Currently there are three third-party libraries supported.

- Tinyprintf: A tiny/lightweight general purpose printf function that could be used to replace the GNU library printf function.
- FatFs (based on version 0.12b): A FAT/exFAT filesystem module. FatFs accesses the storage devices via a simple media access interface which the FT9xx application should implement.
- lwIP (based on version 2.0.3): A lightweight TCP/IP stack for embedded device.

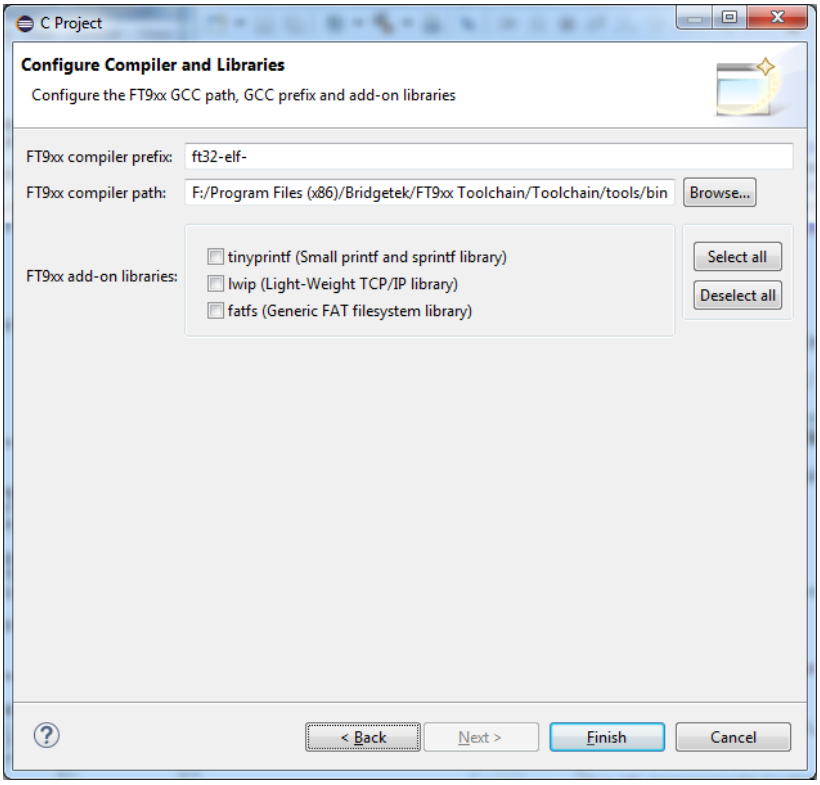


Figure 52 Add-on Libraries

6 Advanced Topics

6.1 Running the Toolchain from the command prompt

6.1.1 Compiling the sample applications using a Makefile

The FT9XX GNU toolchain can be used to compile source code from a command prompt in the same way the official GNU Toolchain is used, often with the help of a Makefile or a batch file.

The sample applications are available in "C:\Users\<User name>\Documents\Bridgetek\FT9xx\<Tool chain version>\Examples\", \ if you have installed them using the installation wizard.

NOTE: makefiles are not included with the toolchain installer.

6.1.2 Programming a binary image into the chip

The programmer can be found in the folder "programmer\dist" in the program installation directory (C:\Program Files (x86)\Bridgetek\FT9xx Toolchain). The command line programmer is FT900Prog.exe. The Toolchain is provided with a default bootloader. The bootloader is located at the top 4 KB of the flash memory (address 0x3F000 to 0x3FFFF). At boot, the FT9XX resets and executes instruction at 0x00000, jumping into the bootloader. The bootloader then performs the initializations needed and jumps to location 0x8c, which is the start of the user program. The bootloader is also needed to support debugging with the FT9XX port of GDB.

1. Run the tool FT900Prog.exe without any arguments, the options and usage will be printed. They will also be printed if the specified options are not valid. The most common usage is programming a binary file through the one-wire interface with the supplied bootloader. To do this, the command is:

   FT900Prog.exe –f <.bin file with path if needed> -O
   in which the options are:

   -f: programming the binary file into the **f**lash. The path to the binary file must follow.
   -O: using the **o**ne-wire interface.

   If you want to **v**erify the content of the flash memory after programming, specify "-v" in the command:

   FT900Prog.exe –f <.bin file with path if needed> -O –v

2. If the bootloader is not required, option "-x" can be specified, in which case the program will start executing from address zero and the command is:

   FT900Prog.exe –f <.bin file with path if needed> -O –x

   The supports for GDB debugging will not be available however.

6.1.3 Debugging the sample applications with ft32-elf-gdb

1. The applications must to be compiled with –g option (i.e. ft32-elf-gcc –g …). An .elf file will be created which includes the debug information, for example GPIO/gpio_example1.elf. Note that this file is not used for programming the chip.

   Note: If the output file name for the linker is not specified in the Makefile (i.e. option –o is missing), a.out will be created instead of an .elf file. They are the same and these steps can be applied to a.out as well.

2. Flash the .bin file into the chip. Refer to section 5.1.2 above.

3. Open a command line window, run:

   "python <Installation directory>\Toolchain\utilities\gdb_bridge.py live"

   Note: An alternative is to double click on the shortcut "GDB Bridge" created after the installation.

   The correct response should be:

Figure 53 FT9XX Debugging Status

   Note 1: If there is an error message about permission being denied, the command line window may need to be opened with administrator rights by right-clicking and selecting 'Run as administrator'.

   Note 2: It is also possible to run the GDB Bridge using the shortcut created after the installation.

   Note 3: If the path to gdb_bridge.py contains spaces, enclose it with double quotes ("").

4. Open another command line window, go to the folder that includes the .elf file, run "ft32-elf-gdb <.elf file>", for example "ft32-elf-gdb gpio_example1.elf".

5. After ft32-elf-gdb starts, type in "target remote localhost:9998" to establish a connection to the MCU.

6. Use standard GDB commands to debug the program. Note that the command to start execution should be "continue", not "run".

6.2 Installing Eclipse and the FT9XX plugin manually

When running the installer, it is possible to choose not to install Eclipse as part of the installation. This might be useful if the user have already installed Eclipse for other purposes. This section details how to set it up for use with the FT9XX.

6.2.1 Eclipse Installation

1. Go to Eclipse website, download "Eclipse IDE for C/C++ Developers". At the time of this writing, Eclipse Mars is the latest release and is the recommended version.

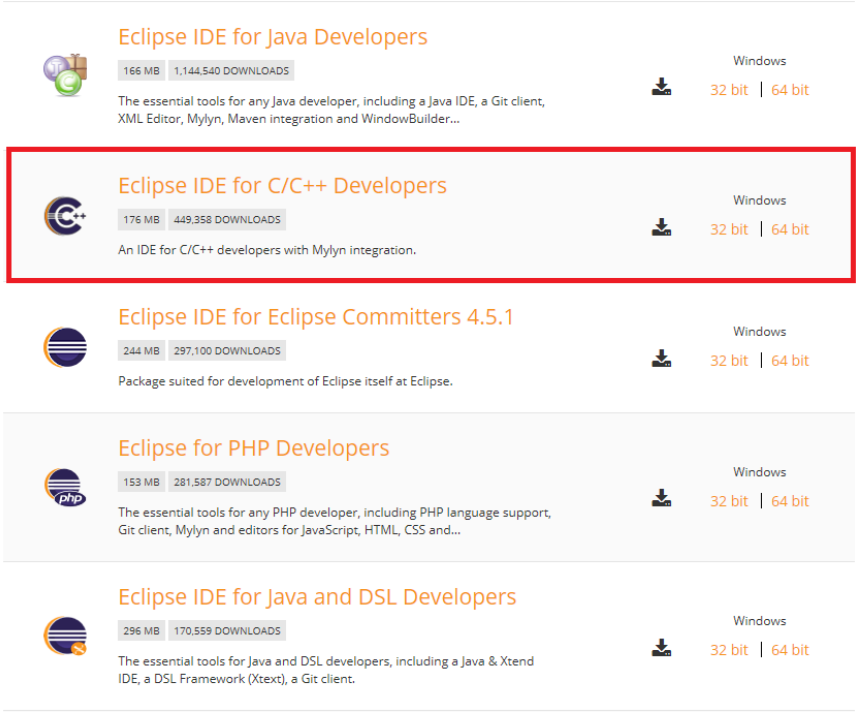


Figure 54 Eclipse Versions

2. When Eclipse is run for the first time, it will ask for the workspace location.

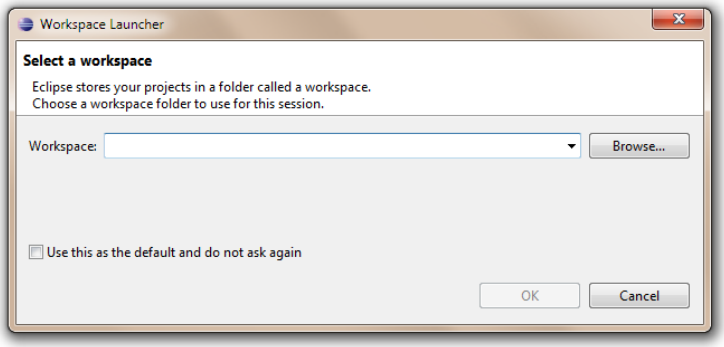


Figure 55 Eclipse Workspace Location

A workspace is a directory on the hard drive where Eclipse stores the projects defined to it. More specifically, a workspace is a logical collection of projects. When you specify this directory name to Eclipse, Eclipse will create some files within this directory to manage the projects. The projects controlled by this workspace may or may not reside in this directory. Specify a directory name and click OK.

Note: To run Eclipse, it is required to download and install the Java Run Time Environment (JRE) or Java Developer Kit (JDK). Eclipse should display a warning if this is not installed. Oracle provides these tools for free.

6.2.2 FT9XX Eclipse Plugin Installation

To assist with completing the configuration of Eclipse for FT9XX coding an extra plug-in is provided as part of the download. To install the plug-in, the following steps are required:

1. From the Eclipse toolbar select Help -> Install New Software which will pop up the window as below.

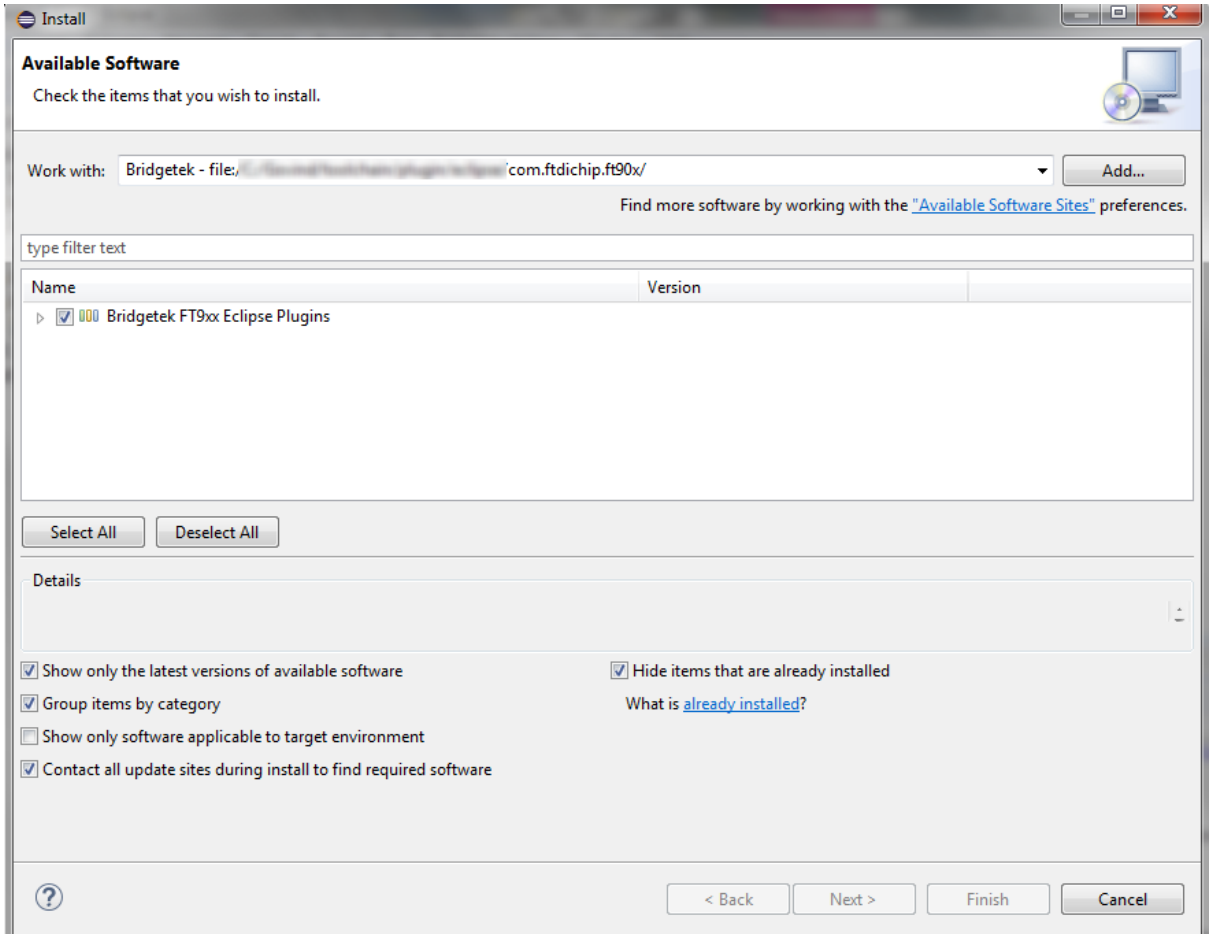


Figure 56 Eclipse Plugin Setup Wizard

2. Select the ADD button, and browse to the LOCAL location of the folder 'com.ftdichip.ft90x' which can be found in "Toolchain\eclipse plugins" in the toolchain installation directory.

3. Press "SELECT ALL" followed by NEXT to install the plugin

4. Close the window when complete.

6.3 Common project settings in Eclipse

6.3.1 Include paths

Eclipse uses its built-in indexer to resolve dependencies between files. In order for the indexer to work correctly, paths that contain the header files in the project need to be added as follows:

1. Right-click on the project and select **Properties**

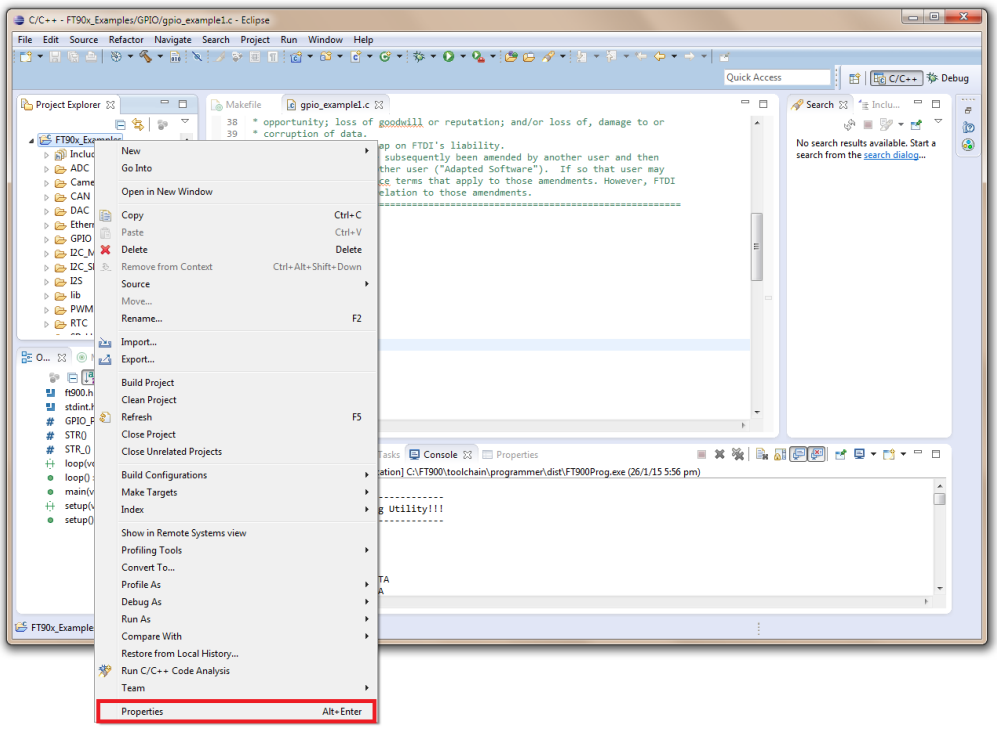


Figure 57 Eclipse Project Properties

2. In the Properties window, **select C/C++ General > Paths and Symbols**

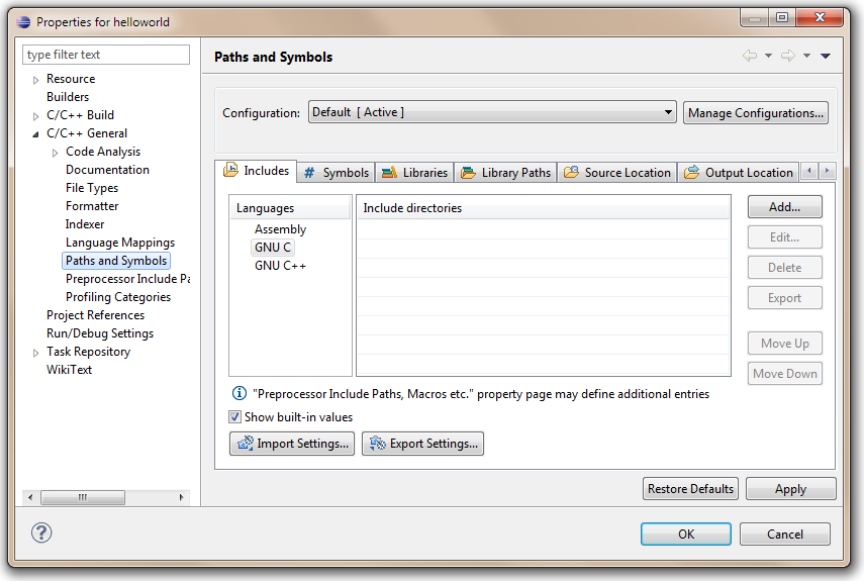


Figure 58 Eclipse Paths and Symbols

3. Under the **Includes** tab, choose **"GNU C"** under **Languages**, then click **"Add..."** on the right side of the window

4. In the **"Add directory path"** window, specify the path to the folder that contains the header files. If the same path is used for some C++ files, check the box **"Add to all languages"**, then click **OK**.

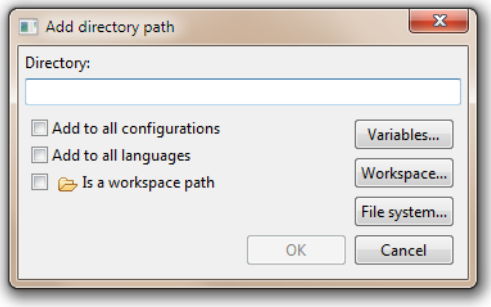


Figure 59 Eclipse Add Directory Path

Note: The paths should be added one at a time. The use of semicolon is not supported.

6.3.2 Toolchain settings

The FT9XX toolchain supports most GNU toolchain options. To specify an option that is not included by default, for example to create a map file, do it as follows:

1. Right click on the project and select Properties

2. In the Properties window, select C/C++ Build > Settings. The toolchain settings can be adjusted in the Settings window.

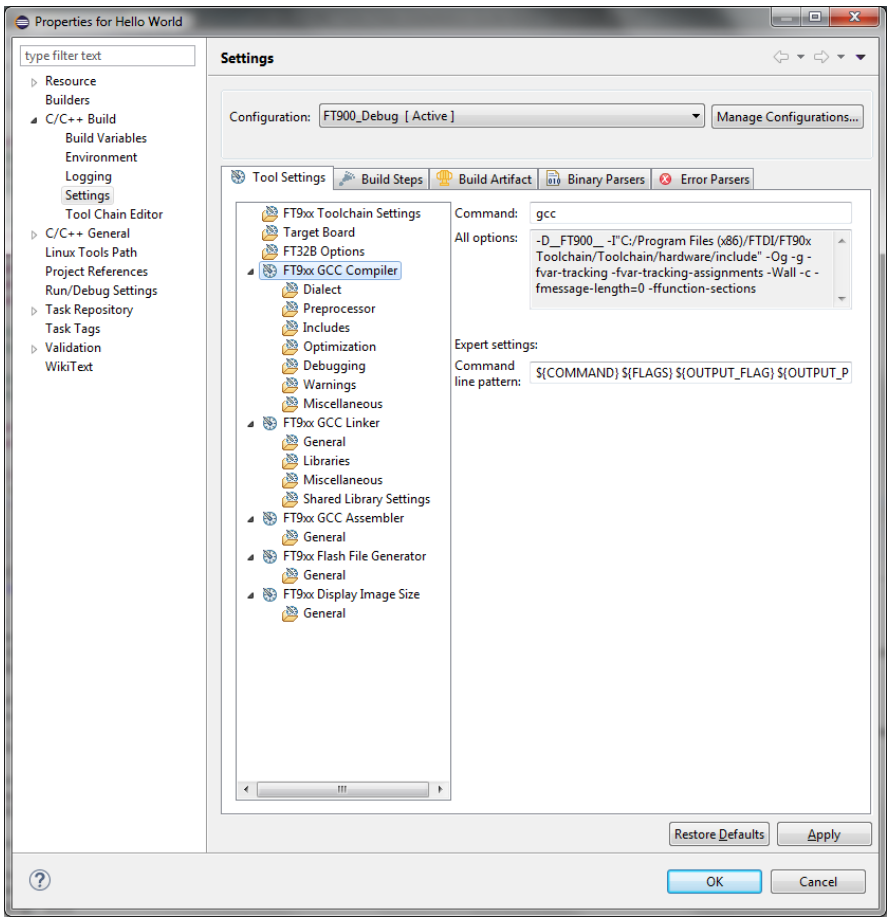


Figure 60 Eclipse Toolchain Settings

6.3.2.1 FT32B options (only for FT93x)

The FT93X target has two special compiler options `-mft32b` and `-mcompress`. `-mft32b` enables the FT32B instruction set and `-mcompress` enables code compression, which can typically result in a code size reduction of about 20 – 30%. These options can be updated in the toolchain settings as shown in **Figure 61**. Note that this option is only available in the FT930_* configurations.

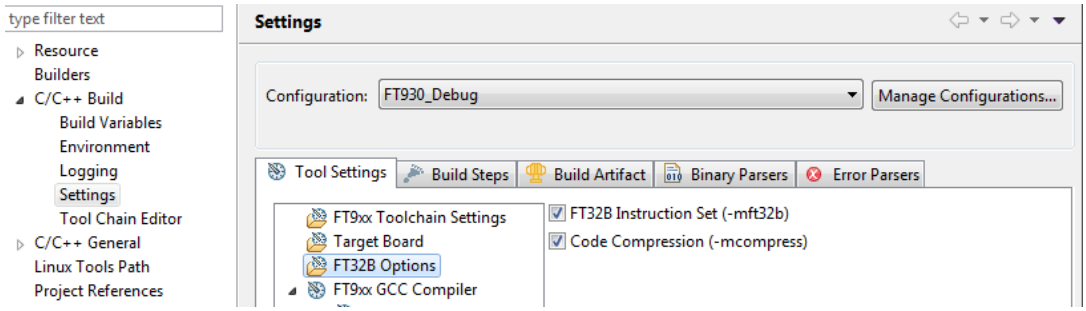


Figure 61 FT32B options (for FT93X)

6.3.3 C/C++ Indexer Settings

For Eclipse syntax highlighting to work correctly as you switch configurations, the Indexer has to be configured to work with the *active build configuration* as shown in Figure 64. This is a workspace specific setting and can be accessed in Eclipse via `Window | Preferences | C/C++ | Indexer`

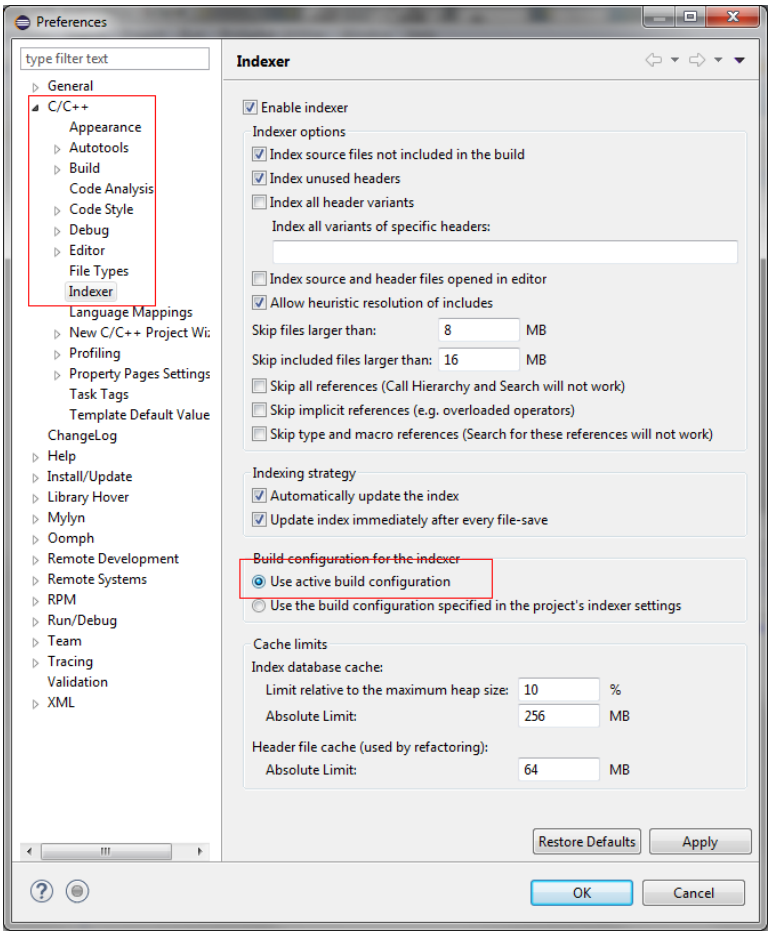


Figure 62 Configure Eclipse indexer to use the active build configuration

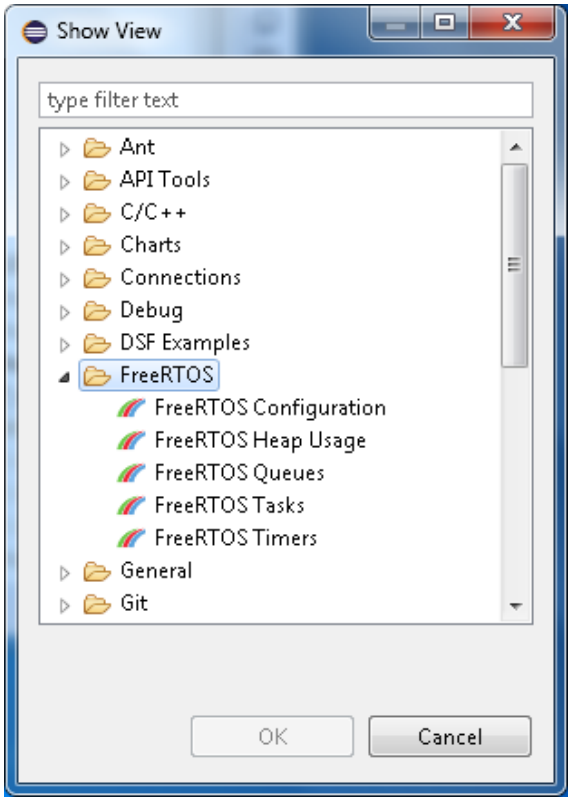
6.3.4 C++ Compilation

C++ compilation is supported; however there is no support for the standard C++ libraries or STL libraries. Some language features are also not supported, e.g. new and delete operators. Include files of FT9xx libraries are C++ safe when wrapped in extern "C" {} scope in order to be excluded from the C++ namespace. Constructors and destructors of singleton classes are not supported and will require the programmer to supply his own crt0.s file. Support for global and static objects shall be added in a future version.

6.4 FreeRTOS Kernel-Aware Debugging

FT9XX supports the popular real-time operating system, FreeRTOS. FreeRTOS allows creation of tasks, queues, events, semaphores, mutex and timers for inter-task communication and synchronization. To help debug these kernel objects, the FT9XX Eclipse plugin has been updated to provide custom views to list the FreeRTOS kernel objects.

These views can be opened via the menu **Window → Show View → Others → FreeRTOS**.



6.4.1 FreeRTOS views

The views will show the kernel objects that have been created at the point where the application is suspended, that is, when a breakpoint has been triggered.

These views allow the user to do the following:

- save the table of values to a CSV file
- clear the table
- refresh the table
- sort the table by the selected column

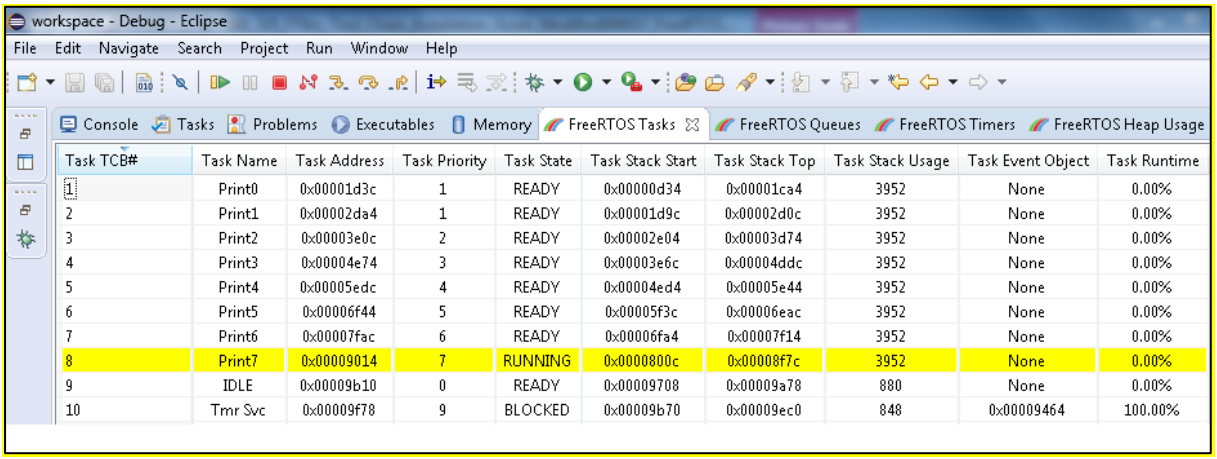
A tooltip description is also provided for each column of the views for a description of the column values.

For a demonstration of these views, refer to "FreeRTOS Example 4" application.

6.4.2 FreeRTOS Tasks view

This view displays the tasks that have been created. Each task has the following properties: task control block (TCB#), name, address, priority, state, start of stack, top of stack, total stack usage, event object and runtime percentage.

Note that deleted tasks will appear in this view with state 'DELETED'. These tasks will disappear in the view only when the idle task has freed up the corresponding memory allocation.



Task TCB#	Task Name	Task Address	Task Priority	Task State	Task Stack Start	Task Stack Top	Task Stack Usage	Task Event Object	Task Runtime
1	Print0	0x00001d3c	1	READY	0x00000d34	0x00001ca4	3952	None	0.00%
2	Print1	0x00002da4	1	READY	0x00001d9c	0x00002d0c	3952	None	0.00%
3	Print2	0x00003e0c	2	READY	0x00002e04	0x00003d74	3952	None	0.00%
4	Print3	0x00004e74	3	READY	0x00003e6c	0x00004ddc	3952	None	0.00%
5	Print4	0x00005edc	4	READY	0x00004ed4	0x00005e44	3952	None	0.00%
6	Print5	0x00006f44	5	READY	0x00005f3c	0x00006eac	3952	None	0.00%
7	Print6	0x00007fac	6	READY	0x00006fa4	0x00007f14	3952	None	0.00%
8	Print7	0x00009014	7	RUNNING	0x0000800c	0x00008f7c	3952	None	0.00%
9	IDLE	0x00009b10	0	READY	0x00009708	0x00009a78	880	None	0.00%
10	Tmr Svc	0x00009f78	9	BLOCKED	0x00009b70	0x00009ec0	848	0x00009464	100.00%

Figure 63 FreeRTOS Tasks view

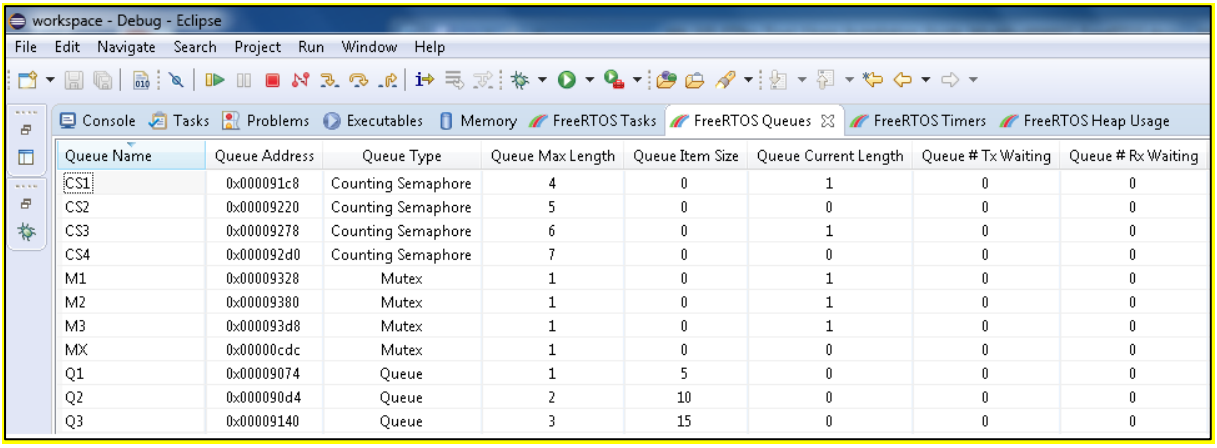
Some of these properties are dependent on a configuration in "FreeRTOSConfig.h". If these macros are set to 0, "Unknown" value will be displayed. Refer to the table below for these dependencies.

Table 1 FreeRTOS Tasks macro dependencies

FreeRTOS Task Property	FreeRTOS Configuration macro
Task TCB#	configUSE_TRACE_FACILITY
Task Runtime	configGENERATE_RUN_TIME_STATS

6.4.3 FreeRTOS Queues view

This view displays the queues that have been registered. Each registered queue has the following properties: name, address, type, maximum length, item size, current length, #tx waiting and #rx waiting.



Queue Name	Queue Address	Queue Type	Queue Max Length	Queue Item Size	Queue Current Length	Queue # Tx Waiting	Queue # Rx Waiting
CS1	0x000091c8	Counting Semaphore	4	0	1	0	0
CS2	0x00009220	Counting Semaphore	5	0	0	0	0
CS3	0x00009278	Counting Semaphore	6	0	1	0	0
CS4	0x000092d0	Counting Semaphore	7	0	0	0	0
M1	0x00009328	Mutex	1	0	1	0	0
M2	0x00009380	Mutex	1	0	1	0	0
M3	0x000093d8	Mutex	1	0	1	0	0
MX	0x00000cdc	Mutex	1	0	0	0	0
Q1	0x00009074	Queue	1	5	0	0	0
Q2	0x000090d4	Queue	2	10	0	0	0
Q3	0x00009140	Queue	3	15	0	0	0

Figure 64 FreeRTOS Queues view

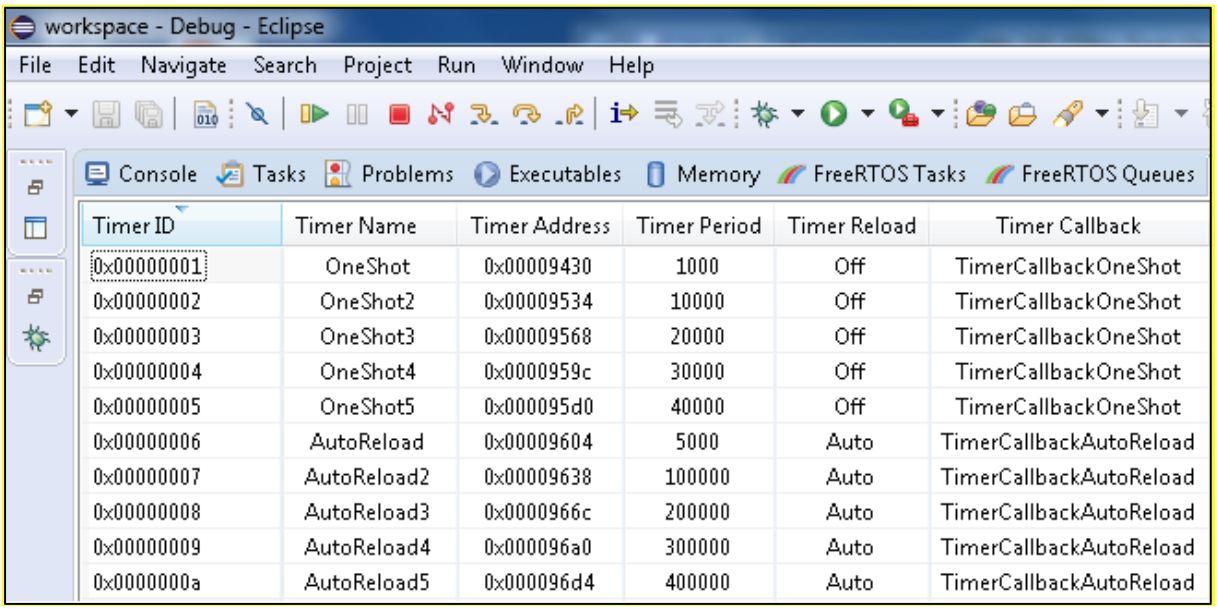
Some of these properties are dependent on a configuration in FreeRTOSConfig.h. If these macros are set to 0, "Unknown" value will be displayed. Refer to the table below for these dependencies.

Table 2 FreeRTOS Queues macro dependencies

FreeRTOS Queue Property	FreeRTOS Configuration macro
Queue Type	configUSE_TRACE_FACILITY

6.4.4 FreeRTOS Timers view

This view displays the timers that have been created. Each timer has the following properties: id, name, address, period, reload and callback function.

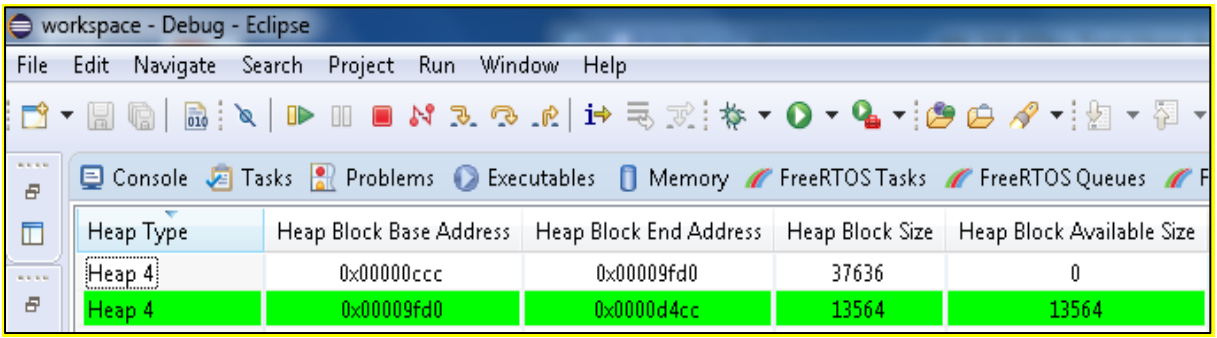


Timer ID	Timer Name	Timer Address	Timer Period	Timer Reload	Timer Callback
0x00000001	OneShot	0x00009430	1000	Off	TimerCallbackOneShot
0x00000002	OneShot2	0x00009534	10000	Off	TimerCallbackOneShot
0x00000003	OneShot3	0x00009568	20000	Off	TimerCallbackOneShot
0x00000004	OneShot4	0x0000959c	30000	Off	TimerCallbackOneShot
0x00000005	OneShot5	0x000095d0	40000	Off	TimerCallbackOneShot
0x00000006	AutoReload	0x00009604	5000	Auto	TimerCallbackAutoReload
0x00000007	AutoReload2	0x00009638	100000	Auto	TimerCallbackAutoReload
0x00000008	AutoReload3	0x0000966c	200000	Auto	TimerCallbackAutoReload
0x00000009	AutoReload4	0x000096a0	300000	Auto	TimerCallbackAutoReload
0x0000000a	AutoReload5	0x000096d4	400000	Auto	TimerCallbackAutoReload

Figure 65 FreeRTOS Timers view

6.4.5 FreeRTOS Heap Usage view

This view displays the current heap allocations or usage. Each heap block has the following properties: type, base address, end address, total size and available size.



Heap Type	Heap Block Base Address	Heap Block End Address	Heap Block Size	Heap Block Available Size
Heap 4	0x00000ccc	0x00009fd0	37636	0
Heap 4	0x00009fd0	0x0000d4cc	13564	13564

Figure 66 FreeRTOS Heap Usage view

The heap type value can be changed via the preprocessor symbol FT32_PORT_HEAP.

6.4.6 FreeRTOS Configuration view

This view allows the user to configure the FreeRTOS configuration macros located at FreeRTOSConfig.h. The user can modify FreeRTOSConfig.h directly or via this view.

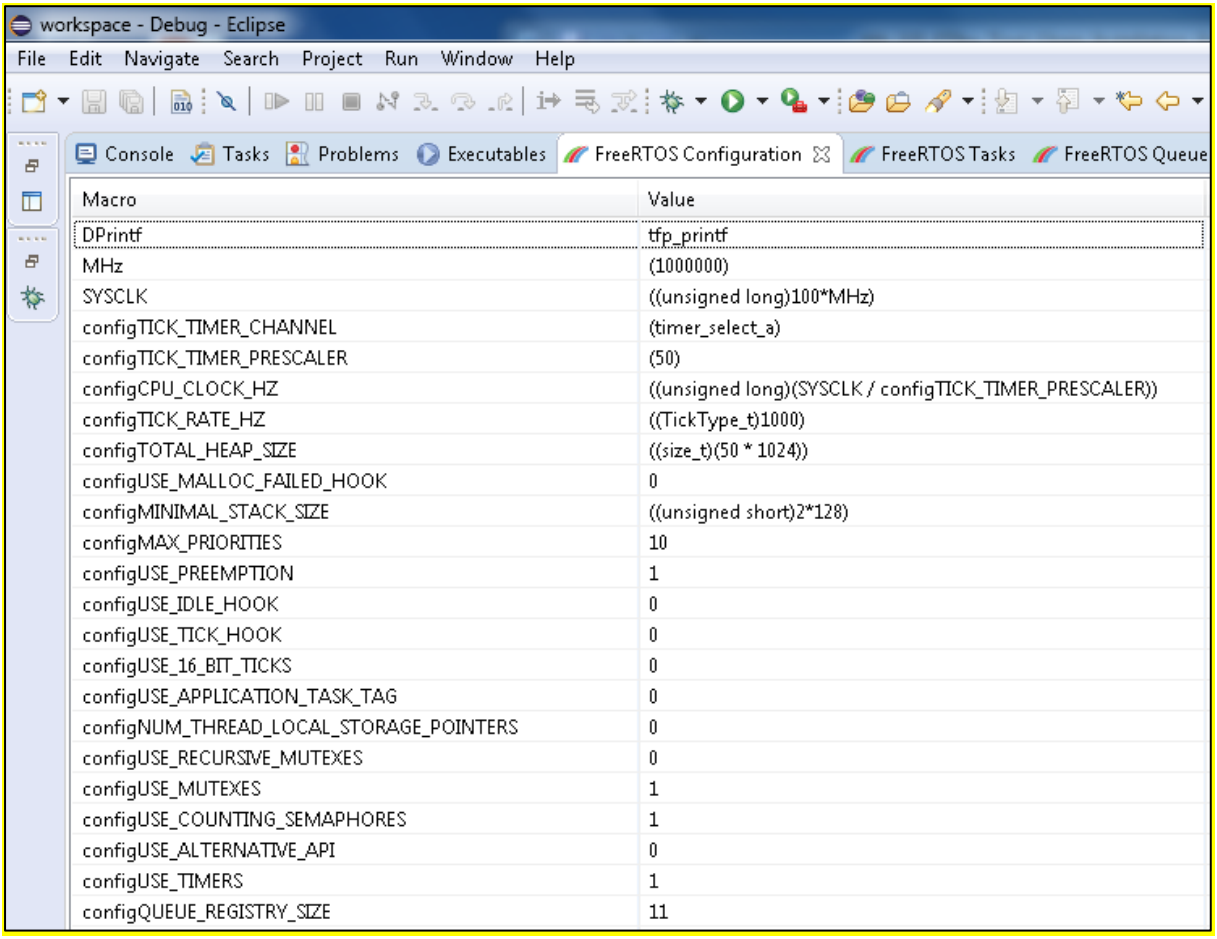


Figure 67 FreeRTOS Configuration view

The values in the table appear when the application is not running. Once the application is running, it is not possible to update the values.

To change a value, just select the value and change. Any changes in it will be highlighted in yellow. To save the changes, click on the save button at the top right corner of this view. This will overwrite the existing configuration file FreeRTOSConfig.h. A backup of the original file will be saved in the same directory.

When overwriting the configuration file, this feature preserves the code comments and whitespaces and also supports macros, multi-line macro definitions and macros enclosed in #ifdef #if defined.

6.4.7 Built-in Debug view

The built-in Debug view has been customized to show the list of FreeRTOS tasks that have been created. Each task indicates its TCB number, name and current state.

Currently, only the running task displays a function call stack. The top frame of the running task call stack will always be selected automatically. In case no frame is selected, user must select a frame before doing a debug command (continue, step into/over/return, etc).

Note that deleted tasks will appear in this view with state 'DELETED'. These tasks will disappear in the view only when the idle task has freed up the corresponding memory allocation.

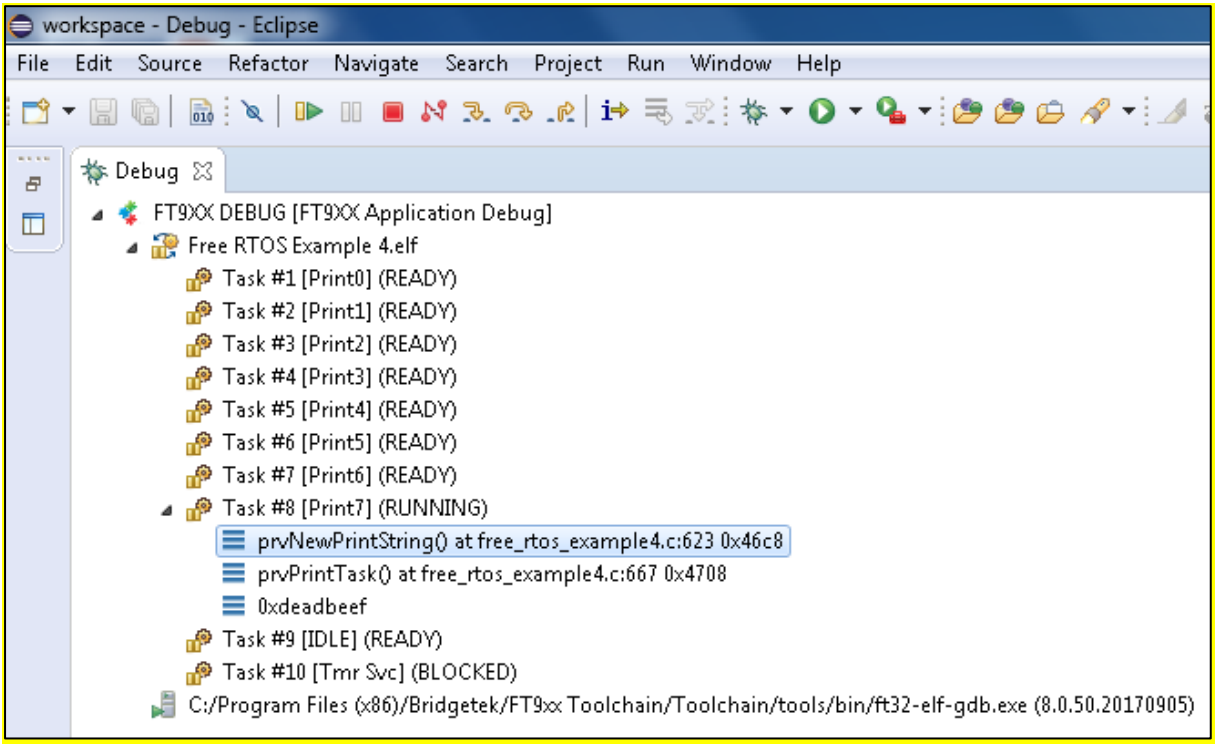


Figure 68 Built-in Debug view

The FreeRTOS configuration macro configUSE_TRACE_FACILITY must be set to 1 in FreeRTOSConfig.h for this view to display all the tasks created. Otherwise, only 1 task will be displayed.

7 Troubleshooting

This section documents the problems you may encounter when using the FT9XX Toolchain.

7.1 Makefile error

If using a makefile to build an application, some makefile errors may be reported, for example:

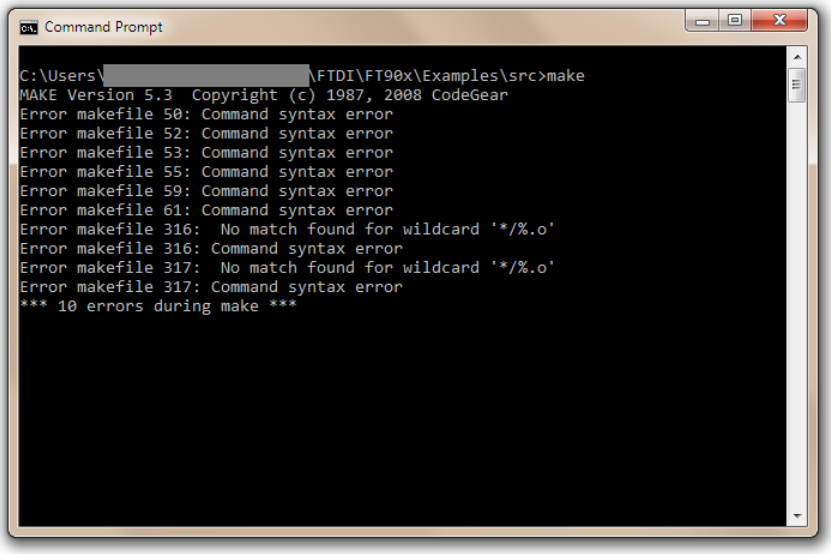


Figure 69 Makefile Error

This is usually because some existing toolchain on the system may be using its own "make" utility which is also referred to in the PATH variable. The FT9XX examples need to be built by the GnuWin32 "make" utility, which can be installed during the toolchain installation. To solve this problem, adjust the PATH variable so that the correct "make" utility is called by the toolchain. Note that it may be necessary to adjust PATH again for the other toolchain. Type "where make" in a command prompt to find out which "make" utilities are present on the system.

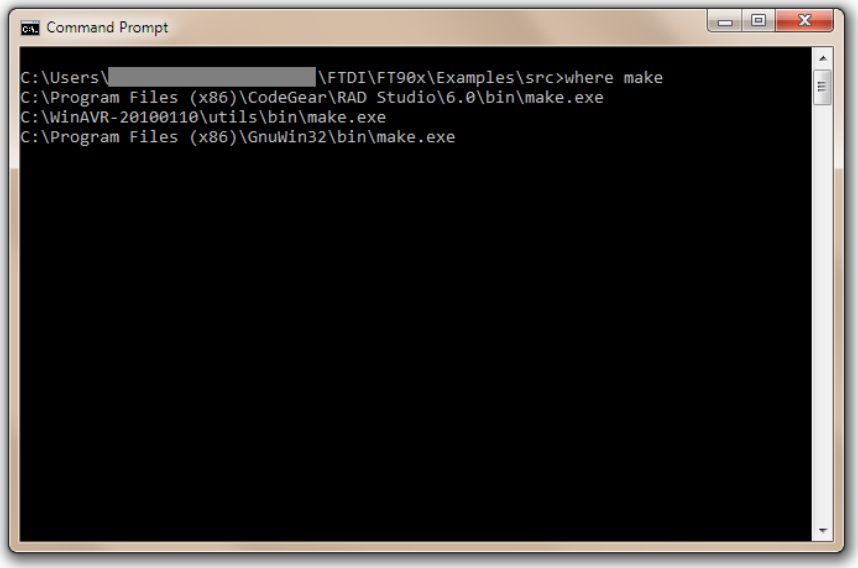


Figure 70 "make" Locations

7.2 Programming does not work for either RUN or DEBUG

1. Ensure that manually-executed FT900 Programmer and GDB Bridge are not running. The new Eclipse plugin automatically runs the FT900 Programmer and GDB Bridge so user does not need to manually run these applications anymore. These applications will fail to run if there are other instances running because they both share the one-wire programming interface.

2. Ensure that Eclipse-executed GDB Bridge is not running. This Eclipse-executed GDB Bridge is launched without a visible window. Check Task Manager and kill the process.

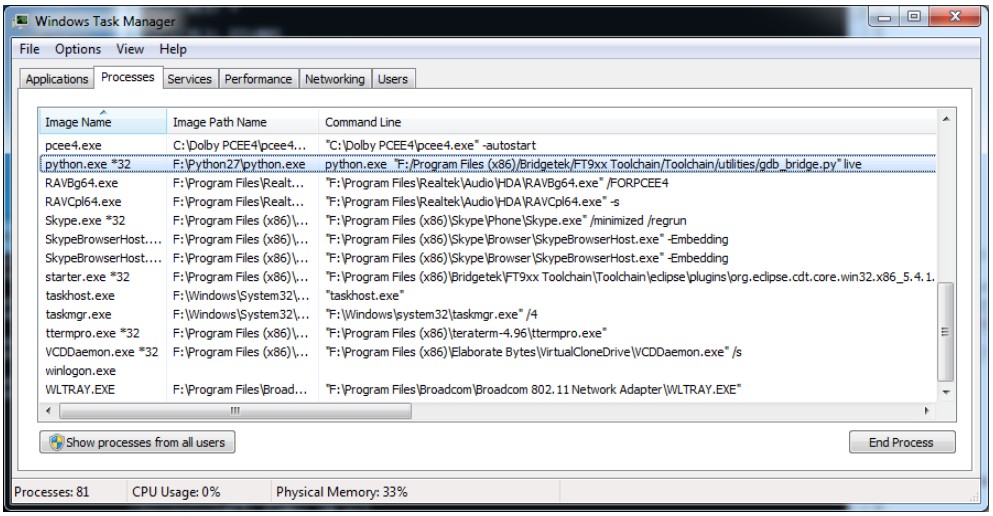


Figure 71 Eclipse-executed invisible GDB Bridge

7.3 Build errors due to anti-virus software protection

When building in Eclipse, the build process will sometimes stop or get delayed with the messages like:

*make: *** Access is denied.*

. Stop.

*make: *** Waiting for unfinished jobs....*

Or

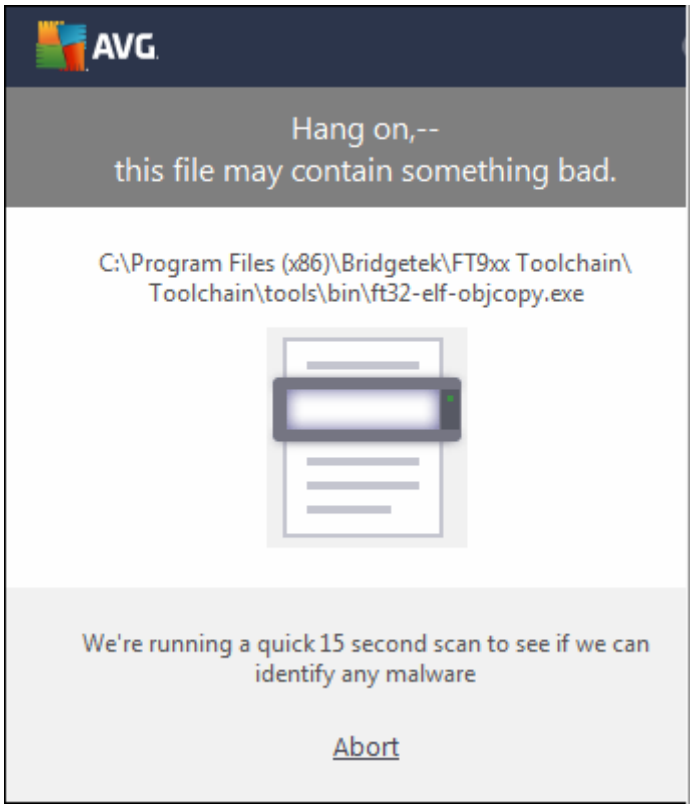


Figure 72 AVG warning during building in FT9xx toolchain

This is a known issue with some antivirus software, such as AVG.

Workarounds include (depending on the antivirus software):

- Temporarily disable the antivirus software.
- Add exceptions to every "exe/bat" under the FT9xx Toolchain folder.

In case of taking exceptions in AVG Business, refer to the following link –

https://support.avg.com/SupportArticleView?l=en&urlname=Excluding-Files-from-Scanning-in-AVG-Business-Products

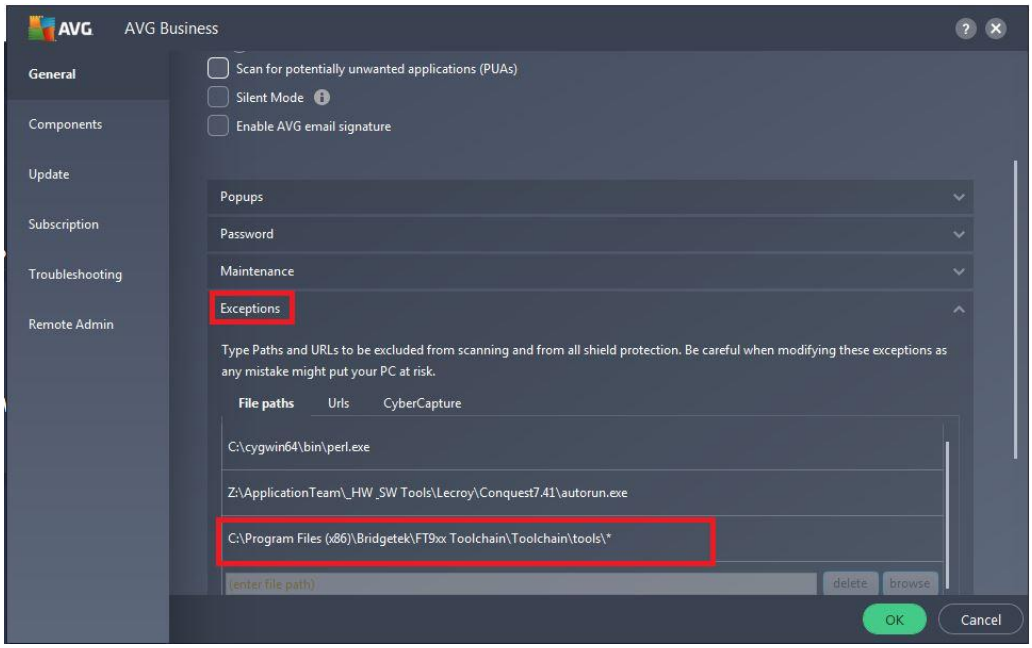


Figure 73 Adding exception in AVG for FT9xx toolchain executables

7.4 Building of header files from Eclipse Virtual Store

If the FT9xx toolchain is installed in the system directory path 'C:\Program Files (x86)\Bridgetek\FT9xx Toolchain', when Eclipse IDE of FT9xx Toolchain is not run in administrator mode, and when the library header files also under system directory path 'C:\Program Files (x86)\Bridgetek\FT9xx Toolchain' are modified by the user in eclipse editor, the files get actually saved in C:\Users\%Username%\AppData\Local\VirtualStore\Program Files (x86)\Bridgetek\FT9xx Toolchain\. This is because Eclipse sees the files it changed in C:\Program Files (x86)\Bridgetek\FT9xx Toolchain, but other applications like the Windows Explorer will see only the unchanged files.

If the above behavior adds confusion to the building of eclipse projects, then,

The User can choose to install the toolchain in a non-system path so that the FT9xx library header files are also installed in non-system path

Or

Run the eclipse IDE with elevated privilege mode by selecting 'Run as administrator' while opening the eclipse.

Or

Clear the Virtual Store path (C:\Users\%Username%\AppData\Local\VirtualStore\Program Files (x86)\Bridgetek\FT9xx Toolchain\) for any stale headers.

More info about Virtual store can be found in the below link:

https://answers.microsoft.com/en-us/windows/forum/windows_7-windows_programs/please-explain-virtualstore-for-non-experts/d8912f80-b275-48d7-9ff3-9e9878954227

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Appendix A – References

Document References

http://brtchip.com/m-ft9/

AN_360 FT9XX Example Applications

TN_160 Eclipse Projects

Acronyms and Abbreviations

Terms	Description
CMD	Command-line interface
DLL	Dynamic-link Library
DLOG	Data Log (Project)
GAS	GNU Assembler
GCC	GNU Compiler Collection
GDB	GNU Project Debugger
GNU	GNU (Gnu's Not Unix) Operating System
GUI	Graphical User Interface
IDE	Integrated Development Environment
JDK	Java Development Kit
JRE	Java Runtime Environment
MCU	Microcontroller Unit
PATH	PATH Environment Variable
TCP	Transmission Control Protocol

Appendix B – List of Tables & Figures

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Appendix C – Revision History

Document Title: AN_325 FT9xx Toolchain Installation Guide
Document Reference No.: BRT_000116
Clearance No.: BRT#074
Product Page: http://brtchip.com/m-ft9/
Document Feedback: Send Feedback

Revision	Changes	Date
1.0	Initial release	2014-05-02
1.01	Expanded screenshots of Installation Wizard in Section 2	2015-08-21
1.02	Updated Version for Toolchain 2.1.0	2016-02-22
1.03	Added section 2.1.1 to document the handling of another instance of MSI installer running in the background while installing JRE (results in JRE install error 1618) Debugger related information moved to section 4.4. from Troubleshooting Updated screenshots for programmer	2016-09-19
1.04	Updated release Migration of the product from FTDI to Bridgetek name – logo changed, copyright changed, contact information changed	2017-03-08
1.05	The toolchain references has been updated from FT90X to FT9XX	2017-03-23
1.06	Updated the document for 'Seamless Debug' eclipse plugin; Section1 and Section 3.3 for Seamless Debug; Added section 6.3.4 on C++ compilation	2018-01-22
1.07	Updated the document for Section 5: Bridgetek Projects, Section 6.4 FreeRTOS Kernel aware debugging, Section 7.3: Build errors due to anti-virus software protection.	2018-11-14