Document Number: WPR1500BUCKMPUG
Rev. 0, 09/2016

WPR1500-BUCK MP Receiver V2.1 Reference Design User's Guide

1 Introduction

This document describes how to use the WPR1500-BUCK medium power receiver reference board designed by NXP Semiconductors. It supports 15 W, is compliant with the WPC Qi V1.2.2 specifications, and has the capability to support future standards. It is a low-cost reference solution that can be easily customized using the FreeMASTER tool.

Contents

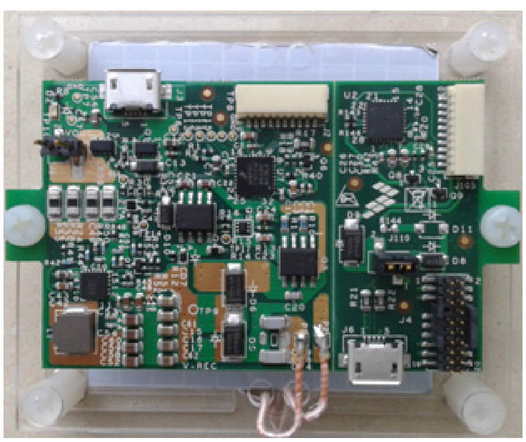

Figure 1. WPR1500 reference board – BUCK

2 System Features

The WPR1500 medium power receiver reference board has the following features:

- Reference design compliant with medium power WPC Qi V1.2.2 specifications
- Input power of 3.5 V – 20 V AC in peak from the transmitter through the receiver coil
- Output power of 15 W (5 V @ 3 A)
- Support of FSK communication signals from medium power transmitter
- Hardware protection of rectifier voltage, output voltage and output current
- Small PCB size (40 mm × 40 mm)
- FreeMASTER tool to enable customization and calibration

3 Package Checklist

Table 1. Package checklist

Name	Count
WPR1500-BUCK board	1
WPR1500 debug board	1
10-pin SWD debug cable	1

4 System Block Diagram

The WPR1500 medium power receiver wireless charging system is shown in Figure 2.

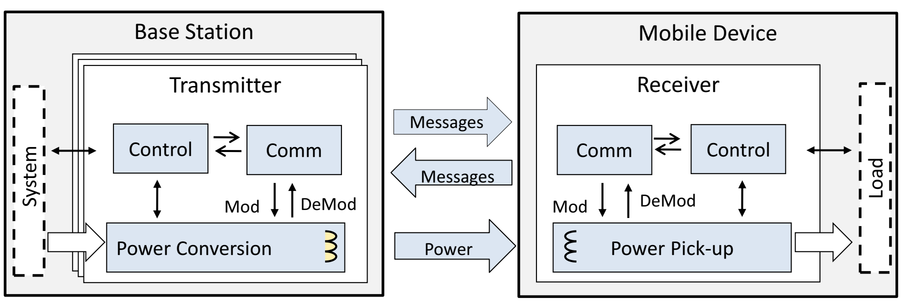

Figure 2. Wireless charging system overview

For the WPC Qi information, visit www.wirelesspowerconsortium.com/developers/

5 Hardware Description

5.1 Reference board block diagram

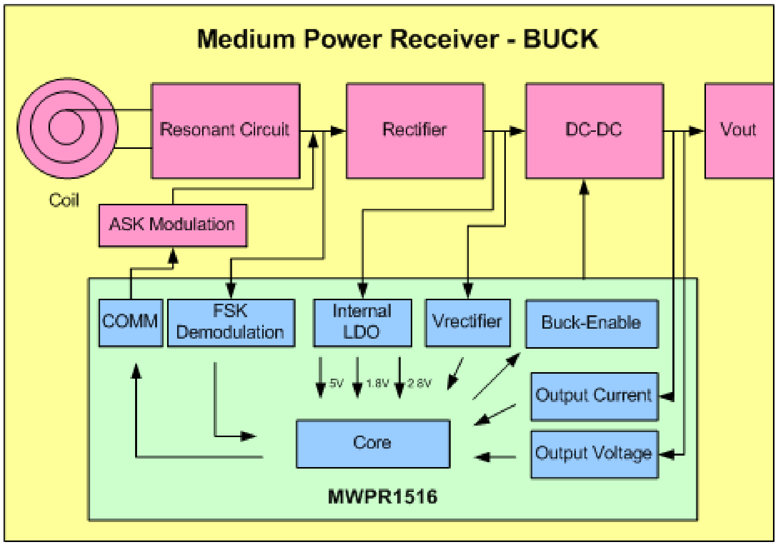

Figure 3. WPR1500 receiver board block diagram – BUCK

5.2 Modules explanation

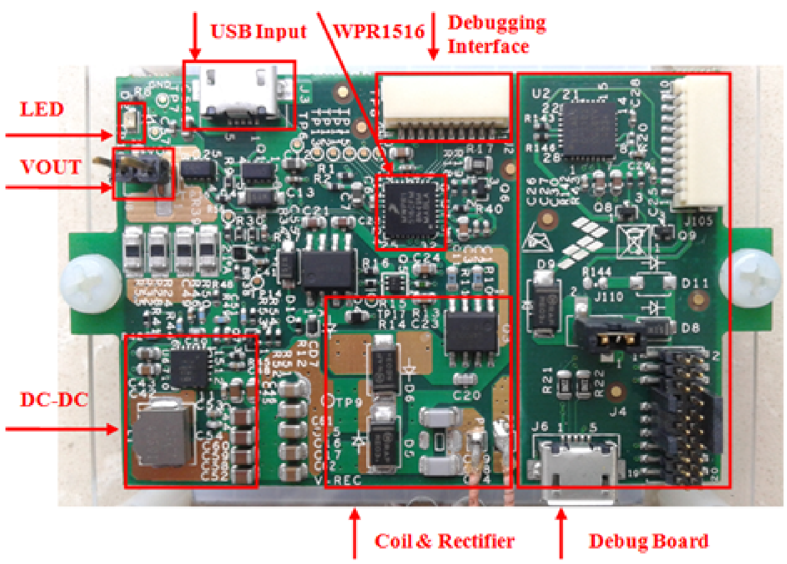

Figure 4. WPR1500-BUCK board modules overview

- Controller

  The NXP WPR15xx MCU is the central controller of the WPR1500 receiver board. The chip is a higher integrated receiver controller MCU for wireless power transfer applications. The WPR15xx is an ARM® Cortex® M0+ core ASSP with NXP's UHV technology. It includes the FSK and CNC models that allow easy development for bi-directional communication architecture between the transmitter and receiver. The PGA model handles small signal, which eases the solution for foreign object detection. The USB / adapter switcher sets the priority between wired and wireless charging.

  The following modules are used in this application:

  — CNC controls the communication and provides AC protection

  — High voltage input PMC module with three power modes: Run, Wait, Stop

  — Programmable gain amplifier (PGA) with differential input and output

  — FSK demodulation timer (FSKDT)

  — WDOG with independent clock source

- Rectifier

  The rectifier uses self-driven sync type. It has the following characteristics:

  — Input voltage : 3.5 V – 20 V AC peak

  — Output voltage: 3.5 V – 20 V DC

- Communication

  — The ASK differential bi-phase signal is modulated by switching the modulation capacitor

  — The FSK signal is demodulated by the CNC and FSKDT modules

- USB switch

  — The CNC module automatically detects the input voltage from wired power plugs, and switches on wired power when the input voltage is in the range of 4.5 V – 5.5 V

- DC–DC converter

  — Input voltage : 5 V – 21 V DC

  — Output voltage / current: 5 V DC / 3 A.

6 Getting Started

6.1 System development environment

The WPR1500 receiver board supports debugging using the IDE (IAR, Keil MDK or CodeWarrior) and FreeMASTER tools. Figure 5 shows setup of the debug connection. The debugger and the debug board are placed between the PC and the receiver board.

To download an image onto the WPR1516 chip, connect a debugger (J-Link or P&E-Multilink FX) to the SWD port of a debug board, and connect the debug board to the receiver board using a 10-pin cable. The micro interface on the debug board must be connected to the USB to get power.

To monitor the working status of the WPR1500 receiver board, short jumper J110 on the debug board, and connect the micro interface on the debug board to the PC through a micro USB cable.

Figure 5 shows the connection diagram and Figure 6 shows a real setup.

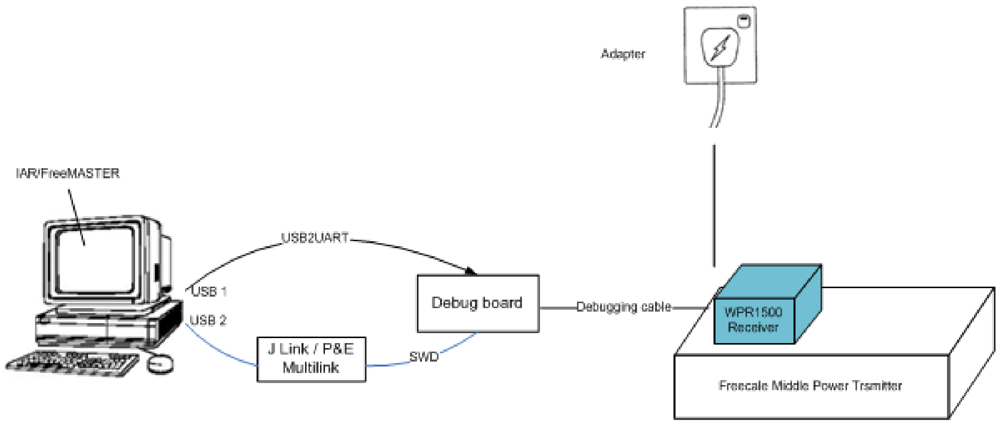

Figure 5. Debug connections

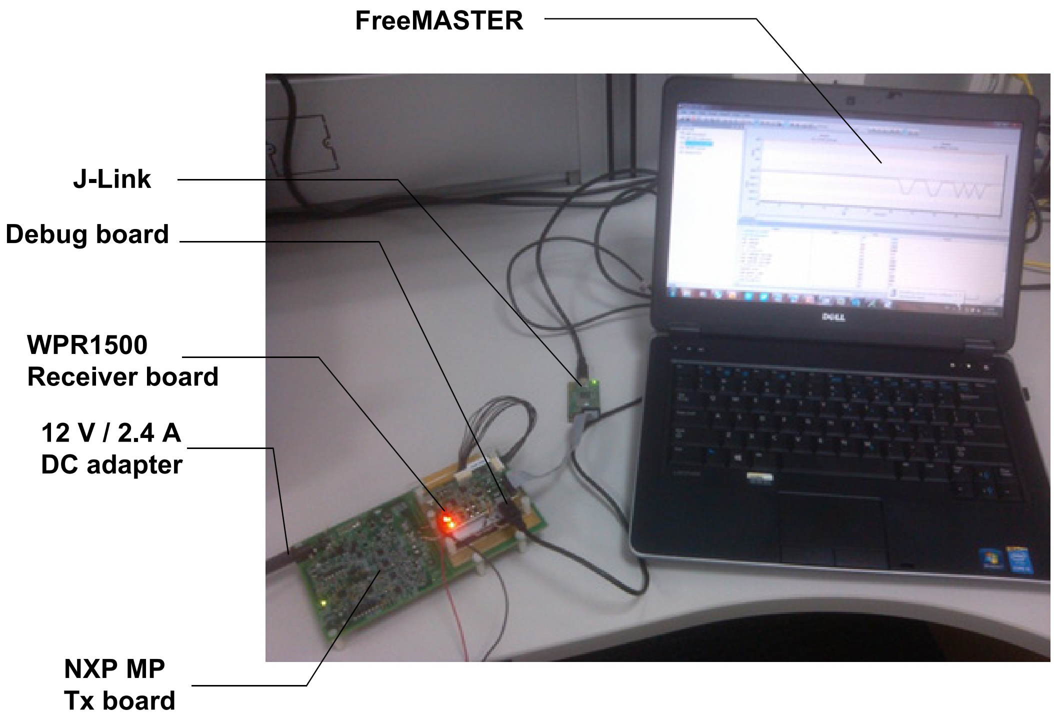

Figure 6. Development environment

For details on the J-Link debugger, visit nxp.com and search for “J-Link”.

6.2 Downloading and debugging firmware

6.2.1 Connecting the J-Link debugger

Connect the J-Link debugger to the SWD port of the debug board, and then connect the debug board to the receiver board using a 10-pin cable.

NOTE

The micro interface on the debug board must be connected to the USB to receive power. Ensure that the jumper J110 is connected before the download.

The J-Link connection is shown in Figure 7.

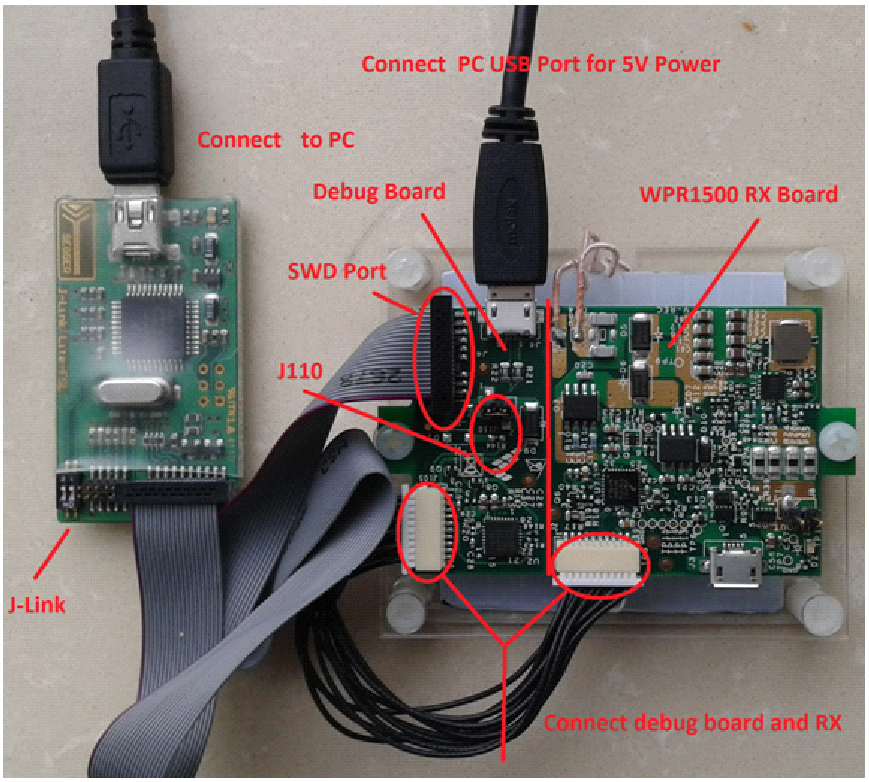

Figure 7. J-Link connection

When the J-Link is plugged into the PC, it can be found in Windows Device Manager, as shown in Figure 8 and Figure 9.

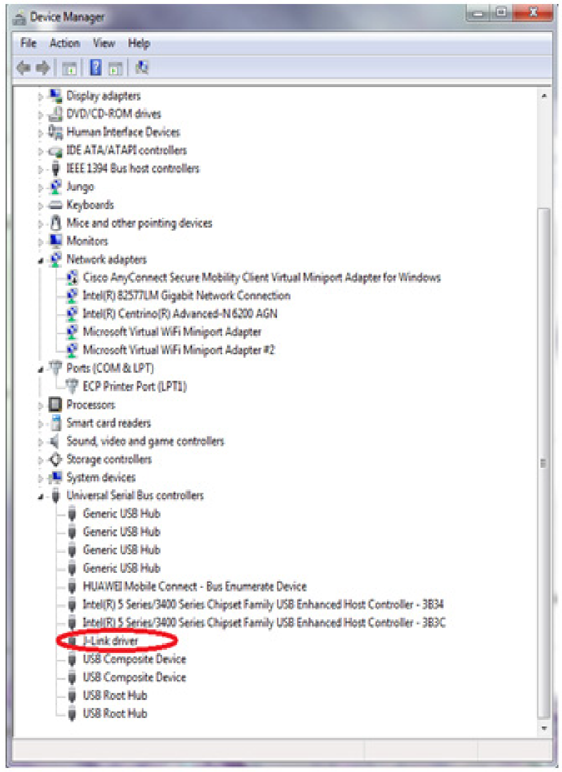

Figure 8. J-Link debugger plugged in

Figure 9. P&E Multilink debugger plugged in

6.2.2 Downloading an existing WPR1500 project using IAR 7.30 or later versions

To download an existing WPR1500 project using IAR, perform the following steps:

1. Set up the IAR embedded workbench.

   The IAR embedded workbench tool is required. Since the receiver driver library is already included in the lib folder of the wireless charger application project, you can open the application project and build the applications directly whenever the wpr_lib.a is ready.

   The configurations in MWPR1516_config.h are set for the BUCK board by default. To build this project for the LDO board, change the macro definition BOARD_OUT_TYPE from #define BOARD_OUT_TYPE OUT_TYPE_BUCK to #define BOARD_OUT_TYPE OUT_TYPE_LDO. Then rebuild all the file in the project.

   The demo applications workspace files are located in:

   <software_package>/build/wpr1500/iar/WPR1500_REF/WPR1500_REF.eww

2. Build a project.

   Click on the “Rebuild All” button:

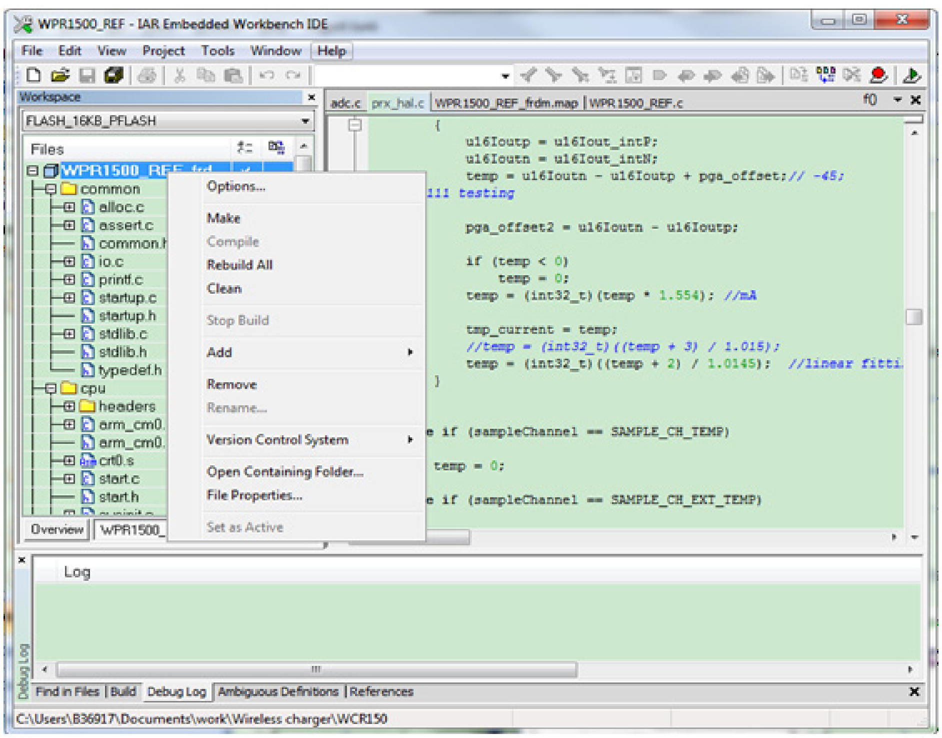

Figure 10. Building a project

When the build is complete, the IAR displays this information in the build window:

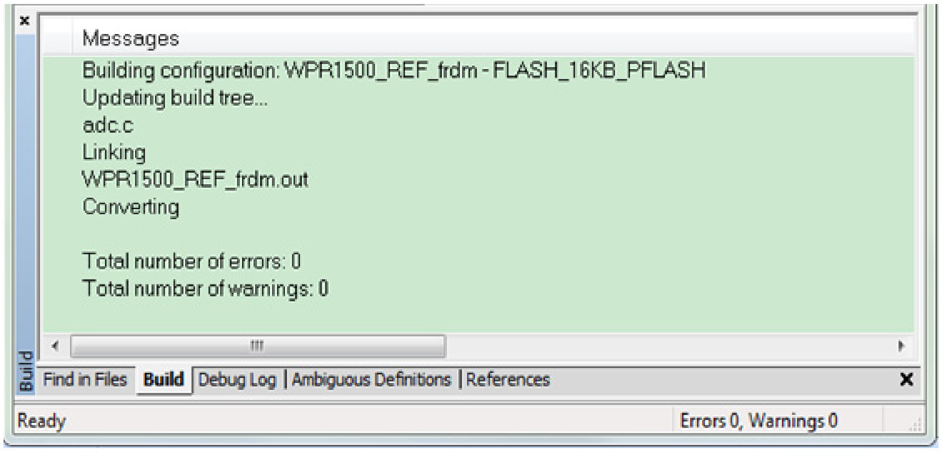

Figure 11. Successfull build of a project

3. Ensure that the debugger is configured properly in the project options.
   Select the flash loader to support downloading of the binary to the internal flash:

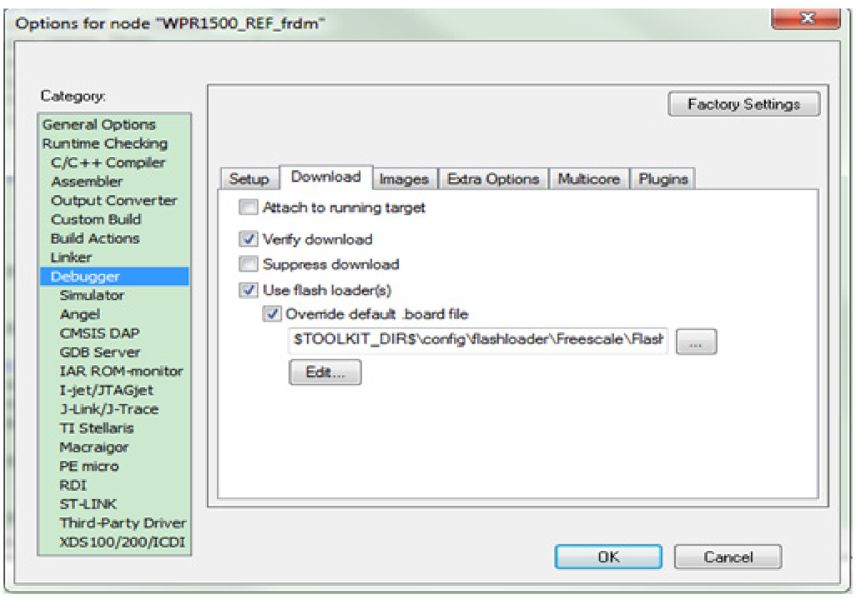

Figure 12. Flash loader configuration

When using J-Link as a debugger, select J-link/J-Trace:

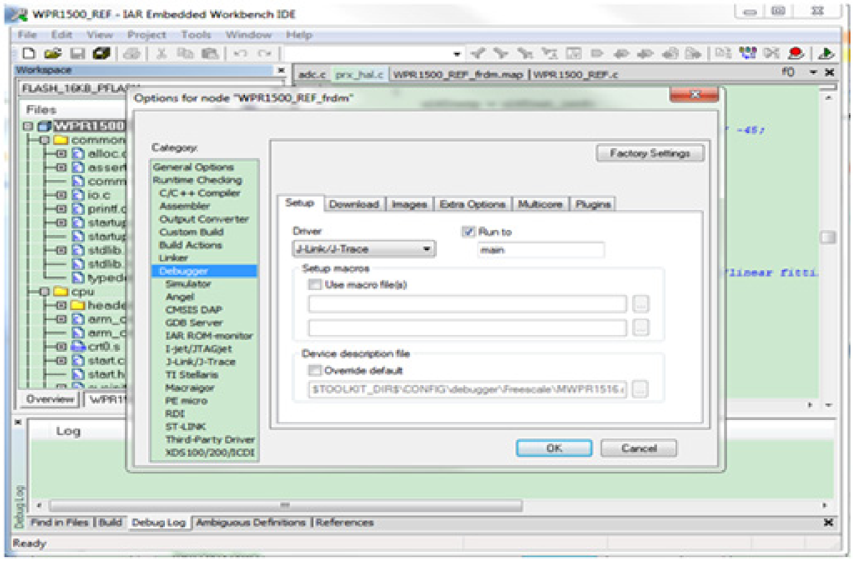

Figure 13. J-Link debugger configuration for driver

When using P&E Multilink as a debugger, select the PE micro:

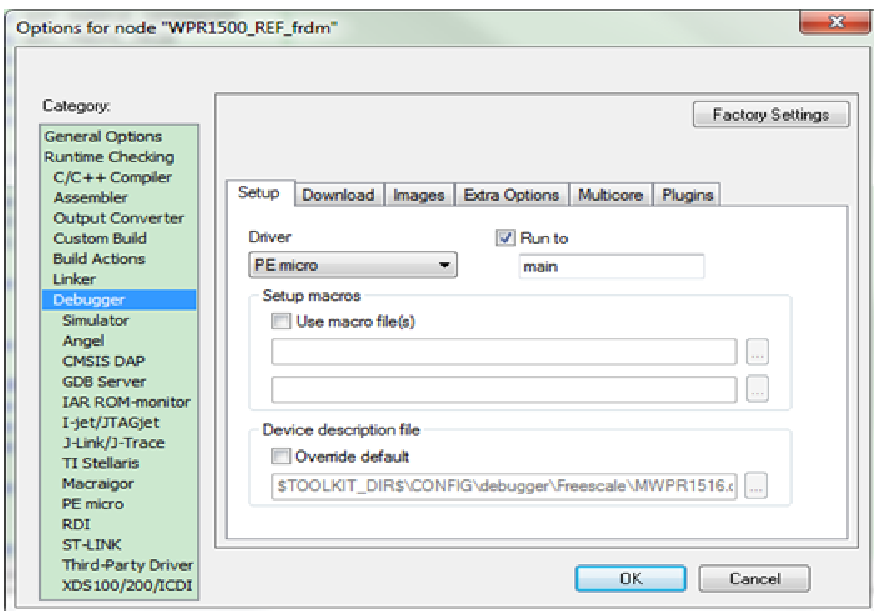

Figure 14. P&E Multilink debugger configuration for driver

The P&E Multilink is configured in the PE micro settings, as shown in Figure 15.

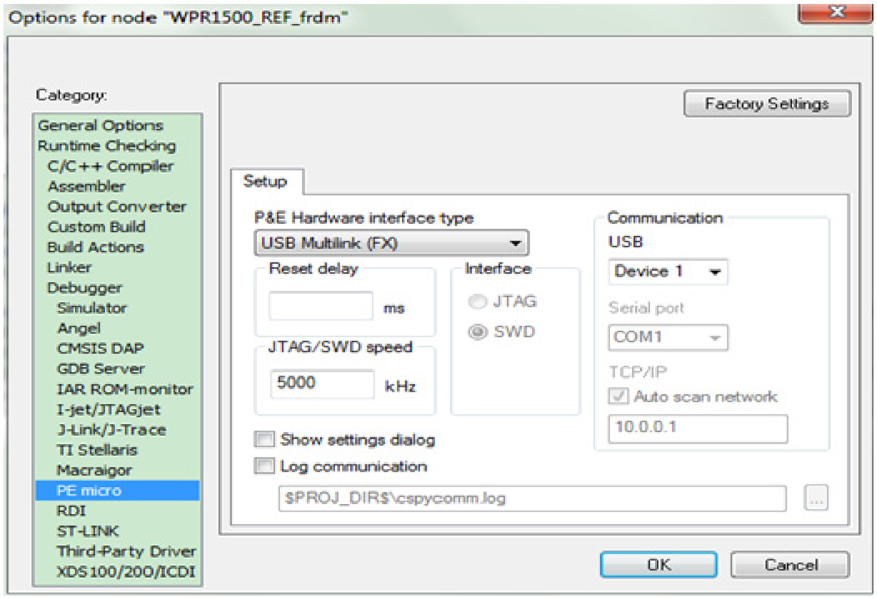

Figure 15. Debugger configuration for PE micro

4. Download the project.

   After the application is built successfully, click the “Download and Debug” button to download the application to the target device.

Figure 16. Download and Debug button

The programming of a project is shown in Figure 17.

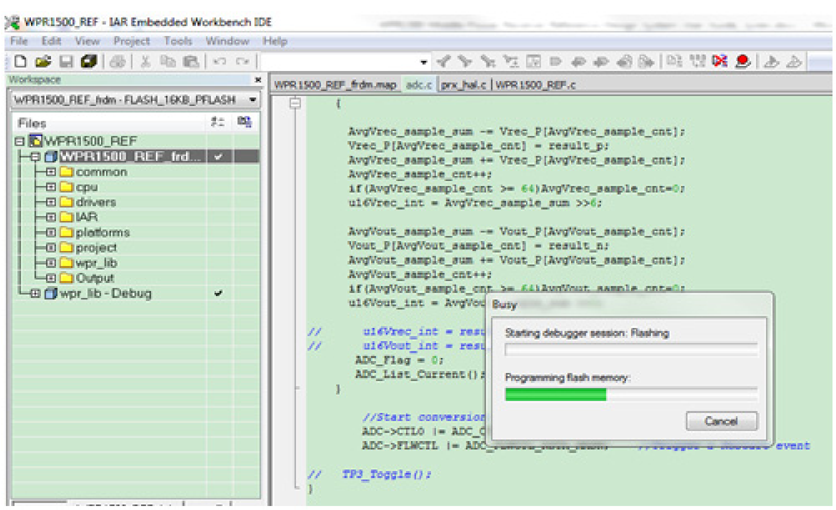

Figure 17. Programming a project

5. After the application is downloaded onto the target device, the debugger stops executing at the start of the main() function:

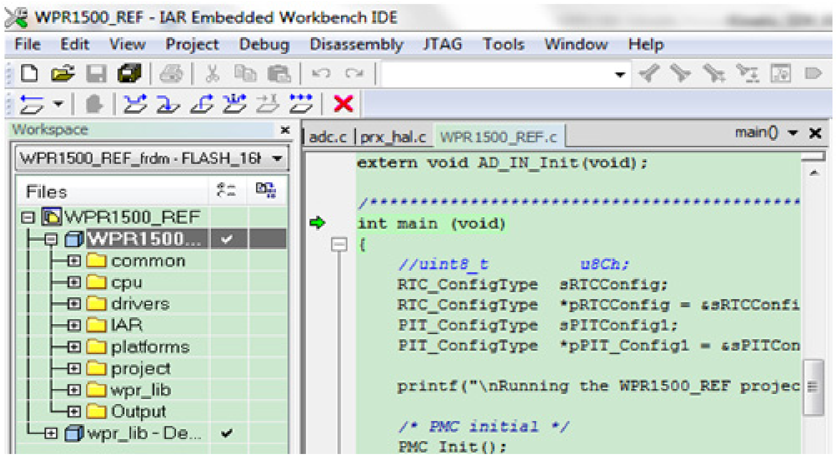

Figure 18. Stopping at main() when debugging

6.2.3 Downloading an existing WPR1500 project with KEIL µVision5

To download an existing WPR1500 project with KEIL, perform the following steps:

1. Set up the KEIL µVision MDK.

   Because the receiver driver library is already included in the library folder and platform folder of the wireless charger application project, you can open the application project and build the applications directly whenever the wpr_lib.lib is ready.

   The configurations in MWPR1516_config.h are set for the BUCK board by default. To build this project for the LDO board, change the macro definition BOARD_OUT_TYPE from #define BOARD_OUT_TYPE OUT_TYPE_BUCK to #define BOARD_OUT_TYPE OUT_TYPE_LDO. Then rebuild all the file in the project.

   The demo applications workspace files are located in:

   <software_package>/build/wpr1500/keil/WPR1500_REF/WPR1500_REF.uvprojx

2. Build a project.

   Click the “Rebuild” button.

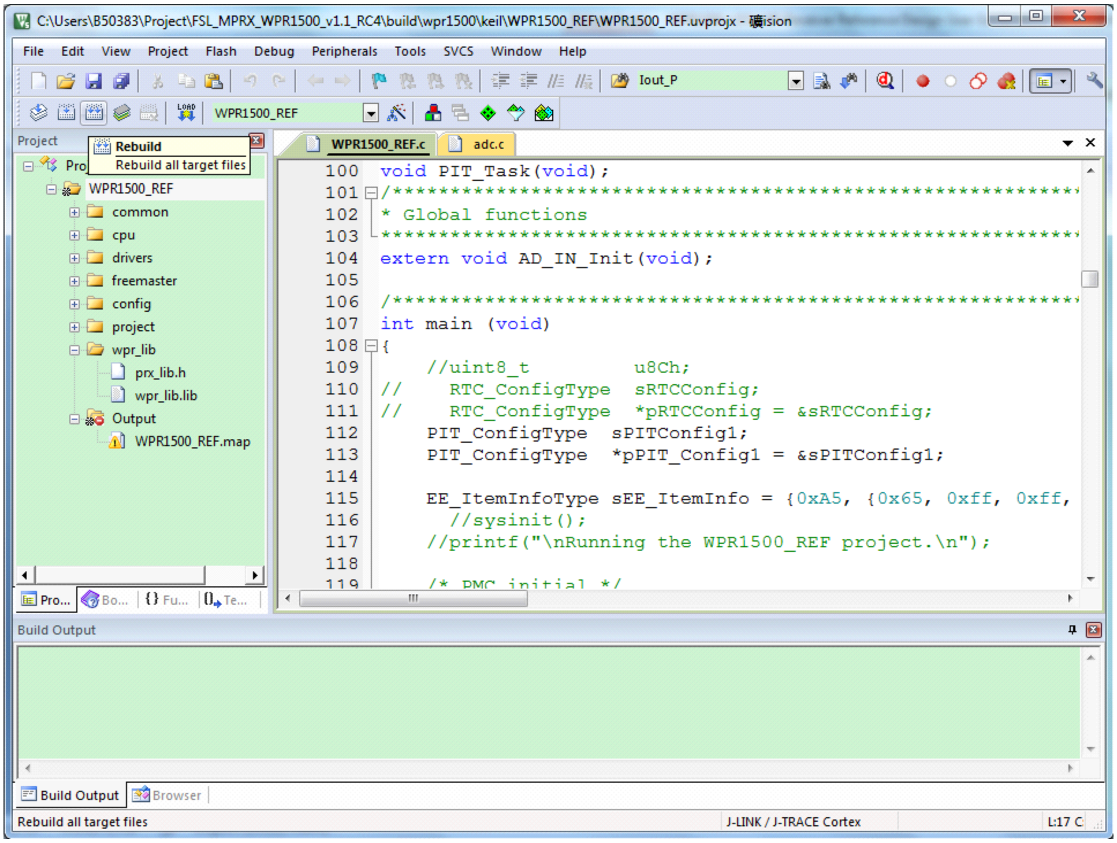

Figure 19. Building a project

When the build is complete, KEIL displays this information in the build window as follows.

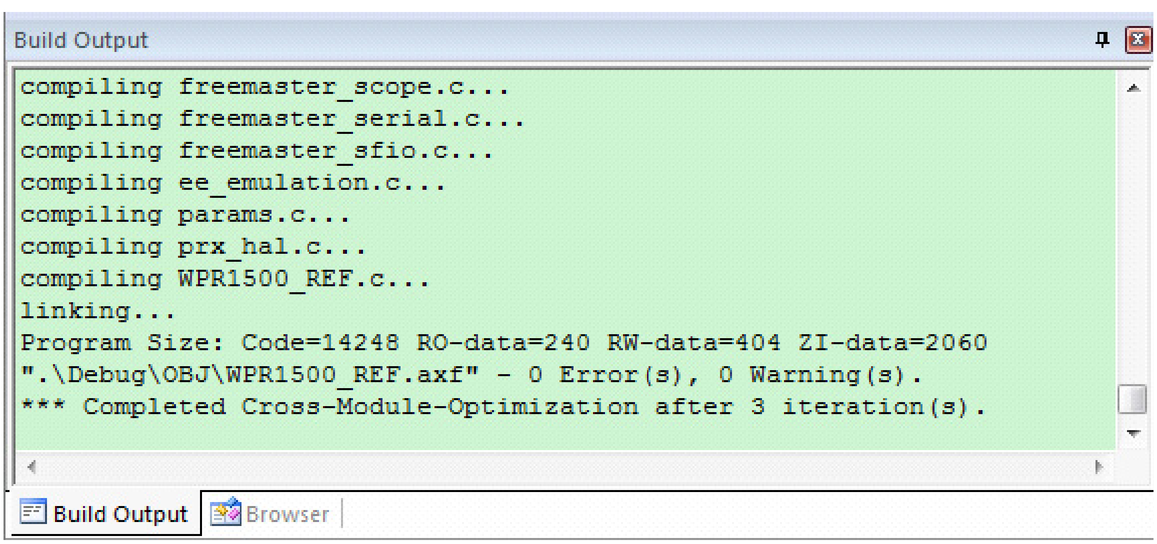

Figure 20. Building a project successfully

3. Ensure that the debugger configuration is correct in the project options.
   The flash loader must be selected to support downloading the binary to the internal Flash.

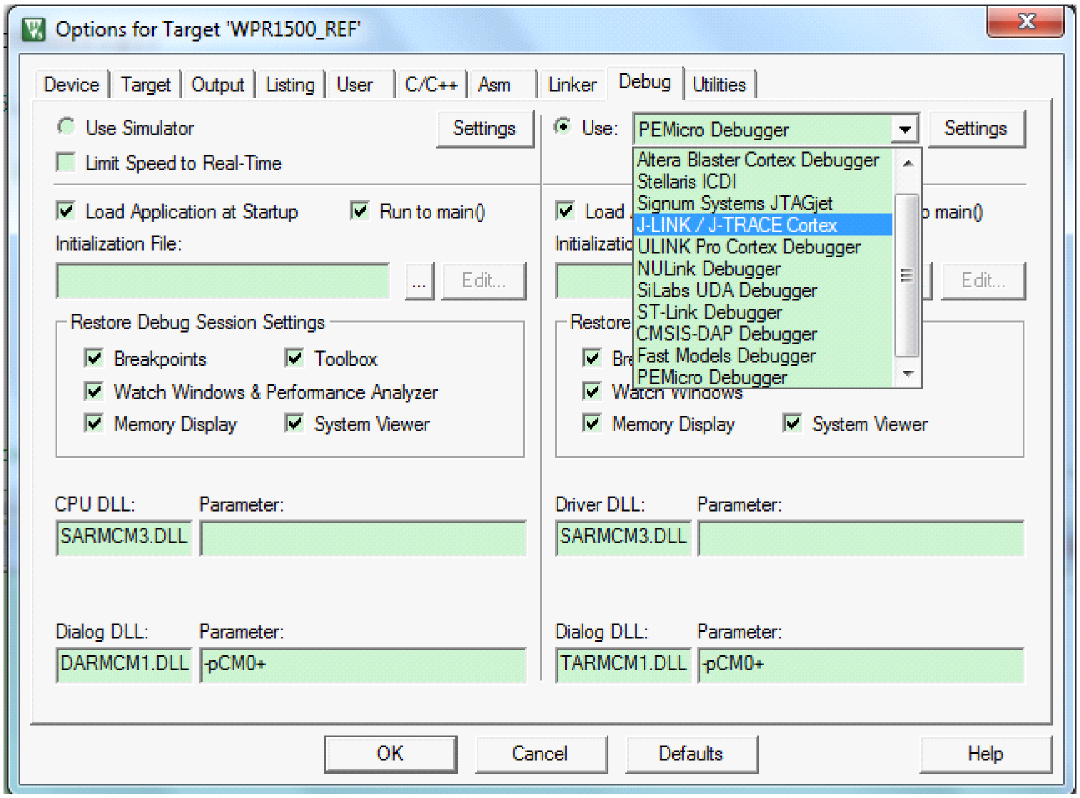

Figure 21. Flash loader configurations

If using the J-Link as debugger, choose J-link/J-Trace.

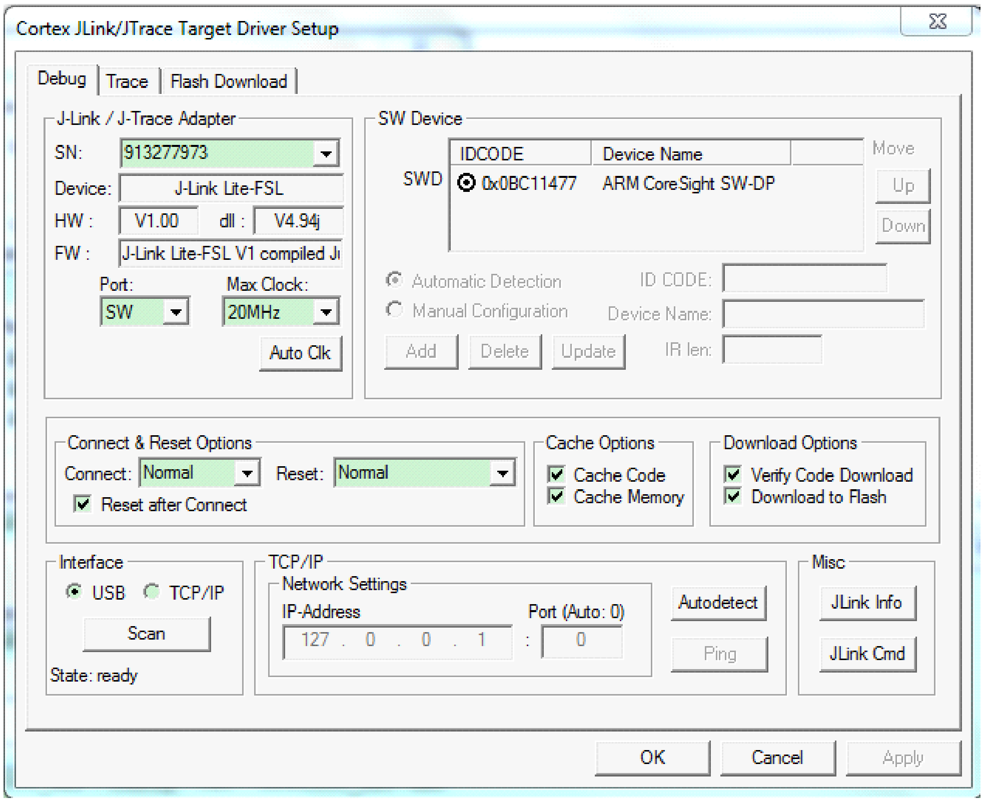

Figure 22. Debugger configurations for J-Link

If using P&E Multilink as the debugger, choose the PE micro.

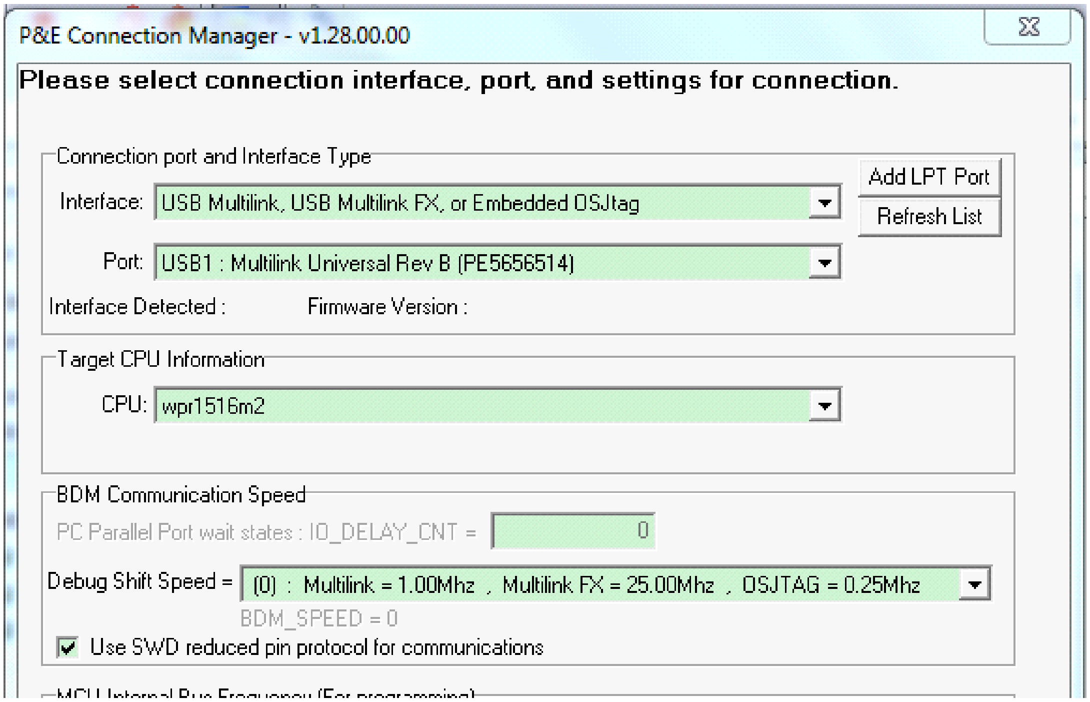

Figure 23. Debugger configurations for PE micro

4. Download the project.

   After the application is built successfully, click the “Download” button to download the application to the target device.

Figure 24. Download button

   Program a project.

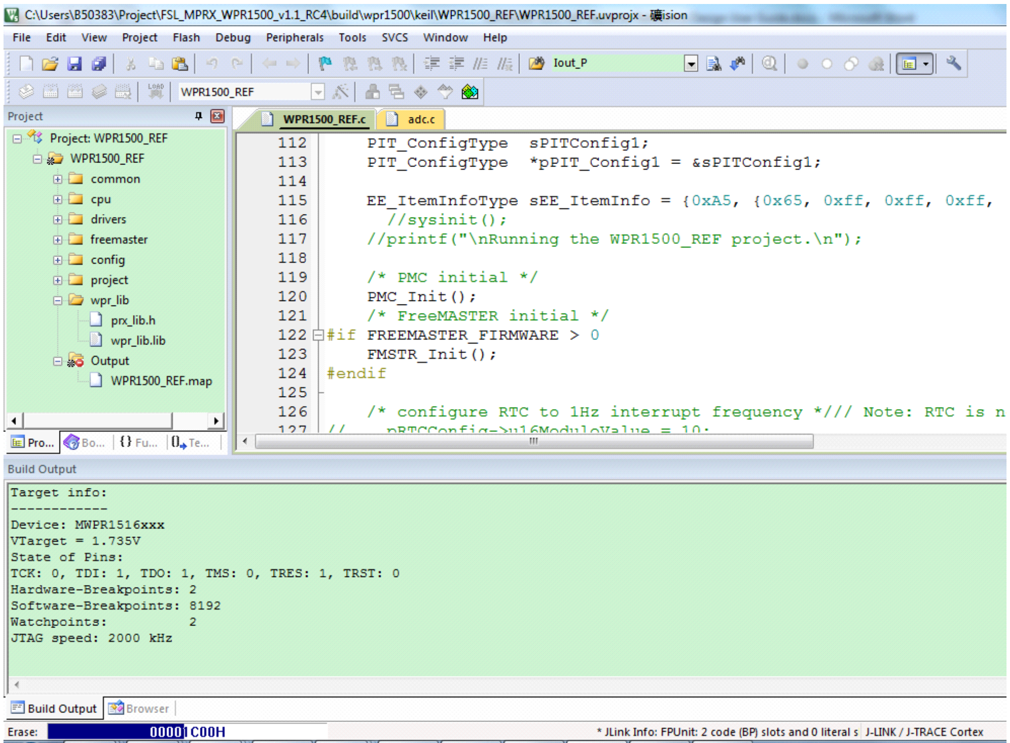

Figure 25. Programming a project

5. After the application is downloaded to the target device, click “Start/Stop Debug Session” to debug the code. The debugger stops executing at the start of the main() function.

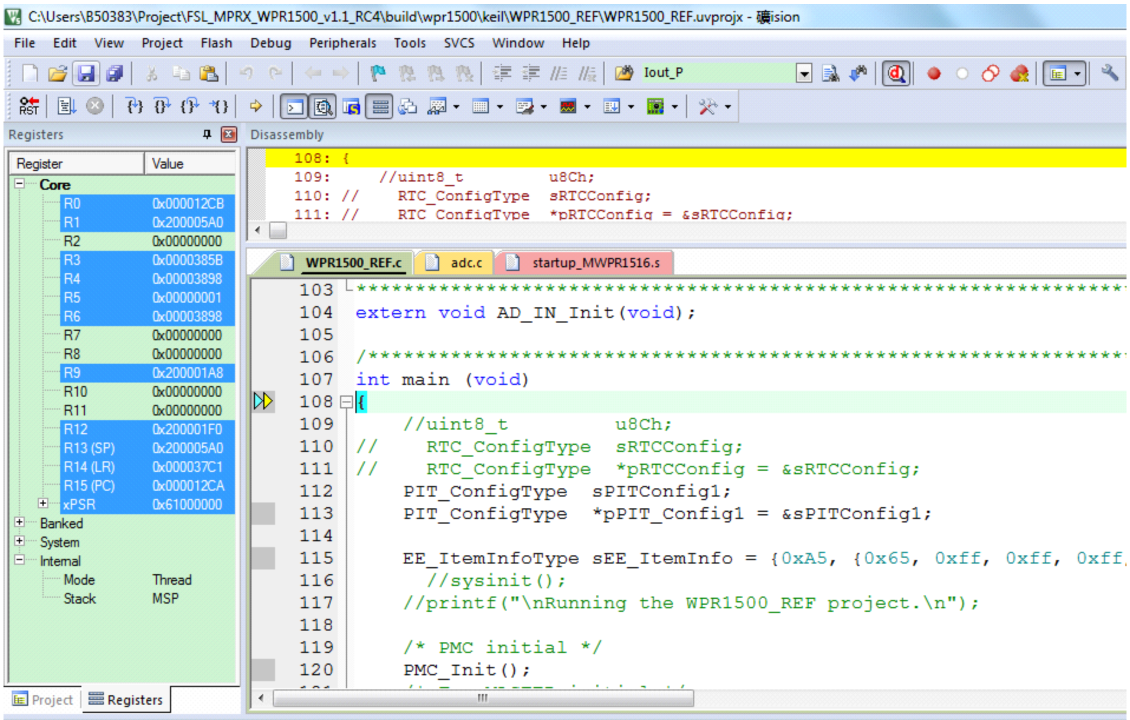

Figure 26. Stopping at main() when running debugging

6.2.4 Downloading an existing WPR1500 project with CodeWarrior

To download an existing WPR1500 project with CodeWarrior, perform the following steps:

1. Set up the CodeWarrior.

   As the WPR1516 chip is a new series chip for CodeWarrior, install CodeWarrior V10.6.4 with update 5 or later. To install update 5 package successfully, check for an update to let CodeWarrior install some essential components.

   Because the receiver driver library is already included in the lib folder and platform folder of the wireless charger application project, you can open the application project and build the applications directly whenever the libwpr_lib.a is ready.

   The configurations in MWPR1516_config.h are set for the BUCK board by default. To build this project for the LDO board, change the macro definition BOARD_OUT_TYPE from #define BOARD_OUT_TYPE OUT_TYPE_BUCK to #define BOARD_OUT_TYPE OUT_TYPE_LDO. Then rebuild all the file in the project.

   The demo applications workspace folder is located in:

   <software_package>/build/wpr1500/cw/WPR1500_REF

2. Build a project.

   Click the **Clean Project** button to clean project, and then click the **Build Project** button.

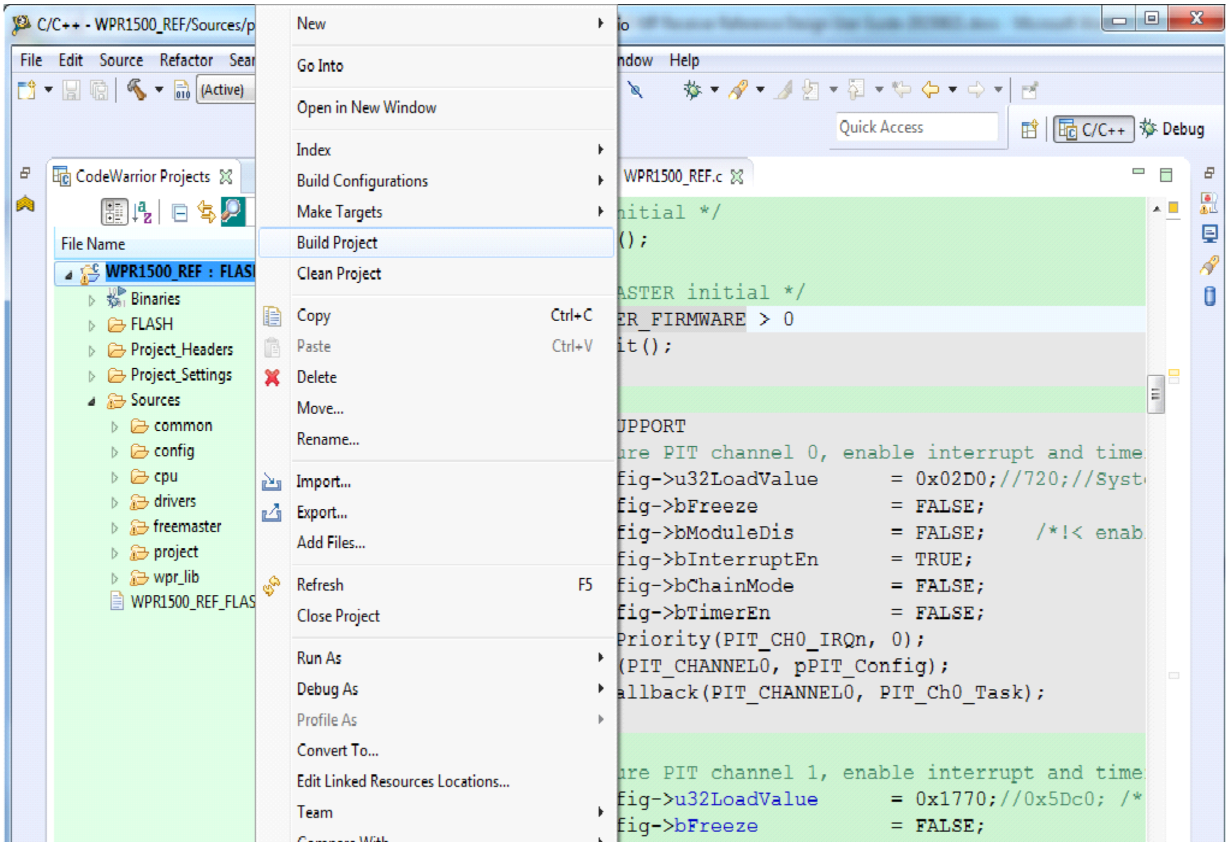

Figure 27. Build the project

When the build is complete, CodeWarrior displays this information in the Console window as follows.

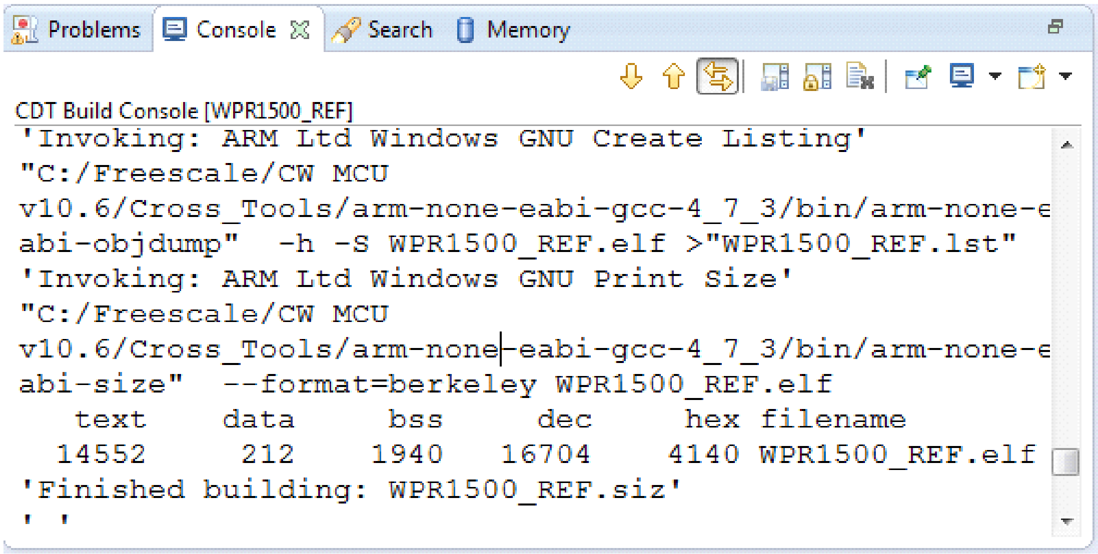

Figure 28. Build the project successfully

3. Select **Debug Configurations** to select debugger setting. Two supported debugger settings are already configured in the project.

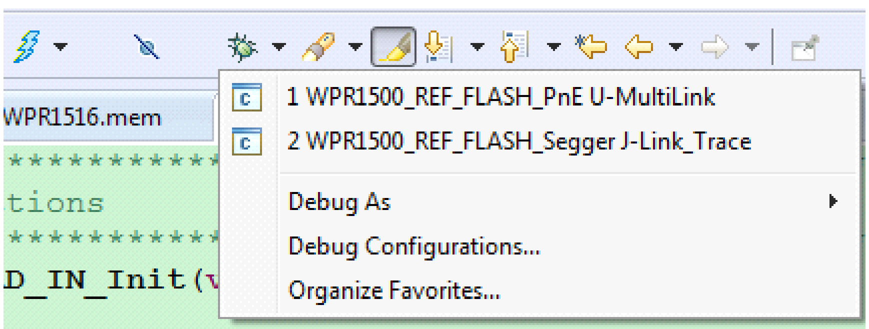

Figure 29. Flash loader configurations

When using the J-Link as the debugger, select **WPR1500_REF_FLASH_Segger Jlink_Trace**. When using the P&E Multilink as the debugger, select **WPR1500_REF_FLASH_PnE U-MultiLink.** If you want to change some parameters, click the **Edit** button in the Target setting subpage. The configuration interface is shown as follows.

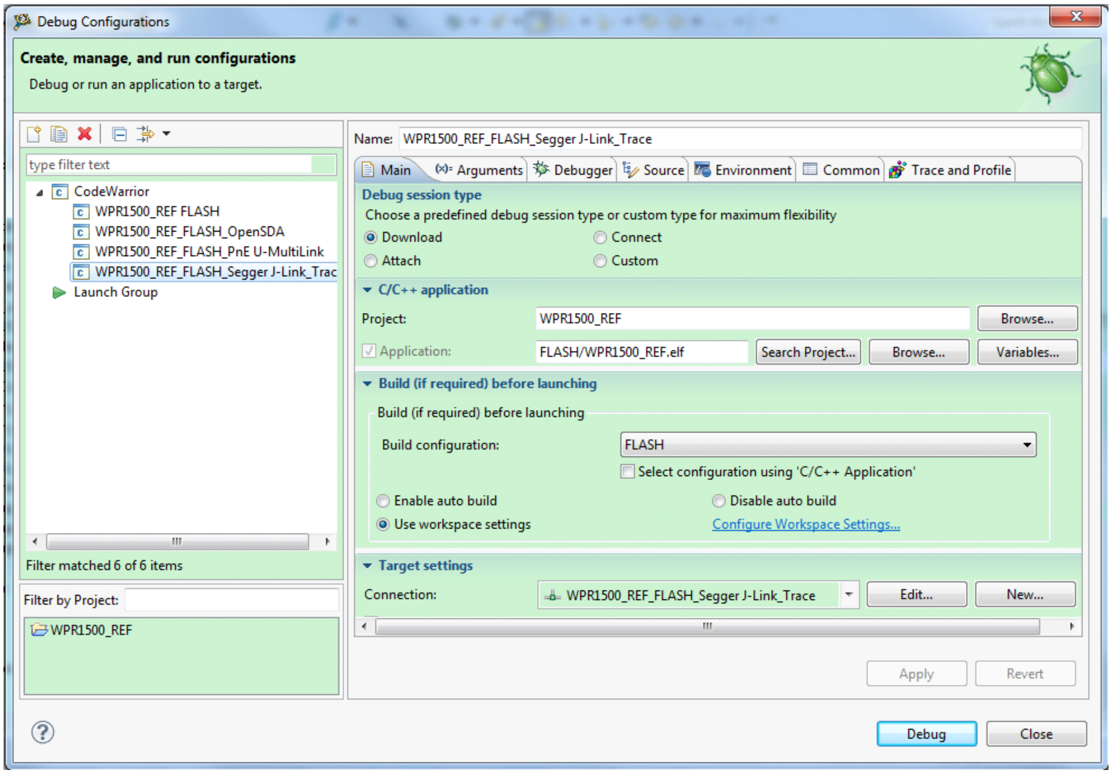

Figure 30. Debug configurations

4. Download and debug the project.

   After the application is built successfully, click the Debug button in the above-mentioned configuration dialog. Then the project code is downloading and the debugger stops executing at the start of the main() function.

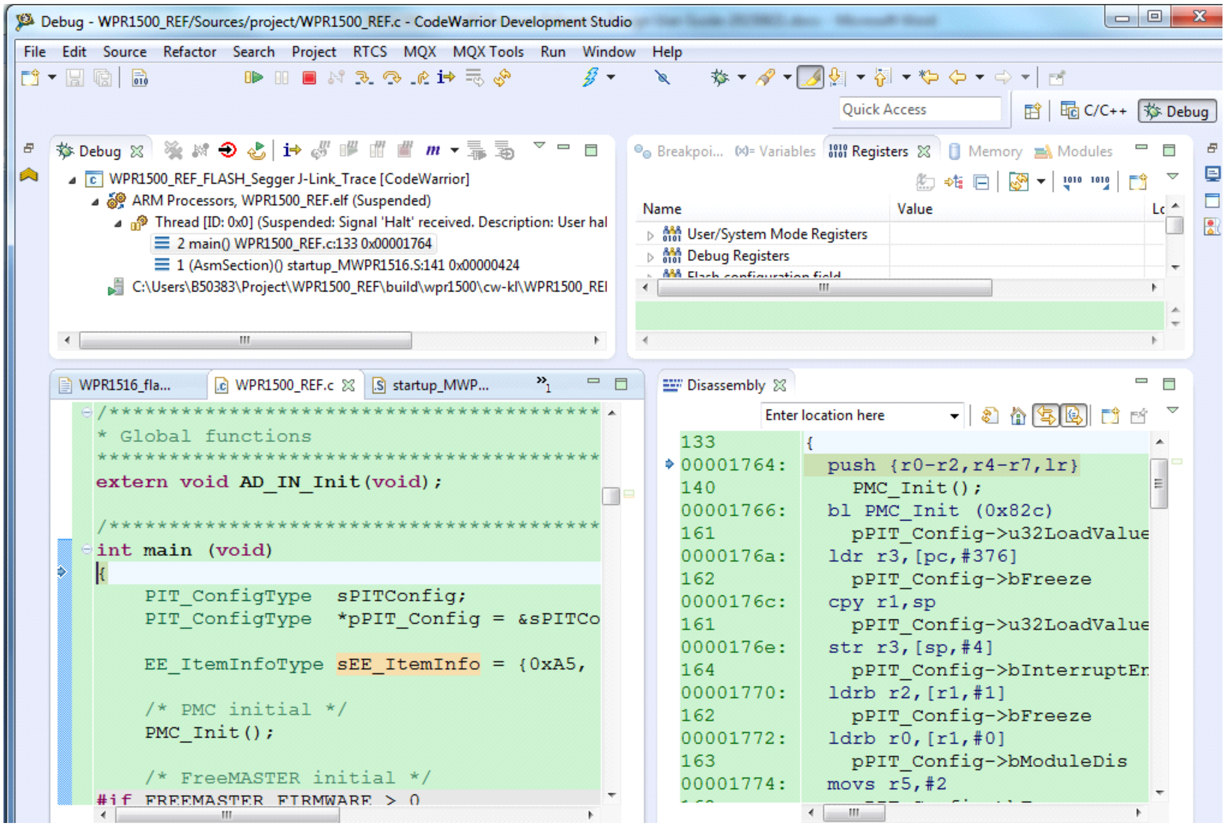

Figure 31. Stop at main() when running debugging

6.3 Debugging the WPR1500 receiver using FreeMASTER

6.3.1 Connecting the debug cable

The FreeMASTER debug connection is shown in Figure 32. Ensure that the jumper J110 is removed before debugging, and then put the receiver on the transmitter panel.

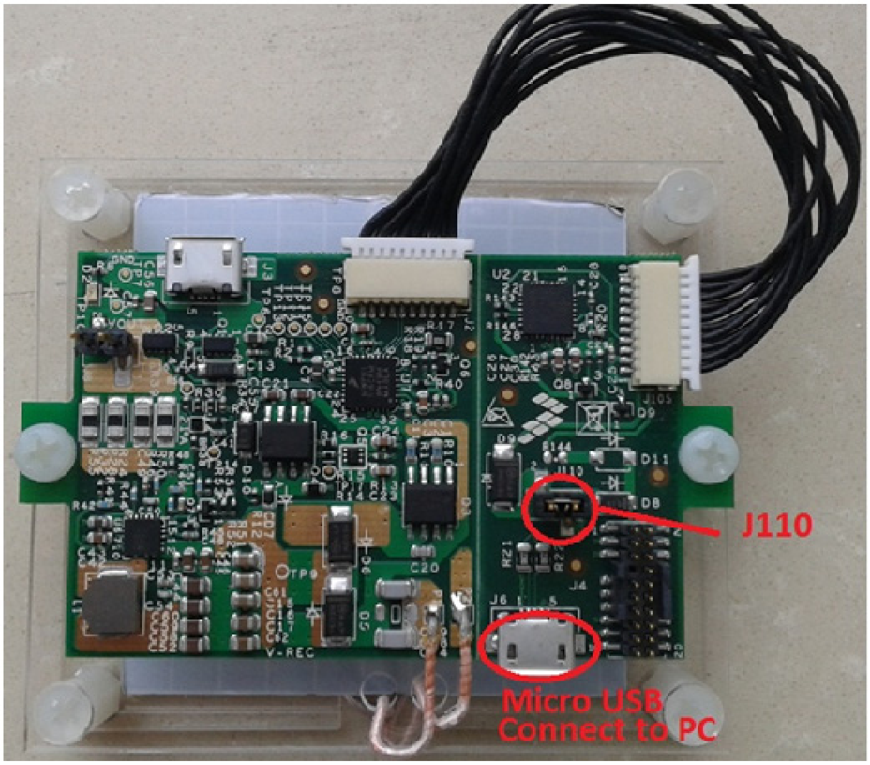

Figure 32. FreeMASTER debug connection

6.3.2 Setting FreeMASTER project options

1. Set the symbol file for your project.

   Select a symbol file from FreeMASTER Project -> Options -> MAP Files, as shown in the following figure. The IAR project is used as an example.

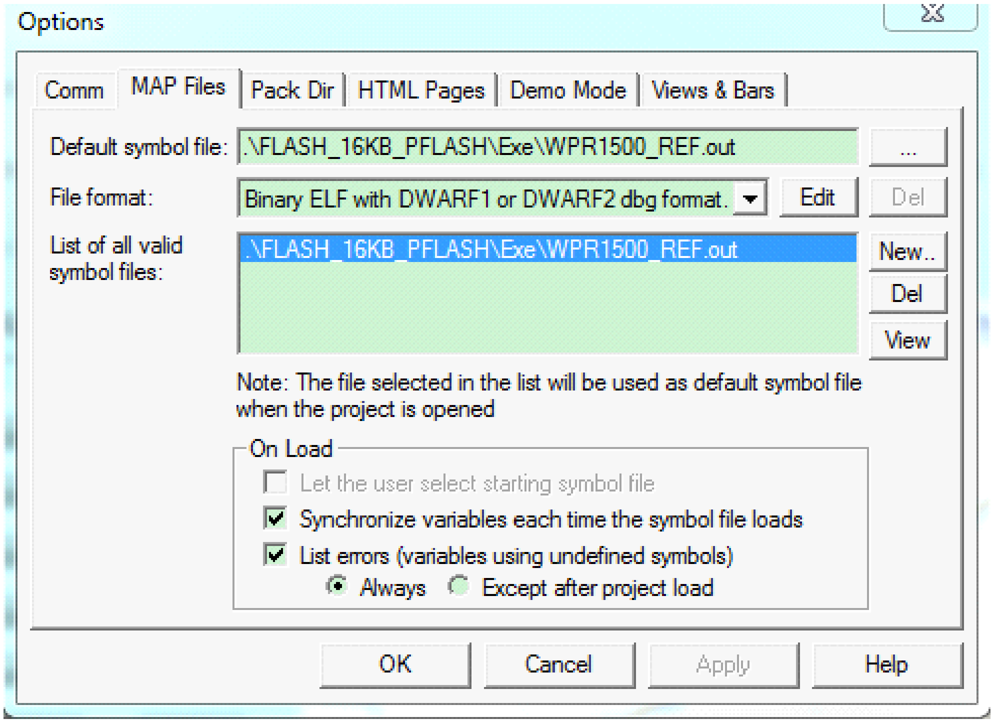

Figure 33. Selecting a symbol file

2. Select a communication interface for FreeMASTER.

   Select **Plug-in Module** in **FreeMASTER Project** -> **Options** -> **Comm**, as shown in the following figure. Then select **FreeMASTER Segger/Jlink Communication Plug-in**.

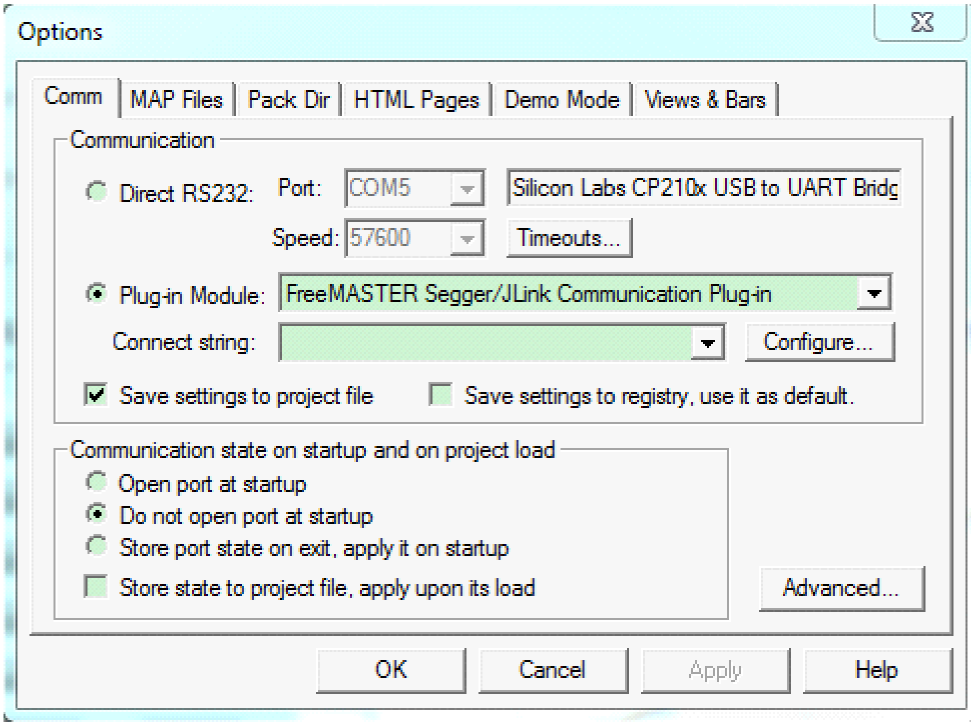

Figure 34. Communication interface setting

6.3.3 Debugging using FreeMASTER

NXP provides the FreeMASTER GUI tool to monitor the system working status. Open WPR1500_REF.pmp with this tool, start up the RX board, and click the red Start/Stop button. For the FreeMASTER tool, visit nxp.com/Freemaster.

The FreeMASTER GUI can be used to monitor the system state and change some parameters manually if necessary. The user can get the system error code through the oscilloscope in the GUI.

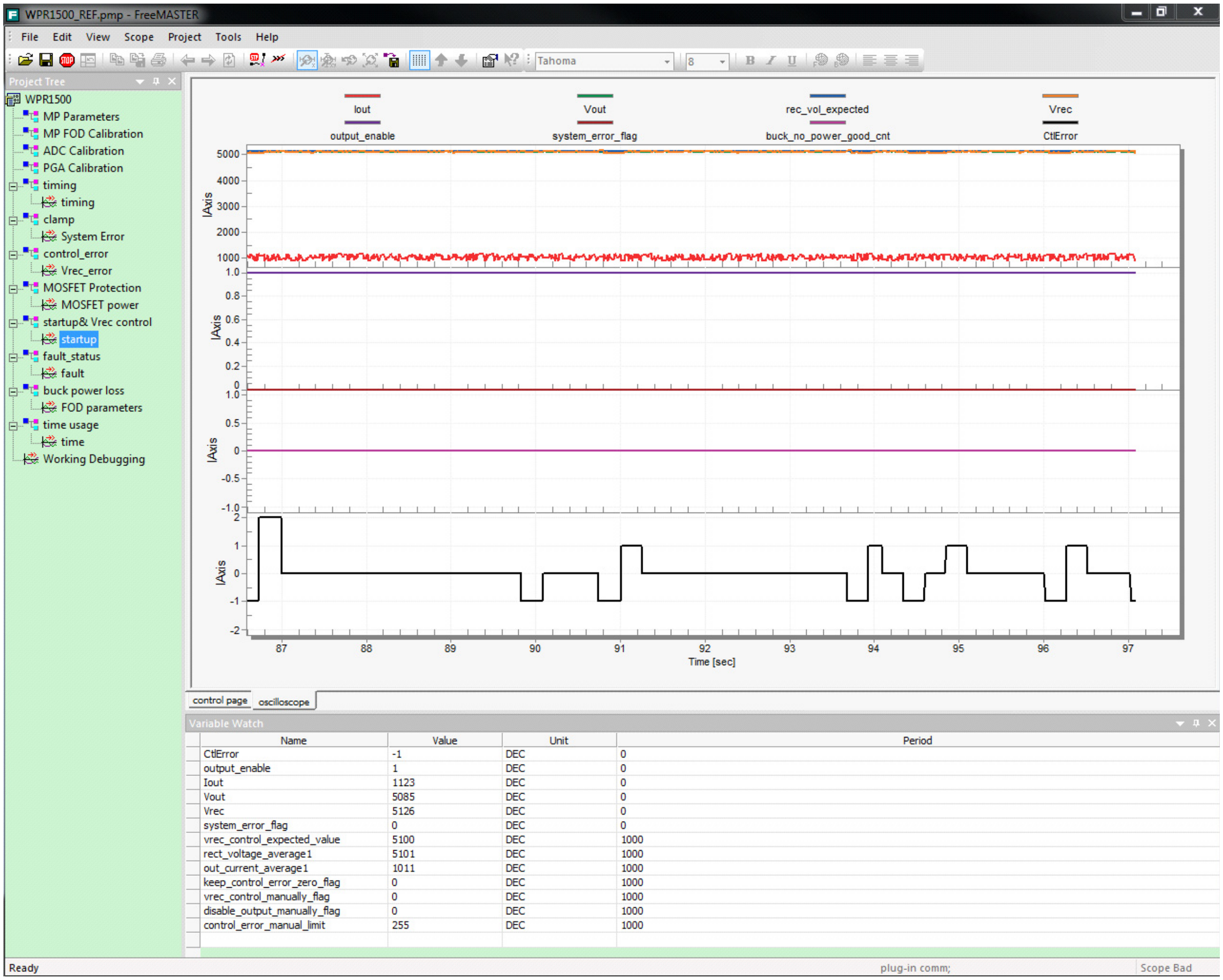

Figure 35. FreeMASTER GUI tool

The control page includes three tabs: Current/PGA Calibration, FOD Calibration, and System Control. The output current calibration function is enabled when the macro ADC_CALIBRATION_FREEMASTER is set to 1.

After getting the calibration result, click the **Store to flash** button to save these parameters in flash. These parameters are used to calibrate the output current every time when the RX board is started. The internal PGA calibration function is disabled by default because of the flash limitation. When this function is enabled, the calibration result can also be saved in flash by default.

The FOD Calibration function can work offline. The user needs to measure some parameters and fulfill them in this page. When calibration is complete, the parameters that can be used in the project code are listed in the bottom area of this page.

The System Control page is used to control the system manually when RX works properly. It can set the expected Vrec voltage, enable or disable output, set the control error packet value, and so on. This function is useful to debug the system in details.

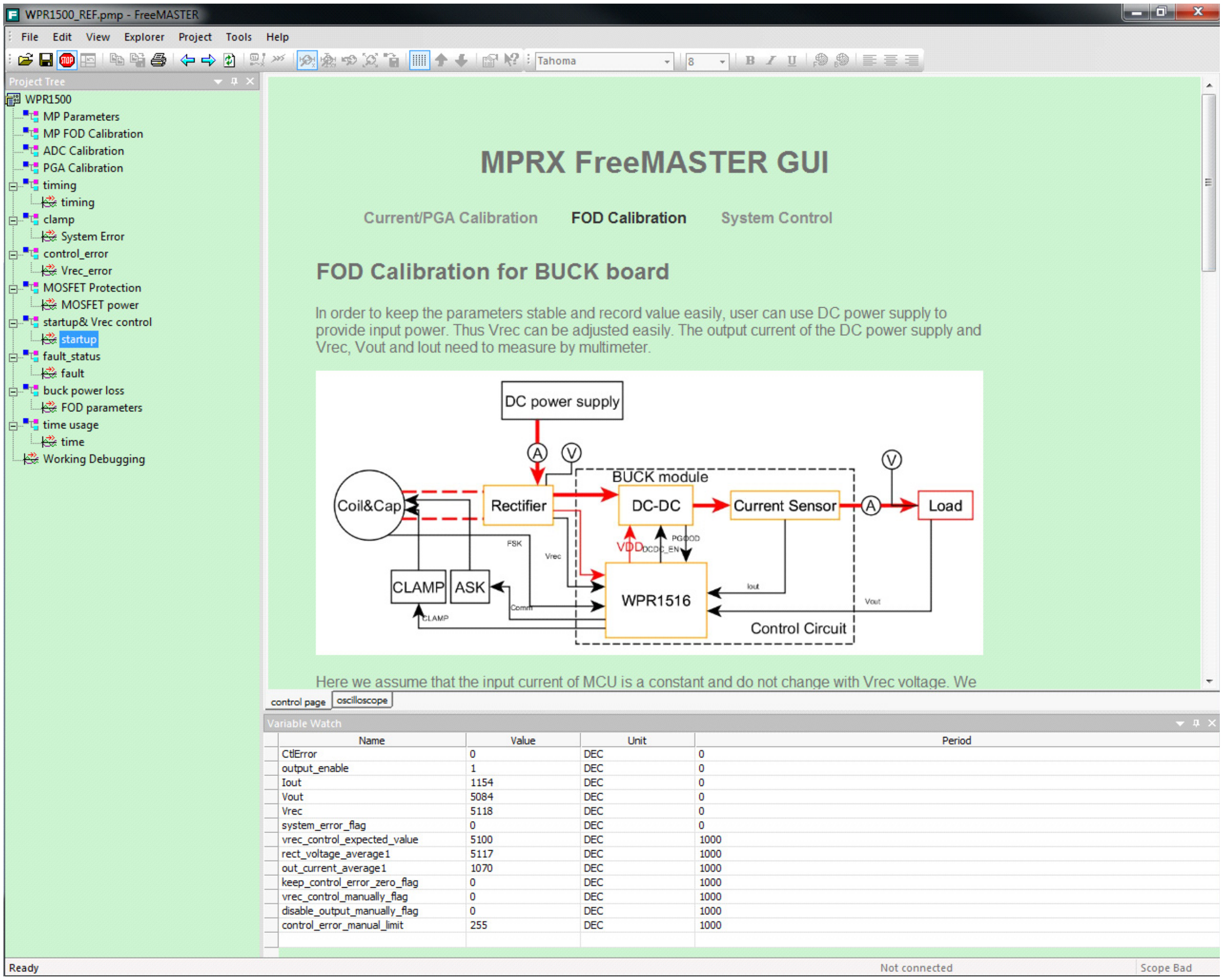

Figure 36. Control page of the FreeMASTER GUI

6.4 Testing

6.4.1 Signals on the board

The main signals on the WPR1500 reference board are shown in Figure 37.

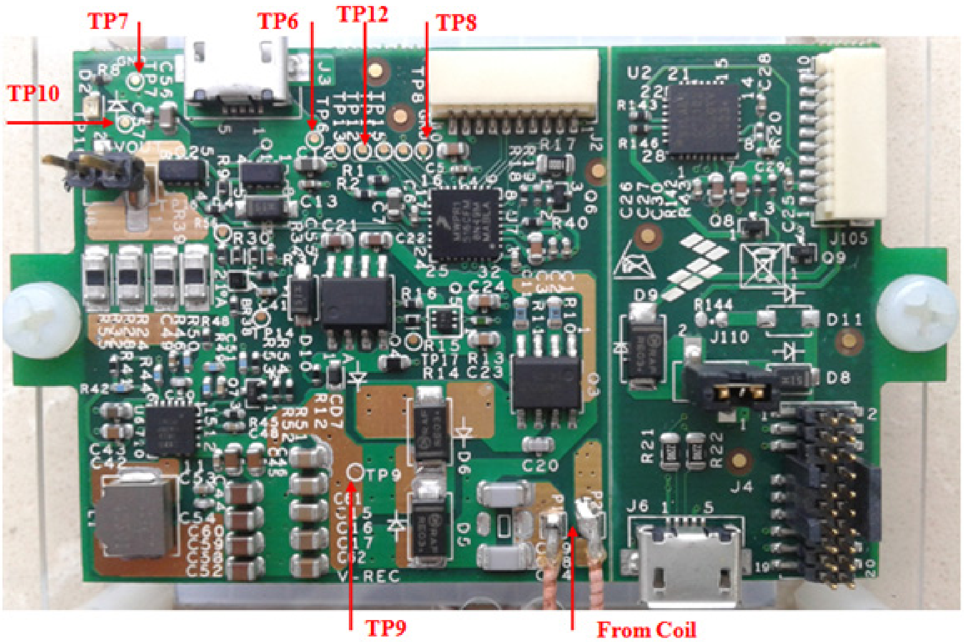

Figure 37. Test points on the WPR1500-BUCK board

Testing points on the WPR1500 BUCK board are as follows:

- TP6: USB input voltage
- TP9: VREC
- TP7 & TP8: GND
- TP12: DC-DC output enable

The following examples show how to measure and debug the board follow.

1. Figure 38 shows the input voltage and communication signal from ping phase to power transfer setup.
   - Channel 1: rectifier DC output voltage VREC
   - Channel 2: coil AC input voltage V_Coil
   - Channel 3: communication signal CTX
   - Channel 4: coil AC input current I_Coil

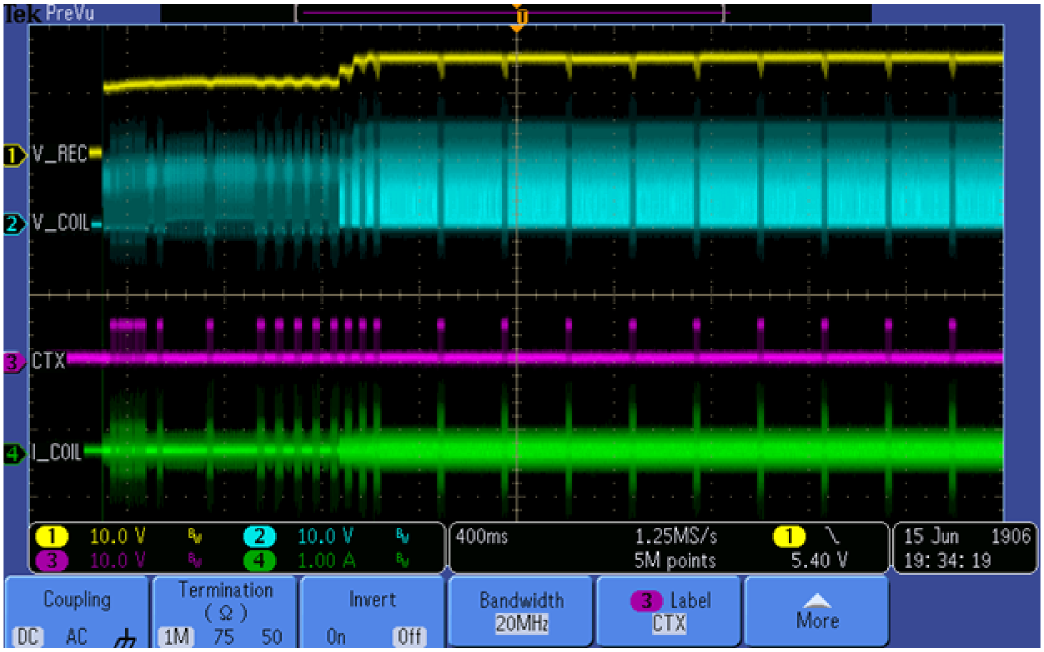

Figure 38. Ping process of the wireless power receiver

2. System response measurement for a 3 A load is shown in Figure 39.

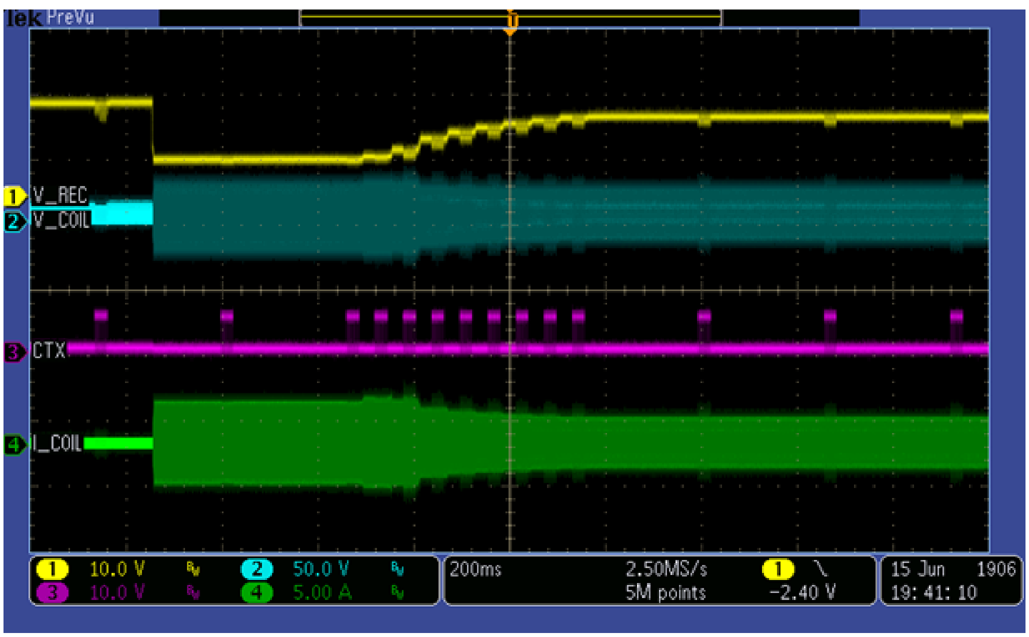

Figure 39. System response for a 3 A load

3. System response measurement for adding the load gradually from 0 A is shown in Figure 40.

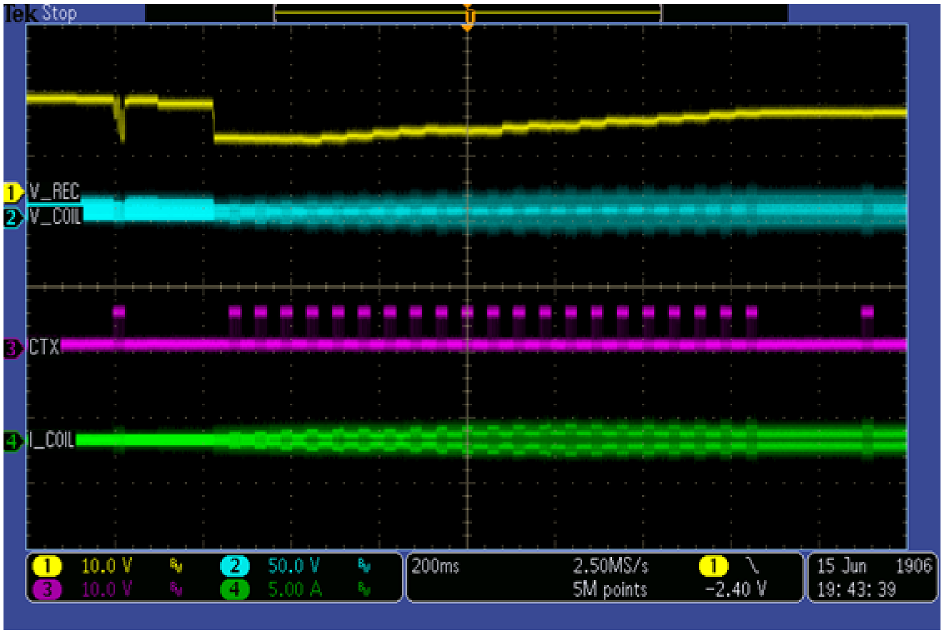

Figure 40. System response for adding loading gradually

4. System response measurement for reducing the load from 3 A to 0 A is shown in Figure 41.

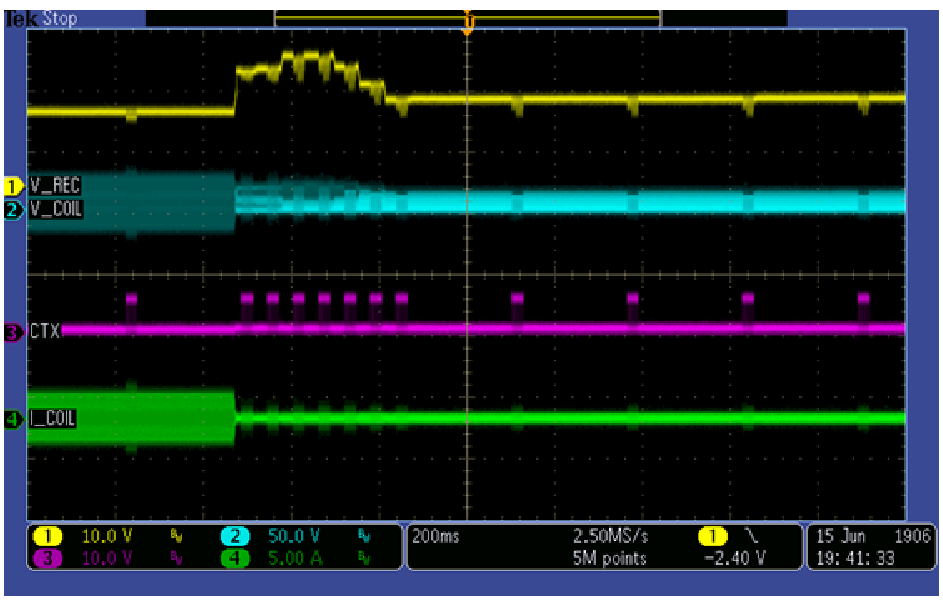

Figure 41. System response for reducing the load from 3 A to 0 A

7 References

- NXP wireless charging solution page:
  nxp.com/wirelesscharging
- NXP FreeMASTER tool page:
  nxp.com/Freemaster
- WPC page:
  www.wirelesspowerconsortium.com

8 Revision History

This table summarizes revisions to this document.

Table 2. Revision history

Revision number	Date	Substantive changes
0	09/2016	Initial release