Advance Information

TPS92520-Q1 LaunchPad-Controlled, ECU Evaluation Module User's Guide

User's Guide

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August 2019–Revised October 2019

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General Texas Instruments High Voltage Evaluation (TI HV EMV) User Safety Guidelines

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center http://ti.com/customer support for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions may result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is *intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments.* If you are not suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety:
   a. Keep work area clean and orderly.
   b. Qualified observer(s) must be present anytime circuits are energized.
   c. Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
   d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   e. Use stable and non-conductive work surface.
   f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
2. Electrical Safety:

   As a precautionary measure, it is always good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.

   a. De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   b. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   c. Once EVM readiness is complete, energize the EVM as intended.

WARNING

While the EVM is energized, never touch the EVM or its electrical circuits, as they could be at high voltages capable of causing electrical shock hazard.

3. Personal Safety
   a. Wear personal protective equipment e.g. latex gloves or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

User's Guide

SLUUC29B–August 2019–Revised October 2019

TPS92520EVM-074 LaunchPad-Controlled, ECU Evaluation Module

This user's guide describes the specifications, board connection description, operation, and use of the TPS92520EVM-074. The EVM consists of a CV boost stage, creating a regulated voltage rail that is used by two TPS92520 ICs. The two TPS92520 ICs then create four current regulated channels for driving strings of LEDs. The EVM is a representative of a lighting module suitable for automotive applications creating advanced lighting features.

The TPS92520-Q1 buck current regulator device implements an adjustable constant on-time, valley detect, current-mode control technique with programmable pseudo-fixed-frequency operation. Additional features include the following:

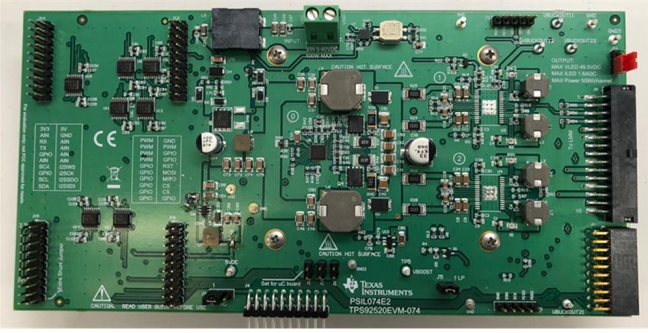
- Wide input voltage range (4.5 V to 65 V)
- Analog adjustable output current setting
- Fault reporting
- Internal and external PWM dimming

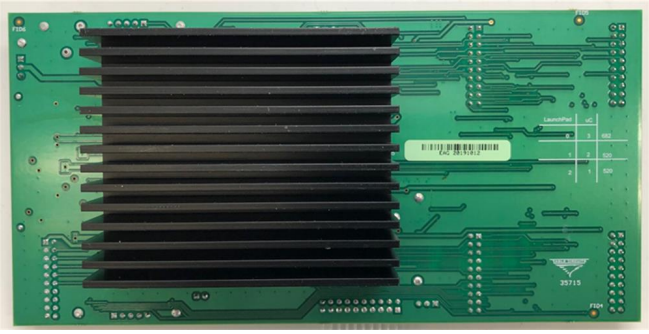
The TPS92682-Q1 boost controller device implements a fixed-frequency peak-current mode control technique with programmable switching frequency, slope compensation, and soft-start. Additional features include the following:

- Wide input voltage range (4.5 V to 65 V)
- Programmable spread spectrum frequency modulation
- Programmable fault handling
- Adjustable output current setting

Optionally, to exercise advanced lighting control features, an accompanying EVM to the TPS92520 ECU EVM, LMM EVM PWR901, can be used. The TPS92662-Q1 and TPS92663-Q1 (LMM, LED Matrix Manager) devices include series-connected integrated switches for bypassing individual LEDs. The individual sub-strings allow the device to accept either single or multiple current sources for bypassing high current LEDs.

A complete schematic diagram, printed circuit board layouts, and bill of materials are included in this document.





1 Trademarks

SimpleLink, LaunchPad are trademarks of Texas Instruments.
All other trademarks are the property of their respective owners.

2 Description

The TPS92520EVM-074 solution provides four current-regulated channels, providing up to 49.5 V, 1.6 A for each channel (expandable voltage range with board modification), from a 12 V (nom) input. The four TPS92520 channels and one dual-phase TPS92682 CV (constant voltage) channel are all configurable via serial peripheral interface (SPI). The maximum output voltage of the TPS92682 CV boost can be physically adjusted by modifying R34 (see Table 1). The EVM is designed to operate with an input voltage in the range of 6 V to 40 V and provides a maximum total output power of 100 W (maximum of 50 W per channel). For example, if one channel is operated at 50 W, the total power of the other three channels must not exceed 50 W. The TPS92520EVM-074 provides a unique high-efficiency, SPI-programmable solution with fault handling and reporting. It also includes standard ECU features: CAN (physical layer) interface and reverse battery protection.

The EVM is operated via a standard TI LaunchPad (MSP-EXP432E401Y) and does not function if the launchpad and GUI are not installed. It is possible to use your own or a different SPI controller after reviewing the documentation for all parts in detail.

Figure 1 shows the block diagram of the system.

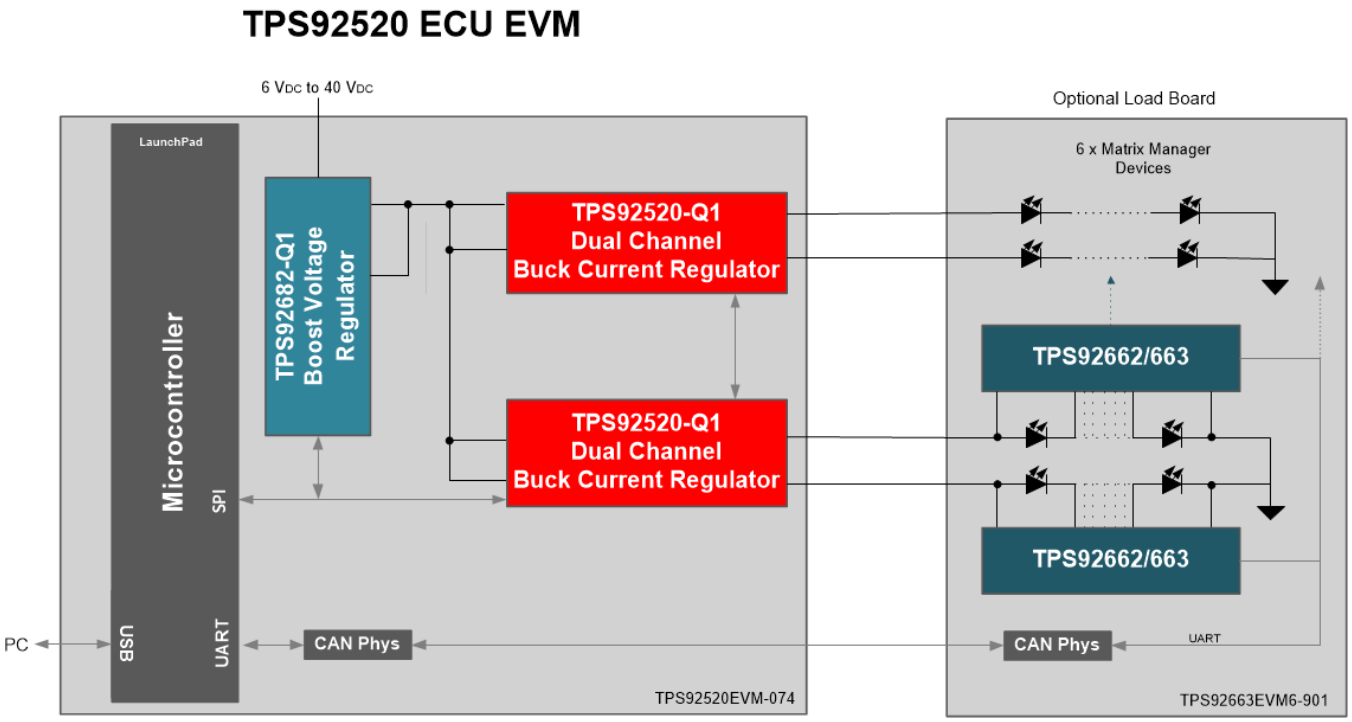


Figure 1. TPS92520EVM-074 Block Diagram

2.1 Typical Applications

This document outlines the operation and implementation of the TPS92520-Q1 as a four-channel LED current regulator. Table 2 lists the specifications. For applications with a different input voltage range or different I_{LED} range, refer to the *TPS92520-Q1 1.5-A Dual Synchronous Buck LED Driver Data Sheet*. The MSP-EXP432E401Y SimpleLink™ Ethernet MSP432E401Y MCU LaunchPad™ Development Kit controls the TPS92520EVM-074 evaluation board. The MSP-EXP432E401Y is available on ti.com. Ensure that the LaunchPad board from TI has been programmed using the UNIFLASH application before running the GUI. Section 7 provides the programming instructions.

2.2 Warnings

Observe the following precaution when using the TPS92520EVM-074 evaluation module. Do not leave the EVM powered when unattended.

CAUTION

Do not touch. This is a hot surface and contact can cause burns.

CAUTION

Do not stare at the operation LED: (Risk Group 2 (RG2) at a distance <0.9m), (Risk Group 1 (RG1) at a distance > 0.9m(, (Risk Group Exempt (RGE) at a distance > 1.8 m). The LED may be hardmful to the eyes. See IEC62471:2008 ("photo biological safety of lamps and lamp systems") for risk group definitions.

2.3 Connector Description

Table 1 describes the connectors on the EVM and how to properly connect, set up, and use the TPS92520EVM-074.

Figure 2 shows the connection diagram and the jumper locations of the TPS92520EVM-074.

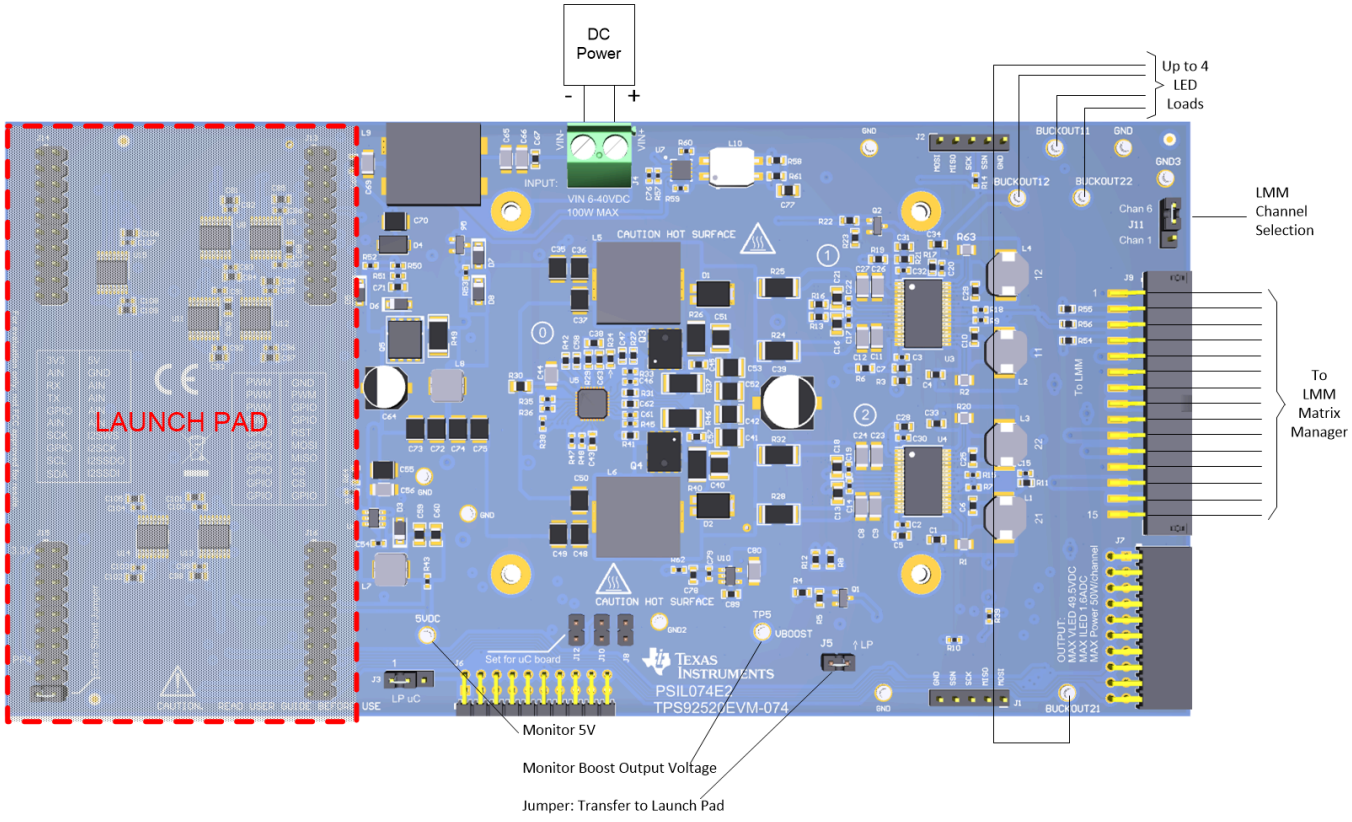


Figure 2. Component Connections

Table 1. Connector Descriptions

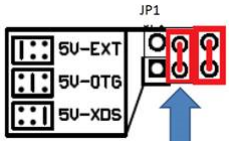
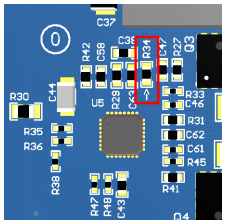
CONNECTOR	TOPIC	DESCRIPTION
J1	Remote SPI	Auxiliary SPI port connection. Use this port to monitor SPI BUS communications to TPS92520 device U1 and U4.
J2		Auxiliary SPI port connection. Use this port to monitor SPI BUS communications to TPS92520 device U2 and U3.
J3	5 V Control	J3 controls the 5 V enable line. Select position 1–2 for launchpad interface.
J4	Vin	Input Voltage Connector
J5	Spare Jumper >> Transfer to Launch Pad	Spare LaunchPad Jumper – remove from EVM and transfer to the LaunchPad at JP1 as shown in Figure 3.  **Figure 3. Jumper Placement for Launch Pad Use**
J6, J7	Expansion Port	These ports can be ignored. This port provides a connection port for EVM use with the PWR879 microcontroller board (interface board used with TPS92518). This port also provides a port to connect an additional TPS92520 EVM.
J8, J10, J12	Expansion Port	Provides connection point for additional SSN (slave select n) signals when using additional TPS92520 EVM connections via the J7 port. Leave the port open for normal operation with the launchpad.
J9	LMM	Matrix Manager Connection. Port and GUI are compatible with the TPS92663EVM6-901. Note that current sources are in parallel with 520-BxCx output pins. It is not recommended to use both at the same time.
J11	Channel Selector	The TPS92663EVM6-901 has six inputs and the TPS92520-074 EVM provides four outputs. J11 allows the user to power five of the six LED strings. Set J11 to route 520-B1C2 to either the top string of LED controlled via Address 1 OR the bottom string of LEDs controlled by Address 2.
J13, J14, J15, J16	Launch Pad Port	LaunchPad connection ports. Ensure the launchpad is aligned before applying power or it can result in the launchpad getting damaged.
5VDC	5 V Monitor	5 V output of the U6 controlled LMR16006Y-Q1, fixed 5 V switching regulator
520-B1C1, 520-B1C2, 520-B2C1, 520-B2C2	Output Pins	Positive outputs of the four buck regulators
VBOOST	Boost Output	TPS92682 Dual-Phase VC Boost Output. Adjust R34 to set the maximum boost output voltage.
GND	Ground	Ground test points

Table 1. Connector Descriptions (continued)

CONNECTOR	TOPIC	DESCRIPTION
R34	VBOOST_Max	The maximum boost output voltage can be adjusted to match your LED string requirements. For safety requirements, the voltage has been limited to <50 V (49.5 V) by setting R34 to 5.1 kΩ. The voltage can be adjusted to a maximum of 65 V by changing the value of R34: R34 = (2.39 × 100 k) / (VBOOST_Max - 2.39). **WARNING** **Once R34 is changed, the maximum slider position corresponds to the new programmed value. A voltage greater than 50 V can require special handing precautions at your location. Consult your local lab manager and safety codes before making any changes to the EVM.**  **Figure 4. Boost Output Voltage Limit Adjustment**

3 REACH Compliance

In compliance with the Article 33 provision of the EU REACH regulation, TI is notifying you that this EVM includes component or components that contain at least one substance of very high concern (SVHC) above 0.1%. These uses from Texas Instruments do not exceed one ton per year. The SVHC specifications are:

COMPONENT MANUFACTURER	COMPONENT PART NUMBER	SVHC SUBSTANCE	SVHC CAS (WHEN AVAILABLE)
PHOENIX CONTACT GmbH & Co. KG	1715721 and 1715747	Lead (Pb)	7439-92-1

4 Performance Specifications

This section provides the performance specifications and requirements for the dual-phase CV TPS926682 boost and TPS92520 buck current regulators.

4.1 ECU Current Regulator

Table 2 provides the EVM electrical performance specifications for the lighting ECU.

Table 2. TPS92520EVM-074 ECU EVM Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS					
Voltage, V_{IN}		6	12	40	V

Table 2. TPS92520EVM-074 ECU EVM Performance Specifications (continued)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Output Power, P_{OUT}				100	W
Maximum Input Current, I_{IN}	Note: derating of 100 W maximum is necessary below 10 V			10	A
OUTPUT CHARACTERISTICS					
Total LED forward voltage, $V_{(LED)}$				49.5	V
Output voltage V_{OUT}	Maximum voltage on 520-CxBx terminal			65	V
Maximum output current, I_{LED}				1.6	A
Maximum Channel Output Power, P_{OUT}				50	W
SYSTEMS CHARACTERISTICS					
TPS92520 Switching frequency F_{SW}	Target for this EVM design (On Time = 7)		400		kHz

5 Performance Data and Typical Characteristic Curves

Figure 5 shows the efficiency results for the system versus CH_{xIADJ}. The results shown have used eight LED in series. It is important to note that the efficiency results include the all EVM power losses, including the input reverse battery protection circuitry.

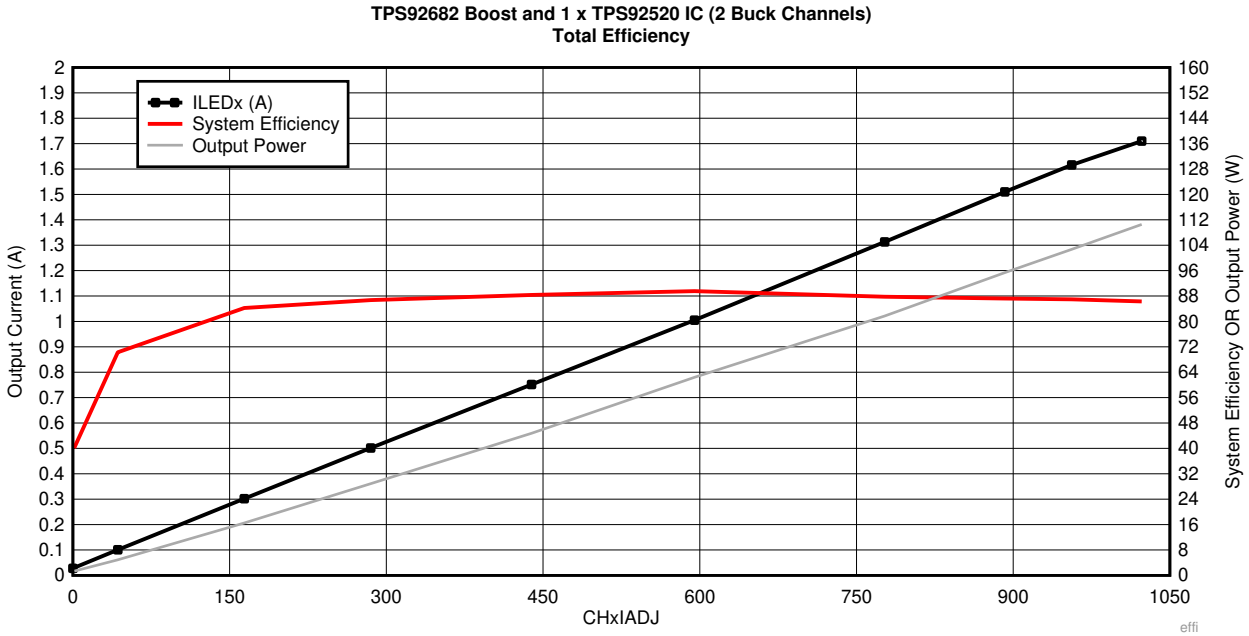


Figure 5. ECU Metrics, V_{IN} = 12 V, TPS92682 Boost Channel and 2 Channels from 1 x TPS92520 IC

5.1 Start-up Waveforms

Figure 6 shows the start-up waveforms, V_{LED} , COMP, and the switch-node voltage (SWN). In this setup, a string of 7×LEDs are connected to the buck output and the boost is set to 47 V.

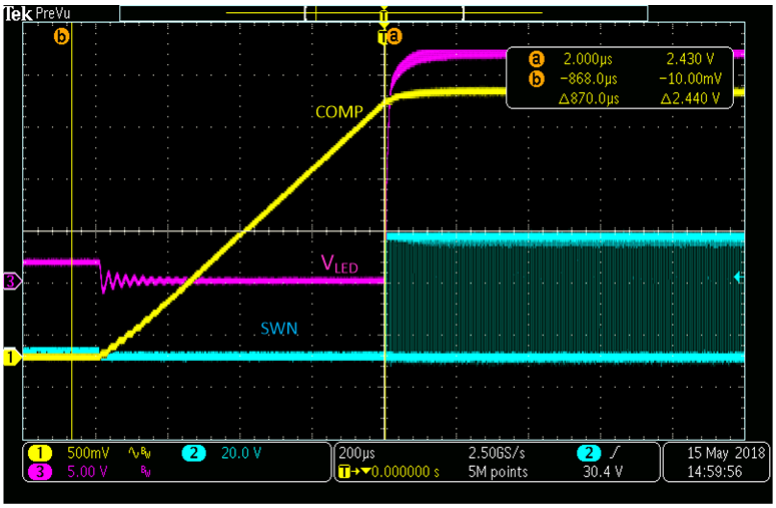
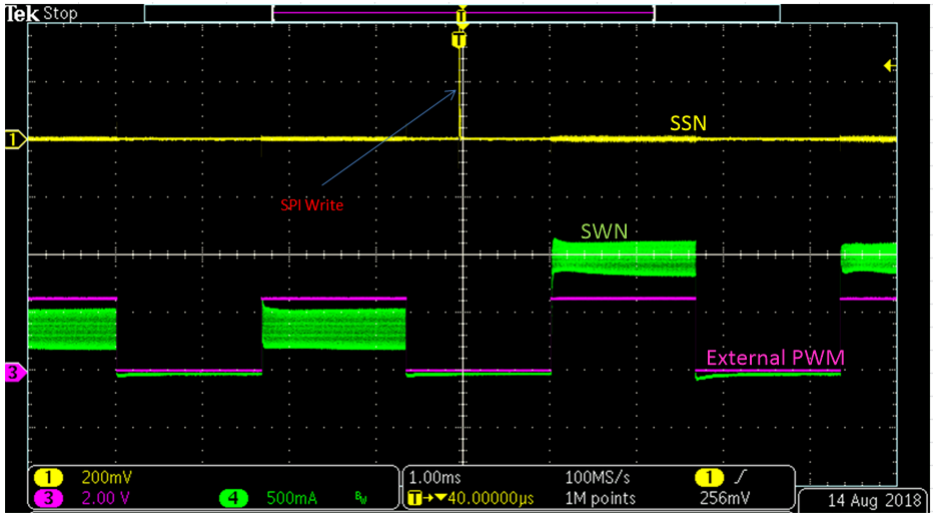


Figure 6. Start-up Waveforms

5.2 PWM Dimming

Figure 7 shows PWM dimming of a buck channel of the TPS92520EVM-074 EVM. An additional feature of the waveform is that the I_{LED} is programmed to a different value during 300Hz PWM dimming.



V_{IN} = 12 V

Figure 7. PWM Dimming with IADJ Level Adjustment

6 Schematic, PCB Layout, and Bill of Materials

This section contains TPS92520EVM-074 schematics, PCB layouts, and bill of materials (BOM).

6.1 Schematic

Figure 9 illustrates the TPS92520EVM-074 schematic.

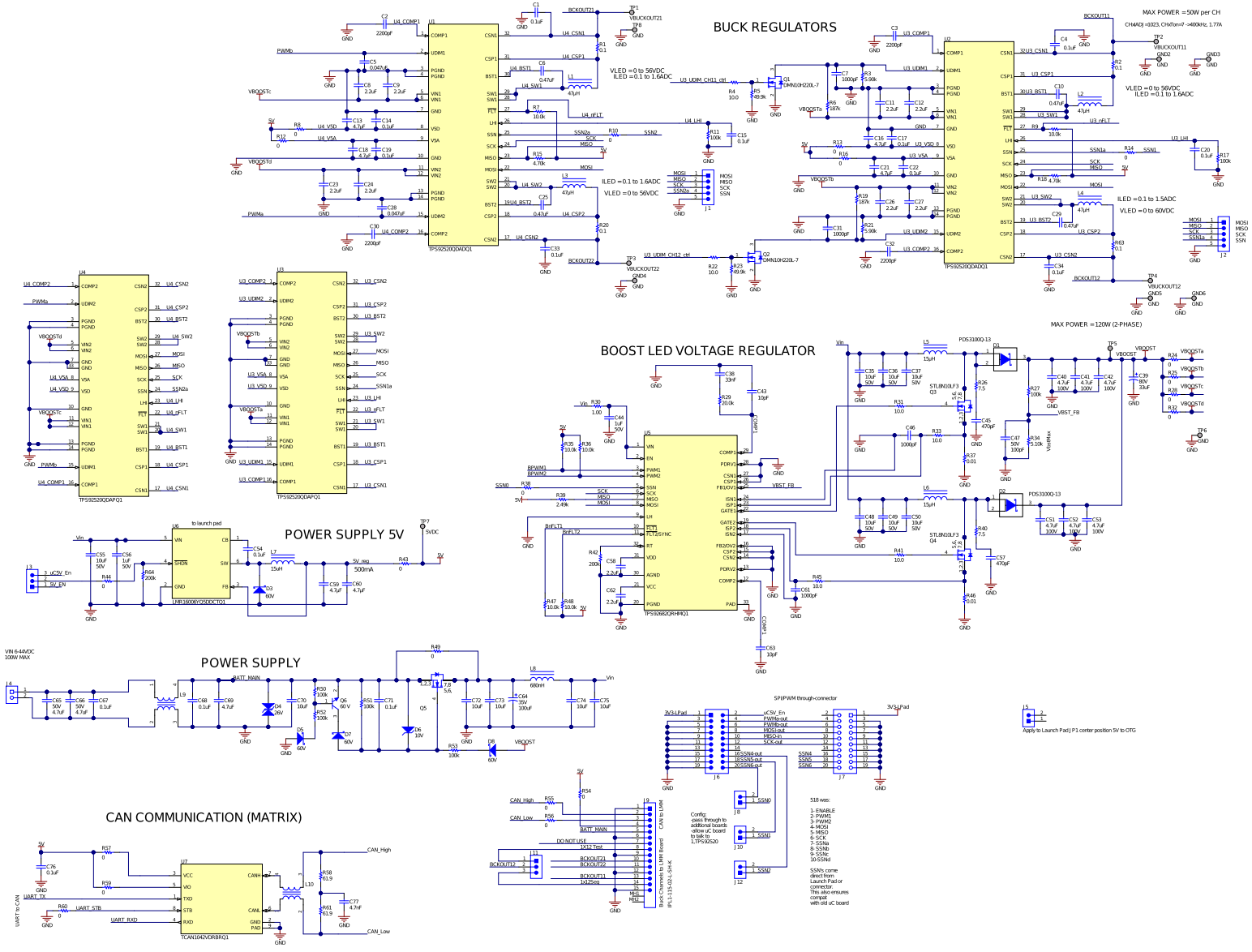


Figure 8. TPS92520EVM-074 Schematic

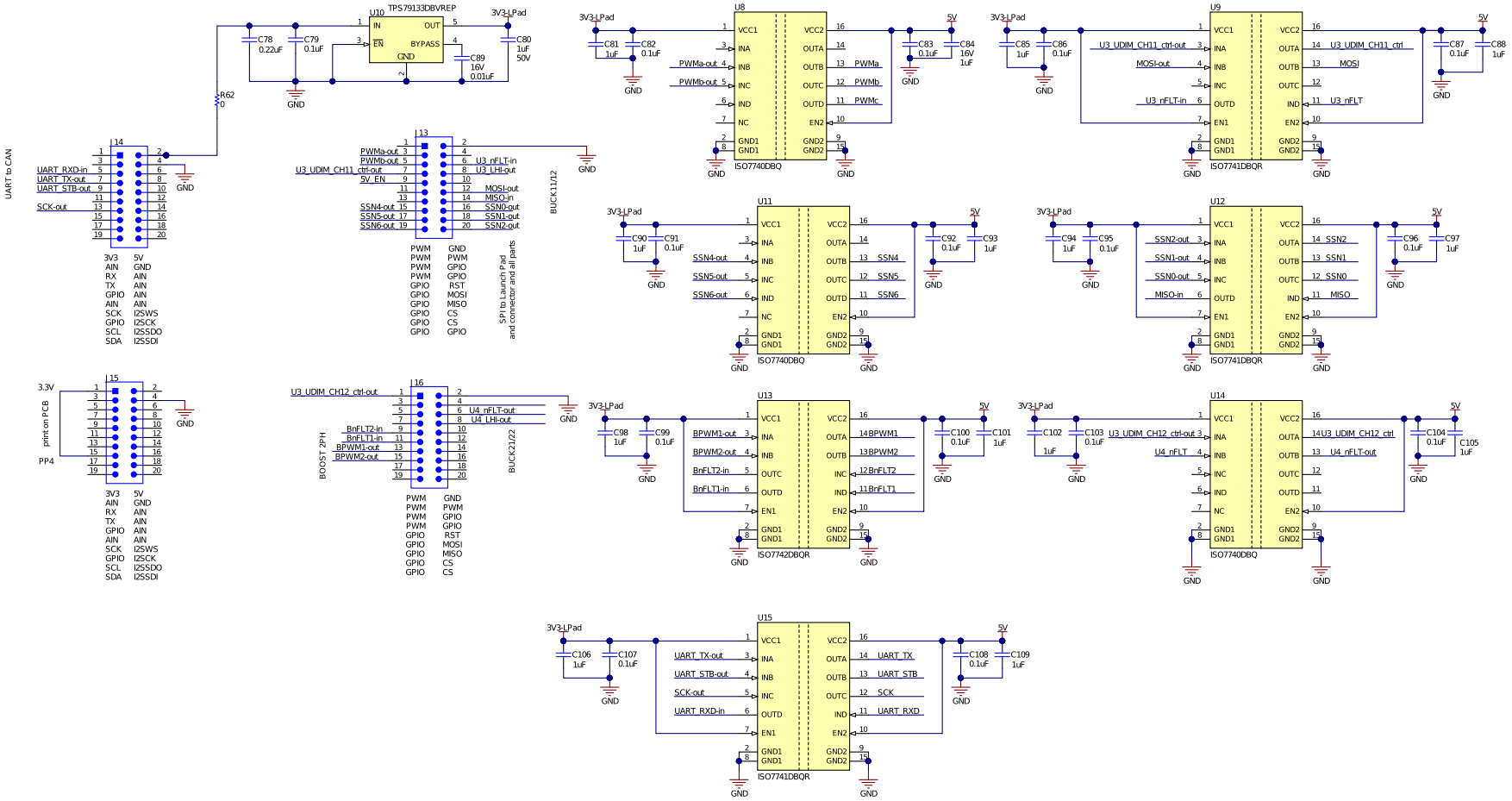


Figure 9. TPS92520EVM-074 Schematic - Page 2

6.2 Layout

The TPS92520EVM-074 is a four-layer board. Figure 10 through Figure 13 illustrate the following TPS92520EVM-074 PCB layout layers:

- Assembly
- Top
- Inner layer 1
- Inner layer 2
- Bottom

One layer is a ground plane and there is no routing on this layer.

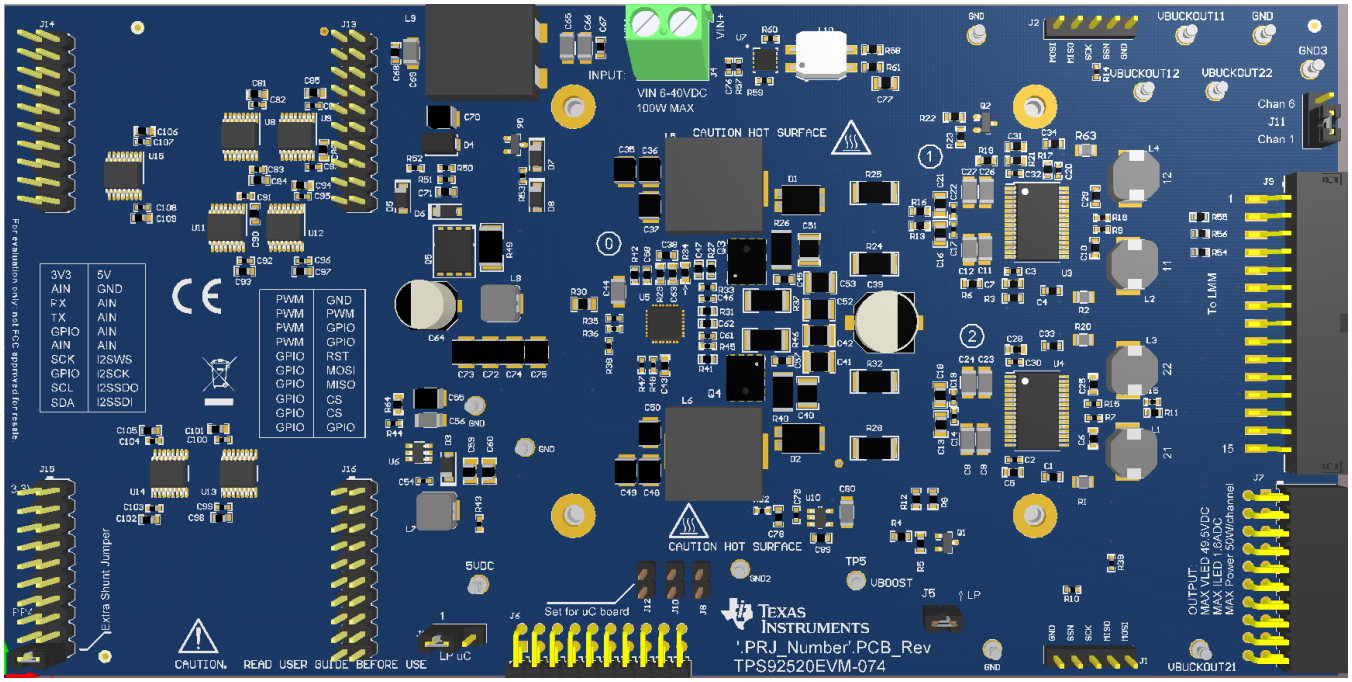


Figure 10. TPS92520EVM-074 Assembly

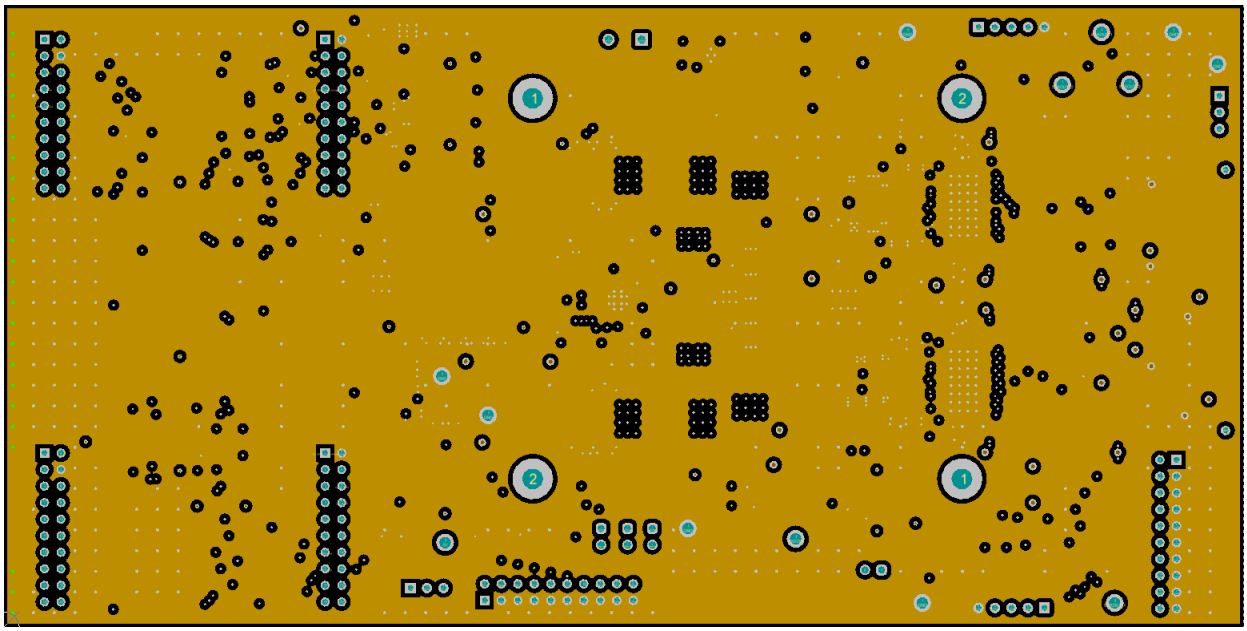


Figure 11. TPS92520EVM-074 Inner Layer (Ground Plane)

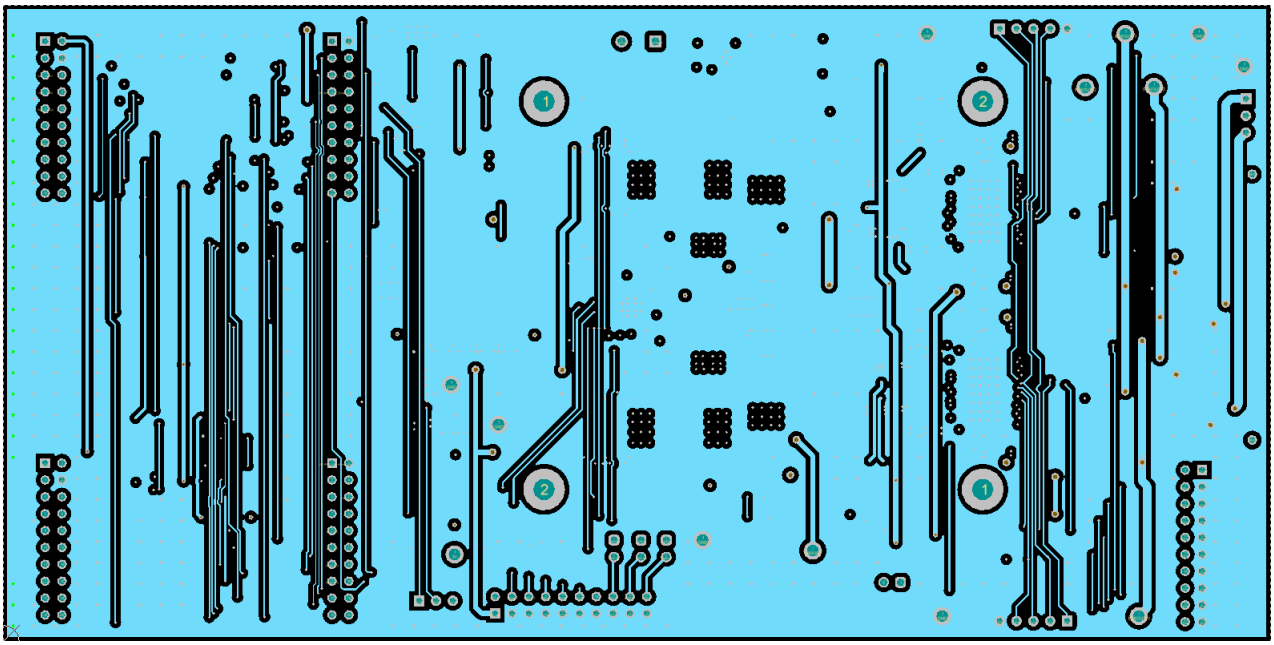


Figure 12. TPS92520EVM-074 Inner-Layer 1

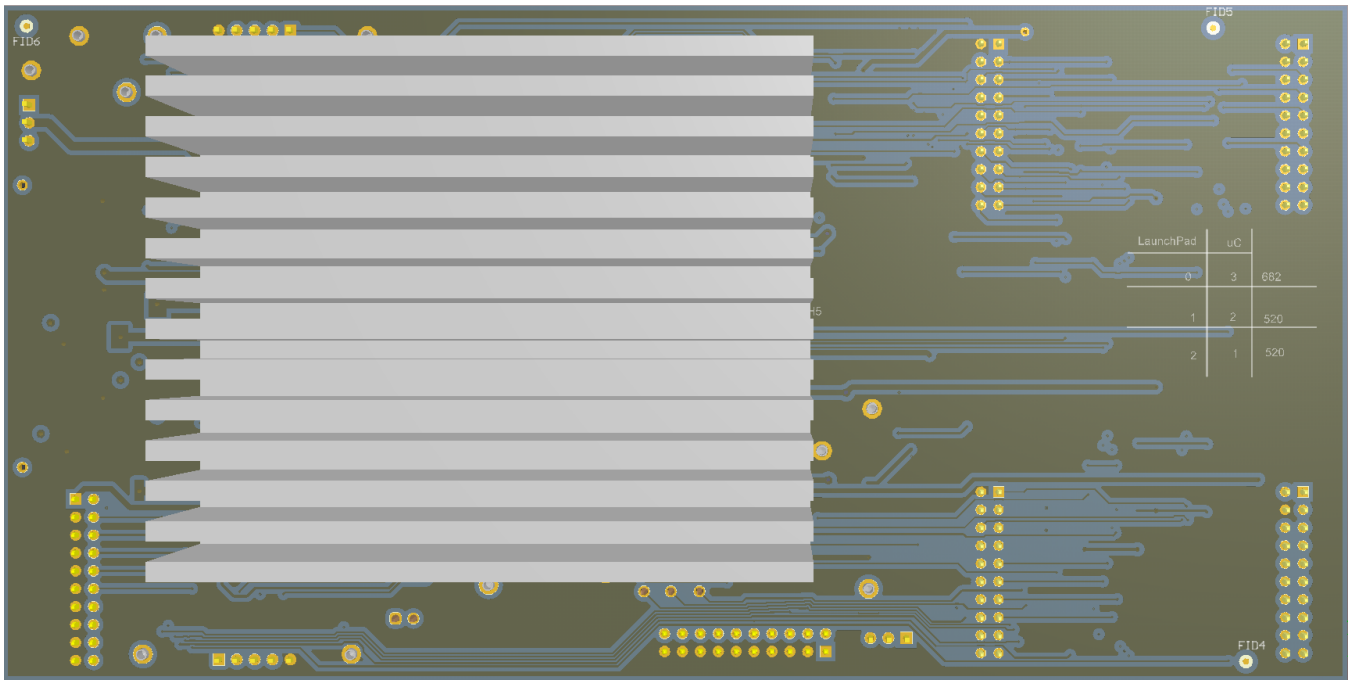


Figure 13. TPS92520EVM-074 Bottom Layer (Bottom View)

6.3 Bill of Materials

Table 3 lists the TPS92520EVM-074 bill of materials.

Table 3. TPS92520EVM-074 Bill of Materials

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE	PART NUMBER	MANUFACTURER
C1, C4, C33, C34, C67, C68, C71	7	0.1 µF	CAP, CERM, 0.1 µF, 100 V, ±10%, X7S, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7S2A104K080AB	TDK
C2, C3, C30, C32	4	2200 pF	CAP, CERM, 2200 pF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B2X7R1H222K050BA	TDK
C5, C28	2	0.047 µF	CAP, CERM, 0.047 µF, 100 V, ±10%, X7S, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7S2A473K080AB	TDK
C6, C10, C25, C29	4	0.47 µF	CAP, CERM, 0.47 µF, 25 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1E474K080AB	TDK
C7, C31	2	1000 pF	CAP, CERM, 1000 pF, 16 V, ±10%, X7R, 0603	0603	885012206034	Wurth
C8, C9, C11, C12, C23, C24, C26, C27	8	2.2 µF	CAP, CERM, 2.2 µF, 100 V, ±20%, X7S, AEC-Q200 Grade 1, 1206_190	1206_190	CGA5L3X7S2A225M160AB	TDK
C13, C16, C18, C21, C59, C60	6	4.7 µF	CAP, CERM, 4.7 µF, 16 V,±10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J3X7R1C475K125AE	TDK
C14, C15, C17, C19, C20, C22, C54, C76, C79, C82, C83, C86, C87, C91, C92, C95, C96, C99, C100, C103, C104, C107, C108	23	0.1 µF	CAP, CERM, 0.1 µF, 50 V, ±20%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7R1H104M050BB	TDK
C35, C36, C37, C48, C49, C50, C55, C70, C72, C73, C74, C75	12	10 µF	CAP, CERM, 10 µF, 50 V, ±10%, X7S, AEC-Q200 Grade 1, 1210	1210	CGA6P3X7S1H106K250AB	TDK
C38	1	0.033 µF	CAP, CERM, 0.033 µF, 50 V, ±5%, X7R, 0603	0603	06035C333JAT2A	AVX
C39	1	33 µF	CAP, AL, 33 µF, 80 V, ±20%, 1.3 Ω, AEC-Q200 Grade 2, SMD	SMT Radial F	EEE-FK1K330P	Panasonic
C40, C41, C42, C51, C52, C53	6	4.7 µF	CAP, CERM, 4.7 µF, 100 V, ±10%, X7S, 1210	1210	C3225X7S2A475K200AB	TDK
C43, C63	2	10 pF	CAP, CERM, 10 pF, 50 V, ±5%, C0G/NP0, 0603	0603	CGA3E2NP01H100D080AA	TDK
C44, C56, C80	3	1 µF	CAP, CERM, 1 µF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L3X7R1H105K160AB	TDK
C45, C57	2	470 pF	CAP, CERM, 470 pF, 100 V, ±10%, X7R, 0603	0603	06031C471KAT2A	AVX
C46, C61	2	1000 pF	CAP, CERM, 1000 pF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B2X7R1H102K050	TDK
C47	1	100 pF	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, AEC-Q200 Grade 0, 0603	0603	CGA3E2NP01H101J080	TDK
C58, C62	2	2.2 µF	CAP, CERM, 2.2 µF, 16 V, ±20%, X7S, AEC-Q200 Grade 1, 0603	0603	CGA3E1X7S1C225M08	TDK
C64	1	100 µF	CAP, AL, 100 µF, 35 V, ±20%, 0.34 Ω, AEC-Q200 Grade 2, SMD	SMT Radial D8	EEE-FK1V101XP	Panasonic
C65, C66, C69	3	4.7 µF	CAP, CERM, 4.7 µF, 50 V, ±10%, X7R, 1206	1206	C3216X7R1H475K160A	TDK
C77	1	4700 pF	CAP, CERM, 4700 pF, 50 V, ±10%, X7R, 0805	0805	C0805C472K5RACTU	Kemet
C78	1	0.22 µF	CAP, CERM, 0.22 µF, 25 V, ±10%, X8R, AEC-Q200 Grade 0, 0603	0603	CGA3E3X8R1E224K080	TDK
C81, C84, C85, C88, C90, C93, C94, C97, C98, C101, C102, C105, C106, C109	14	1 µF	CAP, CERM, 1 µF, 16 V, ±10%, X5R, 0603	0603	C0603C105K4PACTU	Kemet
C89	1	0.01 µF	CAP, CERM, 0.01 µF, 16 V, ±10%, X7R, 0603	0603	C0603C103K4RACTU	Kemet
D1, D2	2	100 V	Diode, Schottky, 100 V, 3 A, AEC-Q101, PowerDI5	PowerDI5	PDS3100Q-13	Diodes Inc.
D3, D5, D7, D8	4	60 V	Diode, Schottky, 60 V, 1 A, AEC-Q101, SOD-123	SOD-123	PMEG6010CEGWJ	Nexperia
D4	1	26 V	Diode, TVS, Bi, 26 V, 42.1 Vc, AEC-Q101, SMA	SMA	SMAJ26CAHE3/61	Vishay-Semiconductor
D6	1	10 V	Diode, Zener, 10 V, 500 mW, AEC-Q101, SOD-123	SOD-123	MMSZ4697-HE3-08	Vishay-Semiconductor
H5	1		HEAT SINK	HEATSINK	ATS-TI1OP-1304-C2-R0	Advanced Thermal Solutions Inc

Table 3. TPS92520EVM-074 Bill of Materials (continued)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE	PART NUMBER	MANUFACTURER
J4	1		Terminal Block, 5.08 mm, 2x1, TH	2POS Terminal Block	1715721	Phoenix Contact
L1, L2, L3, L4	4	47 µH	Inductor, Shielded, Metal Composite, 47 µH, 1.5 A, 0.318 Ω, SMD	SMD	SPM6545VT-470M-D	TDK
L5, L6	2	15 µH	Inductor, Shielded, 15 µH, 8.5 A, 0.02299 Ω, AEC-Q200 Grade 0, SMD	13x12.5mm	SPM12565VT-150M-D	TDK
L7	1	15 µH	Inductor, Shielded Drum Core, Powdered Iron, 15 µH, 1.9 A, 0.265 Ω, SMD	5.18x3x5.5mm	IHLP2020CZER150M01	Vishay-Dale
L8	1	680 nH	Inductor, Shielded, 680 nH, 10.2 A, 0.00896 Ω, AEC-Q200 Grade 1, SMD	5.18x3x5.5mm	IHLP2020CZERR68M01	Vishay-Dale
L9	1		Coupled inductor, 0.004 Ω, SMD	15x13mm	ACM1513-551-2PL-TLHF	TDK
L10	1	51 µH	Coupled inductor, 51 µH, A, 0.14 Ω, SMD	7.1x6mm	B82793S513N201	TDK
Q1, Q2	2	100 V	MOSFET, N-CH, 100 V, 1.4 A, SOT-23	SOT-23	DMN10H220L-7	Diodes Inc.
Q3, Q4	2	100 V	MOSFET, N-CH, 100 V, 20 A, AEC-Q101, 8-PowerVDFN	8-PowerVDFN	STL8N10LF3	ST
Q5	1	40 V	MOSFET, N-CH, 40 V, 100 A, AEC-Q101, PG-TDSON-8	PG-TDSON-8	IPC100N04S51R9ATMA1	Infineon
Q6	1	60 V	Transistor, NPN, 60 V, 0.5 A, AEC-Q101, SOT-23	SOT-23	MMBTA05LT1G	ON
R1, R2, R20, R63	4	0.1	RES, 0.1, 1%, .5 W, AEC-Q200 Grade 0, 0805	0805	KRL1220E-M-R100-F	Susumu
R3, R21	2	5.90 k	RES, 5.90 k, 1%, 0.1 W, 0603	0603	RC0603FR-075K9L	Yageo
R4, R22	2	10.0	RES, 10.0, 1%, 0.25 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310R0FKEAH	Vishay-Dale
R5, R23	2	49.9 k	RES, 49.9 k, 1%, 0.1 W, 0603	0603	RC0603FR-0749K9L	Yageo
R6, R19	2	187 k	RES, 187 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603187KFKEA	Vishay-Dale
R7, R9, R35, R36, R47, R48	6	10.0 k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0FKED	Vishay-Dale
R8, R12, R13, R16	4	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
R10, R14, R38, R43, R44, R57, R59, R60, R62	9	0	RES, 0, 5%, 0.063 W, 0402	0402	MCR01MZPJ000	Rohm
R11, R17, R27	3	100 k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R24, R25, R28, R32	4	0	RES, 0, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW20100000Z0EF	Vishay-Dale
R26, R40	2	7.5	RES, 7.5, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW20107R50JNEF	Vishay-Dale
R29	1	20.0 k	RES, 20.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0720KL	Yageo
R30	1	1.00	RES, 1.00, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08051R00FKEA	Vishay-Dale
R31, R41	2	10.0	RES, 10.0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
R33, R45	2	10.0	RES, 10.0, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210R0FKED	Vishay-Dale
R34	1	5.10 k	RES, 5.10 k, 1%, 0.1 W, 0603	0603	RC0603FR-075K1L	Yageo
R37, R46	2	0.01	RES, 0.01, 1%, 1 W, 2010	2010	WSL2010R0100FEA18	Vishay-Dale
R39	1	2.49 k	RES, 2.49 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K49FKED	Vishay-Dale
R42	1	200 k	RES, 200 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603200KFKEA	Vishay-Dale
R50, R51, R52, R53	4	100 k	RES, 100 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100KFKED	Vishay-Dale
R54, R55, R56	3	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R58, R61	2	61.9	RES, 61.9, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060361R9FKEA	Vishay-Dale
R64	1	200 k	RES, 200 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD07200KL	Yageo America
U1, U2	2	IC	4.5 to 65-V Input Dual 1.6-A Synchronous Buck LED Driver with SPI Control, DAD0032A (HTSSOP-32)	DAD0032A	TPS92520QDADQ1	Texas Instruments
U3, U4	2	IC	4.5 to 65-V Input Dual 1.6-A Synchronous Buck LED Driver with SPI Control, DAP0032A (HTSSOP-32)	DAP0032A	TPS92520QDAPQ1	Texas Instruments
U5	1	IC	Dual Channel Constant Voltage and Constant Current Controller with SPI Interface, RHM0032C (VQFNP-32)	RHM0032C	TPS92682QRHMQ1	Texas Instruments

Table 3. TPS92520EVM-074 Bill of Materials (continued)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE	PART NUMBER	MANUFACTURER
U6	1	IC	Automotive Qualified SIMPLE SWITCHER® 40 V (65 V transient), 0.6A Buck Regulator with 28 μA IQ, DDC0006A (SOT-23-THIN-6)	DDC0006A	LMR16006YQ5DDCTQ1	Texas Instruments
U7	1	IC	Automotive Fault Protected CAN Transceiver With Flexible Data-Rate, DRB0008F (VSON-8)	DRB0008F	TCAN1042VDRBRQ1	Texas Instruments
U8, U11, U14	3	IC	High-Speed, Low-Power, Robust EMC Quad-Channel Digital Isolator, DBQ0016A (SSOP-16)	DBQ0016A	ISO7740DBQ	Texas Instruments
U9, U12, U15	3	IC	High Speed, Robust EMC Quad-Channel Digital Isolators, DBQ0016A (SSOP-16)	DBQ0016A	ISO7741DBQR	Texas Instruments
U10	1	IC	Single Output High PSRR LDO, 100 mA, Fixed 3.3 V Output, 2.7 to 5.5 V Input, 5-pin SOT-23 (DBV), -40 to 125°C, Green (RoHS and no Sb/Br)	DBV0005A	TPS79133DBVREP	Texas Instruments
U13	1	IC	High Speed, Robust EMC Reinforced Quad-Channel Digital Isolator, DBQ0016A (SSOP-16)	DBQ0016A	ISO7742DBQR	Texas Instruments
R15, R18	0	4.70 k	RES, 4.70 k, 1%, 0.063 W, 0402	0402	CRG0402F4K7	TE Connectivity
R49	0	0	RES, 0, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW20100000Z0EF	Vishay-Dale

7 GUI Installation, Description, and Use

This section describes the installation process of the GUI software and the drivers needed to operate the TPS92520EVM-074. The installation process takes approximately 15 minutes. The installation is broken in to six steps:

1. Run the Installer (Section 7.1).
2. Flash the LaunchPad (Section 7.2).
3. Install Jumper on LaunchPad (Figure 26).
4. Install the LaunchPad on to the TPS92520EVM-074 (Section 8).
5. Connect LED Loads or Matrix Manager EVM and apply V_{IN} (Section 8).
6. Launch the GUI (Section 8.1).

7.1 TPS92520EVM-074 GUI Installer

1. Right-click on *LED_Controller_GUI_Mkt.exe*.
2. Select **Run As Administrator**.
3. *Windows Account Control* asks to allow the program to make changes to the computer. Click **Yes**.
4. Select **Agree** to the installation license terms and install in the recommended location. Installation can take a while, as it may need to install Microsoft .NET Framework.
5. If the installer asks to reboot after installing Microsoft .NET, click **restart later** to complete the driver installation.
6. After running the *TLED_Controller_GUI_Mkt.exe*, the evaluation software window appears as shown in Figure 14.

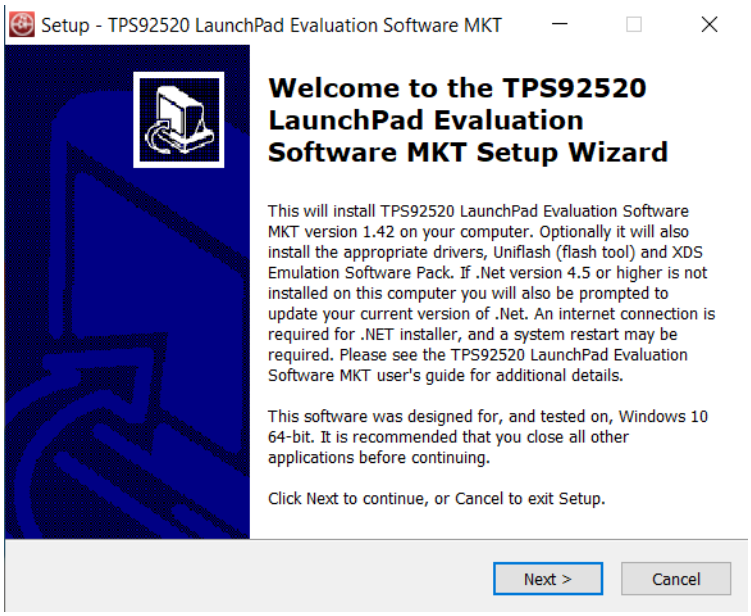


Figure 14. Setup Screen 1

7. Click **Next >** to install.

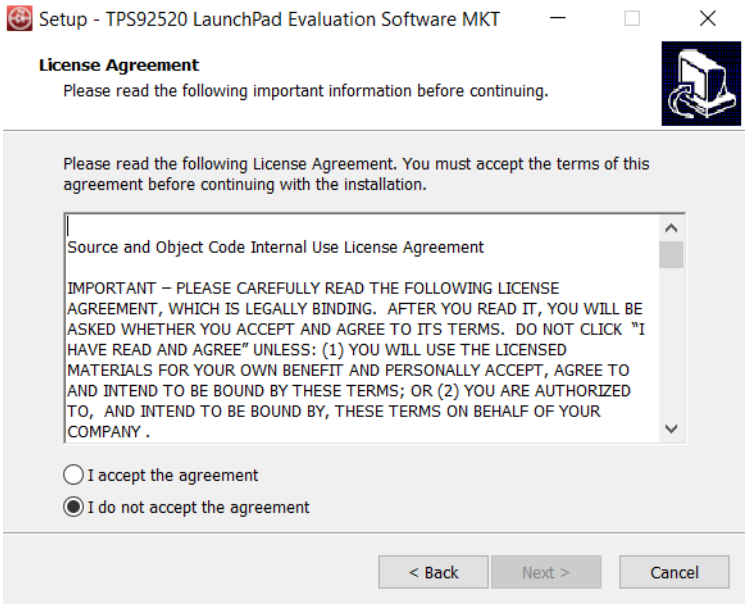


Figure 15. Setup Screen 2

8. Click **I accept the agreement >** and **Next >** to accept the License Agreement.
9. Select **Full Install** from the drop-down menu.
10. Click **Next >** to install the evaluation software, the UniFlash, and the required XDS drivers. If .NET Framework 4.5 or higher does not exist on the computer, the .NET Framework installation begins. Installation of the .NET Framework takes several minutes. If .NET Framework 4.5 or higher exists on the computer, the installation jumps to the XDS driver installation.

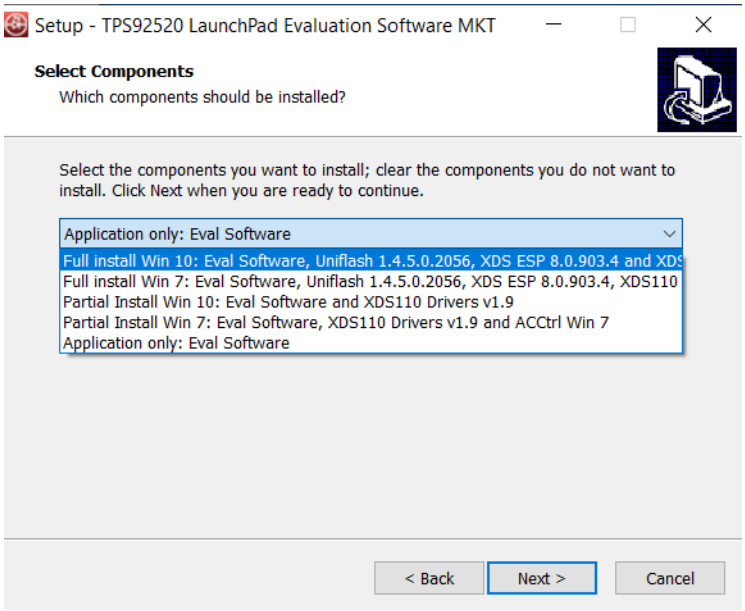


Figure 16. Setup Screen 4

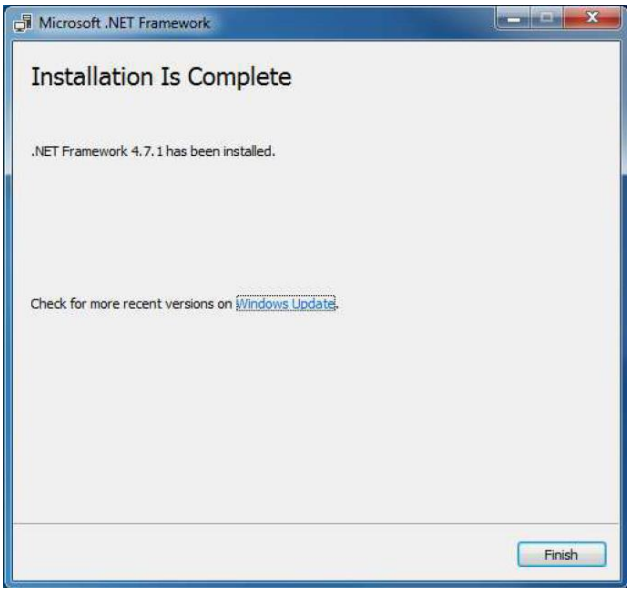


Figure 17. Setup Screen 5

11. A window appears indicating the completion of the .NET Framework installation.

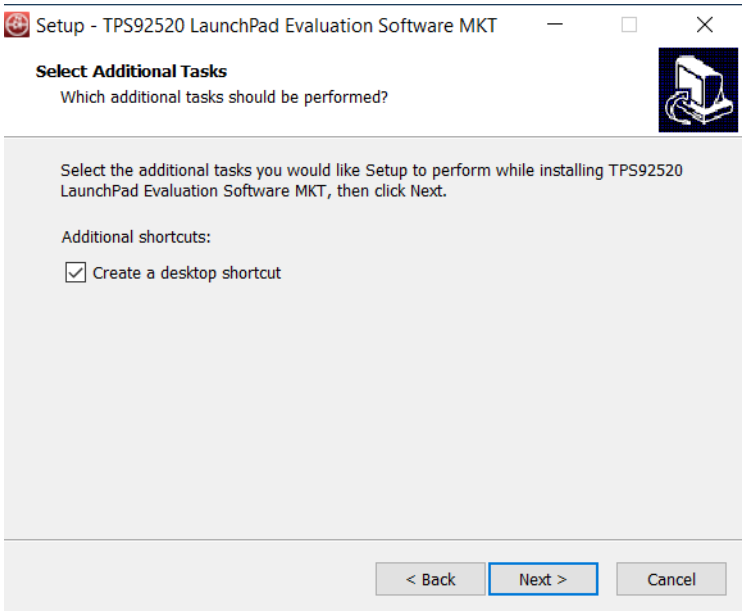


Figure 18. Setup Screen 6

12. Click **Next >** to continue the installation.

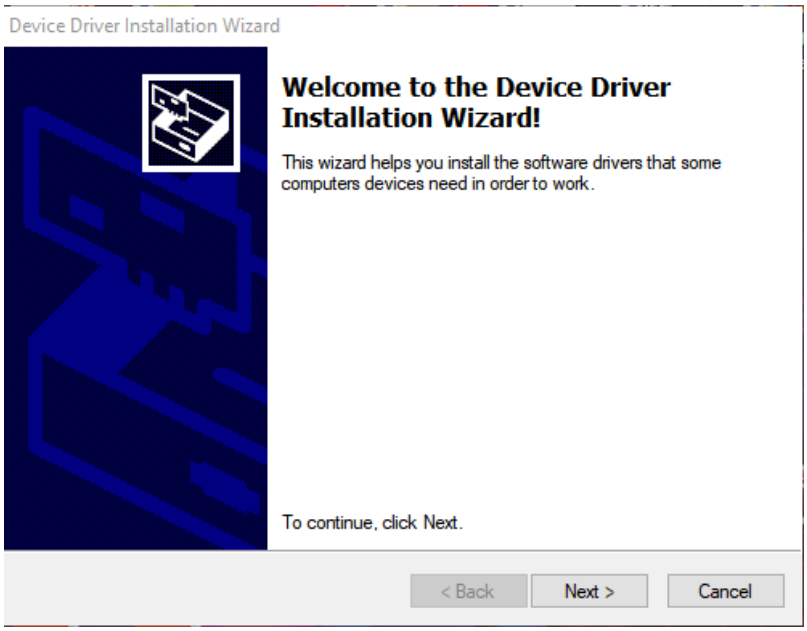


Figure 19. Setup Screen 7

13. Click **Next >** to install the XDS driver.

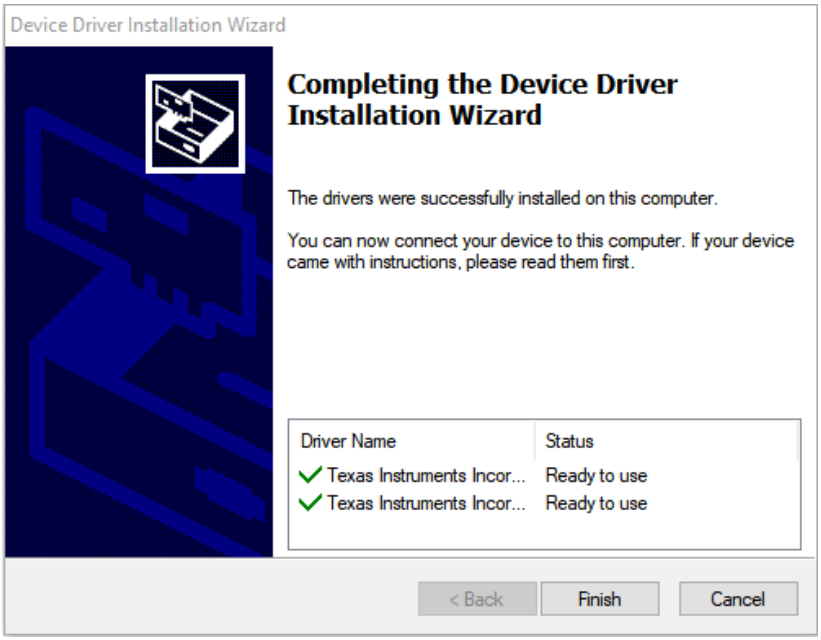


Figure 20. Setup Screen 8

14. Figure 20 shows the screen showing the completion of the XDS driver. The UniFlash installation starts at this point. Click **Next >** to start the installation.

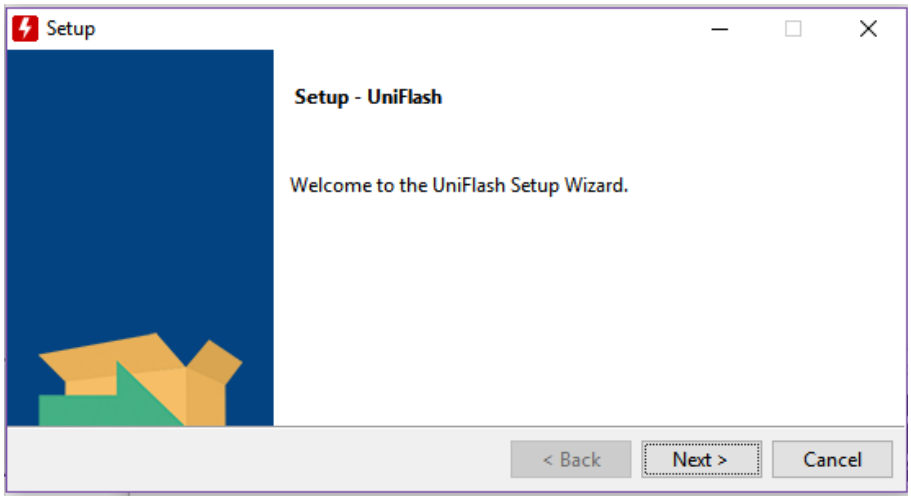


Figure 21. Setup Screen 9

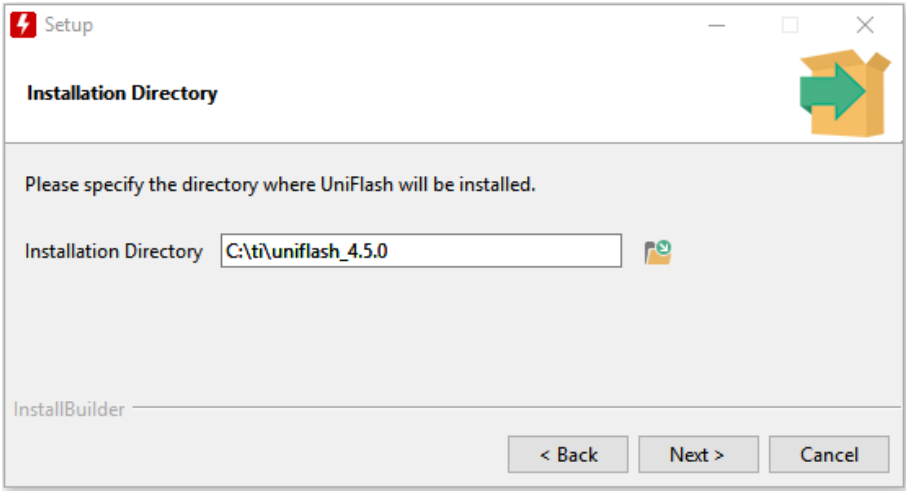


Figure 22. Setup Screen 10

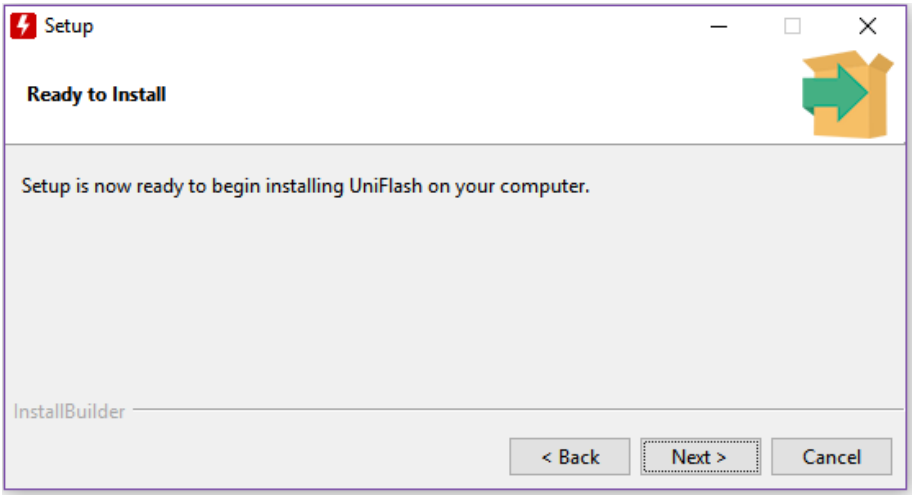


Figure 23. Setup Screen 11

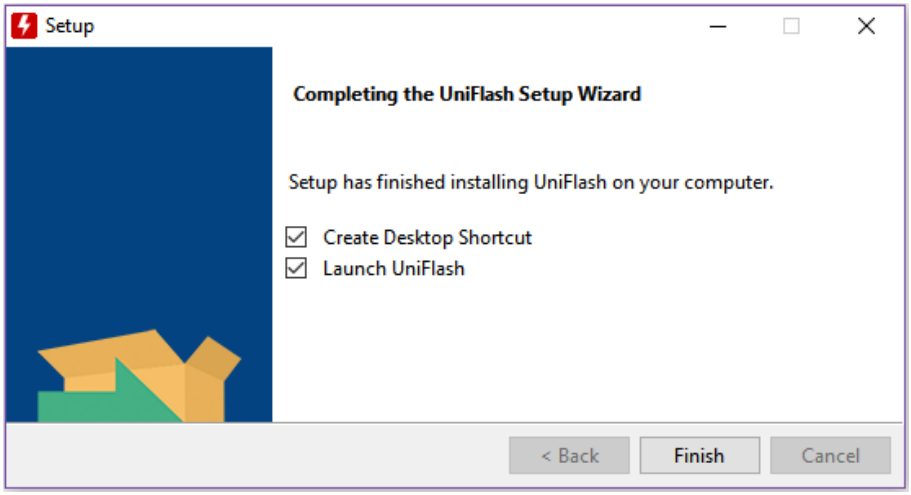


Figure 24. Setup Screen 12

15. When UniFlash installation completes, click **Finish** to launch the UniFlash and program the LaunchPad.

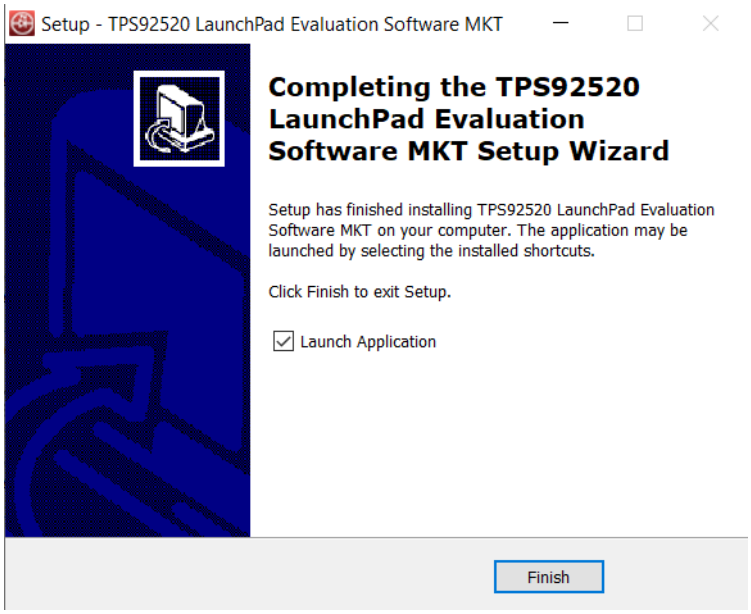


Figure 25. Setup Screen 13

16. Figure 25 shows the completion notification of the TPS92520-Q1 Evaluation Software. Click **Finish**.

7.2 Programming the MSP-EXP432E401Y LaunchPad Board

NOTE: The LaunchPad Board must be programmed using the UniFlash software before running the GUI.

1. Connect the included Micro-USB cable to the USB port of the PC and the LaunchPad as shown in Figure 26.
2. Connect a jumper between pins 3 and 4 of the JP1 as shown in Figure 26. This jumper has been provided on the TPS92520EVM-074 at location J5 (also marked with ↑LP).
3. Simply remove the jumper and relocate it to the launchpad.

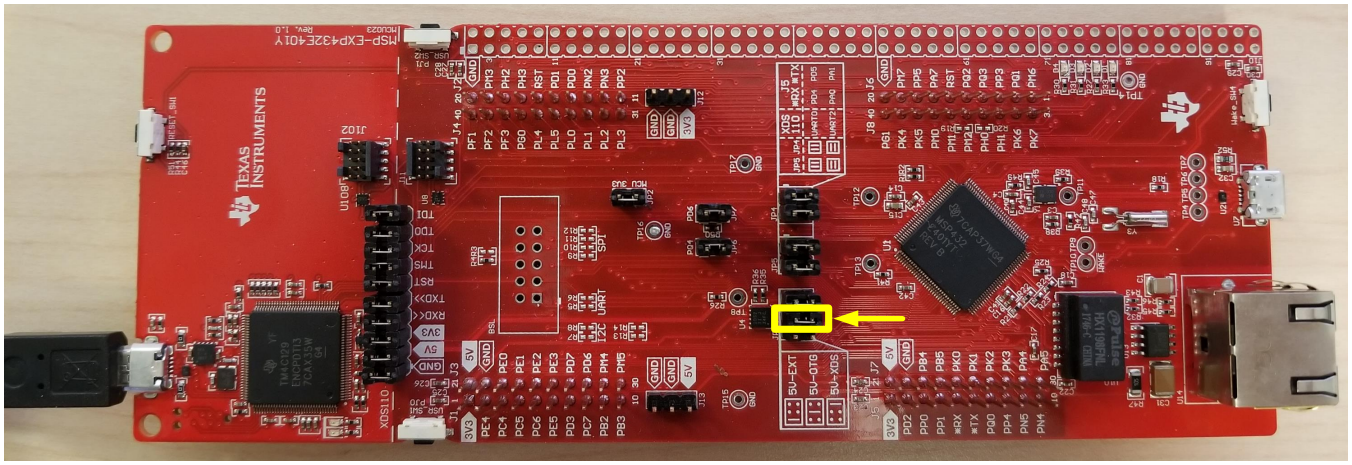


Figure 26. LaunchPad Connection for Programming

4. Typically, the installed UniFlash program opens at the end of the software setup shown in Figure 24. If the UniFlash program is not open, launch the program. The window shown in Figure 27 opens.

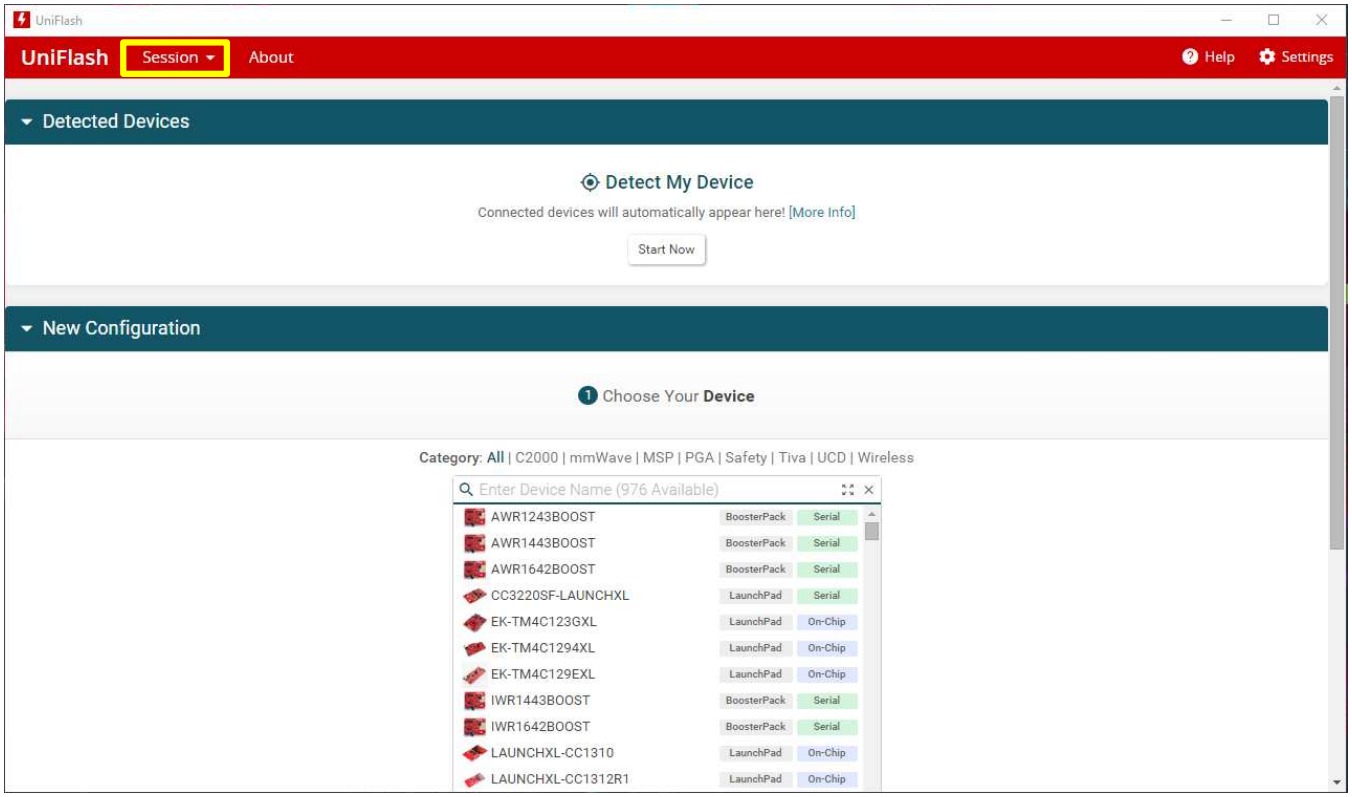


Figure 27. UniFlash Programming, Step 1

5. Click **Session** shown in Figure 27.
6. Select **Load Session**.

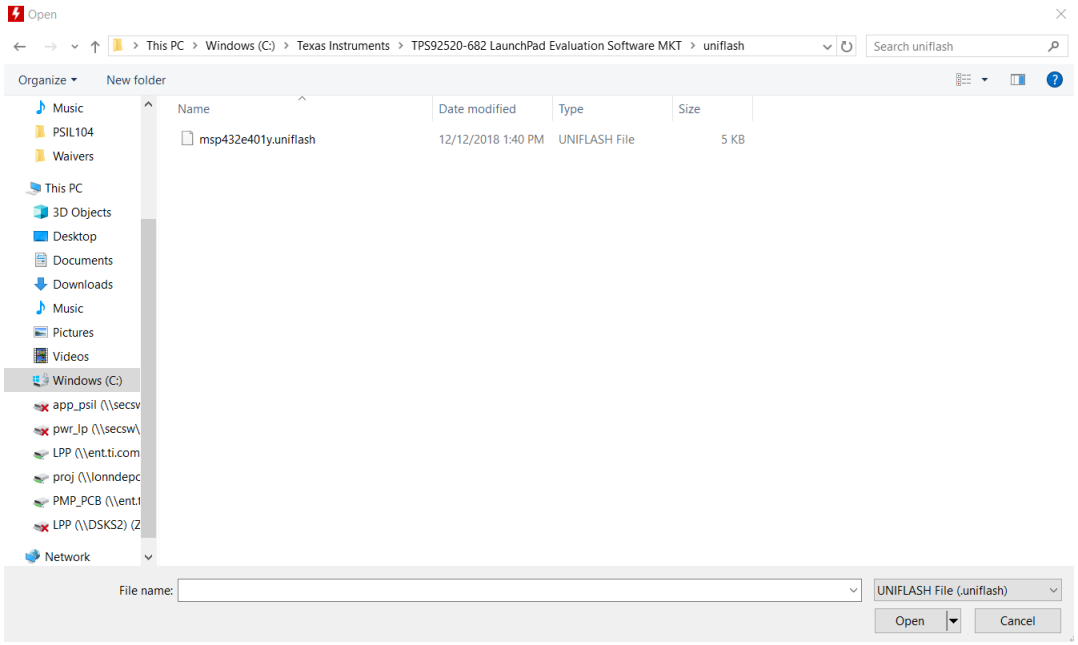


Figure 28. UniFlash Programming, Step 2

7. As shown in Figure 28, navigate to the *":\Texas Instruments\TPS92520-682 LaunchPad Evaluation Software MKT\uniflash"* location.
8. Select the **msp432e401y.uniflash** file.
9. As shown in Figure 29, click on the 'Flash Image(s)' file field.
10. Click Browse (even though the field is populated, browse to the new location outlined here).
11. Navigate to the *":\Texas Instruments\TPS92520-682 LaunchPad Evaluation Software\uniflash"* location.
12. Select the **AlgCSM_DRV.out** file as shown in Figure 29.

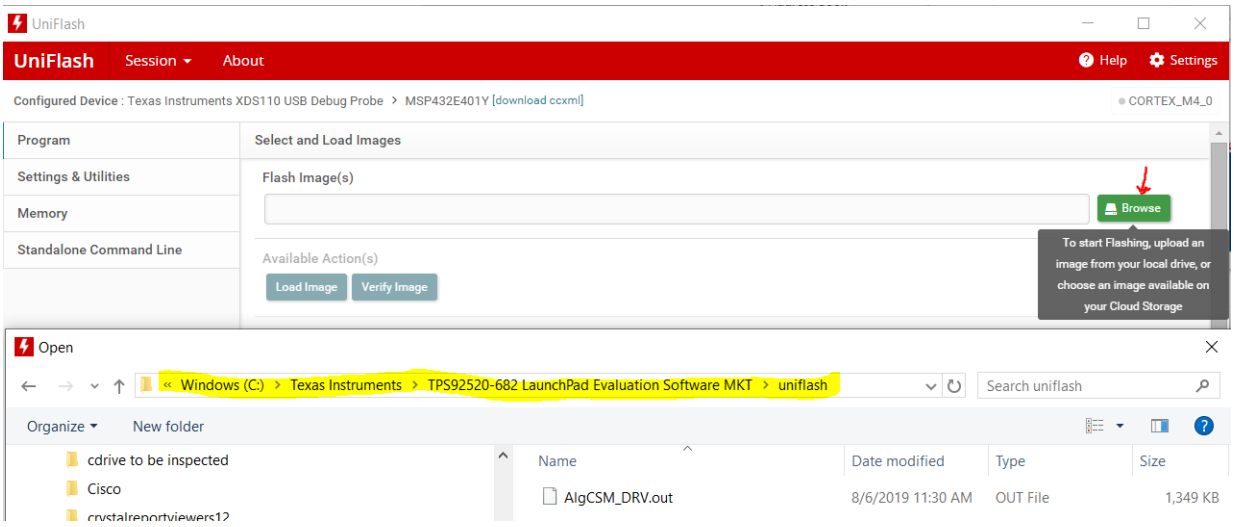


Figure 29. UniFlash Programming, Step 4

13. Click **Load Image** under 'Available Action(s)'. After the program is loaded into the LaunchPad, a message appears in the console that the program load completed successfully, as shown in Figure 30 at the bottom left of the image.

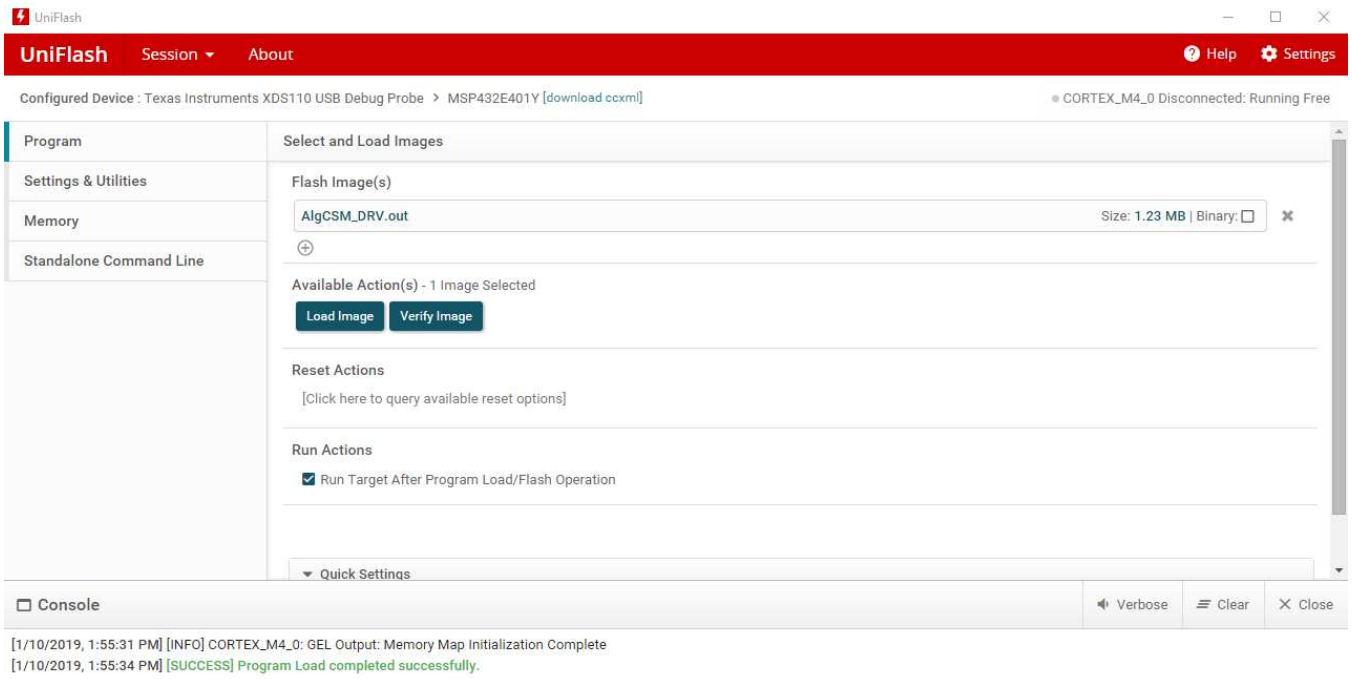


Figure 30. UniFlash Programming, Step 5

NOTE: The first time the LaunchPad is flashed, updates to the 'Debug Probe' block can be required.

14. If Uniflash determines an update is required, the following notification is displayed, as shown in Figure 31. Select 'Update' to allow the update to occur.

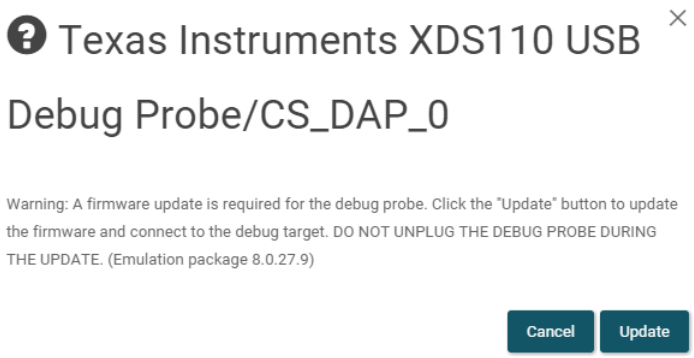


Figure 31. Debug Probe Update Required on First Flash of Launch Pad

15. Close the UniFlash program.
16. Disconnect the Micro-USB from the LaunchPad.
17. Connect it to the USB port U7 on the other end of the LaunchPad, as shown in Figure 32.

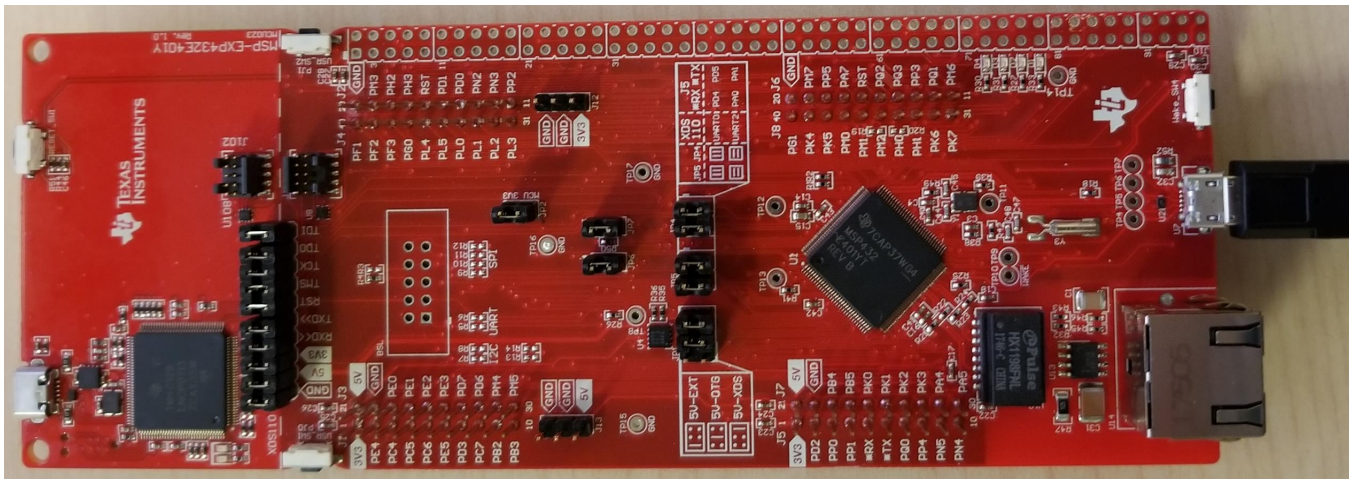


Figure 32. LaunchPad Connection for GUI Operation

8 TPS92520EVM-074 Power UP and Operation

1. The EVM and LaunchPad are now ready for operation. Connect an input DC power source (12 V nominal) to the TPS92520EVM-074 EVM at the input terminal J4.
2. Connect one of the following:
   a. Up to four independent LED loads. One load is connected as shown in Figure 33.
   b. Figure 34 shows the Lighting Matrix Manager EVM containing the TPS92662 and TPS92663. The EVM can be requested via the TPS92663 EVM page.

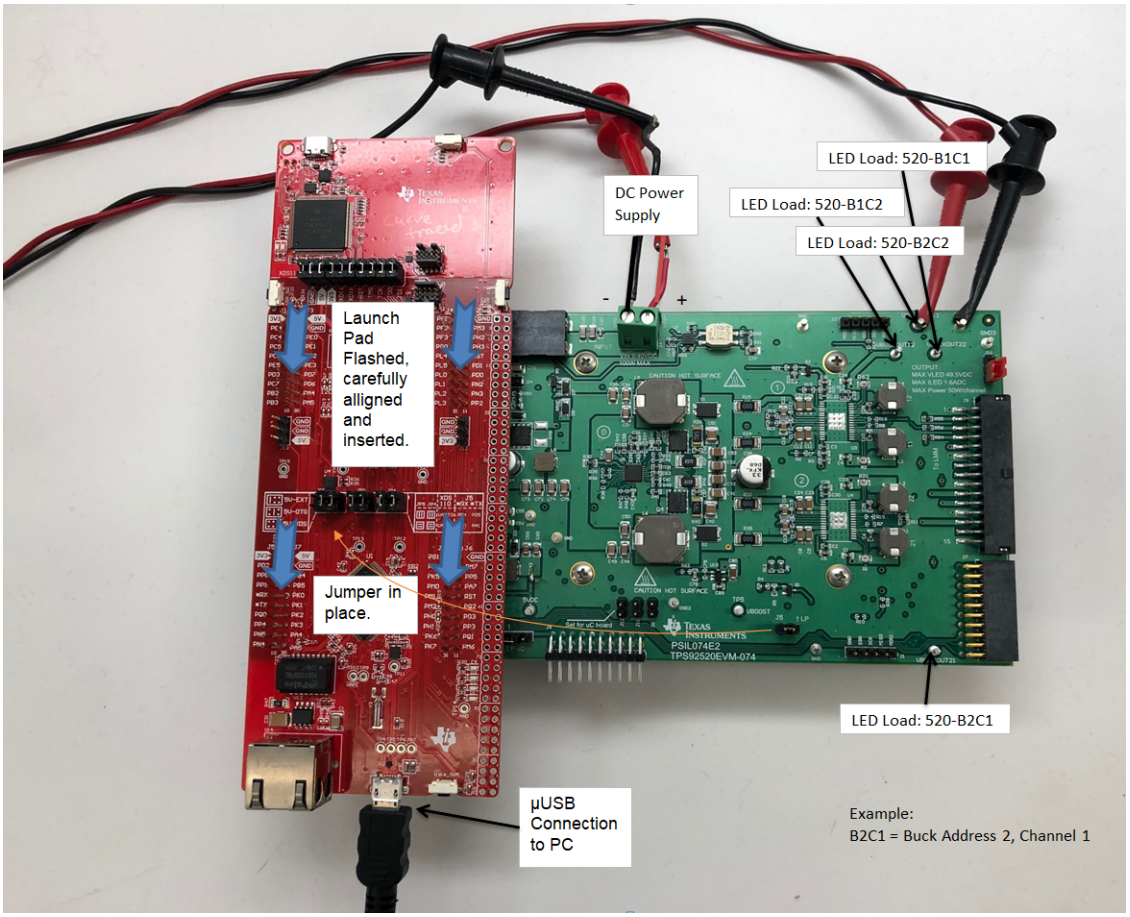


Figure 33. LaunchPad Connection to the TPS92520EVM-074

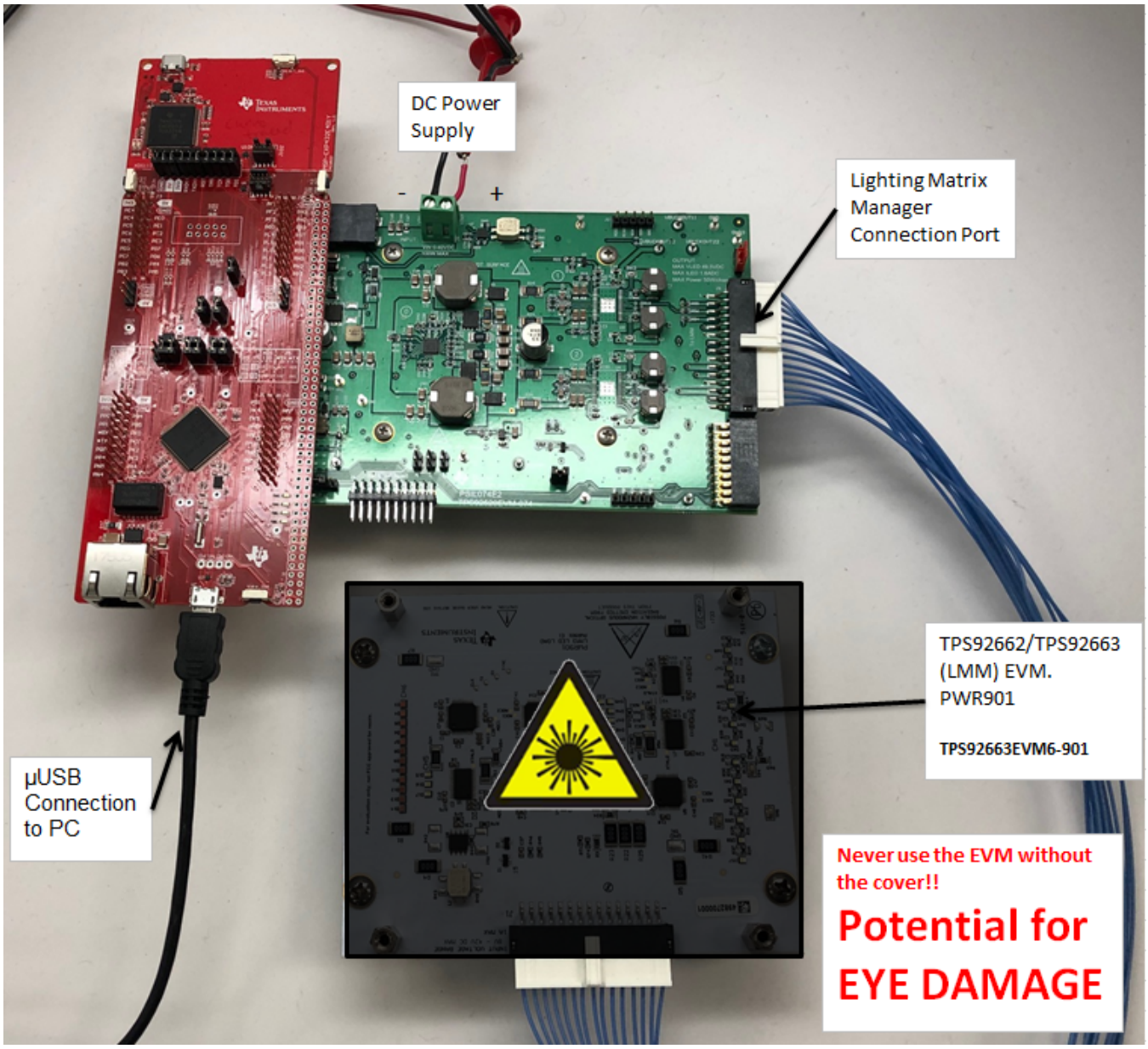


Figure 34. LaunchPad Connection to the TPS92520EVM-074 and PWR901 Matrix Manager EVM

8.1 Launch the GUI (Graphical User Interface)

1. If not done already, connect the USB connection to the PC from the LaunchPad.
2. Decide which load type you will use and connect it now.
3. Enable the DC power source.
4. Launch the GUI.
5. Run the program **LED_Controller_GUI_Mkt.exe** located at *C:\Texas Instruments\TPS92520-682 LaunchPad Evaluation Software MKT*.

When the GUI application is launched, it senses if the TPS92662 EVM or TPS92663 EVM is present and provides modified control options for each.

The window appears as one of Figure 35, then as Figure 36.

Figure 35. GUI Splash Screen with Configuration Information

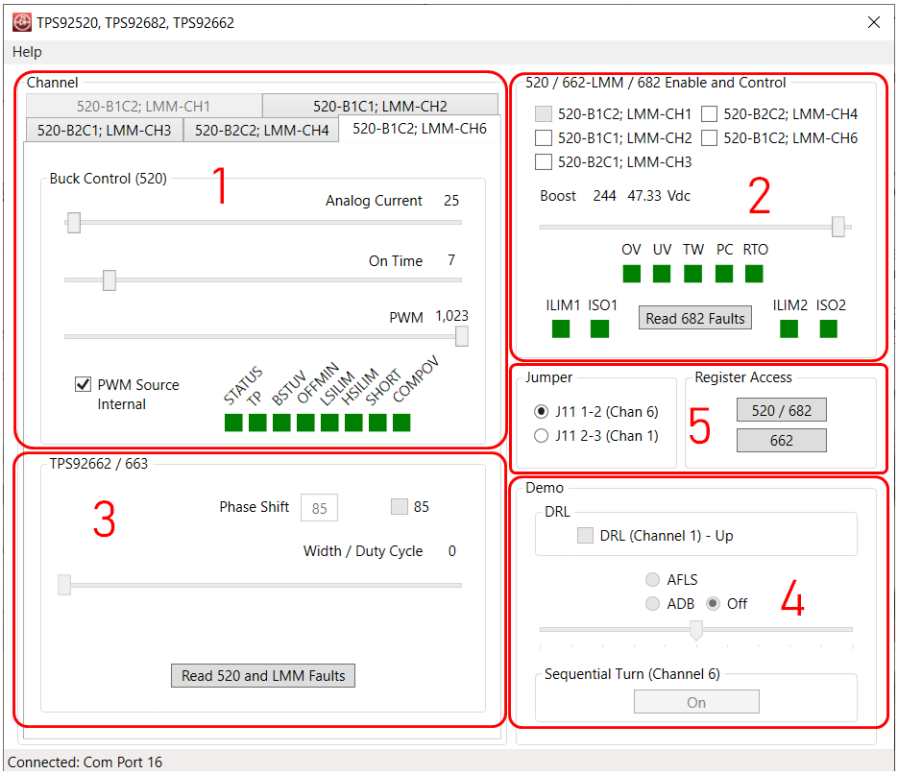


Figure 36. GUI, Main Window (Numbered areas are for explanation purposes only)

8.1.1 Quick Start Guide

1. Start with the EVM in the ready state as described in Section 8.1. This includes opening the GUI while having the input powered and the desired LED load type attached. By opening the GUI, the system automatically enables the on-board 5 V supply and initiates communication with the TPS92520 and TPS92682. The TPS92682 is automatically configured to provide approximately 47 V and is enabled with programmed defaults. The TPS92682 dual-phase boost output voltage can be monitored at the **VBOOST** test point on the EVM.
2. Enable the LED load. Directions depend the type of selected load: User Provided or LMM Load (see below).

8.1.1.1 Quick Start With User Provided LED Load

1. Connect LED loads to the output terminals as shown in Figure 34. For example, choose **520-B1C1** in the upper right corner of the EVM.
2. Connect the LED load anode (+) to 520-B1C1 and use any terminal marked GND for the cathode (-).
3. In the GUI **Enable and Control** area (boxed area 2), select the check box by **520-B1C1**. You should now see a light output.
4. From the **Channel** area with tabs (boxed area 1), select the tab matching the 520-B1C1 channel (also identified as LMM-CH2).
5. Make adjustments to the current level using the slider labeled **Analog Current**.

8.1.1.2 Quick Start With LMM Load (TPS92663EVM6-901)

1. This assumes that the GUI was launched after the TPS92663EVM6-901 was connected and DC input power enabled. The sensing of the load type is performed when the GUI is launched.
2. If the load was not present when the GUI was opened, close the GUI and re-open with the load attached. See Figure 34.
3. **Ensure the TPS92663EVM6-901 (LMM Load) cover is in place.**
4. Select a channel to be tested in the **Enable and Control** area of the GUI (boxed area 2 shown in Figure 36). For example, select **LMM-CH2** by checking the box beside the text.
5. Select the matching tab in the **Channel** area with tabs. Select the tab matching this channel (LMM-CH2, also identified as 520-B1C1). Make adjustments to the current level using the slider labeled **Analog Current**. Set the slider to a higher value (for example, approximately 200).
6. Move the slider in the **TPS92662 and TPS92663** area of the GUI. The slider adjusts the duty cycle of the previously selected LMM channel. Move the slider to the mid-point. You should now see light output.

8.1.2 GUI Operation

Figure 36 shows the main GUI window. This window includes **five** sub-windows:

- **TPS92520 Channel Control Box (1)**: This window includes controls for selecting the internal or external PWM. Setting **Analog Current** to full scale (1023) results in 1.6 A of output current. Ensure your load can accept this current level and adjust your settings accordingly. The slider automatically adjusts the respective CHxIADJL and CHxIADJH registers as the slider is moved. A checkmark in the **PWM Source Internal** box sets the PWM dimming input to the internal PWM generator (which is AND'd with the UDIMx input). The **PWM** slider adjusts the duty cycle where 1023 = 100%, 512 represents 50%, and so forth. The PWM dimming frequency is programmed to the default value (610 Hz) but can be adjusted using the terminal window and modifying the PWMDIV (0x0Ch) register. Refer to the *TPS92520-Q1 1.5-A Dual Synchronous Buck LED Driver Data Sheet* for details. The **STATUS** flags are also shown and report any faults occurring on the selected channel. Refer to TPS92520 registers STATUS1, STATUS2, and STATUS3 for a full description.
- **Channel Control and Boost Configuration Box (2)**: This window is used to enable and disable each of the four channels. A sixth channel is referenced as the TPS92663EVM6-901 EVM contains six controllable channels, five of which are accessible. Figure 38 shows the physical channel configuration. A different channel can be selected using the jumper (J11) located near the header (J9). The boost voltage can also be adjusted using the slider control. The approximate output voltage is noted above the slider.

NOTE: The maximum boost voltage can be adjusted by modifying a resistor value - see Table 1.

- The TPS92682 fault status can be updated by selecting the **Read 682 Faults** button. A description of the faults can be found in the *TPS92682-Q1 Dual-Channel Constant-Voltage and Constant-Current Controller with SPI Interface Data Sheet*.
- **TPS92662 and TPS92663 Control Box (3)**: This window is used to adjust the Phase and Duty Cycle of the Matrix Manager channels. (not available if companion EVM TPS92663EVM6-901 is not present). For a full explanation of the TPS92662 and TPS92663 operation, refer to the *High-Brightness LED Matrix Manager for Automotive Headlight Systems Data Sheet* and *TPS92663-Q1 6-Channel Enhanced LED Matrix Manager-Automotive Headlight Systems Data Sheet*. The basic operation is as follows: Each LED on the selected matrix device is duty cycle-controlled to the duty cycle set by the slider. The phase of the duty cycle between each LED segment is set with the **Phase Shift** field and the "set to 85" check box. For example, if the phase is set to 0, and the duty cycle to 200, each LMM LED segment is turned on at the same time for the same duty cycle. If the phase is set to 85 (for example, via the check box), each LED is still on for a duty cycle length of 200, but the turn on time of each LED segment is shifted by a count of 85.
- **Demo Control Box (4)**: This window shows the four demo modes (DRL, AFLS, ADB and Sequential Turn) are enabled when the TPS92663EVM6-901 is connected. These highlight headlight features that can be implemented using the Lighting Matrix Manager devices: TPS92662 and TPS92663. Set the corresponding **Jumper** setting and move the physical jumper (J11) to match the selected location. Ensure the channels are off when moving the jumper. Next, select the desired demo mode: DRL, AFLS, ADB, OR Sequential Turn. The following is a brief description of the four demo modes:
  - DRL (Daytime running light): Performs a fade and fill up and down the DRL channel.
  - AFLS (Adaptive Front Lighting System): Simulates an adjustment to the beam shape and direction. Adjust the slider to adjust the beam.
  - ADB (Adaptive Driving Beam): Adjust the slider to control the location of an area of the beam having a reduced intensity.
  - Sequential Turn: Implements a swiping turn signal.
- **Jumper Configuration and Register Access (5)**: Set the jumper to match the EVM configuration. Use the Register Access buttons to open a terminal window for direct command control of the TPS92520 and Lighting Matrix Manager (TPS92662 and TPS92663) devices. Section 8.1.3 describes the register direct access window.

8.1.3 Register Access and Terminal Window

8.1.3.1 520 and 682 Register Direct Access Window

1. Select the address of the device to be communicated with using the address pulldown selector. The TPS92682 is at address '0'. The TPS92520 'B1xx' is at address '1'. The TPS92520 'B2xx' is at address '2'. The physical location of the controller is marked on the EVM with the number in a circle.
2. Read the desired register address by entering the value in the *Register Address* box. For example, write 0x00.
3. Click **Send** *twice*. Two transactions are required when using the SPI bus: one to load and execute the read command, and another to receive the result back to the micro controller and GUI.
4. The SPI Status Window and Data Read field shows the content of the register address 0x00h (shown in this example).
5. For a write, check the write box.
6. Enter the register address and write Data.
7. Click **Send**.
8. Make sure the intended operation was programmed, OR double check the write by reading the register back by un-checking the box and selecting **Send** twice.

Figure 37 shows the terminal boxes. The terminal boxes allow direct access to the TPS92520 and TPS92682 registers OR the TPS92662 and TPS92663 registers.

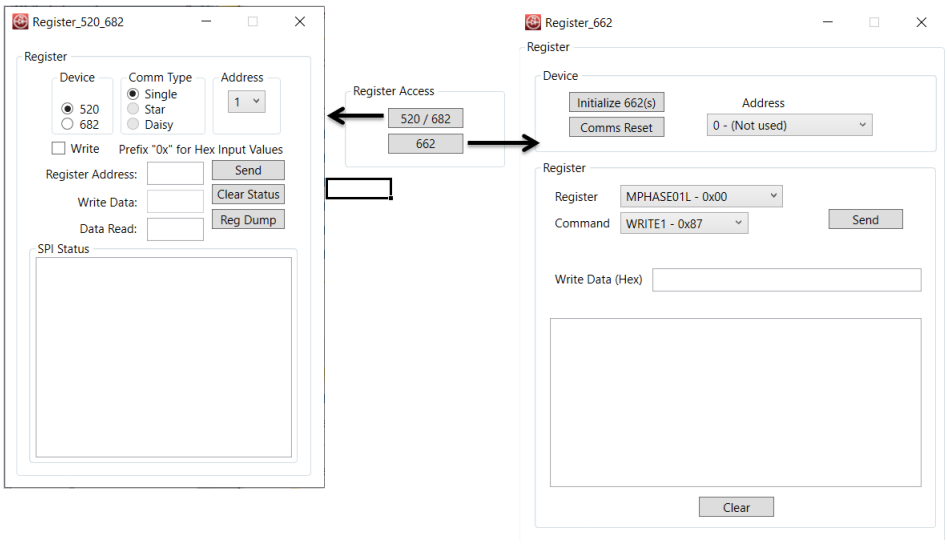


Figure 37. SPI Command Window

8.1.3.2 662 and 663 Register Direct Access Window

This function can assist firmware developers in producing usable register configurations. The function provides utilities for reading or writing a user-specified number of bytes to select TPS92662 and TPS92663 registers. The GUI calculates the correct CRC and adds it to the packet being sent so the user does not need to spend time generating CRCs. Enter register addresses and values in hexadecimal format.

1. Select 'Initialize 662s' to confirm communication with LMM devices on the bus.
2. Select the address of the LMM device to communicate with. Refer to Figure 38 as a guide to find your desired LED string.
3. Select the desired register to control. For example, MPHASE01L allows a read or write starting with the MPHASE01L register. This register is the low byte of the control register setting the phase of LMM channel 1.
4. Select the command field to set the number of bytes to be written using the command. For example, WRITE1 - 0x87 writes one byte, starting at the address MPHASE01L.
5. Multiple bytes can be written by setting the starting point and number of bytes to write. For example, set the command to WRITE1, enter the data 0x00, and select SEND. This writes 00 to the MPHASE01L register. Multiple bits can be separated with commas. If a multiple bit write is selected and not all data bytes are provided, the GUI automatically fills the remaining bytes with 0x00.

9 Appendix

Overview of LED placement and addressing of TPS92663EVM6-901 EVM.

NOTE: This TPS92663EVM6-901 EVM can arrive with white or green soldermask.

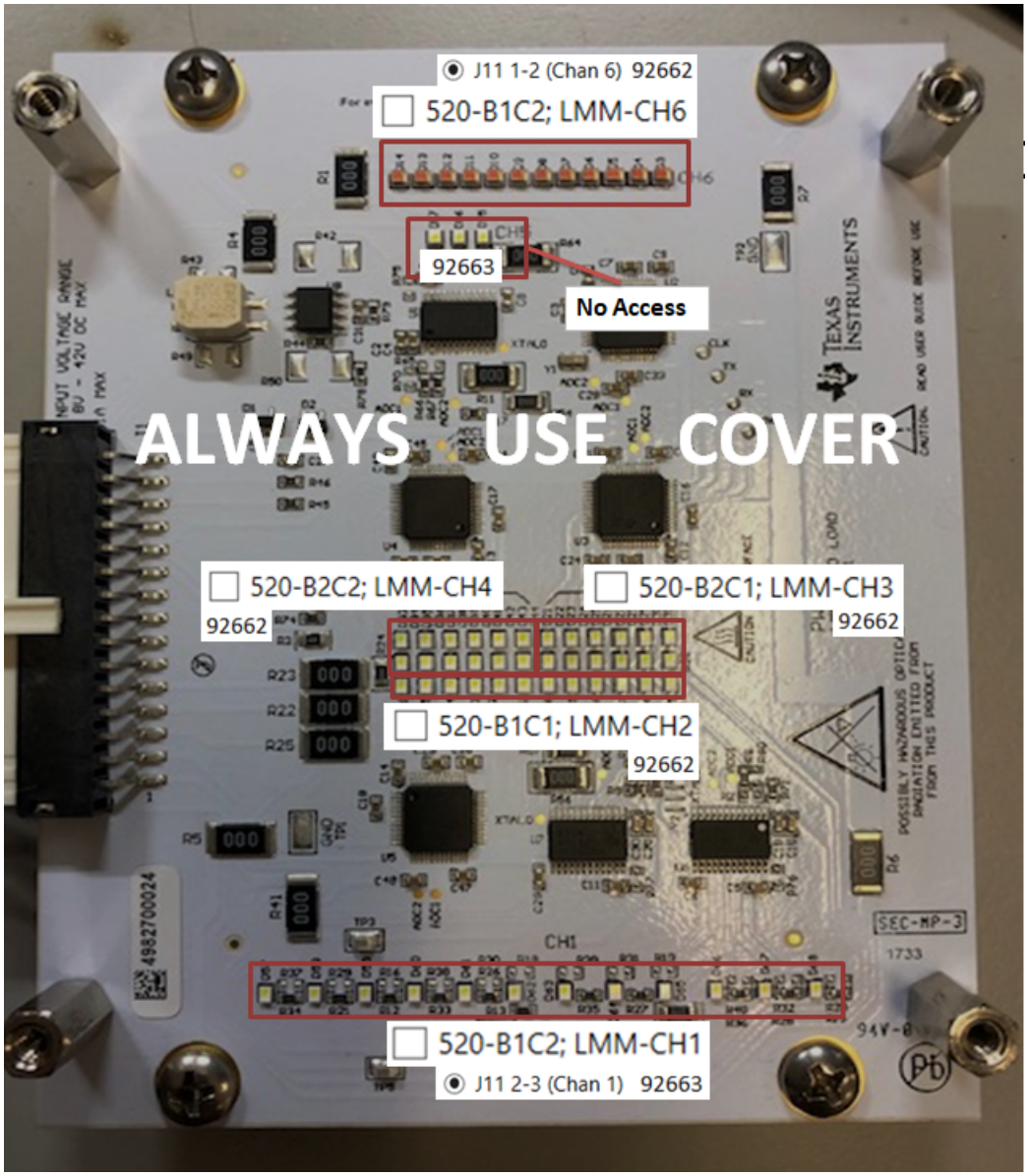


Figure 38. TPS92663EVM6-901 Addressing Outline

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (September 2019) to B Revision	Page
• First public release	7

Changes from Original (August 2019) to A Revision	Page
• Updated Figure 38	39

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