

Freescale Semiconductor, Inc. User's Guide

Document Number: WPR1500LDOMPUG Rev. 0, 12/2014

WPR1500-LDO MP Receiver Reference Design User's Guide

1 Introduction

This document describes how to use the WPR1500-LDO medium medium powerpower receiver reference board designed by Freescale. It supports 15 W, it is built according to the WPC MPWG specification, and has the capability to support future standards. It is a low-cost reference solution that can be easy customized through the FreeMASTER.



Figure 1. WPR1500 Reference Board – LDO

Contents

1.	Introduction
2.	System features 2
3.	Package checklist 2
4.	System block diagram 2
5.	Hardware description 3
6.	Getting started 4
7.	References 18
8.	Revision history 18



© 2014 Freescale Semiconductor, Inc. All rights reserved.



System features

2 System features

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

- Compliance with the medium power WPC Qi specification
- Input power (3.5 V ~ 20 Vac peak) from the transmitter via the receiver coil
- Output power of 15 W (5 V @ 3 A)
- Support of FSK communication signals from the medium power transmitter
- Hardware protection of rectifier voltage, output voltage and output current
- Small PCB size $(40 \text{ mm} \times 40 \text{ mm})$
- FreeMASTER tool to enable customization and calibration

3 Package checklist

Name	Count
WPR1500-LDO board	1
WPR1500-debug board	1
10-pin SWD debugging cable	1

Table 1. Package checklist

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 – LDO

5.2 Modules explanation



Figure 4. WPR1500-LDO board modules overview



• Controller

The Freescale WPR15xx MCU is the central controller of the WPR1500 receiver board. The chip is a higher integration receiver controller MCU for wireless power transfer application. The WPR15xx is a Cortex[®] M0+ core ASSP with Freescale'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 signals that ease 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:

- LDO provides 5 V and 3 A output to the down system
- 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 a self-driven sync type. It has the following characteristics:

- Input voltage : 3.5 20 V AC peak
- Output voltage: 3.5 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 once the wired power is plugged in, and switches on wired power when the input voltage is in the range of $4.5 \text{ V} \sim 5.5 \text{ V}$.

6 Getting started

6.1 System development environment

The WPR1500 receiver board supports debugging using the IAR and FreeMASTER tools. The set-up of the debug connection is shown in Figure 5. The debugger and the debug board are placed between the PC and the receiver board.

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

In order to monitor the working status of the WPR1500 receiver board, the user must 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 image.





Figure 6. Development environment

For details on the J-Link debugger, please visit freescale.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 in the debug board needs to be connected to the USB to receive power. Please confirm the jumper J110 is connected before the download.

The 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

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

1. Set up the IAR embedded workbench.

The IAR embedded workbench tool is required. Because 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 demo application workspace files are located in:

<project_name>/build/iar/<board_name>/<project_name>.eww</project_name>.eww

2. Build a project.

Click the "Rebuild All" button:



Figure 10. Building a project



NP

When the build is completed, the IAR displays the following information in the build window:

^	Messages	
	Building configuration: WPR1500_REF_frdm - FLASH_16KB_PFLASH Updating build tree adc.c Linking WPR1500_REF_frdm.out Converting	
	Total number of errors: 0 Total number of warnings: 0	
•	m	•
Find	d in Files Build Debug Log Ambiguous Definitions References	×
Ready	Erro	rs 0, Warnings 0

Figure 11. Successfull project build

3. Ensure that the debugger is configured properly in the project options. The flash loader must be selected to support downloading of the binary into the internal flash:

Category:						Factory Settings
Seneral Options Runtime Checking C/C++ Compiler	C-t-m	Download	Iteration	Edge Options	14 Minute	Diversion
Output Converter Custom Build Build Actions Linker Debugger Simulator Angel CMSIS DAP GDB Server IAR ROM-monitor I-jet/JTAGjet J-Link/J-Trace TI Stellaris Macraigor PE micro RDI STJ INK	Arti	ach to runnir nfy download ppress down e flash loade Override det STOOLKIT Edit	ng target d load r(s) fault boar _DIR\$\cc	d file nfig Ylashloader	\Freescale\	Flast

Figure 12. Flash loader configuration



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

le Edit View Pr	oject Tools Window	e Help	
	TY -0 BULLED C	• < > X Z [] D & # # # []	
LASH_10KB_PFLA		adc.c. pris_hat.c WPR1500_REP_Rdm.map WPR1500_REP.c	0
Files	Colegory General Options Runtime Checking C/C++ Complet Assembler Output Conventer Custon Build Build Actions Unker Detacger Simulator Angel Child Agent Simulator Angel Child Server IAR ROH-monther I Statistics Gold Server IAR ROH-monther I Statistics Hansiger Homo Factor Distanger Homo Factor Distanger Homo Factor Distanger Homo Factor Distanger Homo Factor Distanger Homo Factor Distanger Homo Factor Distanger Homo Factor Distanger Homo Factor Homo Factor H		-48; 210002 (2001)
e Contas Pierri Dadel - D	eta co la co Camboo vo a Da	M fotion I Beforences	

Figure 13. Debugger driver configuration – J-Link

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

1	Options for node "WPF	R1500_REF_frdm"
	Options for node "WPF Category: General Options Runtime Checking C/C++ Compiler Assembler Output Converter Custom Build Build Actions Linker Debugger Simulator Angel CMSIS DAP GDB Server IAR ROM-monitor I-jet/JTAGjet J-Link/J-Trace TI Stellaris	E1500_REF_frdm"
•	Macraigor PE micro RDI ST-LINK Third-Party Driver YDS 100/200//CDI	STOOLKIT_DIR\$\CONFIG\debugger\Freescale\MWPR1516.c
Ľ	100100/200/1001	

Figure 14. Debugger driver configuration – PE micro



The USB Multilink must be configured in the PE micro settings:

ategory:			Factory Set	inas	
eneral Options untime Checking C/C++ Compiler Assembler Output Converter	Setup	21	Completion		
Custom Build	LISB Multiliok (EX)	USB			
Linker	Reset delay	Interface	Device 1		
Debugger Simulator Angel CMSIS DAP GDB Server IAR ROM-monitor	JTAG/SWD speed 5000 kHz	 JTAG SWD 	Serial port COM1 * TCP/IP		
I-jet/JTAGjet J-Link/J-Trace TI Stellaris Macraigor	Show settings dialog	10.0.0.1			
PE micro	SPROJ DIRS\cspycomm.log				

Figure 15. Debugger configuration for PE micro

4. Download the project.

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



Figure 16. Download and debug button

Programming of a project is shown in Figure 17.



Figure 17. Programming a project



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



Figure 18. Stop at main() when run debugging

6.3 Debugging the WPR1500 receiver with FreeMASTER

6.3.1 Connecting the debug cable

The FreeMASTER debug connection is shown in Figure 19. User must confirm the jumper J110 is removed before debugging, then put the receiver on the transmitter panel.



Figure 19. FreeMASTER debug connection WPR1500-LDO MP Receiver Reference Design User's Guide, Rev. 0, 12/2014





6.3.2 Using FreeMASTER

Freescale provides the FreeMASTER GUI tool for system status monitoring. The WPR1500_REF.pmp must be used. For the FreeMASTER tool, visit freescale.com/Freemaster.



Figure 20. FreeMASTER tool GUI

WPR1500_REF - FreeMASTER				
Eile Edit View Explorer Project Tools	Help			
: 🖆 🖬 😊 🖂 🐘 🐏 🗇 😫 😫	있 🖉 👧 🏚 🛱 👔 🏚 🔸 🛛	😭 🎼 Tahoma	- 8	• B I 🛛 👂 👂 🔳
Image: Second	Please specify the URL of • Show me where can algorithm block description Variable Watch Variable Watch variable Watch variable Watch g. systemCtriphase g. sy	the document of I do it Power Transfer Hiddle Power 0 0x11 15 15 0x28 15 2 0	enum Unit ENUM ENUM DEC HEX W HEX W HEX W DEC DEC	e item currently selecter

Figure 21. Medium power receiver parameters



6.3.2.1 How to set up the FreeMASTER connection to the target board

1. Set a symbol file for your project.

Select the symbol file in FreeMASTER by navigating to Project -> Options -> MAP Files, as shown in Figure 22.

Options	×
Comm MAP Files Pack Dir HTML Pages Demo Mode Views & Bars	
Default symbol file: \.FLASH_16KB_PFLASH\Exe\WPR1500_REF_frdm.out	
Elle format: Binary ELF with DWARF1 or DWARF2 dbg format.	Dej
List of all valid symbol files:	<u>V</u> ew Del View
Note: The file selected in the list will be used as default symbol file when the project is opened	
On Load □ Let the user select starting symbol file □ Synchronize variables each time the symbol file loads □ List errors (variables using undefined symbols) □ Always ○ Except after project load	
OK Cancel Apply He	elp

Figure 22. Selecting a symbol file

2. Adjust the settings for using FreeMASTER.

Select "Direct RS232" in FreeMASTER by navigating to Project -> Options -> Comm, as shown in Figure 23.

Options 📃				
Comm MAP Files Pack Dir HTML Pages Demo Mode Views & Bars Communication Communication C				
Speed: 57600 Timeouts				
O Plug-in Module:				
Configure				
☐ Save settings to project file				
Communication state on startup and on project load				
Open port at startup Open port at startup				
C Store port state on exit, apply it on startup				
Store state to project file, apply upon its load Advanced				
OK Cancel Apply Help				

Figure 23. Options dialog box





6.4 Testing

6.4.1 Signals on the board

The main signals on the WPR1500 reference board are shown in Figure 24.



Figure 24. Test points on the WPR1500-LDO board

Testing points on the WPR1500 LDO board are as follows:

- TP106: USB input voltage
- TP109: VREC
- TP107 & TP108: GND
- TP111: Drive voltage of the LDO MOSFET

Several examples to show how to measure and debug the board follow.

- 1. Figure 25 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 25. Ping process of the wireless power receiver

2. System response measurement for a 3 A load is shown in Figure 26.



Figure 26. System response for a 3 A load



3. System response measurement for increasing the load gradually from 0 A is shown in Figure 27.



Figure 27. System response for adding the load gradually

4. System response measurement for reducing the load gradually to 0 A is shown in Figure 28.



Figure 28. System response for reducing the load gradually to 0 A



References

7 References

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

8 Revision history

Table 2. Revision history

Rev. number	Date	Substantive change(s)
0	12/2014	Initial release



Revision history



How to Reach Us:

Home Page: freescale.com

Web Support: freescale.com/support Information in this document is provided solely to enable system and software implementers to use Freescale products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits based on the information in this document.

Freescale reserves the right to make changes without further notice to any products herein. Freescale makes no warranty, representation, or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale data sheets and/or specifications can and do vary in different applications, and actual performance may vary over time. All operating parameters, including "typicals," must be validated for each customer application by customer's technical experts. Freescale does not convey any license under its patent rights nor the rights of others. Freescale sells products pursuant to standard terms and conditions of sale, which can be found at the following address: freescale.com/SalesTermsandConditions.

Freescale and the Freescale logo are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off. Cortex is the registered trademark of ARM Limited. All other product or service names are the property of their respective owners. © 2014 Freescale Semiconductor, Inc.

Document Number: WPR1500LDOMPUG Rev. 0 12/2014

