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XR77103
Universal PMIC 3 Output Programmable Buck Regulator

EVK User Manual

Document Revision History

Document No.	Release Date	Change Description
1A	4/21/16	Initial release of document.
007UMR00	11/15/19	Complete re-write. Converted to MaxLinear format.

Table of Contents

List of Figures

List of Tables

Introduction

The XR77103 evaluation board provides a platform to evaluate the features and performance of the XR77103 Universal PMIC 3 Output Programmable Buck Regulator. The XR77103 output voltages are programmable from 0.8V to 6V (50mV resolution) via an I^2C interface with a 4.5V to 14V input voltage range, and it is packaged in a 4mm x 4mm TQFN. Many other features can also be programmed through the I^2C interface such as switching frequency, power on sequence, peak inductor current limit and soft-start timing.

The most convenient way to evaluate the XR77103 is to use the XR77103 evaluation board in conjunction with the Arduino Uno microcontroller board and MaxLinear's XR77103 configuration tool. The scope of this manual is the XR77103 evaluation board. The links for the additional software tools and configuration *.hex files needed to install and run the GUI can be found under Reference Documentation.

Quick EVB Set Up and Start Up

Quick Set Up - Factory Settings

The Evaluation Board has been set up with the following factory default configuration for quick set up and operation:

- V_{IN} = 5.5V to 14V, optimized for a 12V input rail.
- Default V_{OUT} for each channel is listed below. For different V_{OUT} selections, see VOUT Programming
  - Buck 1: V_{OUT} = 0.8V
  - Buck 2: V_{OUT} = 0.8V
  - Buck 3: V_{OUT} = 0.8V
- Maximum I_{OUT} per channel is 2A
- 440kHz Switching Frequency
- Buck 1 and 2 operate 180º out of phase with Buck 3 (so they can be paralleled, however additional hardware modification is required for parallel operation)
- Low power mode operation enabled
- UV set at 7V
- Peak inductor current limit = 2.0A
- Start-Up delay
  - Buck 1 = 10ms
  - Buck 2 = 10ms
  - Buck 3 = 10ms
- Soft start ramp-up time = 6ms (all channels)

Quick Start Up

To quickly see the regulator in operation:

1. Use the factory settings and default configuration. If other settings or components are desired, apply them before the next steps and see System Set-Up for more.
2. Connect a turned-off power supply that is within the above V_{IN} specification (5.5V to 14V, 12V typical) to V_{IN}+ and V_{IN}- with short and thick leads. Use test pins EXT. VIN (J39) and AGND (J7) to connect and monitor V_{IN}+ and V_{IN}- respectively. See locations in Figure 1.
3. Initially set to 0A, connect electronic loads to each desired channel that will be no more than the maximum I_{OUT} (2A) to VOUTx and PGNDx (where x = the channel number) with short and thick leads. Use test pins in Table 1 to connect and monitor VOUTx and PGNDx respectively. See locations in Figure 1. For all channels with the electronic load connected, ensure that the respective V_{IN} jumper is installed per Table 1.

Table 1: Jumper Connections for V_{IN}, V_{OUT} and PGND

Channel	V_{IN}(1)	V_{OUT}	PGND
1	J14	VOUT1, J31	PGND1, J35
2	J20	VOUT2, J33	PGND2, J36
3	J24	VOUT3, J1	PGND3, J4

1. Factory default: jumpers installed.

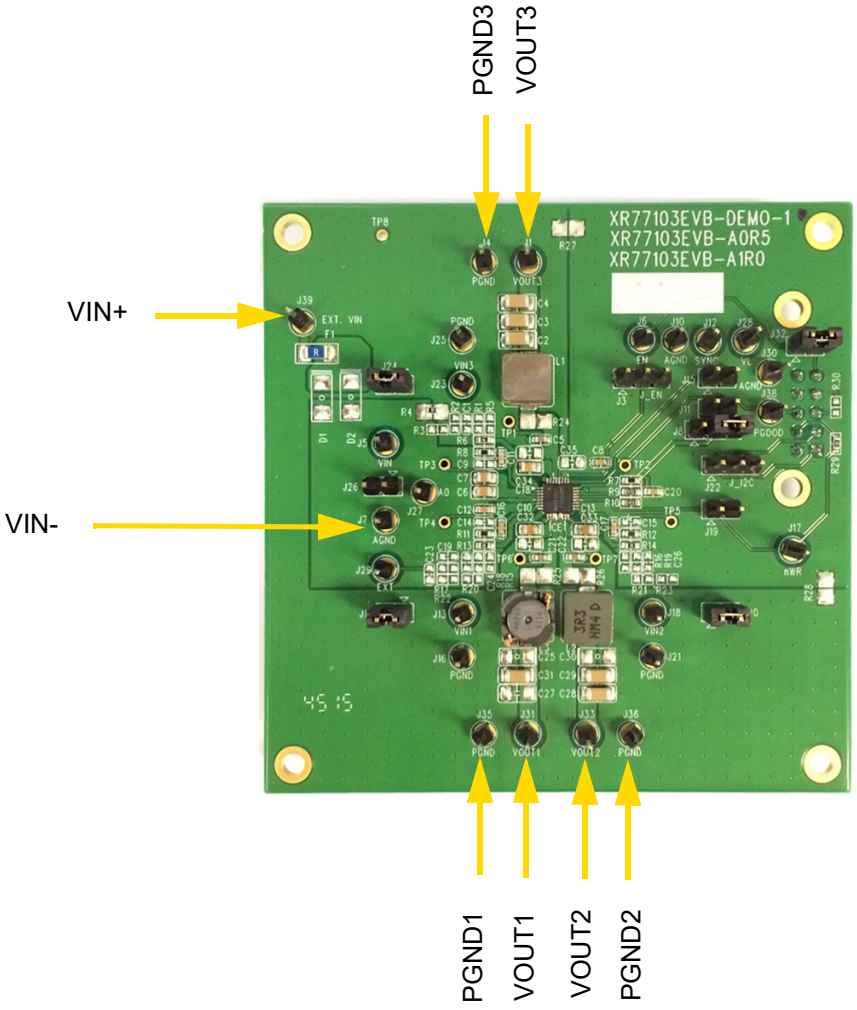

Figure 1: Connecting and Monitoring V_{IN} and V_{OUT}

4. Connect the XR77103EVB-DEMO-1 evaluation board to an Arduino Uno microcontroller board as shown in Figure 2, Figure 3, and Figure 4. Use a USB cable to connect the computer (type A) to the Arduino Uno board (type B).

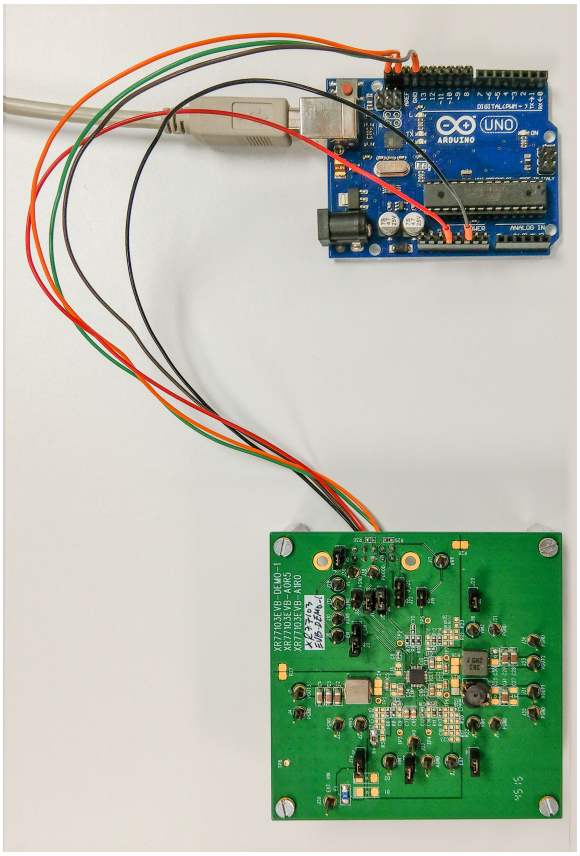

Figure 2: Connecting the XR77103 Demo EVK and Arduino Uno

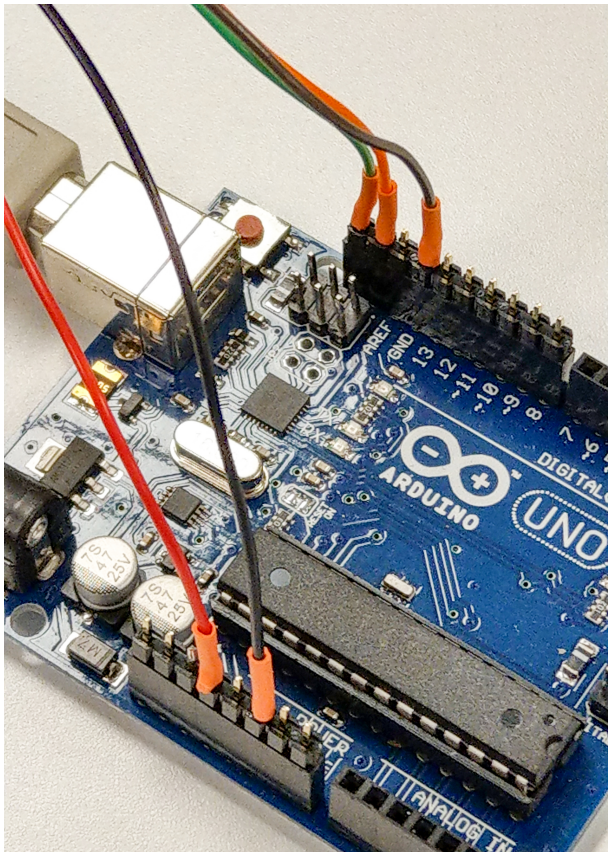

Figure 3: Arduino Uno Connections

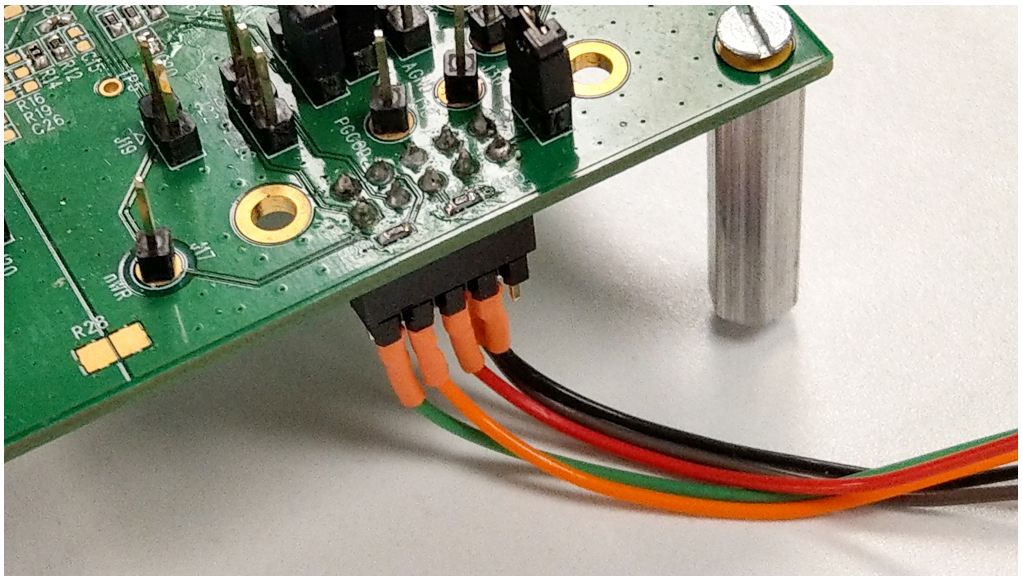

Figure 4: XR77103 Demo EVK Connections

5. Install the Xloader application software to load the hex file into the Arduino Uno board. See Figure 5.
   a. Download and run the executable from http://www.hobbytronics.co.uk/arduino-xloader.
   b. Select the 'PMIC_Bridge.ino.standard.hex' file.
   c. Select the 'Uno(ATmega328)' device.
   d. Select the COM port. Use the Device Manager to identify the COM port that the Arduino Uno has been assigned to.
   e. Set the baud rate to 115200.
   f. Upload the hex file to the Arduino.

   Note: If successful, the LED L will turn on and off in 1 second intervals.

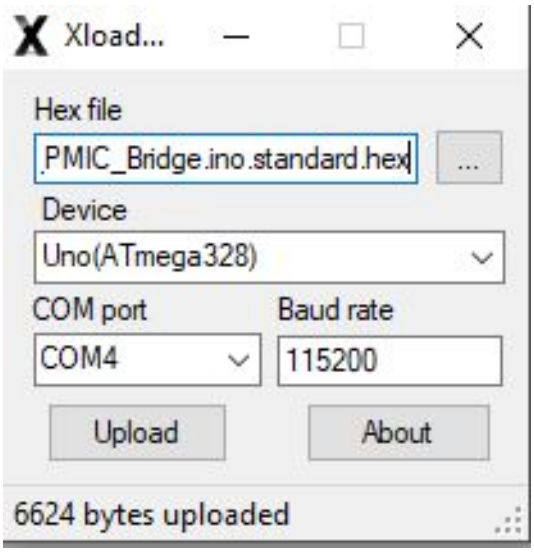

Figure 5: Xloader

6. Open the XR77103 configuration tool, see Figure 6.

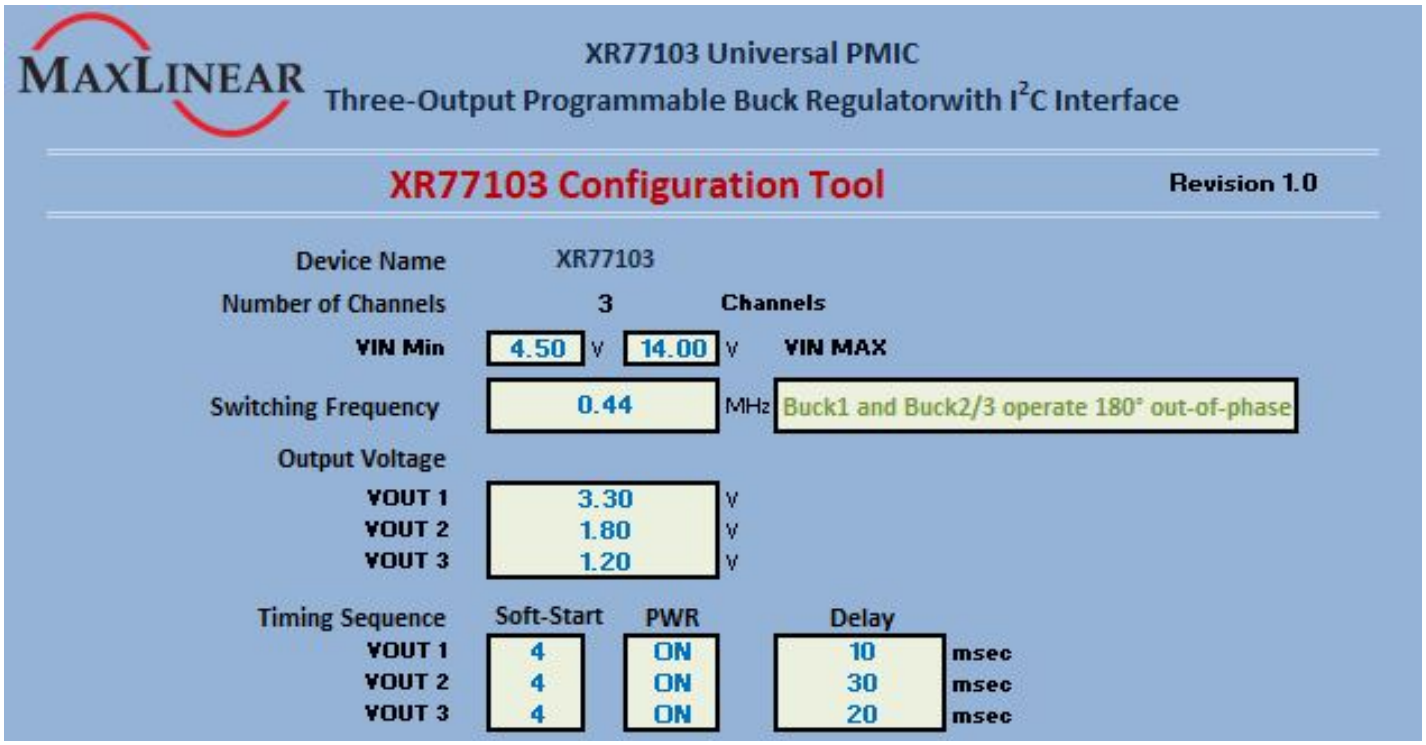

Figure 6: XR77103 Configuration Tool

a. Click on the MxL Bridge Control Panel button to SW bridge, see Figure 7.

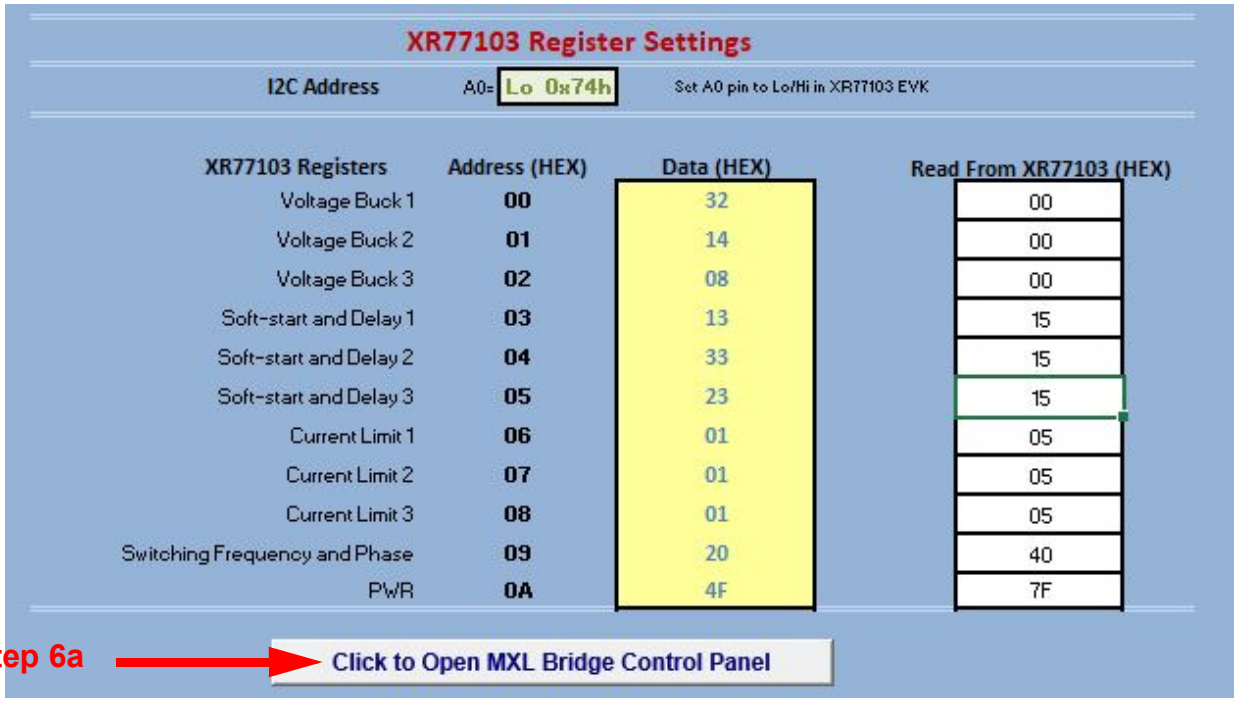

Figure 7: Bridge Control Button

b. The bridge SW window should open, see Figure 8.

c. Connect to the Arduino.

d. Establish the connection to XR77103 EVK. Turn on the power applied to V_{IN} and scan for the device. Enter your key "MXLBEST" and enter Baud of 9600. You may need to "Scan Device" multiple times before the link is established (you will see either address 0x74h or 0x75h), see Figure 9.

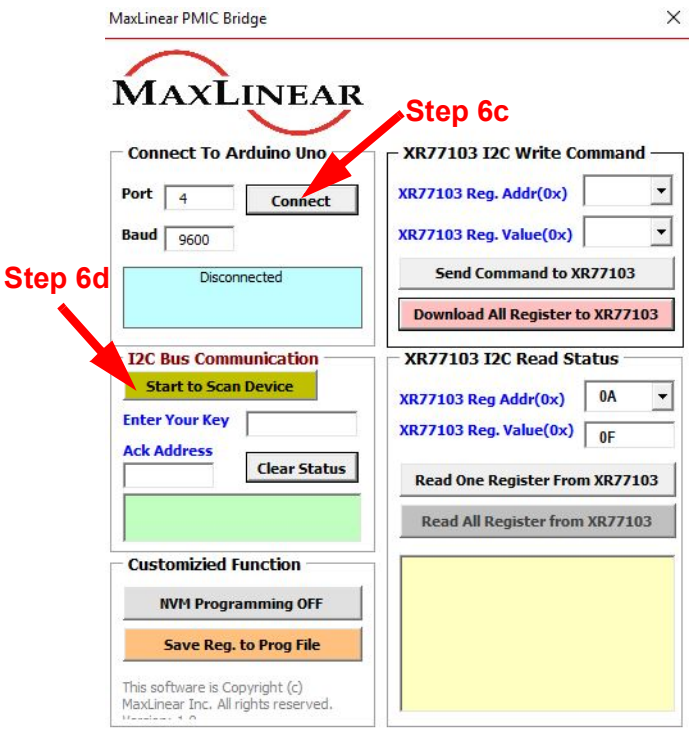

Figure 8: Bridge Application

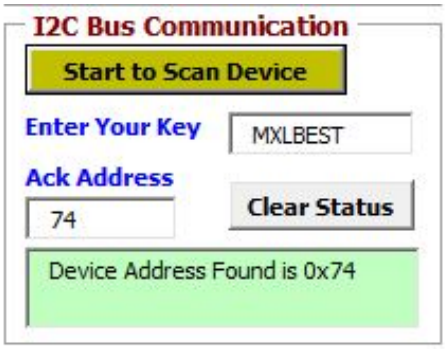

Figure 9: Start Scan

7. The XR77103 configuration tool has pre-set values shown in Table 2 that are **different** from the EVK factory default settings described in Quick Set Up - Factory Settings, as this step illustrates how the EVK can be programmed. For performance other than these pre-set values, see Step 7c.

Table 2: Configuration Tool GUI Pre-Set Values

Item	Setting	Item	Setting
Output Voltages		Start Up Delays	
Buck1	3.3V	Buck1	10ms
Buck2	1.8V	Buck2	30ms
Buck3	1.2V	Buck3	20ms
Phase		Other	
Buck 1 operates 180 degrees out of phase of Buck 2 and 3		Soft-start	4ms
		Current limit	2A
		UV	7V

   a. Use the bridge control to program the XR77103 EVK by clicking on the "Download All Register to XR77103", see Figure d.

Figure 10: Download All Register

   b. The EVK is now re-configured to the GUI pre-set values, not the factory default settings.

   c. For other desired performance, make the changes with the XR77103 Configuration Tool GUI and once the changes are set, repeat Step 7a.

   d. The EVK now operates at the new values.

   e. To confirm that the EVK has been updated, read back the internal register settings using the "Read All Register from XR77103" button, see Figure 11.

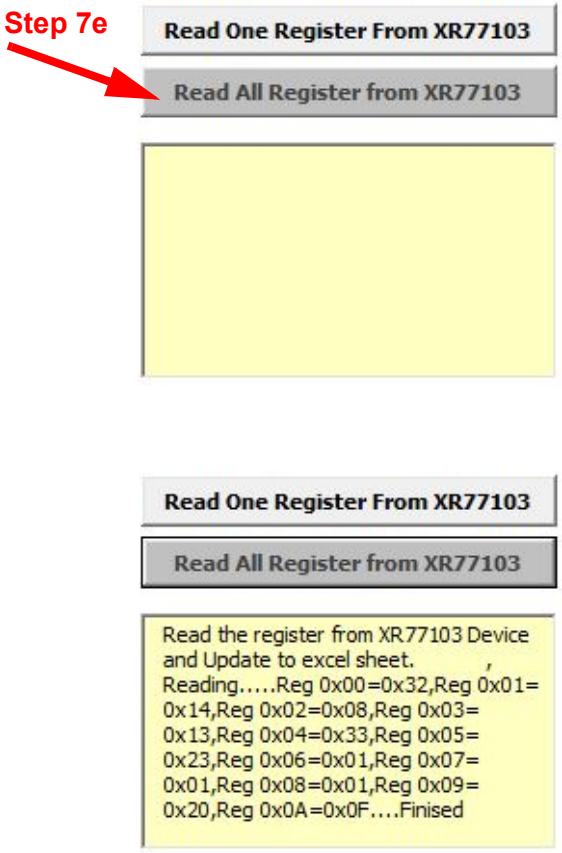

Figure 11: Read Register

8. Set or vary the load (do not exceed the maximum I_{OUT}) and check V_{OUT} and other desired performance levels such as regulation and efficiency. See I/O and Test Points for more on monitoring.

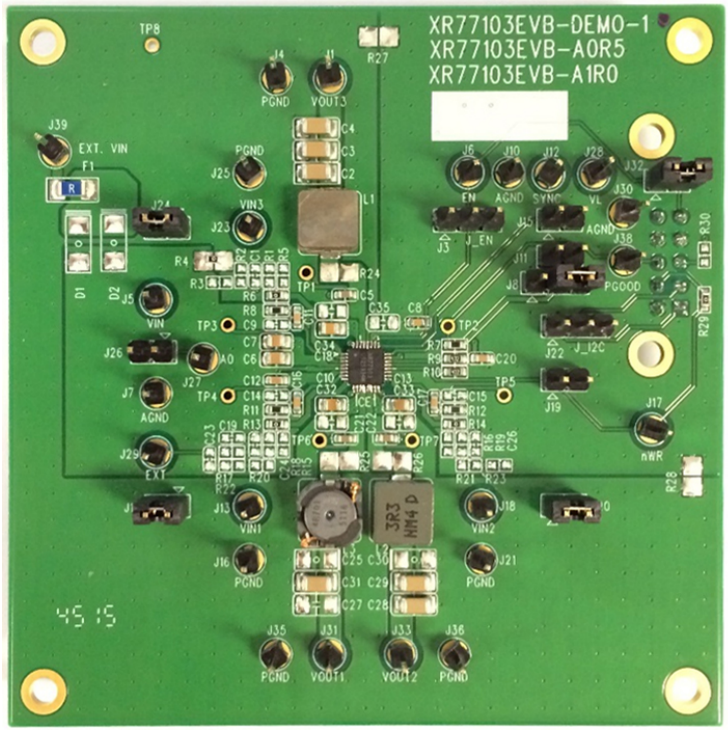

Figure 12: Top View of XR77103EVB, REV2.0

Reference Documentation

Please refer to the XR77103 Data Sheet for additional information, including a full list of IC features, pinout, pin descriptions, typical performance characteristics and external component calculations. This manual is meant to be a companion to the datasheet when using the evaluation board.

In development, the XR77103 may be used with the Arduino microcontroller board and XR77103 configuration tool. If using the Arduino microcontroller board, refer to its manual which can be found on the XR77103 Product Page under the Documentation tab.

This manual provides EVB schematics (XR77103EVB Schematic), PCB layout (XR77103EVB PCB Layers) and bill of materials (XR77103EVB Bill of Materials) that can be utilized to assist in your board design. The schematics are also available on the XR77103 Product Page.

Ordering Information(1)

Table 3: Evaluation Board Ordering Part Number

Evaluation Board	Board Description
XR77103EVB-DEMO-1	XR77103 evaluation board
XR77103EVB-DEMO-1-KIT	XR77103 evaluation board with interface controller board and software

1. Refer to www.maxlinear.com/XR77103 for most up-to-date Ordering Information.

Evaluation Board Overview

The XR77103 EVB block diagram is shown in Figure 13.

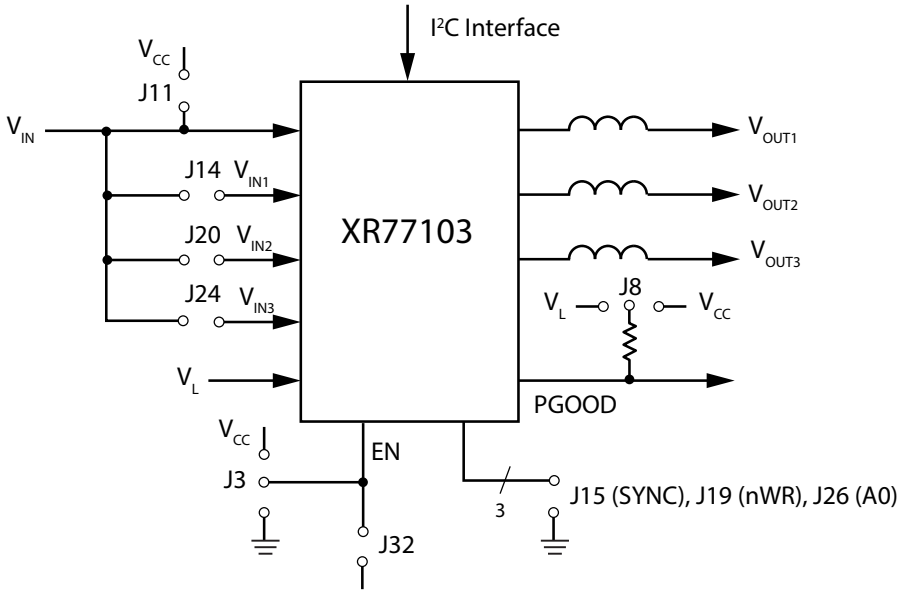

Figure 13: Simplified Block Diagram, XR77103 EVB

I/O and Test Points

J37 Controller Board Connector

The J37 10-pin connector is provided on the back of the evaluation board to easily connect it to the Arduino Uno board via a custom cable. The pinout is listed in Table 3:

Table 4: J37 Pinout

Pin Number	Function
1	SCL
2	GND
3	SDA
4	nWR
5	VL
6	PGOOD
7	GND
8	GND
9	EN
10	VIN

VIN, LX and PGOOD Test Points

Test points are available for VIN (TP8), the LX switching nodes (TP6 for LX1, TP7 for LX2, and TP1 for LX3), the compensation pins (TP4 for COMP1, TP5 for COMP2, TP3 for COMP3), and PGOOD (TP2) for monitoring.

Table 5: Test Points

Test Point	Function
TP1	LX3
TP2	PGOOD
TP3	COMP3
TP4	COMP1
TP5	COMP2
TP6	LX1
TP7	LX7
TP8	VIN

The PGOOD output can be used externally. See Jumper J8 for more on PGOOD options.

System Set-Up

See Table 6 for a summary of jumpers and factory settings to configure the EVB for operation. Jumper options are next described. Refer to the XR77103 Data Sheet for additional information.

Table 6: Factory Settings

Jumper	Factory Setting	Description
EN Pin		
J3	No jumper	Allows J37 to control EN.
J32	Jumper 1-2	EN is connected to the controller board.
PGOOD Pin		
J8	Jumper 2-3	PGOOD is pulled up to V_L.
5V Operation		
J11	No jumper	LDO output is not tied to V_{IN}.
VIN Connection to Individual Channels		
J14, J20, J24	Jumpers installed	VIN is connected to VIN1, VIN2, and VIN3.
SYNC, nWR, and A0 Pins		
J15, J19, and J26	No jumpers	SYNC, nWR, and A0 pins are not tied to GND on the board.

Jumper J3

Table 7: Jumper J3 Options for the EN Pin

Jumper Options	Description
Jumper 1-2	The EN (enable) pin is tied to V_{CC}. Strapping the EN pin to V_{CC} while connected to the Arduino Uno board is not recommended.
Jumper 2-3	The EN (enable) pin is tied to GND. Strapping the EN pin to GND while connected to the Arduino Uno board is not recommended.
No jumper (default)	The jumper is open, allowing J37 to control EN.

Jumper J32

Table 8: Jumper J32 Arduino Uno Connection Options for the EN Pin

Jumper Options	Description
Jumper 1-2	The EN pin is connected to J37 for the Arduino Uno board.
No jumper (default)	The EN pin is disconnected from J37 and the Arduino Uno board.

Jumper J8

Table 9: Jumper J8 Pull Up Options for the PGOOD Pin

Jumper Options	Description
Jumper 1-2	PGOOD is pulled up to the VCC pin. Pulling PGOOD to 5V V_{CC} while connected to the Arduino Uno board is not recommended due to signaling level limitation of the microcontroller.
Jumper 2-3 (default)	PGOOD is pulled up to the 3.3V V_L supply. V_L is supplied between V_L (J28) and AGND (J30).
No jumper	PGOOD is not pulled up by this jumper.

Jumper J11

For operation from a 5V rail, it is required that the LDO output is connected to V_{IN}, which can be accomplished by populating J11. This enhances the operation of the drivers for V_{IN} < 5V.

Important: Please remember to remove J11 for operation at higher V_{IN}. The board also has Zener diode placeholders which can be installed to protect the IC if higher V_{IN} is accidentally applied.

Table 10: Jumper J11 and Operation from a 5V Rail

Jumper Options	Description
Jumper 1-2	Ties the LDO output to V_{IN} which is required for 5V operation
No jumper (default)	LDO output is not tied to V_{IN}.

Jumpers J14, J20 and J24

Jumpers J14, J20 and J24 are available to connect or disconnect VIN from VIN1, VIN2, and VIN3 respectively. Factory default is VIN is connected to VIN1, VIN2, and VIN3.

Jumpers J15, J19, and J26

Jumpers J15, J19, and J26 are available to ground SYNC, nWR, and A0 respectively. Factory default is none of these pins are grounded on the board.

I²C Interface Pullups

The XR77103 PMIC uses a standard I²C interface. The SCL and SDA interface lines are pulled up to the externally supplied V_L rail on the evaluation board via R9 and R10.

V_{OUT} Programming

V_{OUT} is programmed via XR77103 Configuration Tool and the Arduino Uno board. The factory installed configuration of V_{OUT} for each channel is summarized in Quick Set Up - Factory Settings. Alternatively, V_{OUT} can be modified by changing the channel's output resistor divider according to:

$$R_{TOP} = R_{BOTTOM} \times \left(\frac{V_{OUT}}{0.8} - 1 \right)$$

Where R_{TOP} and R_{BOTTOM} are given in Table 8, along with the factory default:

Table 11: V_{OUT} Resistor Dividers

Channel	R_{TOP}		R_{BOTTOM}	
1	R13	0Ω (default)	R15	not populated (default)
2	R14	0Ω (default)	R16	not populated (default)
3	R6	0Ω (default)	R5	not populated (default)

XR77103EVB Schematic

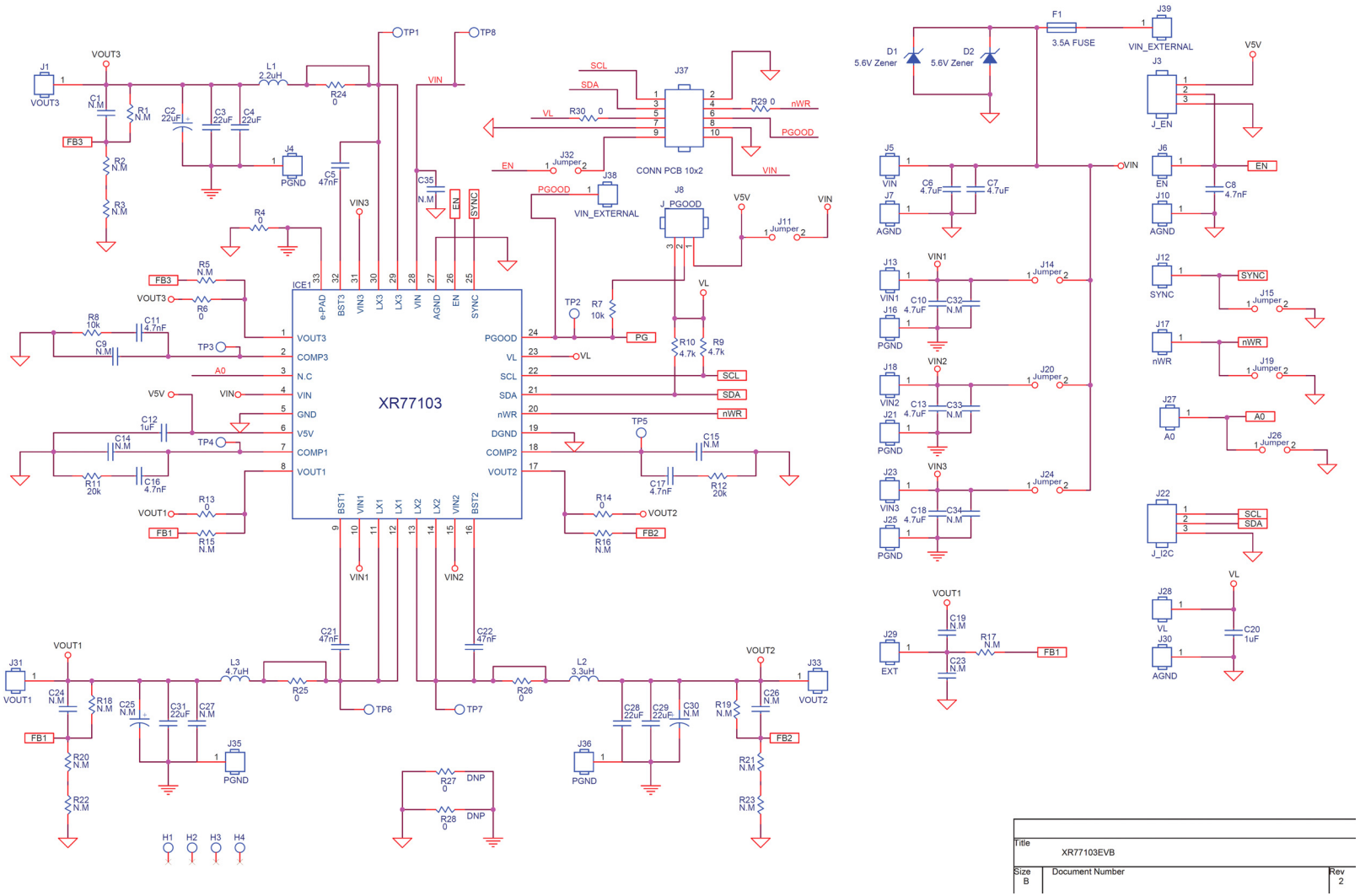

Figure 14: XR77103EVB Schematic

XR77103EVB PCB Layers

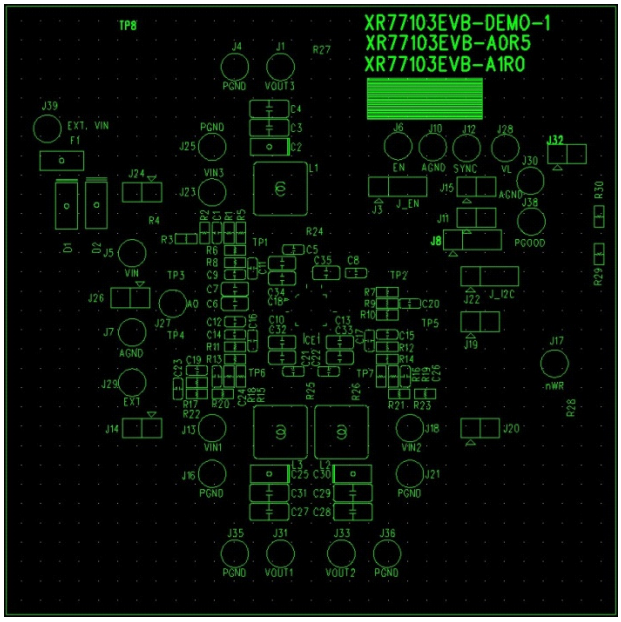

Figure 15: Silkscreen Top

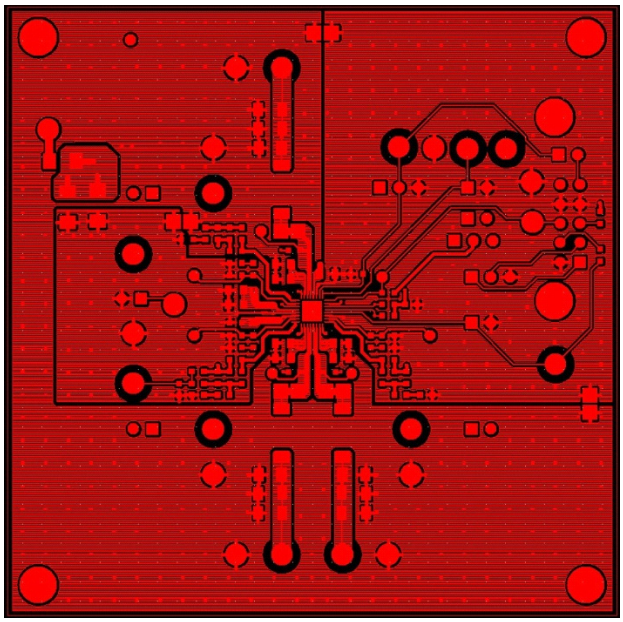

Figure 16: Assembly Top / Layer 1

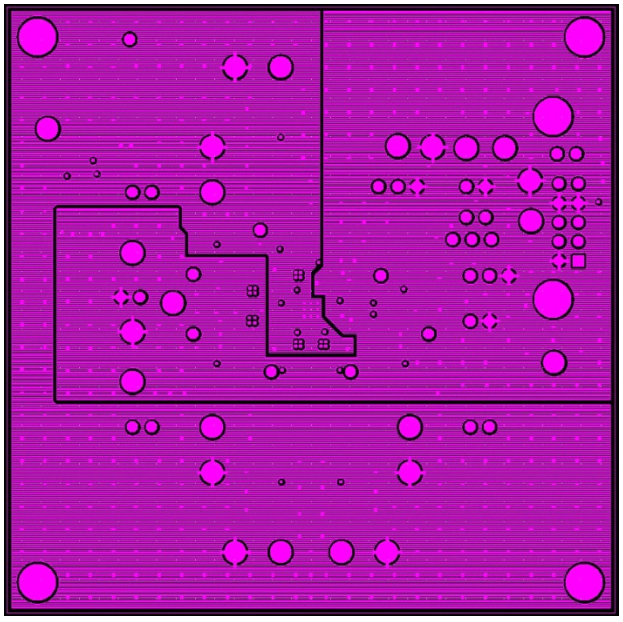

Figure 17: Layer 2

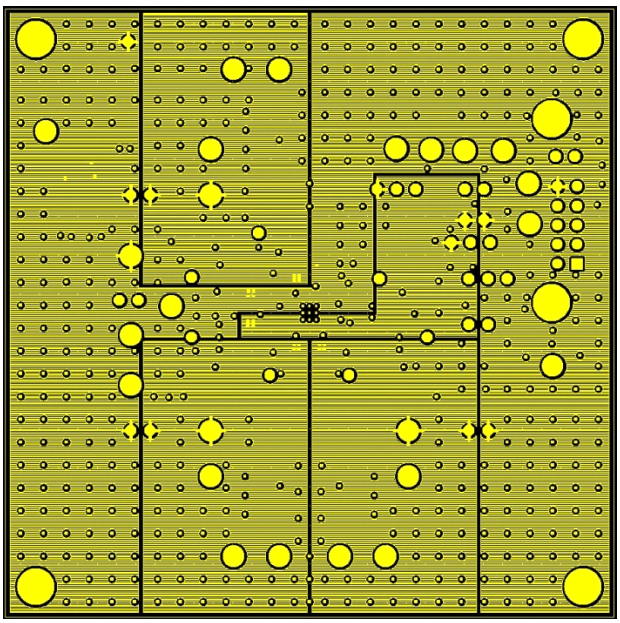

Figure 18: Layer 3

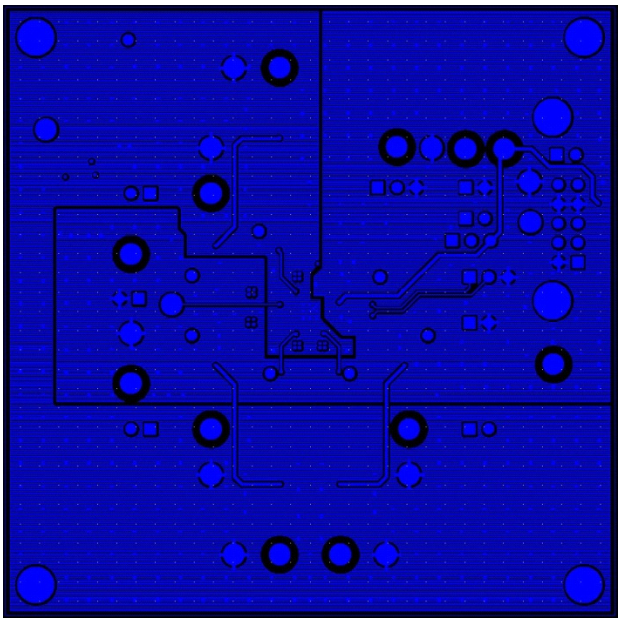

Figure 19: Assembly Bottom

XR77103EVB Bill of Materials

Table 12: XR77103EVB Bill of Materials

Item	Qty	Reference Designator	Component	Manufacturer / Part Number	Package Size
1	1	PCB	XR77103 Evaluation Board	MaxLinear	
2	6	C2, C3, C4, C28, C29, C31	CAP CER 22UF 16V X5R 1206 10%	Murata GRM31CR61C226KE15K	1206
3	3	C5, C21, C22	CAP CER 47nF 50V X7R 10%	Murata GRM188R71H473KA61D	0603
4	5	C6, C7, C10, C13, C18	CAP CER 4.7nF 25V X7R 10%	Murata GRM21BR71E475KA73L	0805
5	4	C8, C11, C16, C17	CAP CER 4.7nF 50V X7R 10%	Murata GRM188R71H472KA01D	0603
6	2	C12, C20	CERAMIC CAP. 1uF, 10V, X7R, 10%	Murata GRM188R71A105KA61D	0603
7	5	R4, R6, R13, R14, R29	Resistor 0Ω, Jumper, 1/10W, SMD	Panasonic ERJ-3GEY0R00V	0603
8	2	R7, R8	Resistor 10.0kΩ, 1/10W, 1%, SMD	Panasonic ERJ-3EFK1002V	0603
9	2	R9, R10	Resistor 4.7kΩ, 1/10W, 5%, SMD	Panasonic ERJ-3EFK4701V	0603
10	2	R11, R12	Resistor 20.0kΩ, 1/10W, 1%, SMD	Panasonic ERJ-3EFK2002V	0603
11	1	F1	Fuse Board Mount 3.5A, 63VDC	Vishay MFU1206FF03500P100	1206
12	25	J1, J4, J5, J6, J7, J10, J12, J13, J16, J17, J18, J21, J23, J25, J27, J28, J29, J30, J31, J32, J33, J35, J36, J38, J39	Header 1-pin	Wurth Elektronik 61300111121	2.54mm
13	3	J3, J8, J22	Header 3-pin	Wurth Elektronik 61300311121	2.54mm
14	7	J11, J14, J15, J19, J20, J24, J26	Jumper 2-pin	Wurth Elektronik 61300211121	2.54mm
15	1	J37	2.54mm Dual Socket Header	Wurth Elektronik 61301021821	2.54mm
16	1	L1	Inductor 2.2µH, 6A, 30mΩ, SMD	Vishay IHLP2525CZER2R2M01	6.86 x 6.47mm
17	1	L2	Inductor 3.3µH, 6A, 30mΩ, SMD	Vishay IHLP2525CZER3R3M01	6.86 x 6.47mm
18	1	L3	Inductor 4.7µH, 4.1A, 18mΩ, SMD	TDK CLF7045NIT-4R7N	7.40 x 7.40mm
19	1	U1	Universal PMIC 3 Output Buck Regulator	MaxLinear XR77103ELBTR	4mm x 4mm

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