

LMZ31710 Parallel User's Guide

The LMZ31710 device is a 2.95-V to 17-V input, 10-A output, Simple Switcher™ power module, which integrates the PWM controller, power MOSFETs, shielded inductor, and passives in a low-profile, QFN package. For applications requiring greater than 10 A, it is possible to parallel up to six LMZ31710 devices. This user's guide provides information on the correct usage of the test board and an explanation of the test points and jumpers on the board.

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1 Description

This test board features the LMZ31710 device configured for parallel operation. The test board operates over the entire input voltage range of the LMZ31710 device (2.95 to 17 V) with the option to select a split input power rail. The output voltage can be set to one of four popular values by using a configuration jumper (P4). This board can be configured to accept an external clock to set the switching frequency. Using a jumper, each paralleled LMZ31710 device can be configured to operate in phase with the master or 180° out-of-phase. Input and output capacitors are included on the board to accommodate the entire range of input and output voltages. Current monitoring test points are available to measure the current of each device. Monitoring test points are provided to allow measurement of efficiency, power dissipation, input ripple, output ripple, line and load regulation, and transient response. Control test points are provided to use the PWRGD, Inhibit/UVLO, synchronization (CLK_IN), and slow-start or tracking features.

2 Getting Started

Figure 1 and Figure 2 highlight the user interface items associated with both the 2x and 4x LMZ31710 parallel test board. The polarized PVIN power terminal blocks are used to connect to the host input supply, and the polarized VOUT power terminal blocks are used to connect to the load. These terminal blocks can accept up to 16 AWG wire. The polarized VBIAS terminal block is used along with the VIN SELECT jumper (P1) when optional split power supply operation is desired. Refer to the LMZ31710 device [datasheet](#) for further information on split power supply operation. Refer to Table 1 for terminal block numbering for either the 2x or 4x LMZ31710 parallel test board.

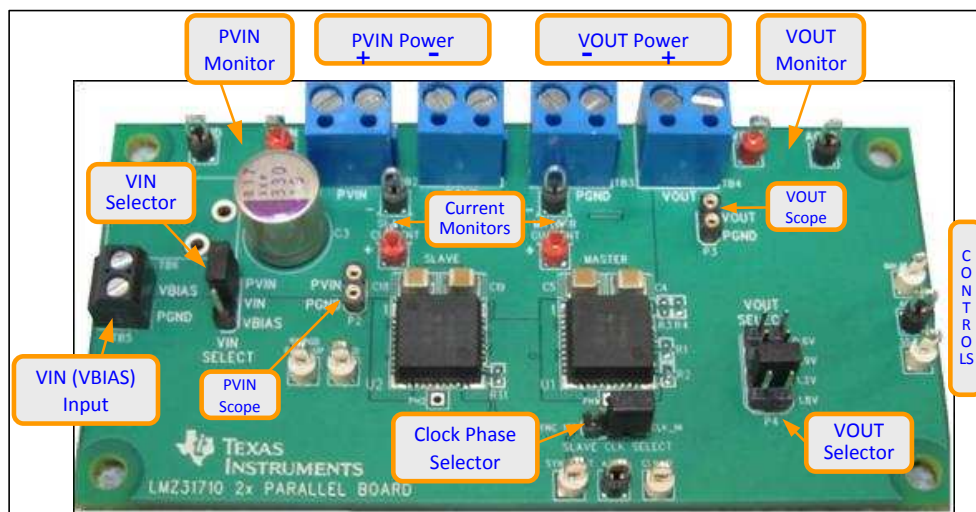


Figure 1. 2x LMZ31710 Test Board User Interface

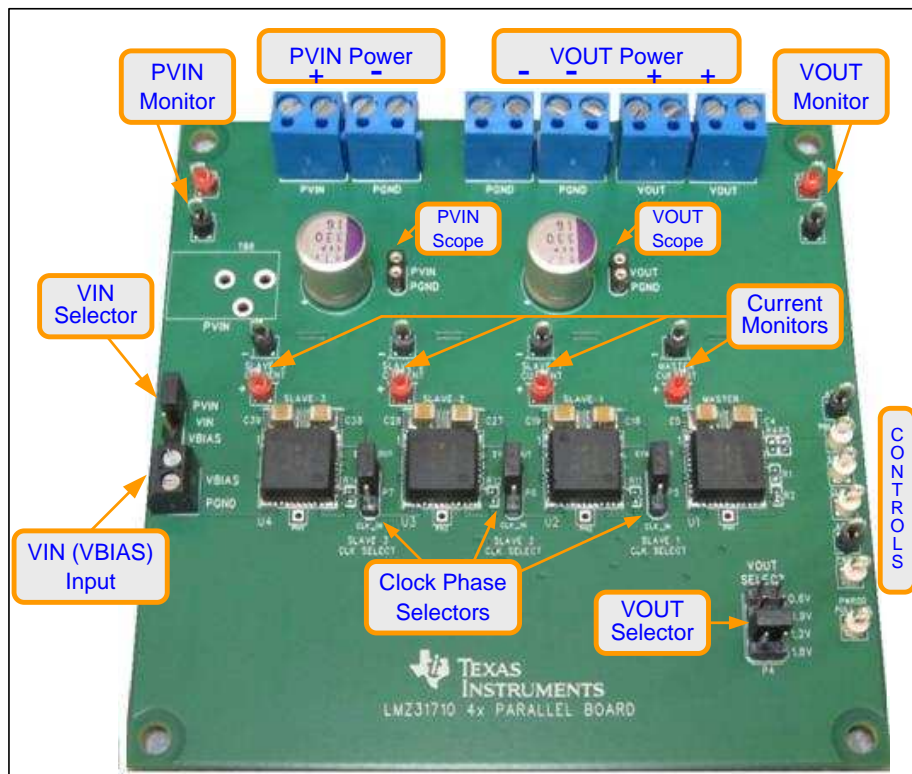


Figure 2. 4x LMZ31710 Test Board User Interface

Table 1. Terminal Block Numbering

Function	2x LMZ31710	4x LMZ31710
PVIN Power	TB1	TB1
PGND (Input)	TB2	TB2
PGND (Output)	TB3	TB3, TB4
VOUT Power	TB4	TB5, TB6
VBIAS Input	TB5	TB7

The PVIN Monitor and VOUT Monitor test points located near the power terminal blocks are intended as voltage monitoring points where digital voltmeters can connect to measure PVIN and VOUT.

CAUTION

Do not use these PVIN and VOUT monitoring test points as the input supply or output load connection points. The PCB traces connecting to these test points are not designed to support high currents. High currents may damage the PCB traces.

The PVIN Scope and VOUT Scope test points can be used to monitor PVIN and VOUT waveforms with an oscilloscope. These test points are intended for use with un-hooded scope probes outfitted with a low-inductance ground lead (ground spring) mounted to the scope barrel. The two sockets of each test point are on 0.1-inch centers. The scope probe tip should be connected to the socket labeled PVIN, or VOUT, and the scope ground lead should be connected to the socket labeled PGND.

The current monitor test points located above each LMZ31710 device are intended to be used with digital voltmeters to monitor the current across a 1-m Ω sense resistor located on the bottom of the board. The controls test points located on the perimeter of the board are made available to test the features of the device. Any external connections made to these test points should be referenced to an AGND test point. Refer to [Section 3](#) for more information on the individual control test points.

The VOUT SELECT jumper (P4) is provided for selecting the desired output voltage. Before applying power to the test board, ensure that the jumper is present and properly positioned for the intended output voltage. Always remove input power before changing the jumper settings.

3 Test Point Descriptions

Wire-loop test points and scope probe test points have been provided as convenient connection points for digital voltmeters (DVM) or oscilloscope probes to aid in the evaluation of the test board. A description of each test point follows:

Test Point	Description
AGND	Control and monitor grounds. Reference the DVMs and any signals associated with the control test points to any of the analog ground points.
CLK_IN	Connects to the RT/CLK pin of the LMZ31710 devices. An external clock signal can be applied to this point to synchronize the devices to an appropriate frequency.
INH/UVLO	Connect this point to control ground to inhibit the LMZ31710 devices. Allow this point to float to enable the device. An external resistor divider (R3 and R4) can be connected between this point, control ground, and PVIN to adjust the undervoltage lockout of the device.
PVIN	Input voltage monitor. Connect the DVM to this point for measuring efficiency.
PVIN Scope (P2)	Input voltage scope monitor. Connect an oscilloscope to this set of points to measure input ripple voltage.
PWRGD	Monitors the power good signal of the LMZ31710. This is an open drain signal that requires an external pull-up resistor if monitoring is desired. TI recommends a 10 to 100-k Ω pull-up resistor.
PWRGD PULL_UP	Power good pull-up voltage connection point. Connect an external voltage (< 6 V) to this pin to supply a voltage for the PWRGD signal. A 100-k Ω pull-up resistor is located on the bottom-side of the board.
SS/TR	Connects to the slow-start connection of the LMZ31710 devices. An external capacitor can be connected from this point to control ground to increase the slow-start time of the devices. This point can also be used as an input for tracking applications.
SYNC_OUT	This output provides a clock signal that is 180° out of phase with the PH node of the LMZ31710 device and can be used to synchronize other devices.
VOUT	Output voltage monitor. Connect DVM to this point for measuring efficiency, line regulation, and load regulation.
VOUT Scope (P3)	Output voltage scope monitor. Connect an oscilloscope to this set of points to measure output ripple voltage and transient response.

4 Operation Notes

To operate the test board using a single power supply, the VIN SELECT jumper (P1) must be in the default PVIN-VIN position as shown in [Figure 1](#) and [Figure 2](#). In this position, the PVIN and VIN pins of the LMZ31710 devices are connected together. When connected together the input voltage range is 4.5 to 17 V. Refer to the LMZ31710 [datasheet](#) for further information on the input voltage range, UVLO operation, and optional split power supply operation when using an external V_{bias} supply.

After a valid input voltage is present, the output voltage ramps to the selected value in approximately 1.2 ms. The soft-start time can be increased by adding a SS capacitor to the C12 position on the bottom of the test board. Refer to the LMZ31710 [datasheet](#) for further information on adjusting the soft-start time.

All LMZ31710 devices on the test board must be synchronized to the same frequency. This can be accomplished by either applying an external clock signal to the CLK_IN test point and running the clock to each device, or by setting the frequency of the master device using the RRT resistor (R2) and running the Sync_Out signal to the remaining slave devices. The Clock Phase Selector for each device is used to select either the external clock or the Sync_Out clock signal. The Sync_Out signal is a clock signal that is the same as the switching frequency, but is 180° out of phase. The test boards are set-up to operate at a free-running frequency of 300 kHz. To change the free-running switching frequency, the value of R2 can be changed according to the LMZ31710 [datasheet](#).

Table 2 lists the switching frequency ranges for each of the VOUT selections. Several factors such as duty cycle, minimum on-time, minimum off-time, and current limit influence selection of the switching frequency.

Table 2. Switching Frequency Range

VOUT (V)	Frequency Range	
	PVIN = 12 V	PVIN = 5 V
0.6	200 to 250 kHz	200 to 550 kHz
0.9	200 to 300 kHz	200 to 800 kHz
1.2	200 to 450 kHz	200 to 1000 kHz
1.8	300 to 600 kHz	300 to 1200 kHz

5 Current Limitations

When operating LMZ31710 devices in parallel, the maximum output current the solution can provide must be calculated using Equation 1. Due to internal variances between devices, the amount of output current must be de-rated to ensure none of the devices operate above the maximum output current of a single device (10 A). See Figure 3 for typical current balancing between four LMZ31710 devices.

$$I_{OUTmax} = 0.9 \times (n \times 10) \text{ (A)}$$

where n is the number of LMZ31710 devices being paralleled (1)

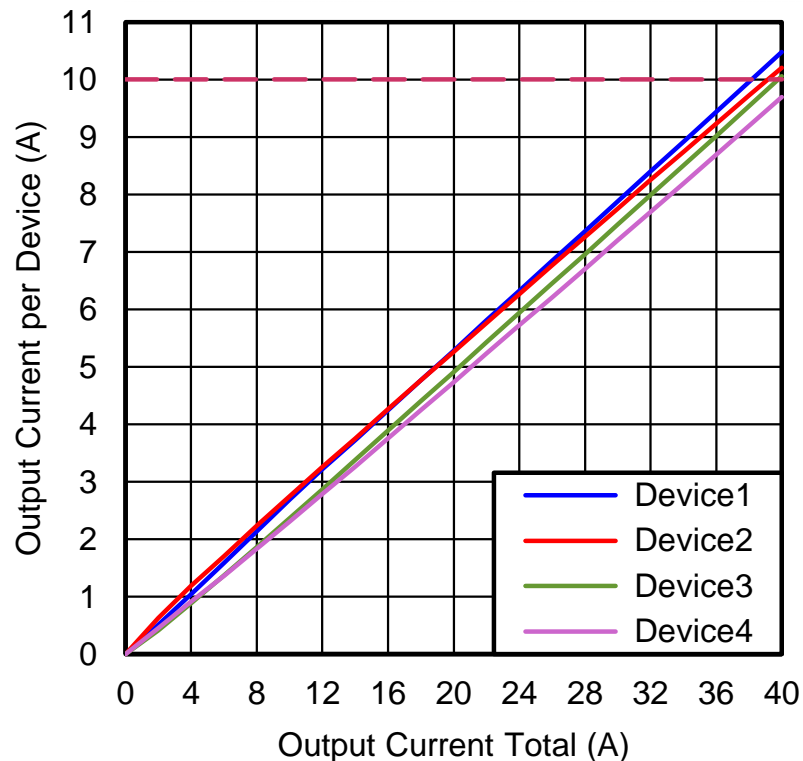


Figure 3. Typical Current Balancing

6 Performance Data

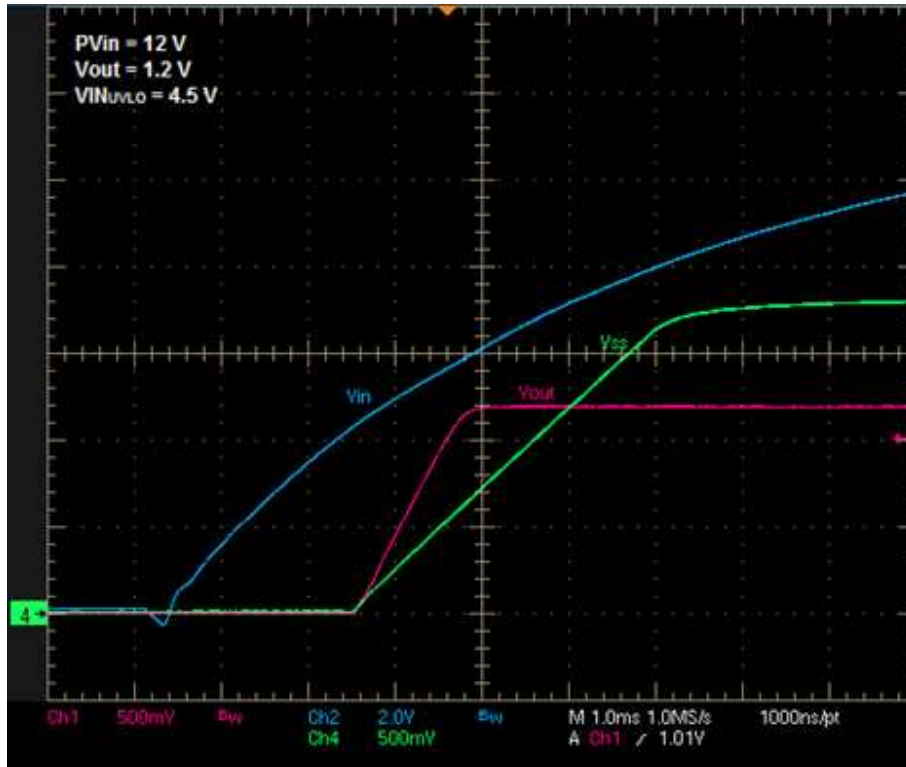


Figure 4. UVLO Start-Up Waveform



Figure 5. UVLO Shutdown Waveform



Figure 6. INH Start-Up Waveform



Figure 7. INH Shutdown Waveform

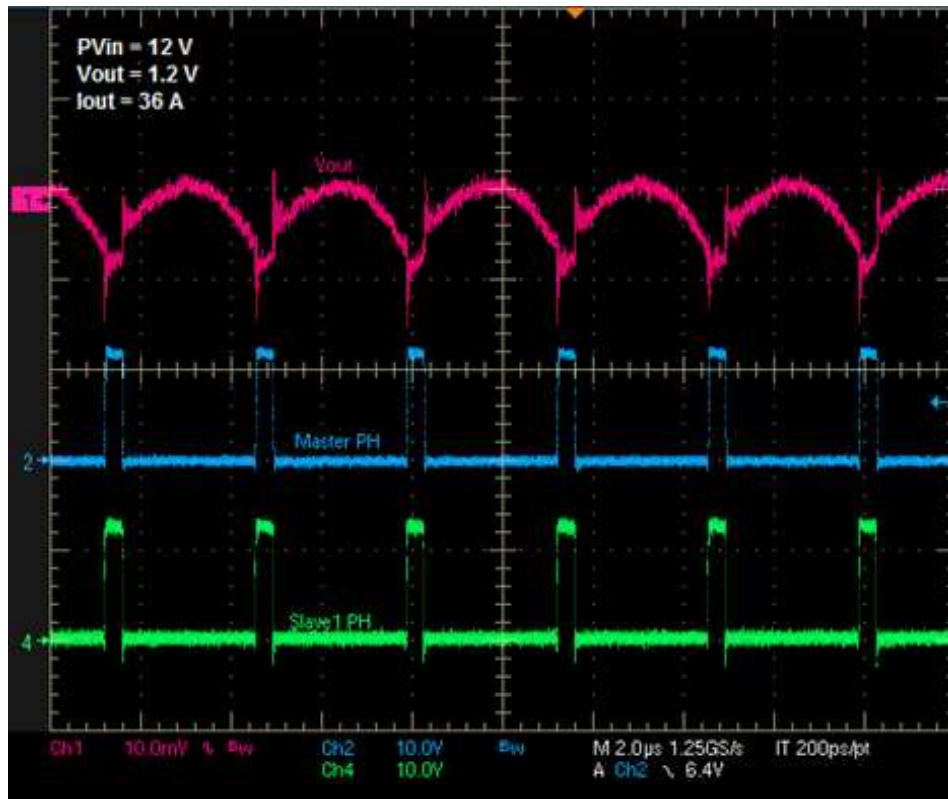


Figure 8. Output Voltage Ripple – In-Phase

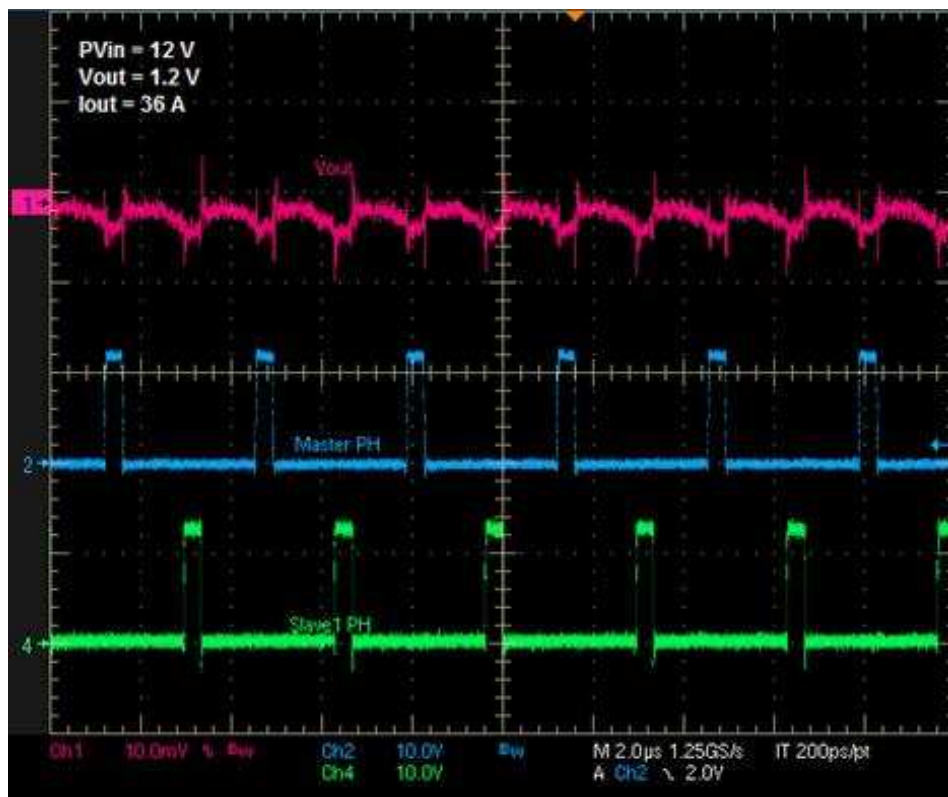


Figure 9. Output Voltage Ripple – 180° Out-of-Phase

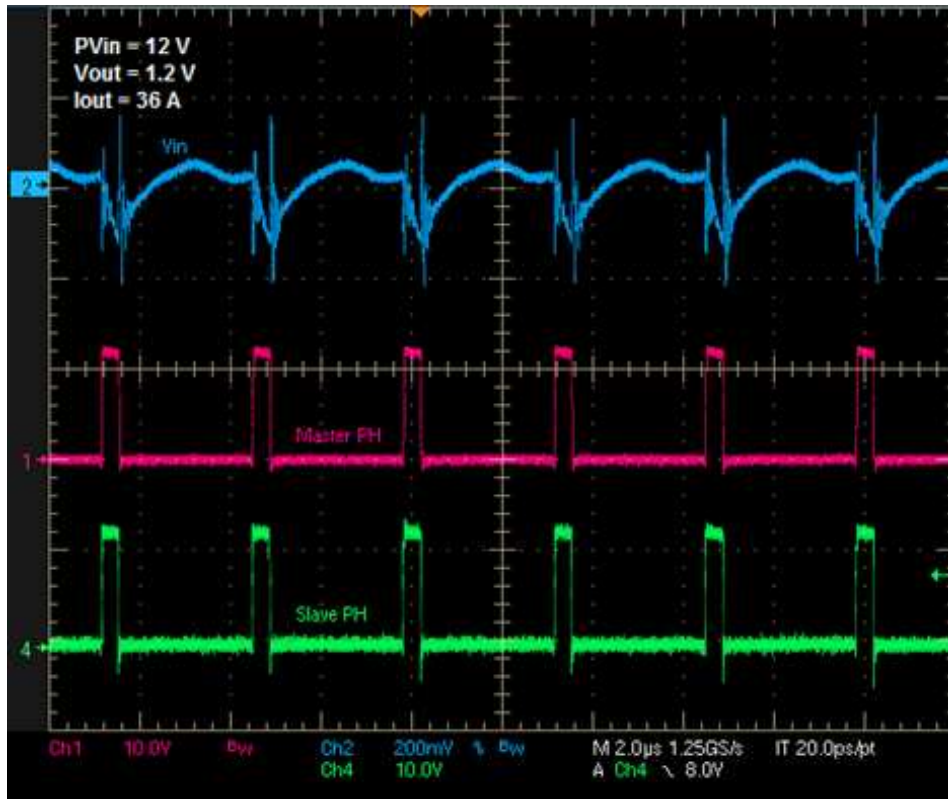


Figure 10. Input Voltage Ripple – In-Phase

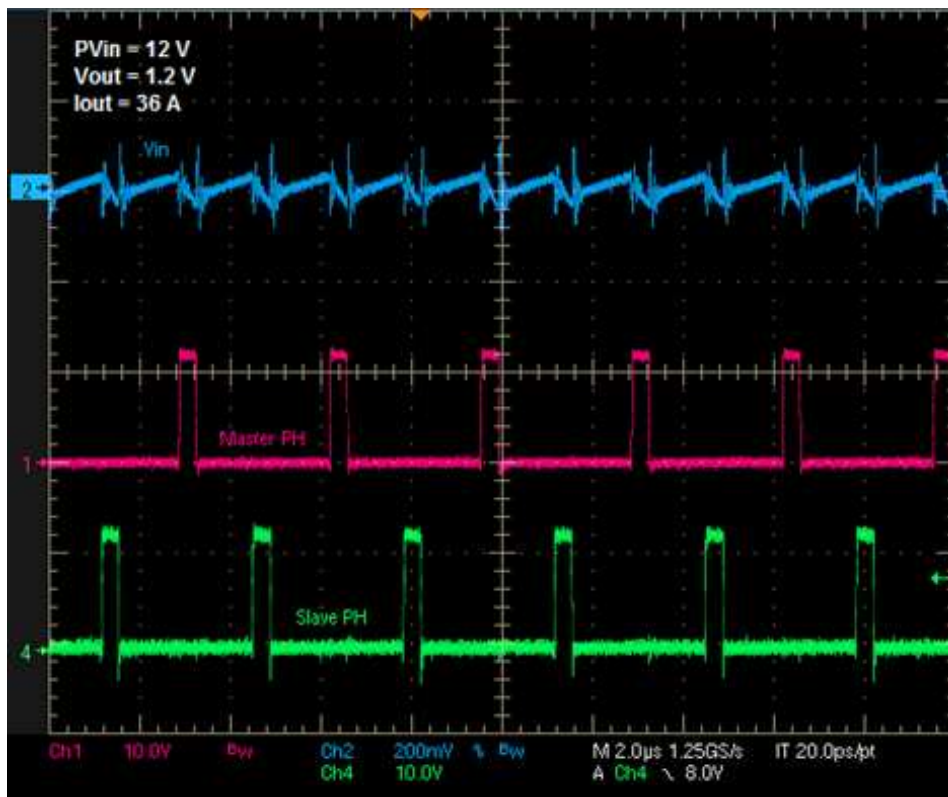


Figure 11. Input Voltage Ripple – 180° Out-of-Phase

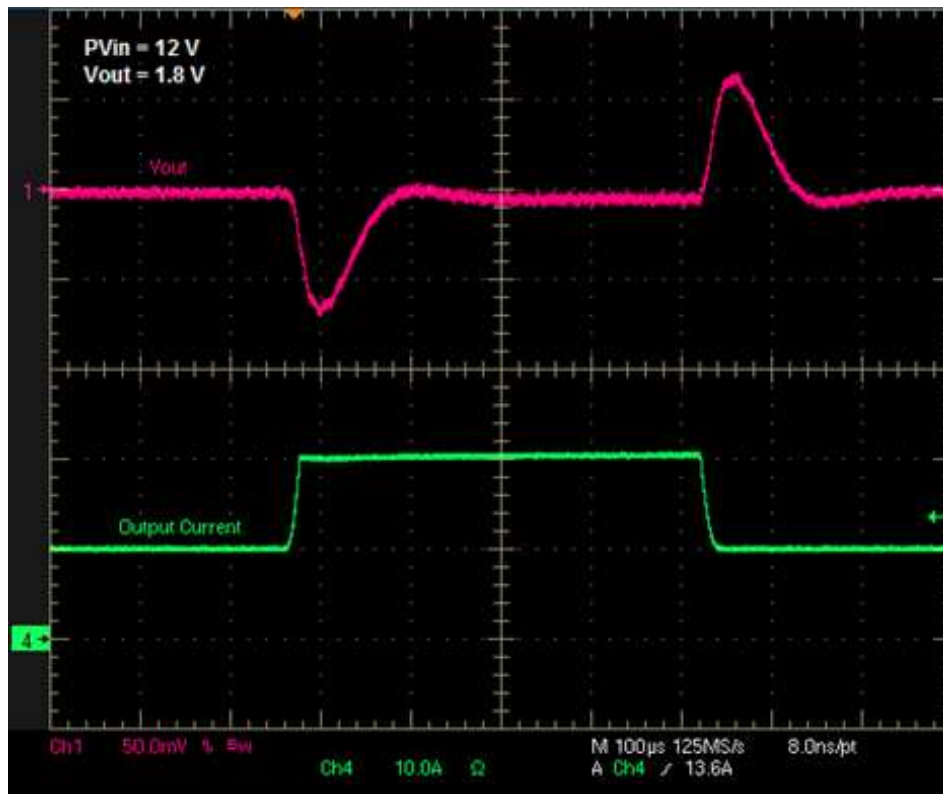
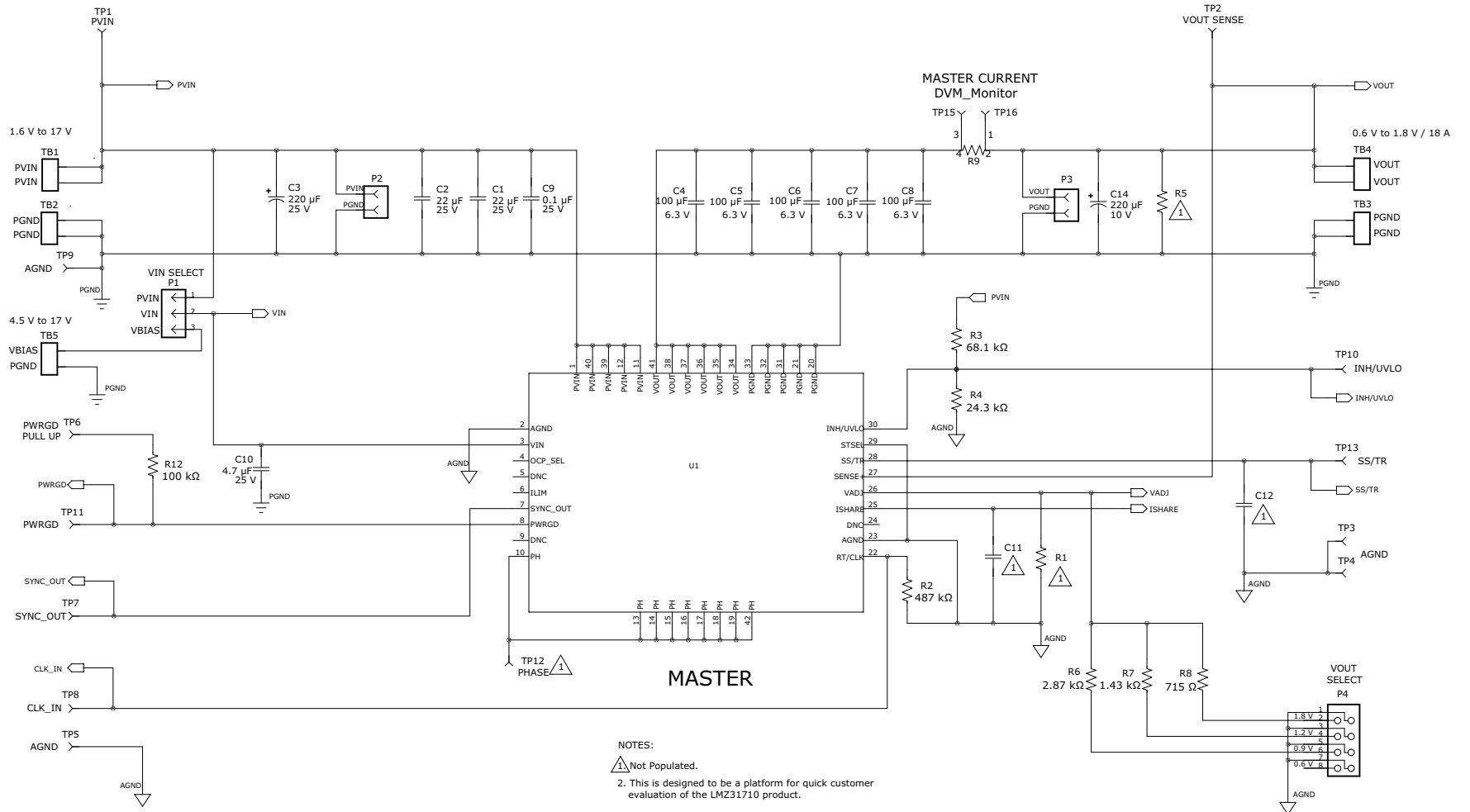


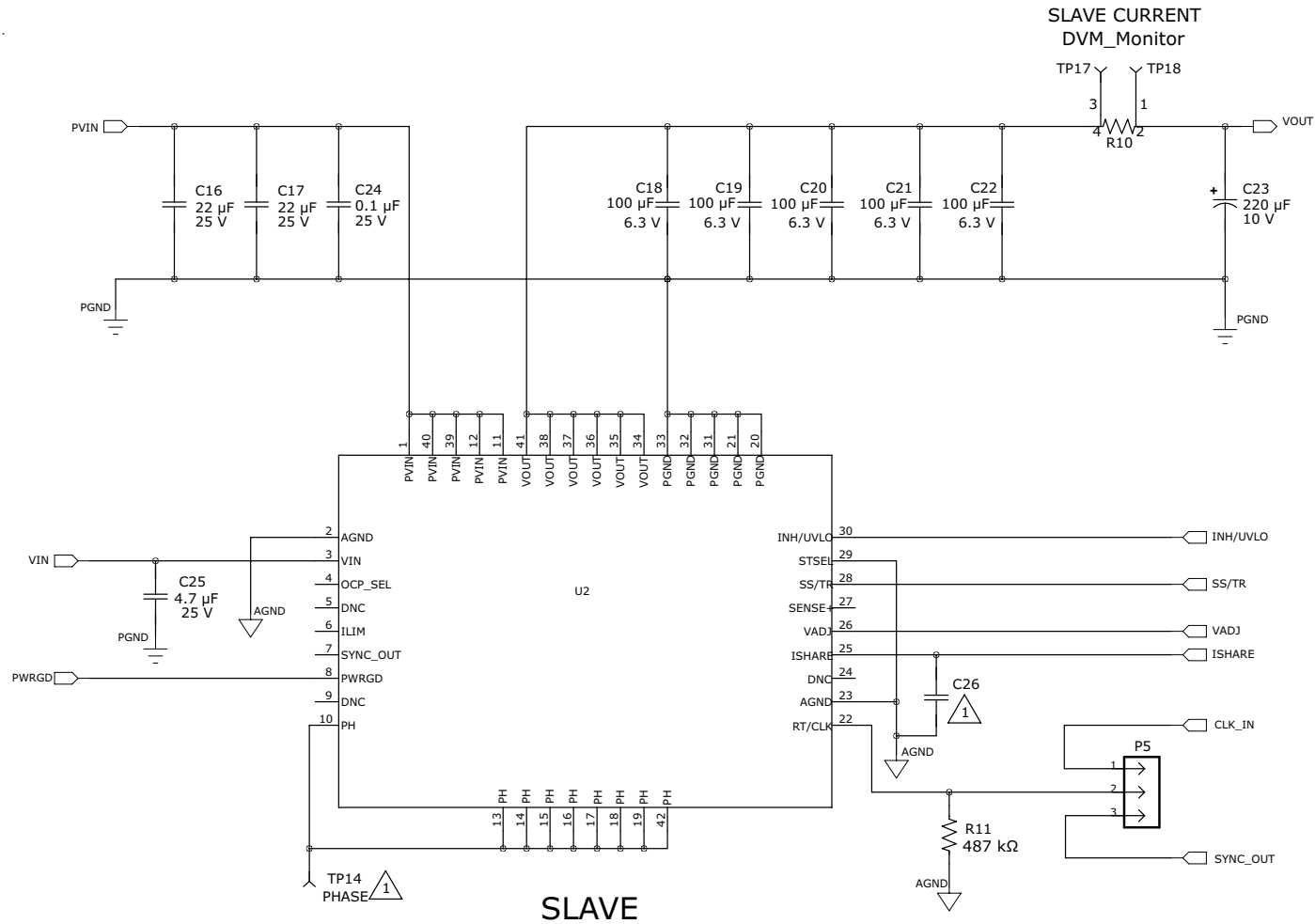
Figure 12. Transient Response – 10-A Load Step (1 A/µs)

7 2x Parallel Bill of Material

RefDes	Part Type	Value
C1, C2, C16, C17	C1210	22 μ F
C4, C5, C6, C7, C8, C18, C19, C20, C21, C22	C1210	100 μ F
C9, C24	C0805	0.1 μ F
C10, C25	C0805	4.7 μ F
C11, C12, C26	C0805	DNL
C3	CAP_ALUM_FC-A	220 μ F
C14, C23	CAP_POSCAP_D	220 μ F
P1, P5	MALE HEADER_1X3	PEC03SAAN
P2, P3	FEMALE HEADER_1X2	SOCKET 2 PIN
P4	MALE HEADER_2X4	PEC04DAAN
R1	R0402	NOT POPULATED
R2, R11	R0402	487k
R3	R0402	68.1k
R4	R0402	24.3k
R5	R0805	NOT POPULATED
R6	R0603_1%	2.87k
R7	R0603_1%	1.43k
R8	R0603_1%	715 Ω
R9, R10	57-WSL3637	R001R 1%
R12	R0603	100k
TB1, TB2, TB3, TB4	TBLK_15A_2X5.1MM	ED120/2DS
TB5	TBLK_6A_2X3.5MM	ED555/2DS
TB6	CONN_DC_PJ-102AH	PJ-102AH
TP6, TP7, TP8, TP10, TP11, TP13	TP-5012-WHITE	5012
TP1, TP2, TP15, TP17	TP-5010-RED	5010
TP3, TP4, TP5, TP9, TP16, TP18	TP-5011-BLACK	5011
TP12, TP14	TP-038	STD
U1, U2	LMZ31710RVQ	LMZ31710RVQ

8 2x Parallel Schematic





NOTES:

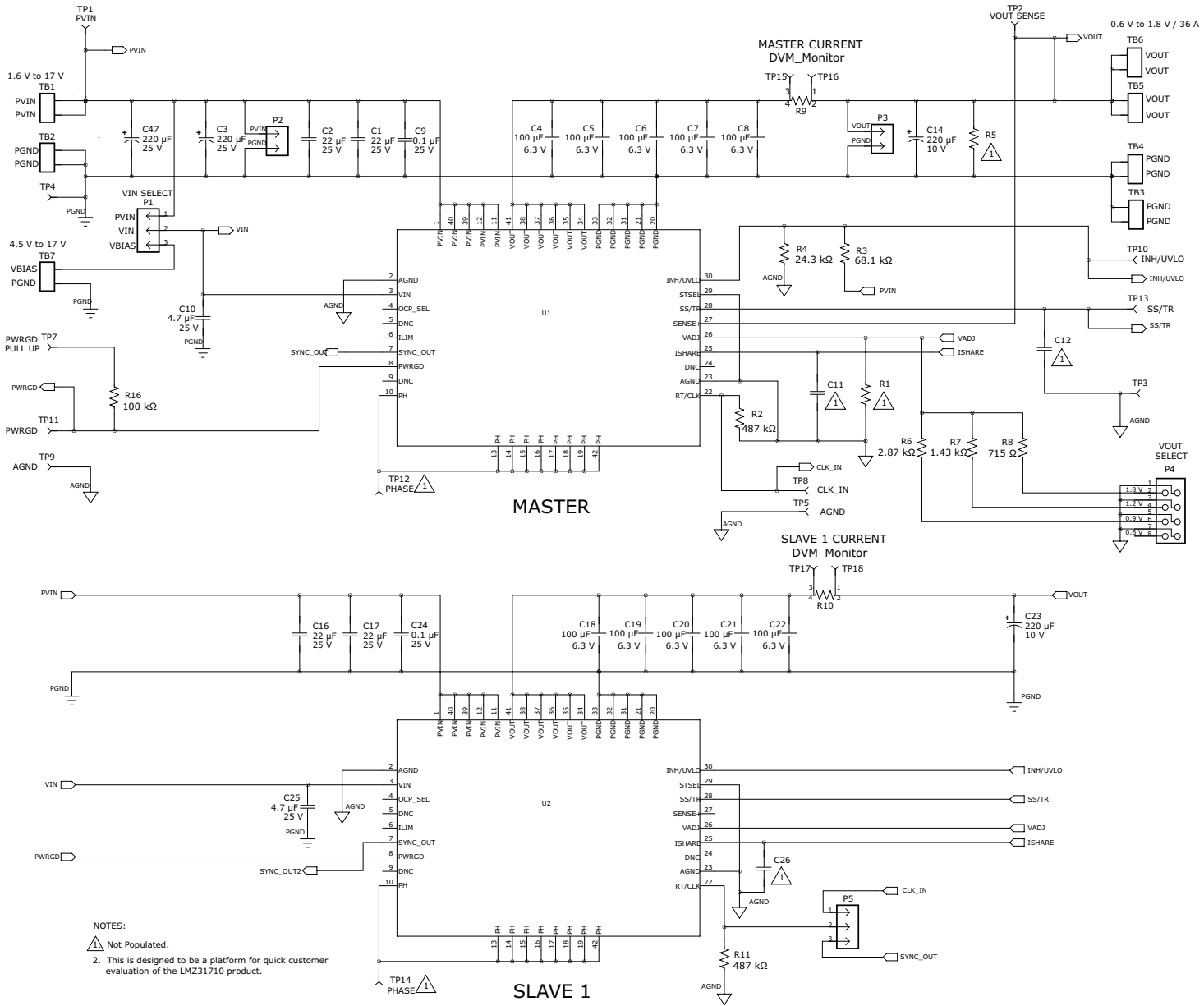
1 Not Populated.

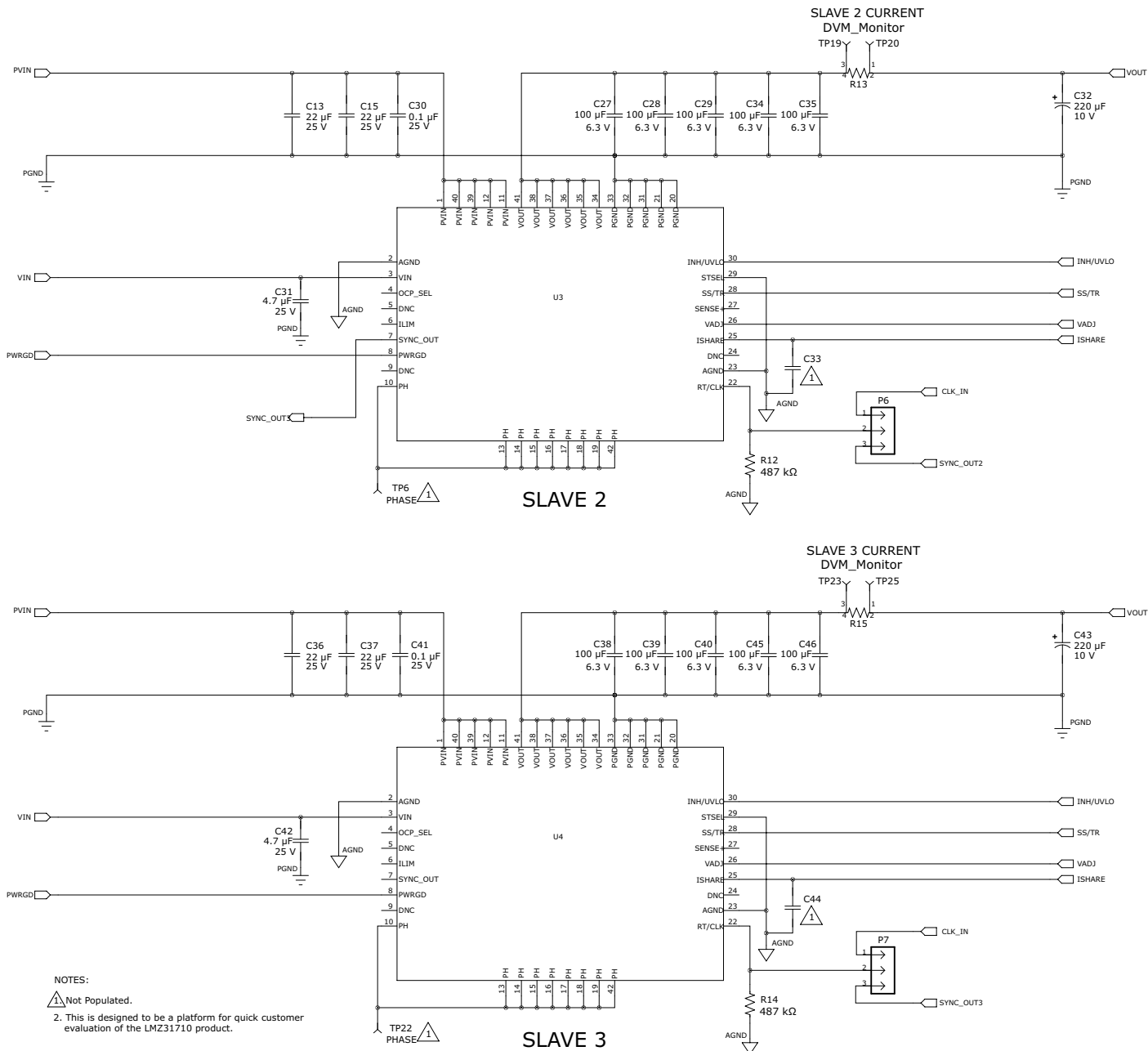
2. This is designed to be a platform for quick customer evaluation of the LMZ31710 product.

9 4x Parallel Bill of Material

RefDes	Part Type	Value
C1, C2, C13, C15, C16, C17,C36, C37	C1210	22 μ F
C4, C5, C6, C7, C8, C18, C19, C20, C21, C22, C27, C28, C29, C34,C35, C38, C39, C40, C45, C46	C1210	100 μ F
C9, C24, C30, C41	C0805	0.1 μ F
C10, C25, C31, C42	C0805	4.7 μ F
C11, C12, C26, C33, C44	C0805	DNL
C3, C47	CAP_ALUM_FC-A	220 μ F
C14, C23, C32, C43	CAP_POSCAP_D	220 μ F
P1, P5, P6, P7	HEADER_1X3	PEC03SAAN
P2, P3	HEADER_1X2	NOT POPULATED
P4	HEADER_2X4	PEC04DAAN
R1	R0402	NOT POPULATED
R2, R11, R12, R14	R0402	487k
R3	R0402	68.1k
R4	R0402	24.3k
R5	R0805	NOT POPULATED
R6	R0603_1%	2.87k
R7	R0603_1%	1.43k
R8	R0603_1%	715 Ω
R9, R10, R13, R15	57-WSL3637	R001R 1%
R16	R0603	100k
TB1, TB2, TB3, TB4, TB5, TB6	TBLK_15A_2X5.1MM	ED120/2DS
TB7	TBLK_6A_2X3.5MM	ED555/2DS
TP1, TP2, TP15, TP17, TP19, TP23	TP-5010-RED	5010
TP3, TP4, TP5, TP9, TP16, TP18, TP20, TP25	TP-5011-BLACK	5011
TP7, TP8, TP10, TP11, TP13	TP-5012-WHITE	5012
TP6, TP12, TP14, TP22	TP-038	STD
U1, U2, U3, U4	LMZ31710RVQ	LMZ31710RVQ

10 4x Parallel Schematic





NOTES:
 1. Not Populated.
 2. This is designed to be a platform for quick customer evaluation of the LMZ31710 product.

Revision History

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
 - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.
3. *Regulatory Notices:*
 - 3.1 *United States*
 - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.
 - 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

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