User Guide for the HR1200 I²C Kit and GUI

Application Note

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ABSTRACT

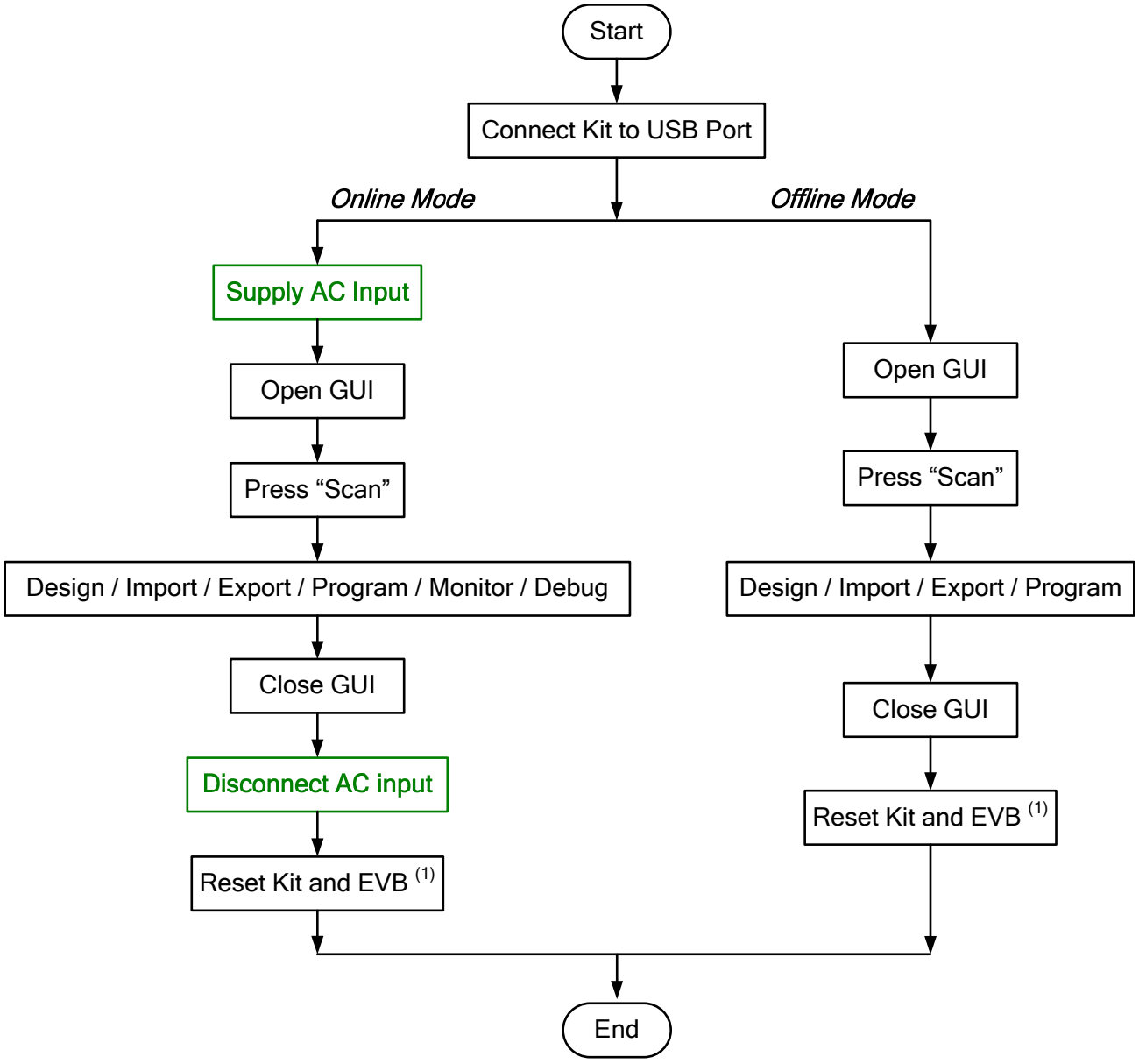
This user guide contains guidelines to configure the electrical parameters and program the HR1200. This guide also provides step-by-step instructions on how to use the GUI and I²C Kit.

QUICK START GUIDE

Preconditions

1) Ensure that the PCB layout of the IC meets our requirements detailed in the AN102 application note, “HR1200 High Performance PFC+LLC Controller”.
2) Connect the pins of the Kit correctly to the corresponding pins of the IC in the EVB.

Operation Sequence



NOTE:

1) **Reset Kit:** Ensure that VCC of the Kit is fully discharged below 2V. The discharge time may vary with different application designs.
   Reset EVB: Offline mode: Ensure that VCC of the EVB is fully discharged.
   Online mode: Ensure that VCC of the EVB is fully discharged and the bus bulk capacitor is discharged below 10V.

TABLE OF CONTENTS

1. INTRODUCTION

The HR1200 integrates a digital PFC controller and an analog LLC controller into a single chip. Under different input and output conditions, the digital PFC enables customers to optimize PFC performance through programming.

There are 1k bytes of EEPROM available. All design parameters can be written into the chip through the I²C interface and GUI.

2. I²C FUNCTION OF THE HR1200

The I²C function is workable under two conditions:

1) The IC is in normal operation and no protection has been triggered, particularly under-voltage lockout (UVLO) and X-cap discharge, which can affect the programming.
2) The IC enters a dedicated test mode when given a pre-determined pulse group on BURST.

Figure 1 shows the HR1200 pins. Pins required for the I²C function are indicated in the red dotted boxes. For programming, RES and CSP should be connected to GNDD through a 20kΩ resistor. V3.3 should be connected to GNDS through a 4.7 ~ 10μF decoupling ceramic capacitor. GNDS should be connected with GNDD. For BURST, considering the pull-down resistor in the Kit, the HR1200 BURST capacitor should be selected carefully to guarantee a full discharge within 100μs.

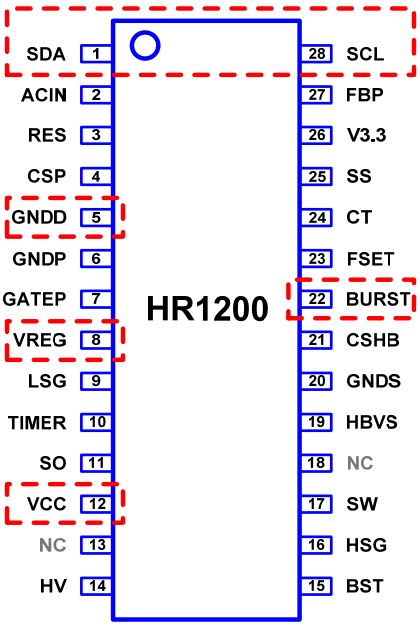


Figure 1: Pins of the HR1200

3. I²C KIT

The Kit has six output signals (see Figure 2). GND is the ground reference. SCL and SDA are standard I²C communication pins. VCC and VREG are power supply pins. BURST is the mode control pin. Kit pins should be connected to the IC pins in the EVB accordingly.

The computer's USB port can provide the Kit with 5V DC voltage. Once the Kit connects successfully with both the USB port and EVB, it can operate in two different modes by detecting the VCC voltage.

- **Online Mode:** If the Kit detects that VCC is higher than 8V when it is hooked up, it will provide power to VCC only.
- **Offline Mode:** If the Kit detects that VCC is lower than 8V when it is hooked up, it will provide power to VCC, VREG, and send a pre-determined signal to BURST.

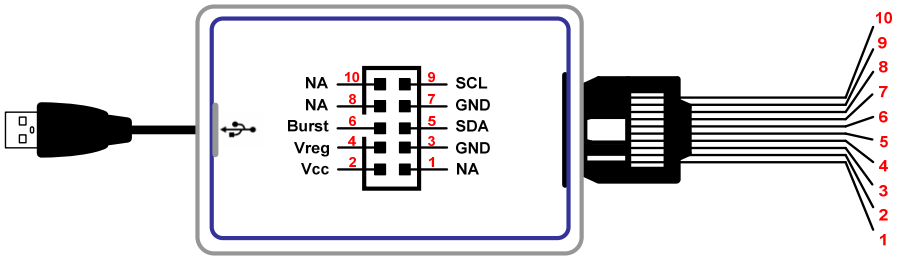


Figure 2: Pins of I²C Kit

When starting up for the first time, it is recommended to program the Kit in offline mode. If the chip is pre-programmed, this step can be skipped. When programming is finished, remember to close the GUI and exit the program. To reset the Kit and EVB, disconnect the Kit from the USB port to fully discharge VCC.

To monitor the input and output of the PFC stage or achieve real-time programming, it is recommended to run in online mode. For standby power, no load or light load evaluations, it is not recommended to keep the Kit connected to the board, as the current consumption of the IC will be influenced.

4. USB ISOLATOR

Since the HR1200 is a primary-side controller, its reference ground is coupled to the AC line (point A). Through the Kit, point A is connected to the USB reference ground of the computer (point B, the negative side of 5V DC voltage). If the USB reference ground connects with earth ground, there is a short-circuit path from the line or neutral to earth ground, as shown in Figure 3 with the red dotted line. Components along the path such as the rectifier bridge and the USB port are at risk of being damaged. To avoid this, a USB isolator is needed between the I²C Kit and computer USB port.

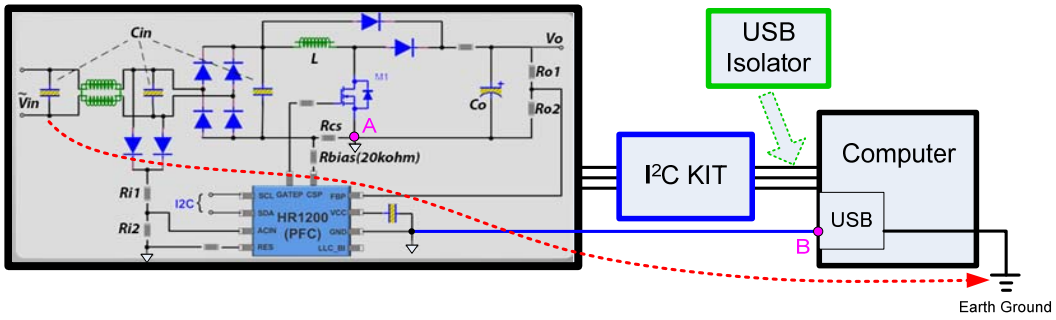


Figure 3: Short-Circuit Risk

5. I²C INTERFACE AND PROTOCOLS

Aside from the reference ground, the standard I²C/PMBus interface consists of SCL and SDA lines. For multiple I²C devices, both masters and slaves can be connected to the I²C bus (see Figure 4).

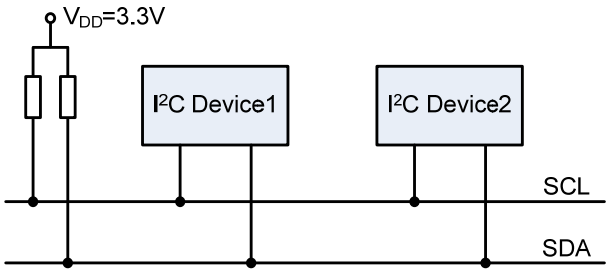


Figure 4: Standard I²C Bus Connection

Figure 5 shows various I²C/PMBus protocols supported by the HR1200 under different conditions. The relevant USB driver should be installed in advance. Refer to Appendix A for installation instructions.

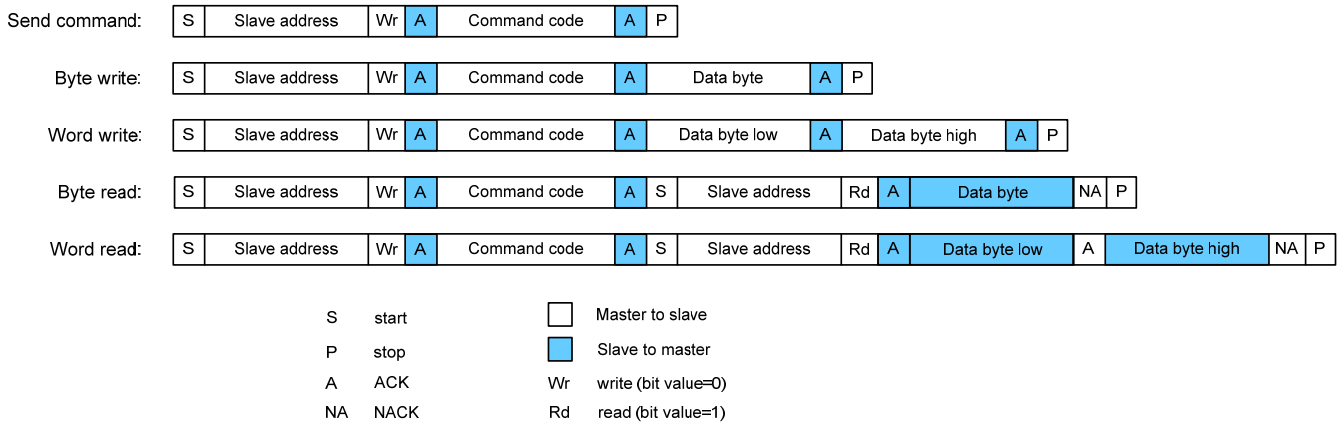


Figure 5: HR1200 I²C Protocols

6. STEP-BY-STEP GUIDE FOR OFFLINE PROGRAMMING

Step 1: Connect the Kit to the computer USB port.

Step 2: Connect the Kit with the EVB after the Kit is recognized by the computer (see Figure 6).

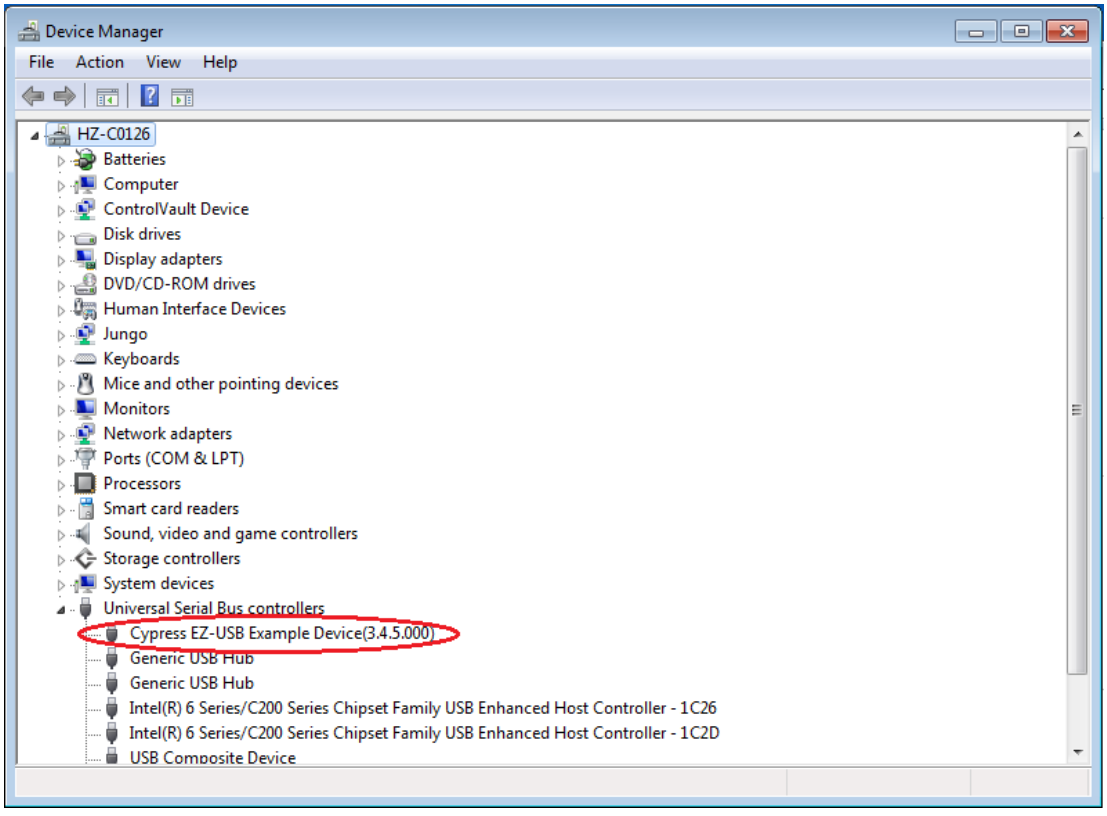


Figure 6: Kit Recognized by Computer

Step 3: Load the GUI folder and double click “HR1200” to start up the GUI (see Figure 7). Then the interface shown in Figure 8 appears.

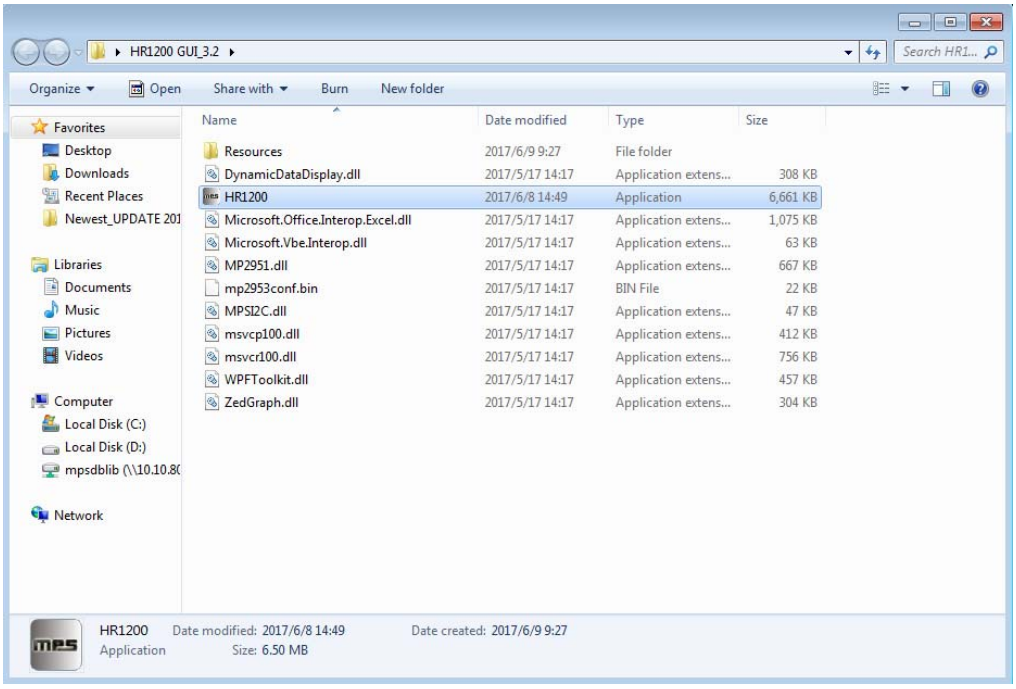


Figure 7: GUI Start-Up

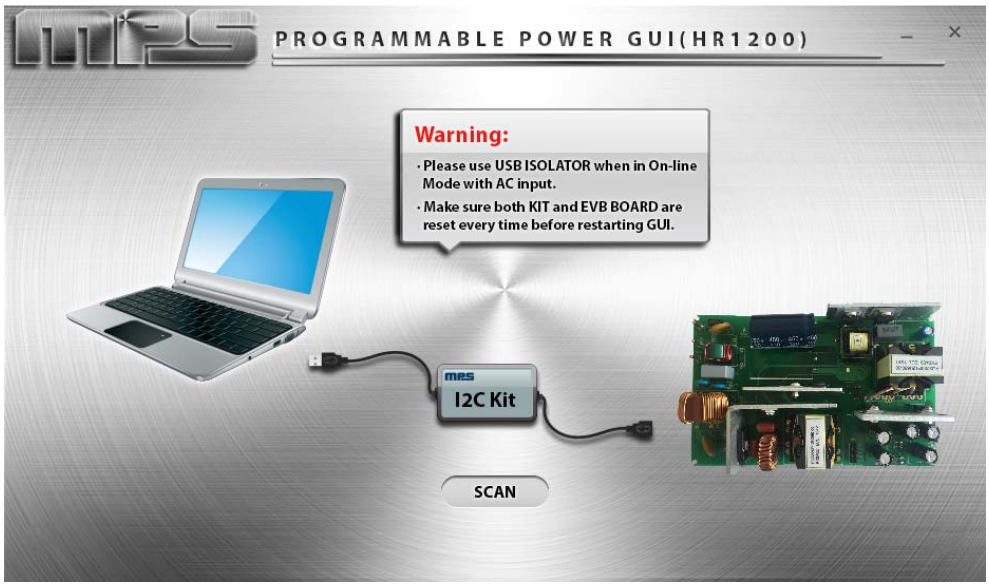


Figure 8: GUI Start-Up Interface

Step 4: Press “SCAN”. The Kit performs the following actions automatically.

A. Connection Check

- If there is something wrong with the connection between the Kit and USB port, the prompt box shows: “Please connect I2C Kit to USB port correctly.”
- If there is something wrong with the connection between the Kit and EVB, the prompt box shows: “Please check whether Kit connects to EVB correctly.”
- If the Kit connects successfully with both the USB port and EVB, then the Kit proceeds to Mode Recognition.

B. Mode Recognition: In this case, VCC is below 8V, and the IC enters offline mode (see Figure 9). Fixed VCC, VREG, and pre-determined BURST values are sent to the EVB.

Warning:

- *DO NOT CONNECT THE AC INPUT in offline mode.*
- *RESET THE KIT AND EVB every time before restarting the GUI. Detach the Kit from USB port and make sure VCC of both the Kit and EVB is fully discharged before making the connection again.*

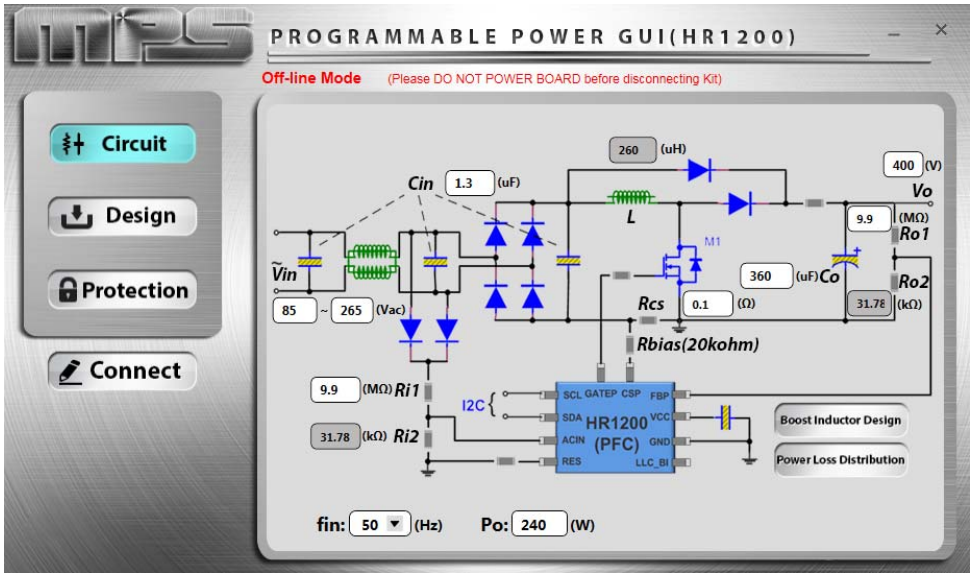


Figure 9: Main Interface in Offline Mode

Step 5: Configure the parameters of the digital PFC part of the HR1200 by selecting various menu items on the GUI interface (see the below list). Personal design parameters can also be imported.

A. Circuit Panel

This panel configures EVB inputs, outputs, and several key design parameters (see Figure 9).

Table 1 explains the circuit panel parameters. Po, Rcs, and Co must be consistent with the actual circuit. They also affect the bode plots of the power stage in "Loop Design" panel.

Table 1: Circuit Panel Parameters

Item	Unit	Description	Range
Vin_min	V_{AC}	Minimum input voltage	0 ~ 305
Vin_max	V_{AC}	Maximum input voltage	0 ~ 305
fin	Hz	Input voltage frequency	50/60
Cin	μF	Total input capacitance	
Ri1, Ri2		Divider resistor to sense input voltage	Ratio is fixed at 0.0032
L	μH	PFC inductor	
Vo	V	Output voltage	0 ~ 500
Po	W	Rated output power	
Co	μF	Output capacitance	
Ro1, Ro2		Divider resistor to sense output voltage	Ratio is fixed at 0.0032
Rcs	Ω	Current sense resistor	

Po and Rcs determine V_{COMP_MAX}. Since V_{COMP_MAX} is also limited internally by the chip, the larger Po is, the smaller Rcs should be. See Equation (1):

$$V_{COMP\_MAX}(digital) = 1.6 \times 0.5 \times Po \times Rcs \times 0.0032 \times \left(\frac{2^{ADC\ bit\ number} - 1}{V_{ADC\_ref}} \right)^2 \times 256 \quad (1)$$

B. Design Panel, Basic

This panel controls the working state of the PFC and LLC separately and configures some basic parameters (see Figure 10). Table 2 explains the parameters of this panel. The difference between *LLC Enable Voltage* and *LLC Disable Voltage* affects the hold-up time of the converter. The input voltage is divided into four ranges by *vin level 1*, *vin level high/low,* and *vin level 2*.

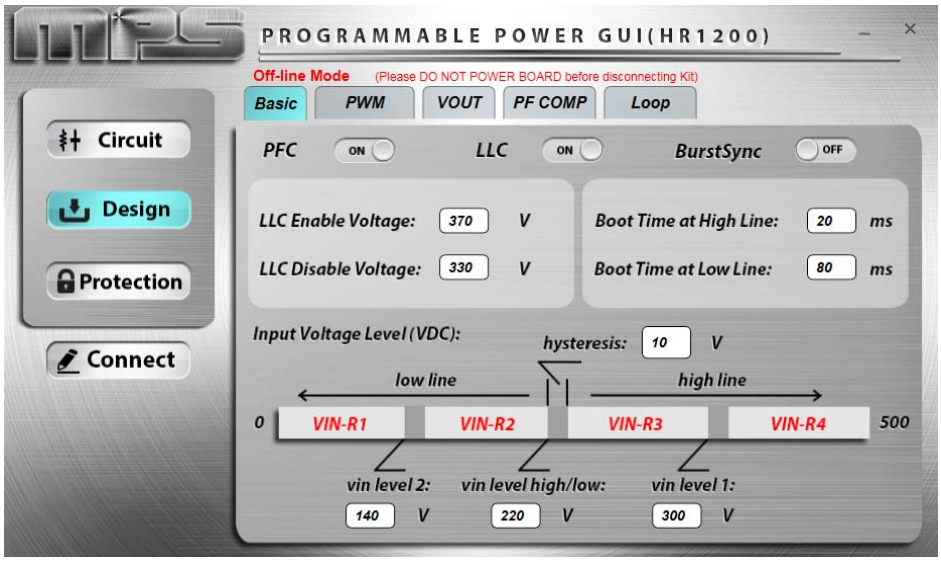


Figure 10: Basic Design Panel

Table 2: Basic Design Panel Parameters

Item	Unit	Description	Range
PFC		Power on the system	ON/OFF
LLC		Enable or disable the LLC part	ON/OFF
Burst Sync		PFC and LLC with same burst frequency	ON/OFF
LLC Enable Voltage	V	Threshold to turn on LLC. LLC is turned on if the PFC output voltage is larger.	0 ~ 430
LLC Disable Voltage	V	Threshold to turn off LLC. LLC is turned off if the PFC output voltage is less.	Less than LLC Enable Voltage
hysteresis	V	Input voltage level hysteresis	0 ~ 30
vin level 2	V	VIN-R2: vin level 2 + hys < Vin < vin level high/low VIN-R1: Vin < vin level 2	0 ~ 430
vin level high/low	V	High line: Vin > vin level high/low + hys Low line: Vin < vin level high/low	0 ~ 430
vin level 1	V	VIN-R4: Vin > vin level 1 + hys VIN-R3: vin level high/low + hys < Vin < vin level 1	0 ~ 430
Boot Time at High Line	ms	Soft-start time of the PFC at high-line voltage	
Boot Time at Low Line	ms	Soft-start time of the PFC at low-line voltage	

C. Design Panel, PWM

This panel configures parameters related to the PWM switching of the PFC (see Figure 11). Specific parameter descriptions are shown in Table 3.

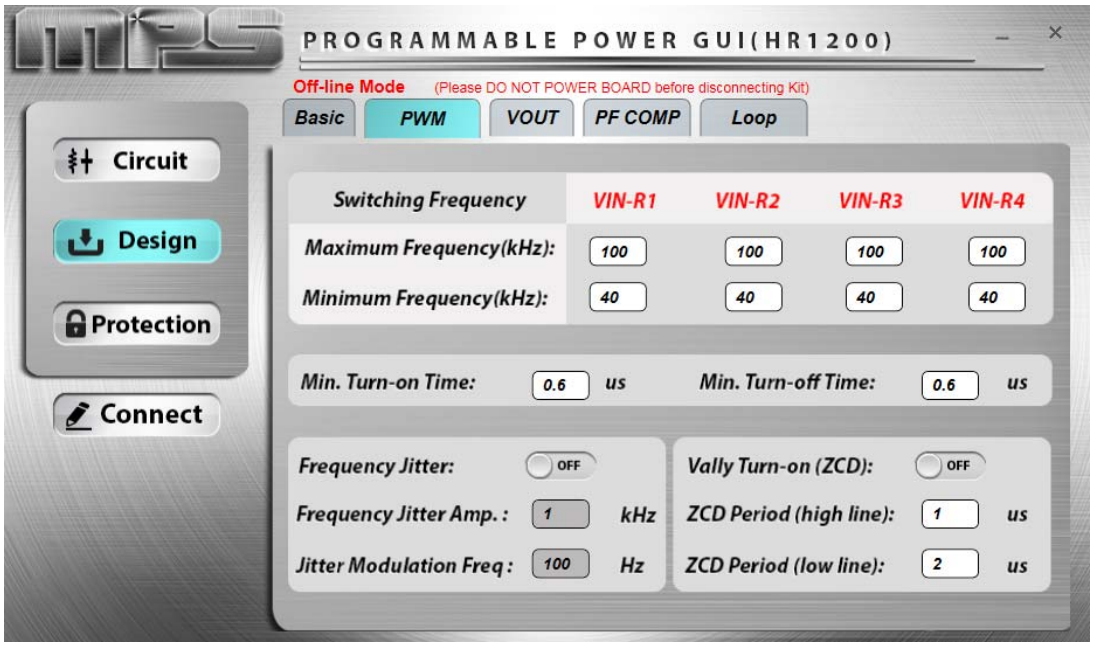


Figure 11: PWM Design Panel

Table 3: PWM Design Panel Parameters

Item	Unit	Description	Range
Maximum Frequency	kHz	Set different maximum switching frequencies according to different input ranges	40 ~ 160
Minimum Frequency	kHz	Set different minimum switching frequencies according to different input ranges	20 ~ 160
Min. Turn-On Time	μs	Minimum turn-on time of the PFC MOSFET	0 ~ 1.5
Min. Turn-Off Time	μs	Minimum turn-off time of the PFC MOSFET	0 ~ 1.5
Frequency Jitter		Enable or disable frequency jitter function	ON/OFF
Frequency Jitter Amp (2)	kHz	Amplitude of frequency jitter	0 ~ 100
Jitter Modulation Freq (2)	Hz	Modulation frequency of frequency jitter	100 ~ 4000
Valley Turn-On (ZCD)		Valley turn-on or turn-off in DCM	ON/OFF
ZCD Period (high line) (3)	μs	Average resonant period of MOSFET V_{DS} at high line in DCM	0 ~ 6
ZCD Period (low line) (3)	μs	Average resonant period of MOSFET V_{DS} at low line in DCM	0 ~ 6

NOTES:

2) *Frequency Jitter Amp* and *Jitter Modulation Freq* can only be changed online when *Frequency Jitter* is enabled.

3) To achieve zero-voltage switching (ZVS) in discontinuous conduction mode (DCM), *ZCD Period* must be measured manually before it can be filled in.

D. Design Panel, VOUT

This panel can configure the PFC output voltage according to different input ranges and output power to optimize efficiency.

When *Adaptive Output Voltage* is enabled, there are eight adjustable PFC output voltages. When *Adaptive Output Voltage* is disabled, the PFC output voltage only can be set according to the high-line or low-line input (see red box in Figure 12).

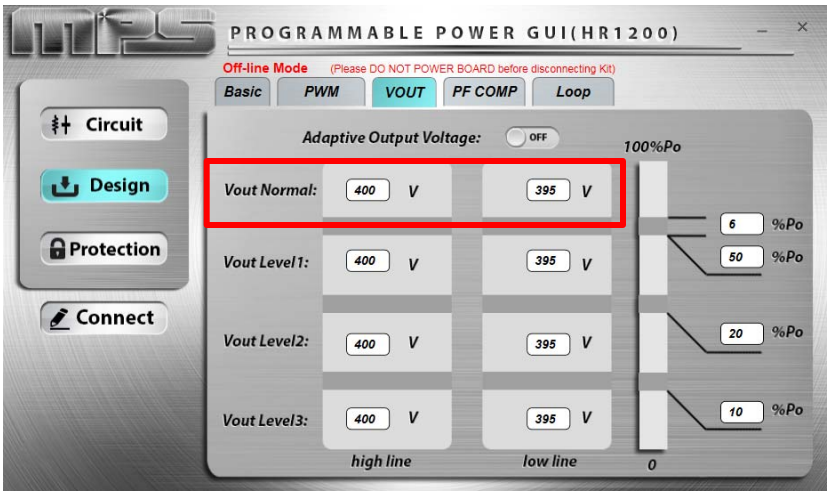


Figure 12: VOUT Design Panel

E. Design Panel, PF COMP

This panel configures the PF compensation parameters, which can improve the power factor (PF) of the PFC stage. Compensation can be controlled in different degrees according to different input ranges (see Figure 13). Five factors influence the compensation degree: Cin and Rcs in “Circuit” panel, *Input Voltage*, *Input Frequency*, and *Cap Compensation*.

For example, the compensation amplitude of input current reference in VIN-R1 can be calculated with Equation (2):

$$I_{REF\_COMP1} = \frac{\pi^3}{4} \times \sqrt{2} \times PF\_Vin1 \times \frac{PF\_Cap1}{100} \times \frac{Cin}{1000000} \times PF\_fin1 \times Rcs \times \frac{2^{ADC\ bit\ number} - 1}{V_{ADC\_ref}} \quad (2)$$

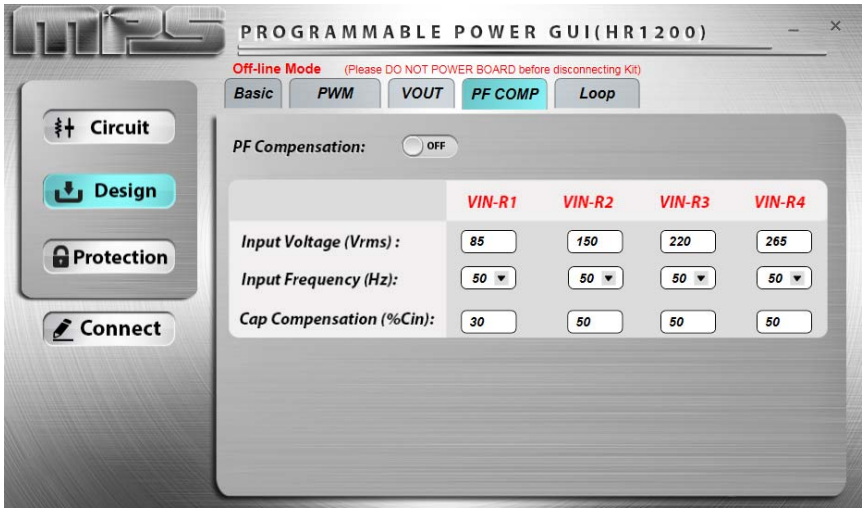


Figure 13: PF COMP Design Panel

F. Design Panel, Loop

This panel can determine the load point to enter burst mode by configuring *Burst Mode Load*. Additionally, Kp and Ki of the closed-loop control can be set. Figure 14 shows the voltage closed-loop control block diagram.

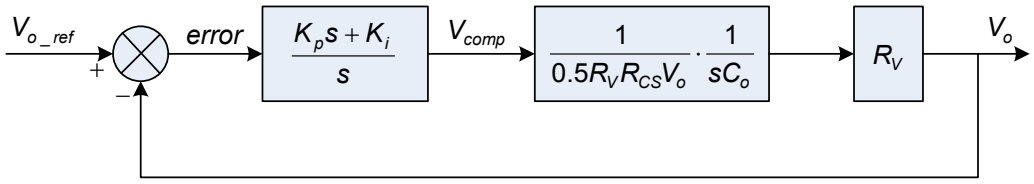


Figure 14: Voltage Closed-Loop Control

If *Setup Mode* is set as “Auto”, Kp and Ki are kept as defaults.

If *Setup Mode* is set as “Manual”, Kp and Ki can be changed. The related bode plots are shown to help check gain and phase margin of the loop (see Figure 15).

During load dynamics, if the PFC output voltage decreases from Vset to Vset minus *FastLoop Voltage*, the internal Ki and Kp increase *FastLoop Gain* times. In this way, the PFC has a very fast loop gain, allowing it to reach the target value faster.

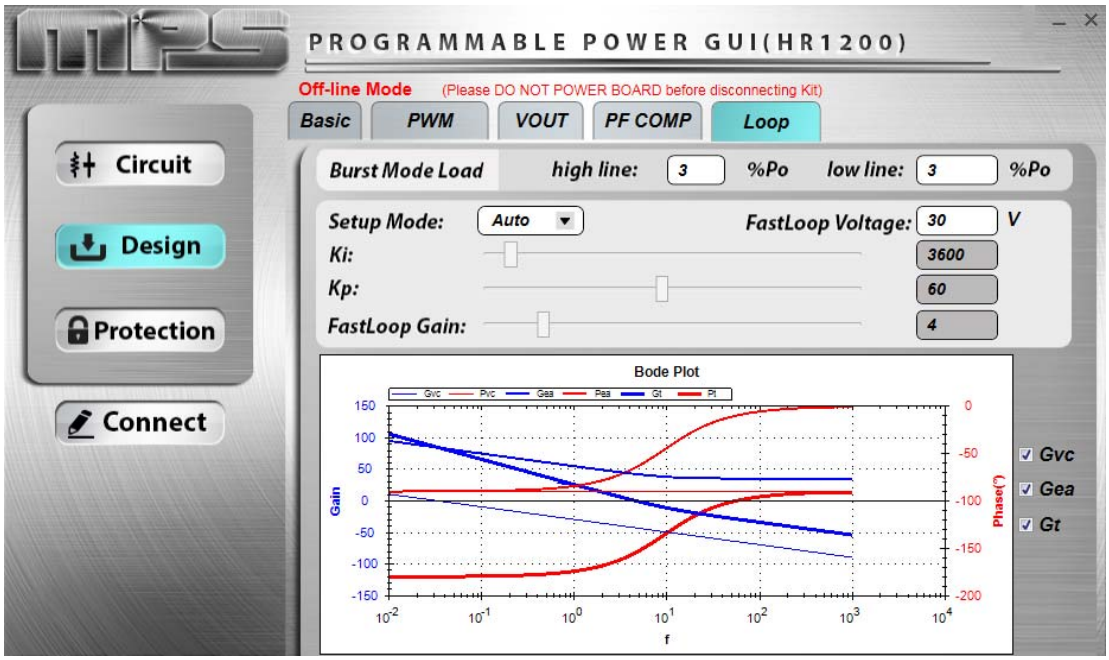


Figure 15: Loop Design Panel

G. Protection Panel

This panel configures the AC brown-in/brown-out voltage and several protection parameters including OVP, OCP, OC limit, etc (see Figure 16).

To precisely compensate the AC brown-out voltage, Trim1, Trim2 and Trim3 are introduced.

Please refer to Appendix B for the corresponding register address.

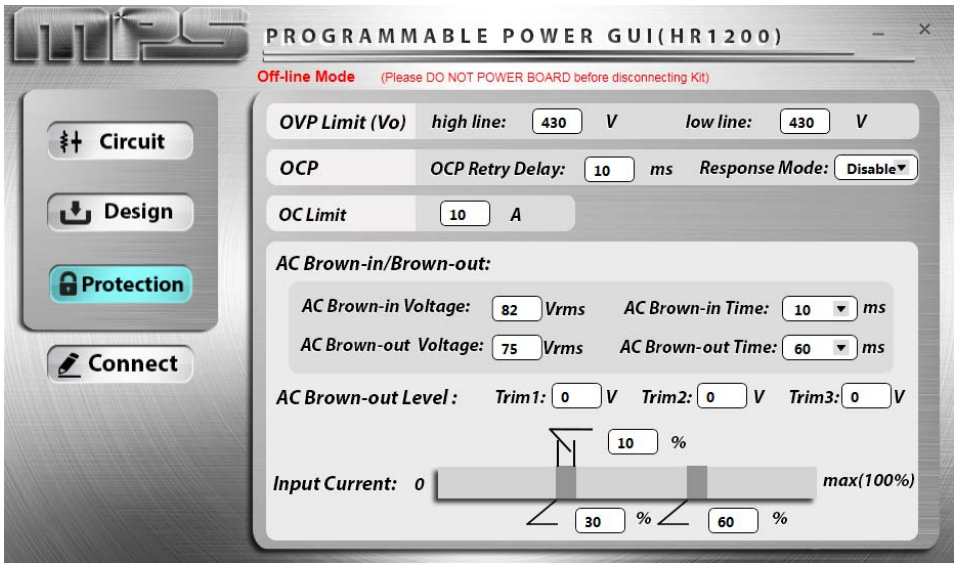


Figure 16: Protection Panel

Step 6: Go to "Connect" panel to program the IC after all of the parameters have been configured (see Figure 17).

Figure 17: Connect Panel

Press "Program" to program all panel parameters to the EEPROM of the HR1200. When programming is finished, the EEPROM data are read out and compared with the original written values to perform a self-check. If something is wrong, a corresponding prompt box displays. If there are no errors, following prompt box is displayed: "Program successfully."

Press "Export" to save all the panel parameters in a Microsoft Excel spreadsheet.

Press "Import" to load data from a external Excel spreadsheet into the GUI panels. Ensure that the external Excel spreadsheet has the same form as the one exported from the GUI.

Step 7: Close the GUI. As the panel parameters restore default values every time restarting the GUI, it is better to save the current panel parameters before exiting.

Step 8: Reset Kit and EVB [(1)].

7. STEP-BY-STEP GUIDE FOR ONLINE PROGRAMMING AND MONITORING

To operate the HR1200 GUI in online mode, follow the steps below.

Step 1: Connect the Kit to the computer USB port.

Step 2: Connect the Kit to the EVB after the Kit is recognized (see Figure 6).

Step 3: Supply AC input to power up the EVB.

Step 4: Load the GUI folder and open the GUI (see Figure 7 and Figure 8).

Step 5: Press “SCAN”. The Kit performs the following actions automatically.

A. Connection Check

- If there is something wrong with the connection between the Kit and USB port, the prompt box displays: “Please connect I2C Kit to USB port correctly.”
- If there is something wrong with the connection between the Kit and EVB, the prompt box displays: “Please check whether Kit connects to EVB correctly.”
- If the Kit connects successfully with both the USB port and EVB, the Kit proceeds to Mode Recognition.

B. Mode Recognition: In this case, VCC is **above 8V**, and the IC enters online mode (see Figure 18). Only the fixed VCC value is sent to the EVB.

Warning:

- *USE A USB ISOLATOR between the Kit and USB port as suggested in Section 4.*
- *KEEP THE AC INPUT IN CONNECTION in online mode.*
- *DO NOT PLUG OR UNPLUG ANY DEVICE in online mode to prevent damaging the EVB.*
- *RESET THE KIT and EVB every time before restarting the GUI. Detach Kit from the USB port and make sure VCC of both the Kit and EVB is fully discharged. In online mode, the bus bulk capacitor should be discharged below 10V to prevent false triggering before making connection again.*

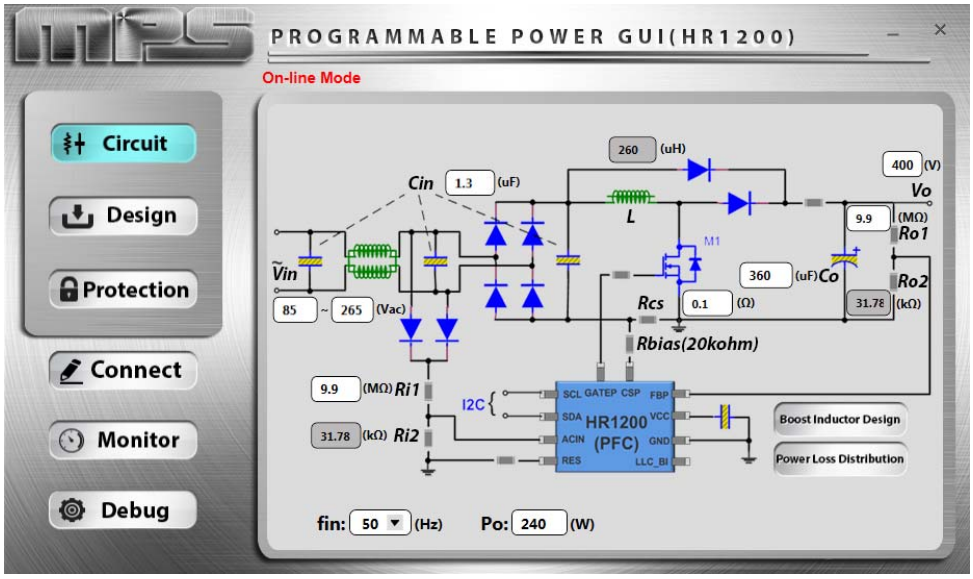


Figure 18: Main Interface in Online Mode

Step 6: Configure the parameters of the digital PFC part of the HR1200 through the GUI. In addition to the panels introduced in Section 6, there is a special panel in online mode.

H. Monitor Panel

This panel provides the function of monitoring the status of the HR1200. The input/output of the PFC stage can be checked to determine the fault state (see Figure 19).

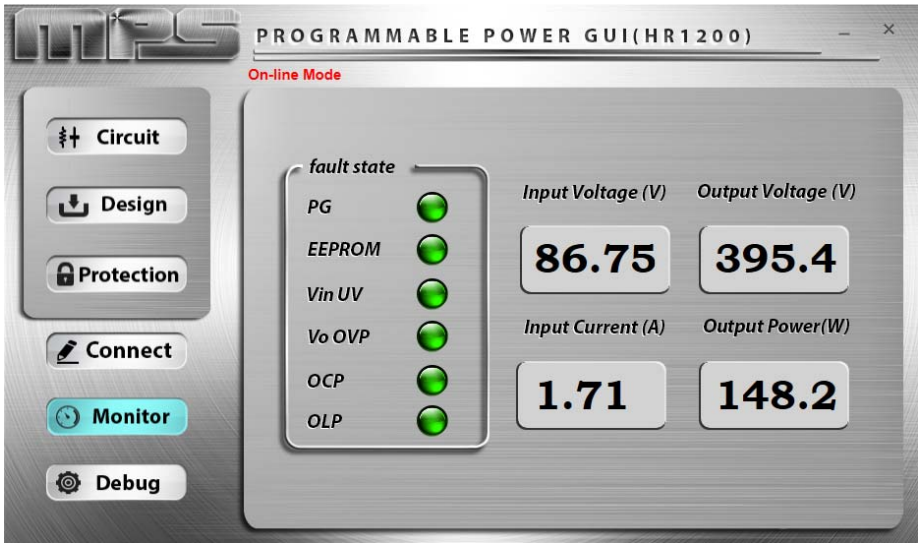


Figure 19: Monitor Panel

Step 7: If the parameters in “Circuit”, “Design”, or “Protection” panels have been changed and need to be programmed to the chip, use “Connect” panel, which is still effective in online mode.

Online mode also has a special “Debug” button. This controls the turning-on and turning-off of the real-time programming function (see Figure 20).

Real-Time Programming

When pressed, the “Debug” button becomes orange. Then the real-time programming function is turned on. Any single change in any panel can be programmed to the chip in real time by pressing ENTER immediately. Under this condition, the “Import” function is disabled.

Press “Debug” again to turn off real-time programming function. Then the button restores gray.

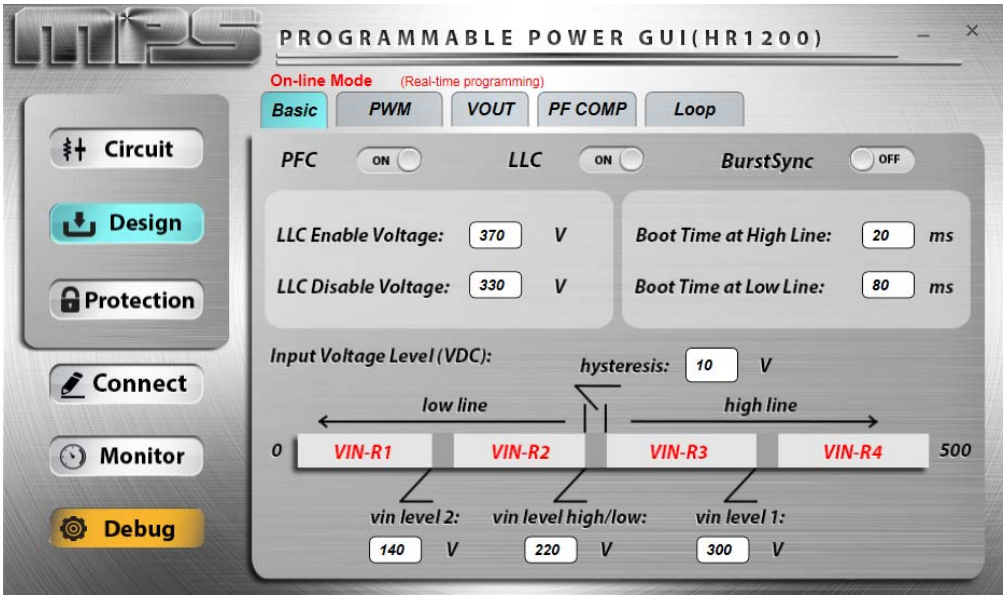


Figure 20: Debug Button

Warning:

- *REAL-TIME PROGRAMMING IS A RISKY PROGRAMMING MODE. If you make a change in a data box and press ENTER, then **all** panel parameters, not only the one changed, will be programmed to the chip. PLEASE CONFIRM PANEL PARAMETERS before pressing ENTER.*
- *DO NOT FORGET TO PRESS ENTER during real-time programming. Otherwise, the data change in GUI will not be updated to the chip*

Step 7: Close the GUI. Since the panel parameters restore the default values whenever the GUI restarts, it is better to save current panel parameters before exiting.

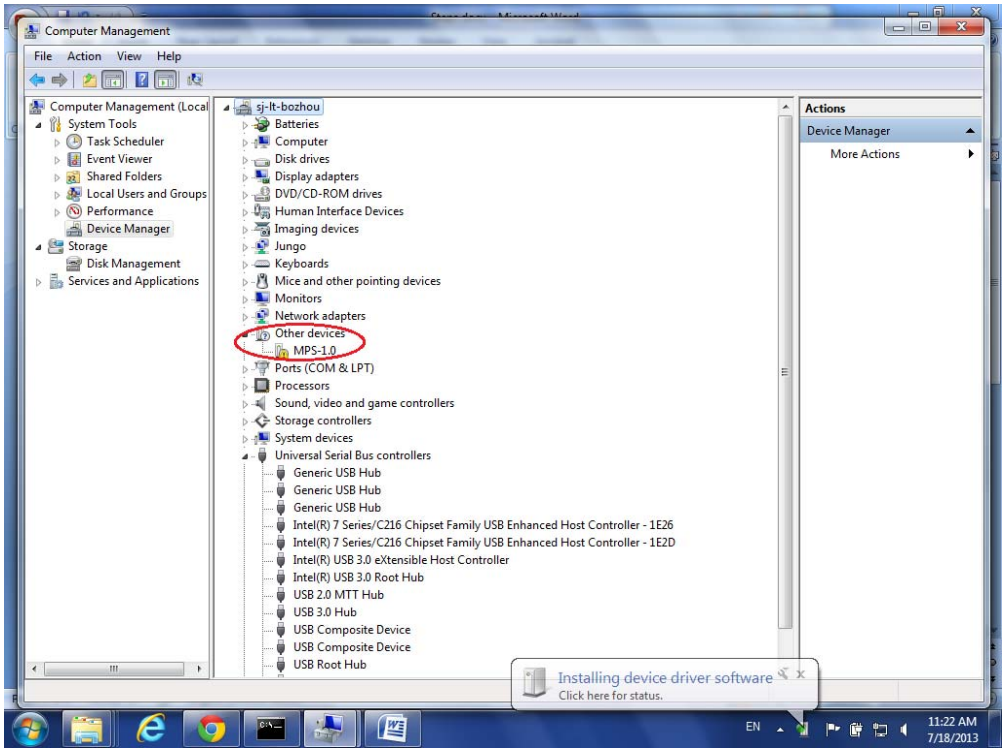
Step 8: Disconnect the AC input.

Step 9: Reset the Kit and EVB (1).

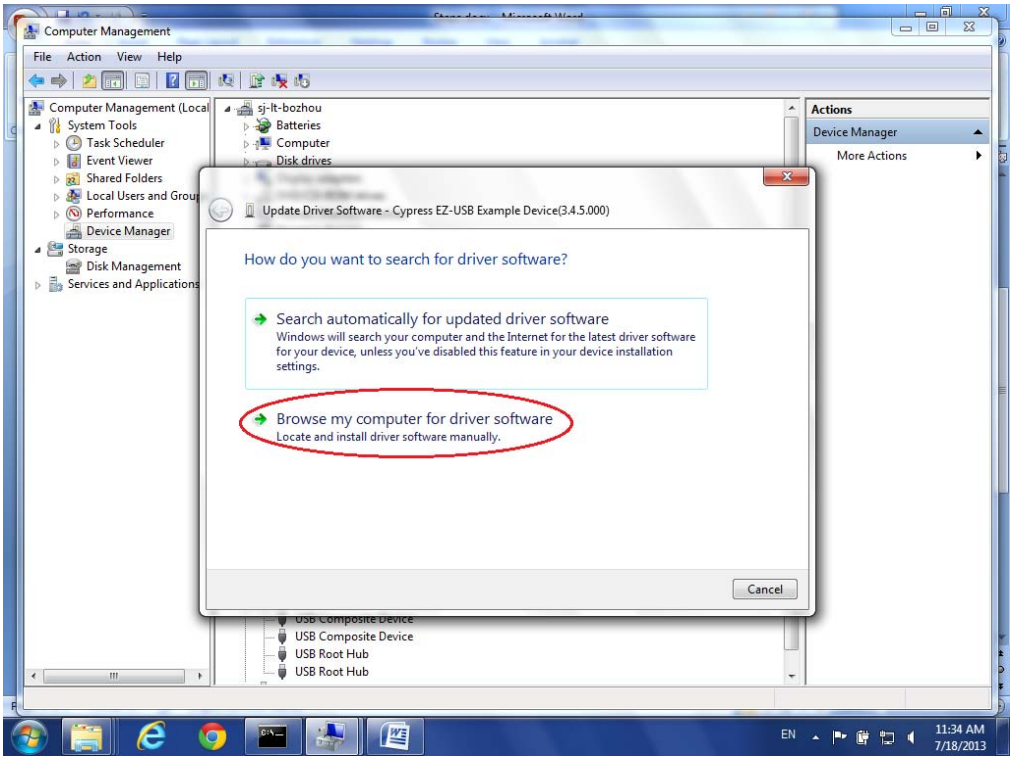
8. APPENDIX A: USB DRIVER INSTALLATION

Step 1: Disconnect the SDL, SDA, and GND cable.

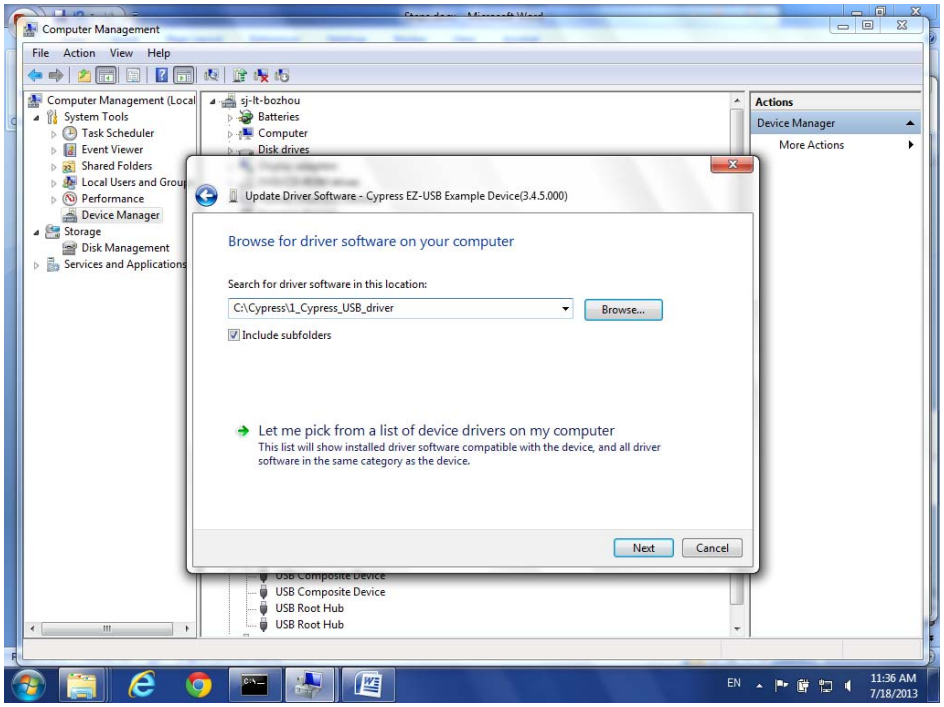
Step 2: Connect the USB board to the computer via USB cable. There should be an unrecognized device in the device manager.



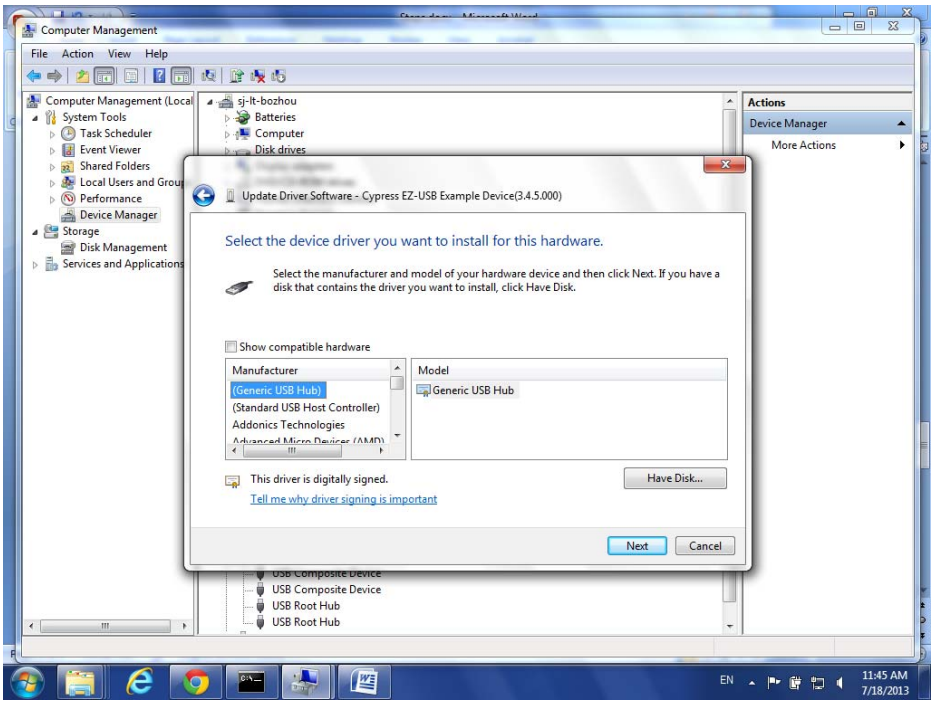
Step 3: Update the drivers.



Step 4: Click on “Browse my computer for driver software”.



Step 5: Navigate to X:\1_Cypress_USB_driver\



This folder includes all the digitally signed CyUSB driver .inf, .cat, and .sys files. Only the digitally signed USB driver could work with a 64-bit operation system.

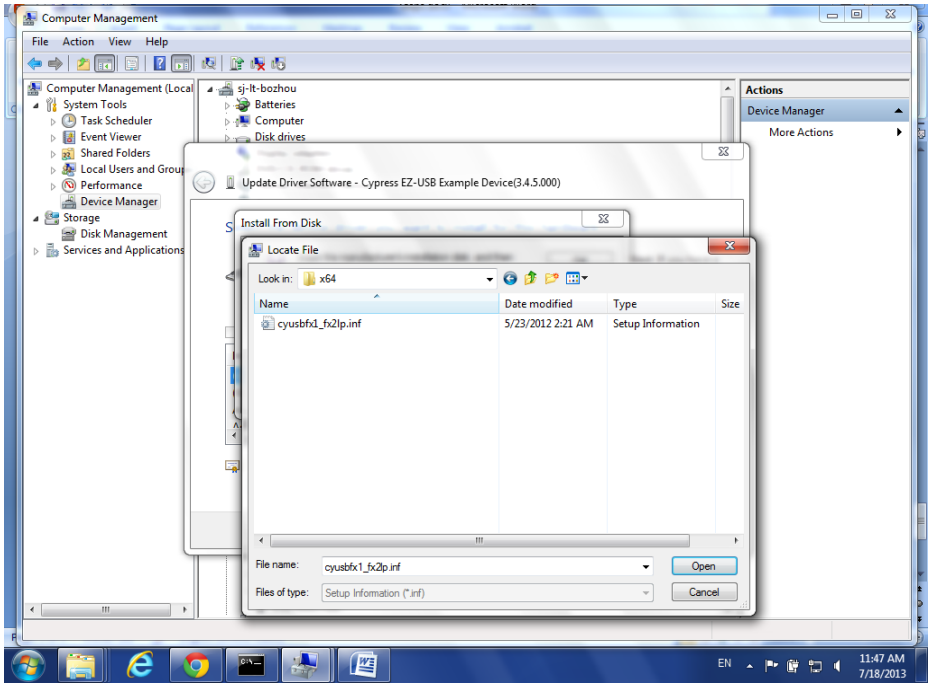
You may also find this resource from Cypress Website signed CyUSB.sys driver: http://www.cypress.com/?id=4&rID=53338

For *WINXP and WIN7 32-bit OS,* the system searches for the driver file automatically. Follow the instructions and click “Next”.

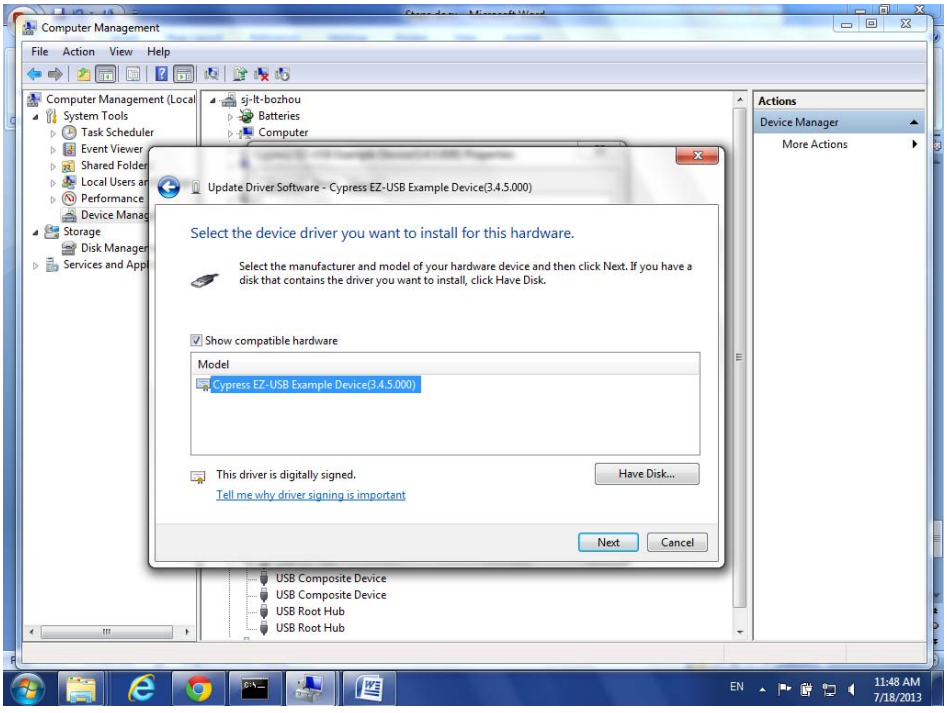
- *WINXP*: the driver is under X:\1_Cypress_USB_driver\cyusbfx1_fx2lp\wxp\
- *WIN7 32-bit*: the driver is under X:\1_Cypress_USB_driver\cyusbfx1_fx2lp\wlh-win7\x86

For *WIN7 64-bit OS,* the USB driver can only be installed manually. Select "Let me pick from a list of device drivers on my computer".

Step 6: Click on "Have Disk" and select "Browse".



Step 7: Navigate to X:\ MPS\MPSDemo\Drivers\cyusbfx1_fx2lp\wlh-win7\x64\cyusbfx1_fx2lp.inf. Click on "Open" and select "OK".



Step 8: Choose "Cypress EZ-USB Example Device" and select "Next". The USB driver will be installed.

9. APPENDIX B: REGISTER ADDRESS

Panel Parameters	Corresponding Register Address
Circuit Panel	
Vin_min	1D, 3D, 3F, 41, 54
Cin	4B, 4C, 4D, 4E
Po	06, 08, 0A, 0C, 2D, 2F, 3D, 3F, 41, 51, 53, 54
Rcs	06, 08, 0A, 0C, 2D, 2F, 3D, 3F, 41, 44, 4B, 4C, 4D, 4E, 51, 53, 54
Design Panel, Basic	
PFC	56 Bit:5
LLC	56 Bit:4
Burst Sync	56 Bit:7
LLC Enable Voltage	16
LLC Disable Voltage	18
hysteresis	6E, 6F
vin level 2	50
vin level high/low	05, 1C
vin level 1	4F
Boot Time at High Line	1C
Boot Time at Low Line	1D
Design Panel, PWM	
VIN_R1 Maximum Frequency	1E, 22, 28, 29, 31, 33
VIN_R2 Maximum Frequency	1F, 22
VIN_R3 Maximum Frequency	20, 22
VIN_R4 Maximum Frequency	21, 22
VIN_R1 Minimum Frequency	23, 27
VIN_R2 Minimum Frequency	24, 27
VIN_R3 Minimum Frequency	25, 27
VIN_R4 Minimum Frequency	26, 27
Min. Turn-on Time	2B
Min. Turn-off Time	2C
Frequency Jitter	1E, 1F, 20, 21, 22, 29, 56 Bit:1
Frequency Jitter Amp	1E, 1F, 20, 21, 22, 28, 29
Jitter Modulation Freq	29
Vally Turn-on (ZCD)	56 Bit:0
ZCD Period (high line)	1A
ZCD Period (low line)	1B
Design Panel, VOUT	
Adaptive Output Voltage	56 Bit:3
Vout Normal at High Line	01, 1C
Vout Level 1 at High Line	0E, 11
Vout Level 2 at High Line	0F, 11
Vout Level 3 at High Line	10, 11
Vout Normal at Low Line	03, 1D

Vout Level 1 at Low Line	12, 15
Vout Level 2 at Low Line	13, 15
Vout Level 3 at Low Line	14, 15
Load Hysteresis	0C
Load Level 1	06
Load Level 2	08
Load Level 3	0A
Design Panel, PF COMP	
PF Compensation	56 Bit:2
VIN_R1 Input Voltage	4B
VIN_R1 Input Frequency	
VIN_R1 Cap Compensation	
VIN_R2 Input Voltage	4C
VIN_R2 Input Frequency	
VIN_R2 Cap Compensation	
VIN_R3 Input Voltage	4D
VIN_R3 Input Frequency	
VIN_R3 Cap Compensation	
VIN_R4 Input Voltage	4E
VIN_R4 Input Frequency	
VIN_R4 Cap Compensation	
Design Panel, Loop	
Burst Mode Load at High Line	2D
Burst Mode Load at Low Line	2F
FastLoop Voltage	37
Ki	31, 33
Kp	32, 35
FastLoop Gain	33, 35
Protection Panel	
OVP Limit at High Line	48
OVP Limit at Low Line	49
OCP Retry Delay	46
OCP Response Mode	45
OC Limit	44
AC Brown-in Voltage	38
AC Brown-out Voltage	3A
AC Brown-in Time	3C Bit:7~4
AC Brown-out Time	3C Bit:3~0
Trim 1	42
Trim 2	43
Trim 3	3A
Input Current Hysteresis	41
Input Current Level 2	3F
Input Current Level 1	3D

10. APPENDIX C: COMMON FAULTS AND TROUBLESHOOTING

Common Faults	Troubleshooting
Prompt box: “Please connect I2C Kit to USB port correctly.”	1. Connection failed. Check and reconnect Kit with USB port. 2. Kit or EVB not reset. Detach Kit from USB port and fully discharge VCC of both the Kit and EVB. Make sure the bulk capacitor is discharged below 10V. Then reconnect.
Prompt box: “Please check whether Kit connects to EVB correctly.”	1. Connection failed. Check and reconnect Kit with EVB. 2. Kit or EVB not reset. Detach Kit from USB port and fully discharge VCC of both the Kit and EVB. Make sure the bulk capacitor is discharged below 10V. Then reconnect.
Prompt box: “Open memory failed.”	1. Communication failed with the EEPROM of the chip. Something may be wrong with EVB or the chip. 2. Kit or EVB not reset. Detach Kit from USB port and fully discharge VCC of both the Kit and EVB. Make sure the bulk capacitor is discharged below 10V. Then reconnect.
Prompt box: “Communication failed.”	Lost communication with the EEPROM of the chip. End GUI process → Reset both Kit and EVB → Reconnect Kit following correct steps → Restart GUI
Displayed as online mode in the GUI but without AC input.	Kit or EVB not reset. Detach Kit from USB port and fully discharge VCC of both the Kit and EVB. Make sure the bulk capacitor is discharged below 10V.
Kit not recognized by computer.	1. Kit or EVB not reset. Detach Kit from USB port and fully discharge VCC of both the Kit and EVB. Make sure the bulk capacitor is discharged below 10V. Then reconnect. 2. Driver installation problems. Reinstall the driver. 3. USB port damaged. Try another port. 4. Restart computer. 5. Kit is damaged. Try another Kit.
GUI or computer crash.	End GUI process → Reset both Kit and EVB → Reconnect Kit following correct steps → Restart GUI
Prompt box: “Import Error.”	1. Nonstandard form of external Excel spreadsheet. 2. *Microsoft Excel* needs to be updated.
Prompt box: “Export Error.”	*Microsoft Excel* needs to be updated.