TPS22966EVM-007 Dual 6A Load Switch

The TPS22966EVM-007 evaluation module contains a dual channel, ultra low ON resistance, 6-A load switch with controlled turn and adjustable rise time.

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1 Description

The TPS22966 device contains two N-channel MOSFETs that can operate over an input voltage range of 0.8V to 5.5 V and can support a maximum continuous current of up to 6-A per channel. Each switch is independently controlled by an on/off input (ON1, ON2), which is capable of interfacing directly with low-voltage GPIO control signals. In the TPS22966, a 260-Ω on-chip load resistor is added for quick output discharge (QOD) when the switch is turned off. The rise time of the device is internally controlled in order to avoid in-rush current and can be adjusted using a ceramic capacitor on the CTx pins. The TPS22966 is available in a small, space-saving 2mm x 3mm 14-pin SON package with integrated thermal pad allowing for high power dissipation.

The TPS22966 device is demonstrated using the TPS22966EVM-007 module. The TPS22966 Dual Load Switch device can be configured in either a dual switch configuration or a parallel switch configuration using the TPS22966EVM-007.

1.1 Typical Applications

- Ultrabooks™
- Notebooks/Netbooks
- Tablet PC
- Consumer Electronics
- Set-top Boxes
- Industrial Systems
- Telecom Systems

1.2 Features

- Integrated dual channel load switch
- Input voltage range: 0.8V to 5.5V
- Ultra-low on-resistance (18 mΩ typical)
- 6A maximum continuous switch current per channel
- Low threshold control inputs
- Adjustable slew-rate control
- Quick Output Discharge transistor
- SON 14-pin package with thermal pad

2 Electrical Performance Specifications

R_{ON} (mΩ) (max)	R_{ON}, C_L = 0.1 µF at VIN						
	Measured values at 25°C						
	VIN (V)	VIN1 - VOUT1 (V)	I_{OUT1} (A)	R_{ON} (mΩ)	VIN2 - VOUT2 (V)	I_{OUT2} (A)	R_{ON} (mΩ)
20.0	5	0.00378	0.208	17.93269231	0.00374	0.2077	18.00674049
20.0	3.3	0.003615	0.208	17.37980769	0.00363	0.2077	17.47713048
20.0	1.8	0.003634	0.208	17.47115385	0.00364	0.2077	17.52527684
20.0	1.5	0.00363	0.208	17.45192308	0.00363	0.2077	17.47713048
20.0	1.2	0.00362	0.208	17.40384615	0.00364	0.2077	17.52527684
20.0	0.8	0.00362	0.208	17.40384615	0.00364	0.2077	17.52527684

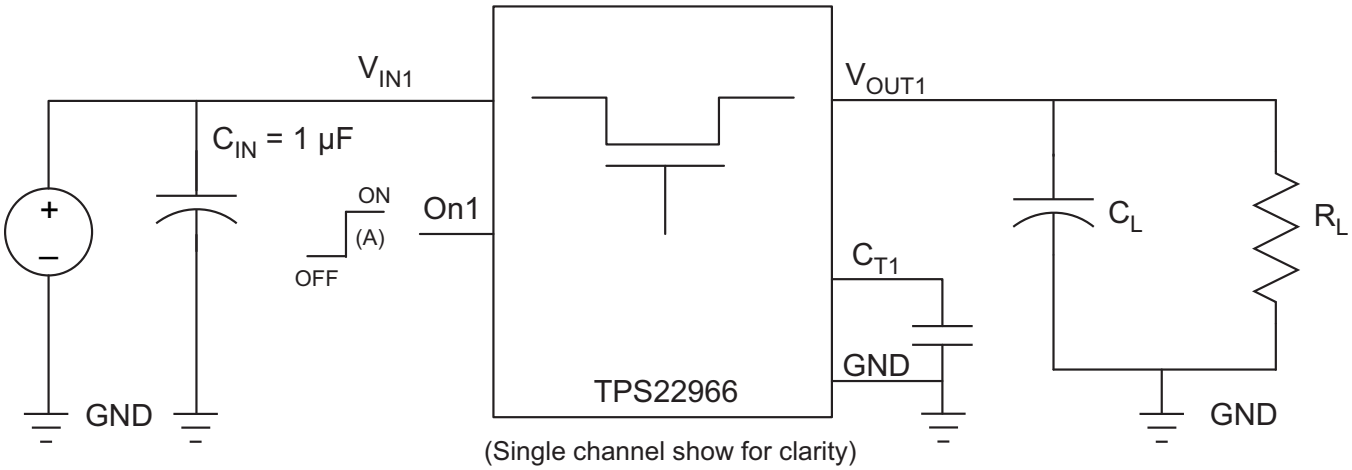
$IIN_{(VIN-OFF)}$ (max)	VIN1, VIN2 (V)	$IIN_{(VIN-OFF)}$ at 25°C	
		V_{ON1}, V_{ON2} = 0 V, VOUT1, VOUT2 = Open	
		$IIN_{(VIN1-OFF)}$ (µA)	$IIN_{(VIN2-OFF)}$ (µA)
1	5.0	0.098	0.075
1	3.3	0.031	0.017
1	1.8	0.012	0.007
1	0.8	0.001	0.007

SWITCHING CHARACTERISTICS

VIN1 = 5.0V, VIN2 = 5.0 V, T_A = 25C (unless otherwise noted)

Parameter		Test Condition	Each Channel	Unit
			TYPICAL	
t_{ON}	Turn on time	RL = 10 Ω, C_L = 0.1 µF, CT = 270 pF	491	µs
t_{OFF}	Turn off time	RL = 10 Ω, C_L = 0.1 µF, CT = 270 pF	20	
t_R	VOUT Rise time	RL = 10 Ω, C_L = 0.1 µF, CT = 270 pF	580	
t_F	VOUT Fall time	RL = 10 Ω, C_L = 0.1 µF, CT = 270 pF	20	
t_D	On delay time	RL = 10 Ω, C_L = 0.1 µF, CT = 270 pF	50% t_R	

Parametric Measurement Information



(Single channel show for clarity)

TEST CIRCUIT

Table 1. t_R vs VIN vs CT capacitor

CTx	Slew Rate (µs/V) (TYP)	Rise Time (µs) 10%–90%, C_L = 0.1 µF at VIN Typical values at 25°C,25 V X7R 10% ceramic cap							
		5V	3.3V	1.8V	1.5V	1.2V	1.05V	1V	0.8V
0	38	188	130	52	44	38	35	33	29
220	101	505	336	182	152	121	106	101	81
270	116	580	384	209	174	139	122	116	93
470	175	877	580	316	263	210	184	175	140
680	238	1192	788	429	358	286	250	238	191
1000	339	1693	1107	609	508	406	256	339	271
2200	693	3464	2301	1247	1039	831	727	693	554
3300	1020	5098	3388	1835	1529	1224	1071	1020	816
4700	1440	7200	4769	2592	2160	1728	1512	1440	1152
10000	3004	15020	9991	5407	4506	3605	3154	3004	2403

3 Schematic

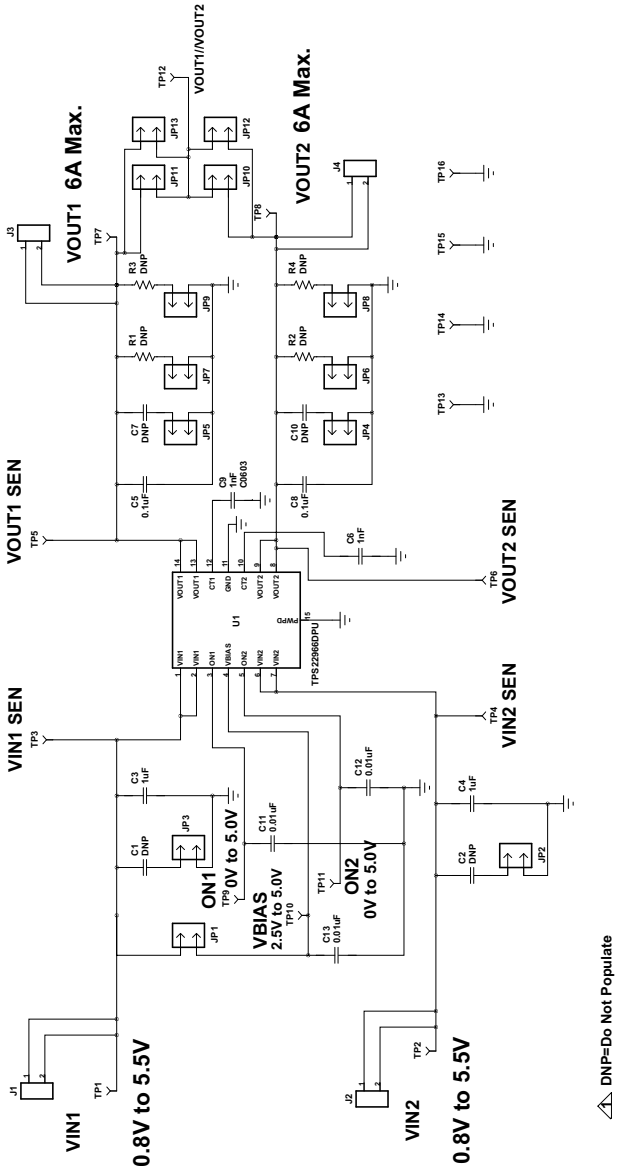


Figure 1. TPS22966EVM-007 Schematic

4 Layout

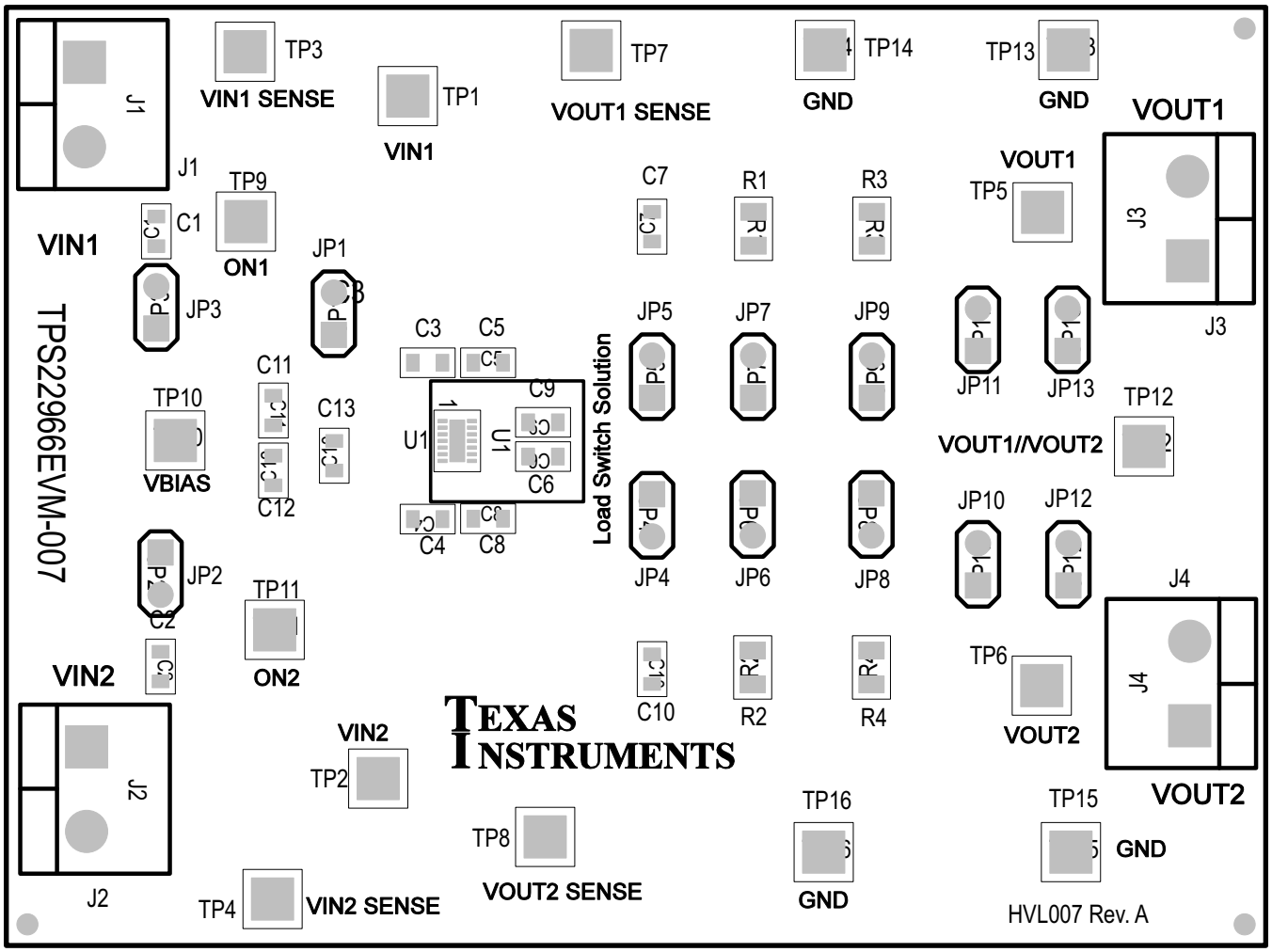


Figure 2. TPS22966EVM-007 Top Assembly

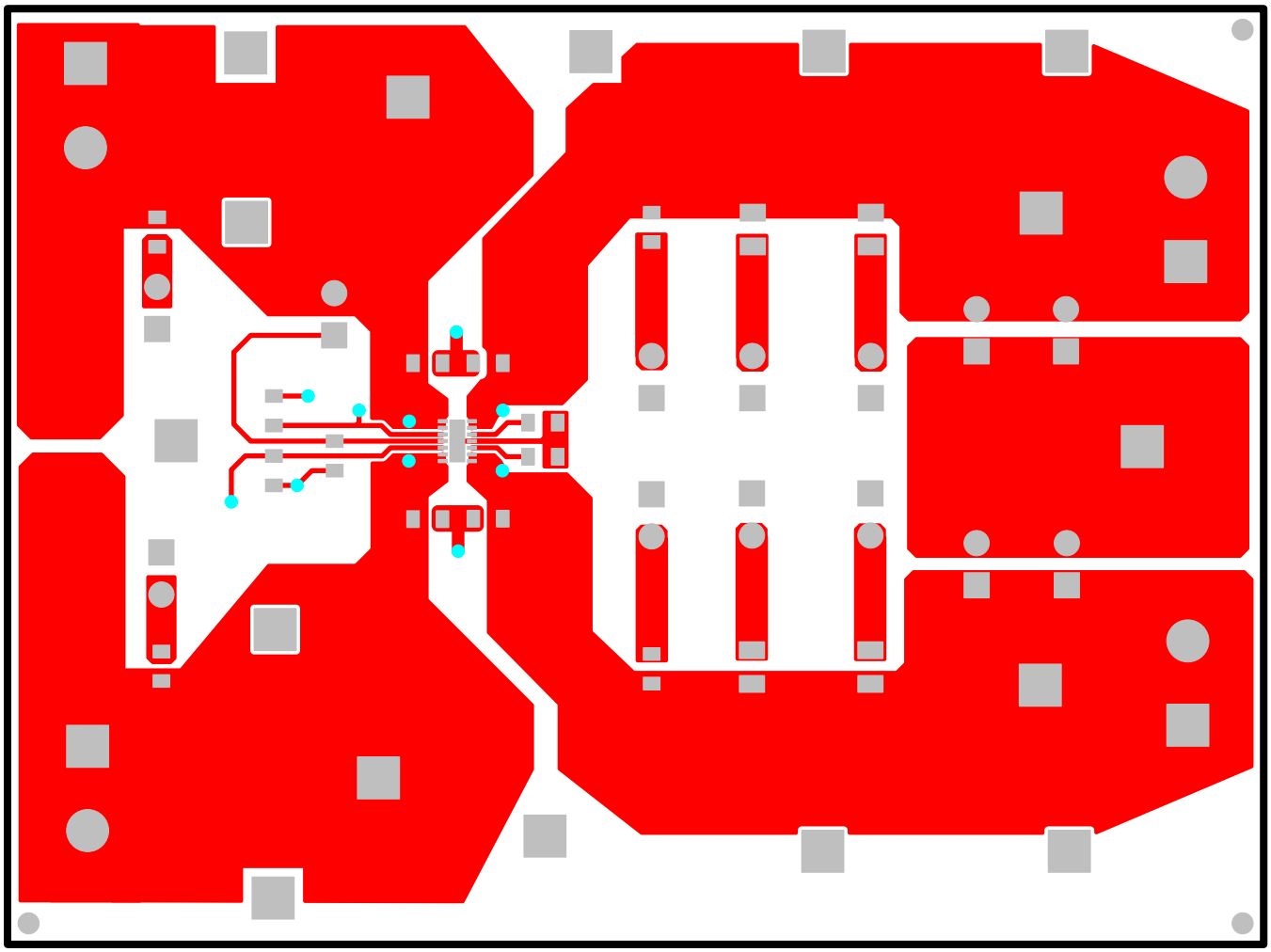


Figure 3. TPS22966EVM-007 Topside

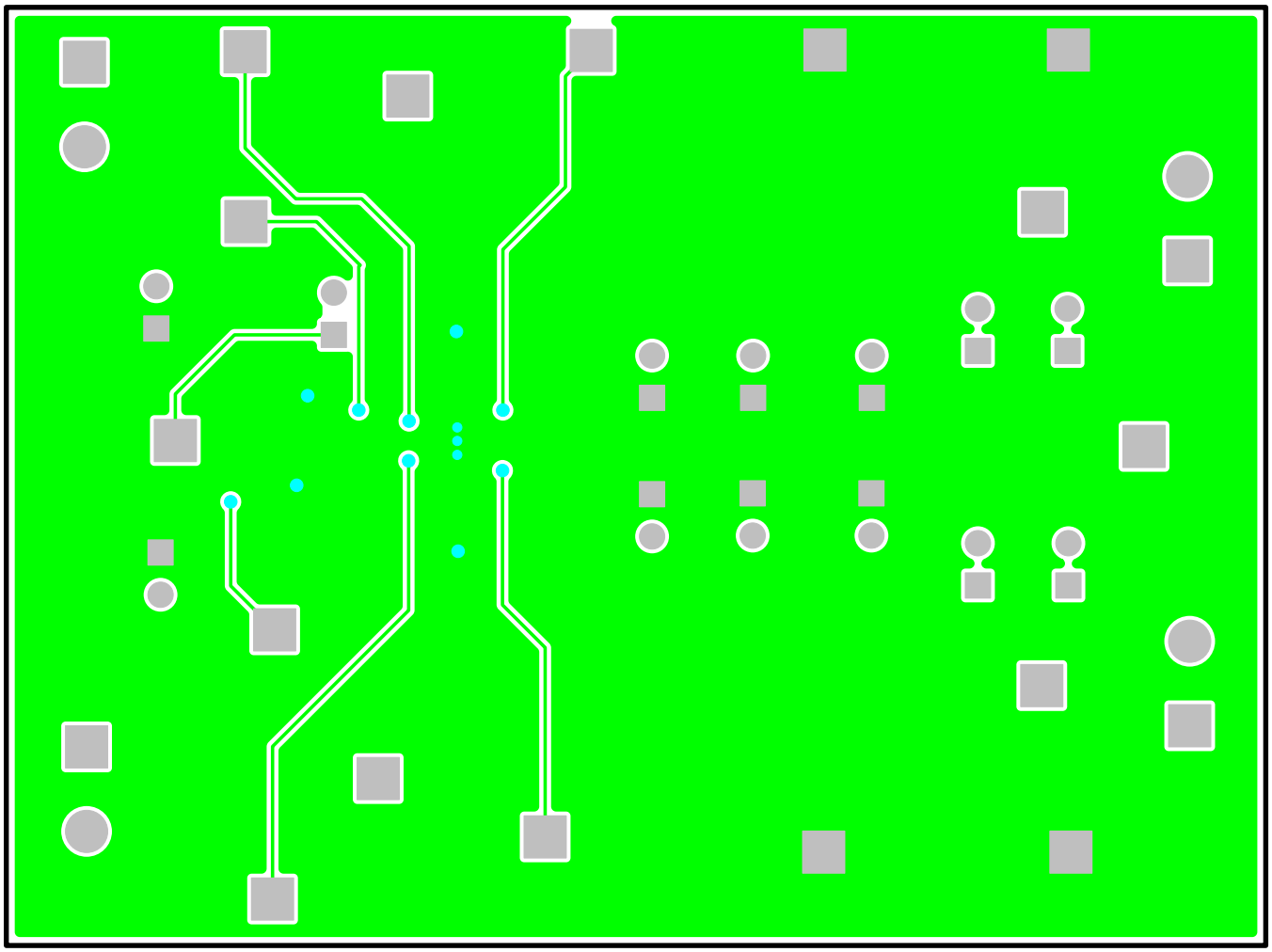


Figure 4. TPS22966EVM-007 Bottomside

5 Test Setup

5.1 Test Equipment

- **Voltage Source:**
  - 1 Power Source capable of 10V 15A
- **Multimeters:**
  - 2 voltmeters
- **Output Loads:**
  - Electronic Load or Resistor(If testing 6A operation of the switch at 5.5V a 33W power rated resistor is needed)
- **Oscilloscope:**
  - 4 channel 100MHz
- **Signal Generator:**
  - Dual Channel Preferred
- **Recommended Wire Gauge:** 18 AWG

5.2 Test Setup

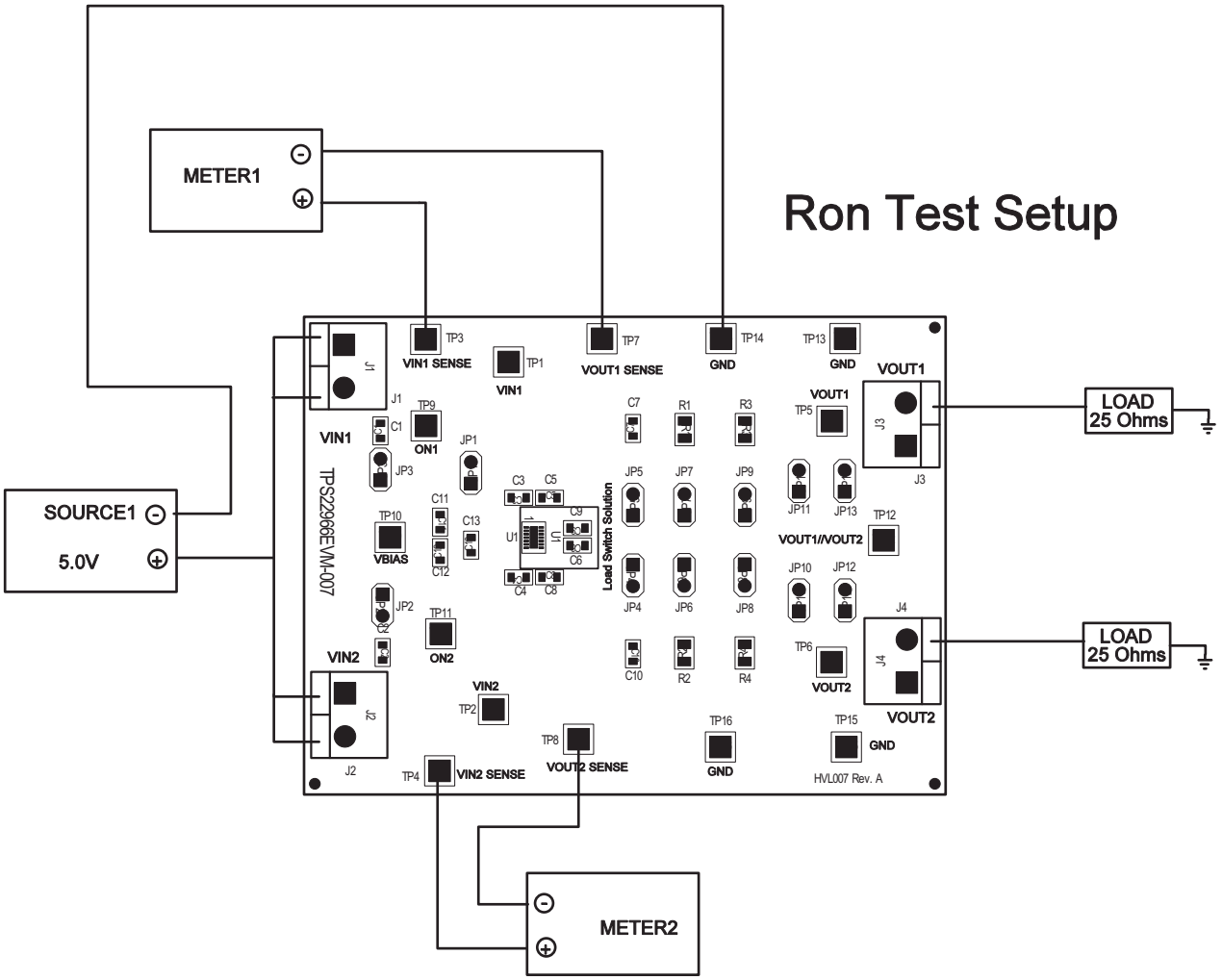


Figure 5. TPS22966EVM-007 Recommended Ron Test Set Up

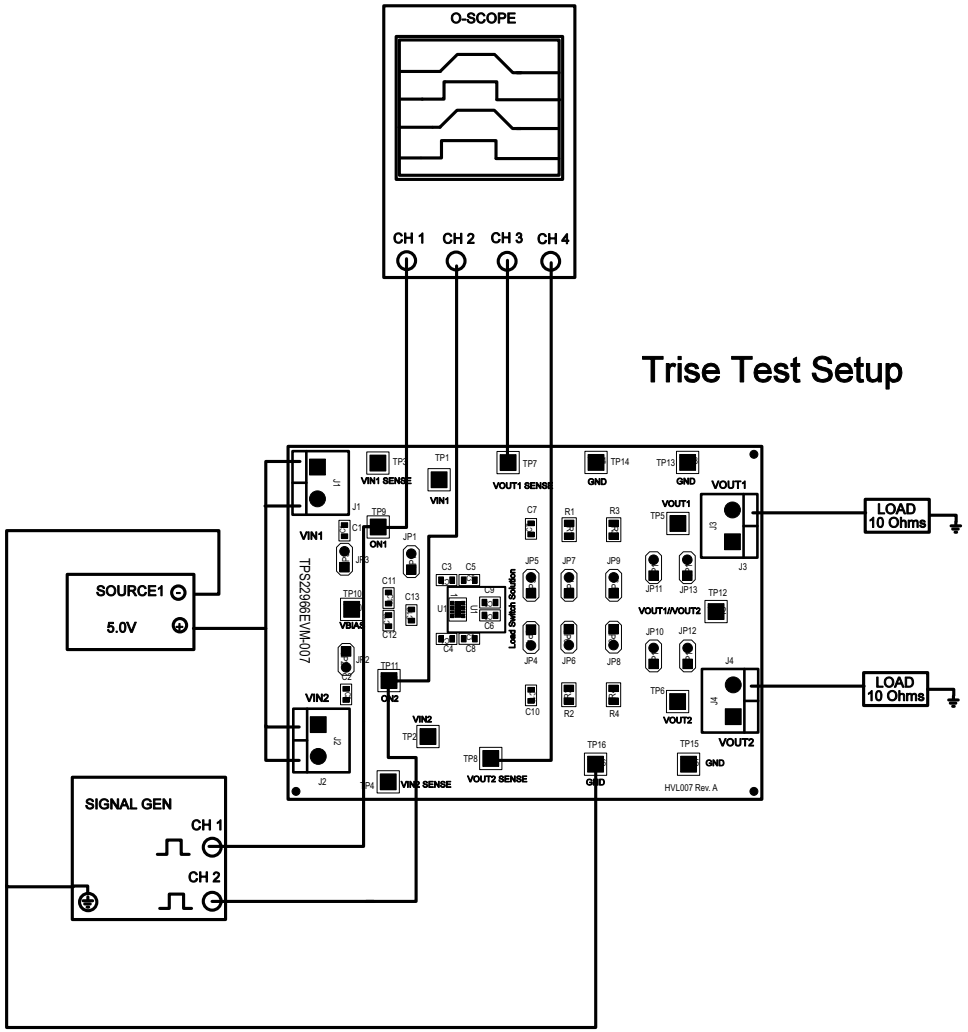


Figure 6. TPS22966EVM-007 Recommended Trise Test Set Up

5.3 List of Test Points

Table 2. The Functions of Each Test Points

Test Points	Name	Description
J1	VIN1	DC Input to VIN1
J2	VIN2	DC Input for VIN2
JP1	VBIAS	Connects VBIAS to VIN1
JP2	C2	Connects C2 to VIN2
JP3	C1	Connects C1 to VIN1
JP4	C10	Connects C10 to VOUT2
JP5	C7	Connects C7 to VOUT1
JP6	R2	Connects R2 to VOUT2
JP7	R1	Connects R1 to VOUT1
JP8	R4	Connects R4 to VOUT2
JP9	R3	Connects R3 to VOUT1
JP10, JP11, JP12, JP13	VOUT1 // VOUT2	Shorts VOUT1 and VOUT2 to VOUT1//VOUT2 used in parallel switch configuration
TP1	VIN1	VIN1 of TPS22966
TP2	VIN2	VIN2 of TPS22966
TP3	VIN1 SEN	Sense connect to VIN1 of TPS22966
TP4	VIN2 SEN	Sense connect to VIN2 of TPS22966
TP5	VOUT1	VOUT1 of TPS22966
TP6	VOUT2	VOUT2 of TPS22966
TP7	VOUT1 SEN	Sense connect to VOUT1 of TPS22966
TP8	VOUT2 SEN	Sense connect to VOUT2 of TPS22966
TP9	ON1	ON1 of TPS22966
TP10	VBIAS	VBIAS of TPS22966
TP11	ON2	ON2 of TPS22966
TP12	VOUT1 // VOUT2	VOUT1 VOUT2 connected in parallel configuration
TP13	AGND	Ground Connection
TP14	AGND	Ground Connection
TP15	AGND	Ground Connection
TP16	AGND	Ground Connection

5.4 Test Procedure

Figure 5 shows a typical setup for the R_{ON} test of the EVM. VBIAS voltage must be present for the device to function, keep this voltage level constant between 2.5V-5.25V. Adding a shunt across JP1 will connect the VBIAS pin to VIN1. When testing with VIN1 below 2.5V JP1 shunt must be removed and VBIAS tied to another voltage source. It is recommended to keep VBIAS voltage level at 5V. Datasheet specifications were taken with VBIAS = 5V.

5.5 R_{ON} Test Procedure

1. Setup the EVM per Figure 5.
2. Set SOURCE1 level to 5.0V.
3. Place a shunt across JP1.
4. Connect ON1 to a DC source between 1.05v and 5.5v, SOURCE1 supply can be used for this. (When testing R_{ON} it is desired to have the switch operating in the always ON condition.)
5. Connect ON2 to GND. This keeps switch 2 in the off state.
6. Place a load on VOUT1 and VOUT2.
7. Turn on SOURCE1.
8. Record the voltage reading from METER1, record the input current reading from SOURCE1. Calculate Ron by dividing METER1 voltage level by the current reading from SOURCE1. The result will be the R_{ON} value for switch 1.
9. Turn SOURCE1 off.
10. Remove ON1 from SOURCE1 and connect to GND.
11. Remove ON2 from GND and connect to SOURCE1.
12. Turn SOURCE1 on.
13. Record the voltage reading from METER2, record the input current reading from SOURCE1. Calculate R_{ON} by dividing the voltage reading of METER2 by the current reading from SOURCE1. The results will be the R_{ON} value for switch 2.
14. Turn SOURCE1 off.

5.6 t_R, t_{ON}, t_F, t_{OFF} Test Procedure

1. The rise time (t_R) is selected by the CT capacitor value on each switch channel. Table 1 shows CT value and the associated t_R value. The EVM is shipped with a default CT value of 1nF.
2. Set up the EVM per Figure 6
3. Set SOURCE1 level to 5.0V.
4. Place a shunt across JP1.
5. Place a load on VOUT1 and VOUT2 (a 10Ω, 3.25W resistor is recommended for this test).
6. Set Signal Generator output to 0-2Vpp, 10-100Hz, and 25% duty cycle.
7. Turn SOURCE1 on.
8. Enable the Signal Generator output.
9. Rise time (t_R) and turn-on time (t_{ON}) can be observed from the Oscilloscope channel 1 for switch 1 and channel 4 for switch 2. A detailed description of t_R, t_{ON}, t_F and t_{OFF} are listed in the TPS22966 Datasheet under the Switching Characteristics Section.
10. Turn SOURCE1 off and disable the signal Generator output.

6 Performance Data and Typical Characteristic Curves

Figure 7 through Figure 11 present typical performance curves for TPS22966EVM-007.

6.1 t_R and t_F Curves

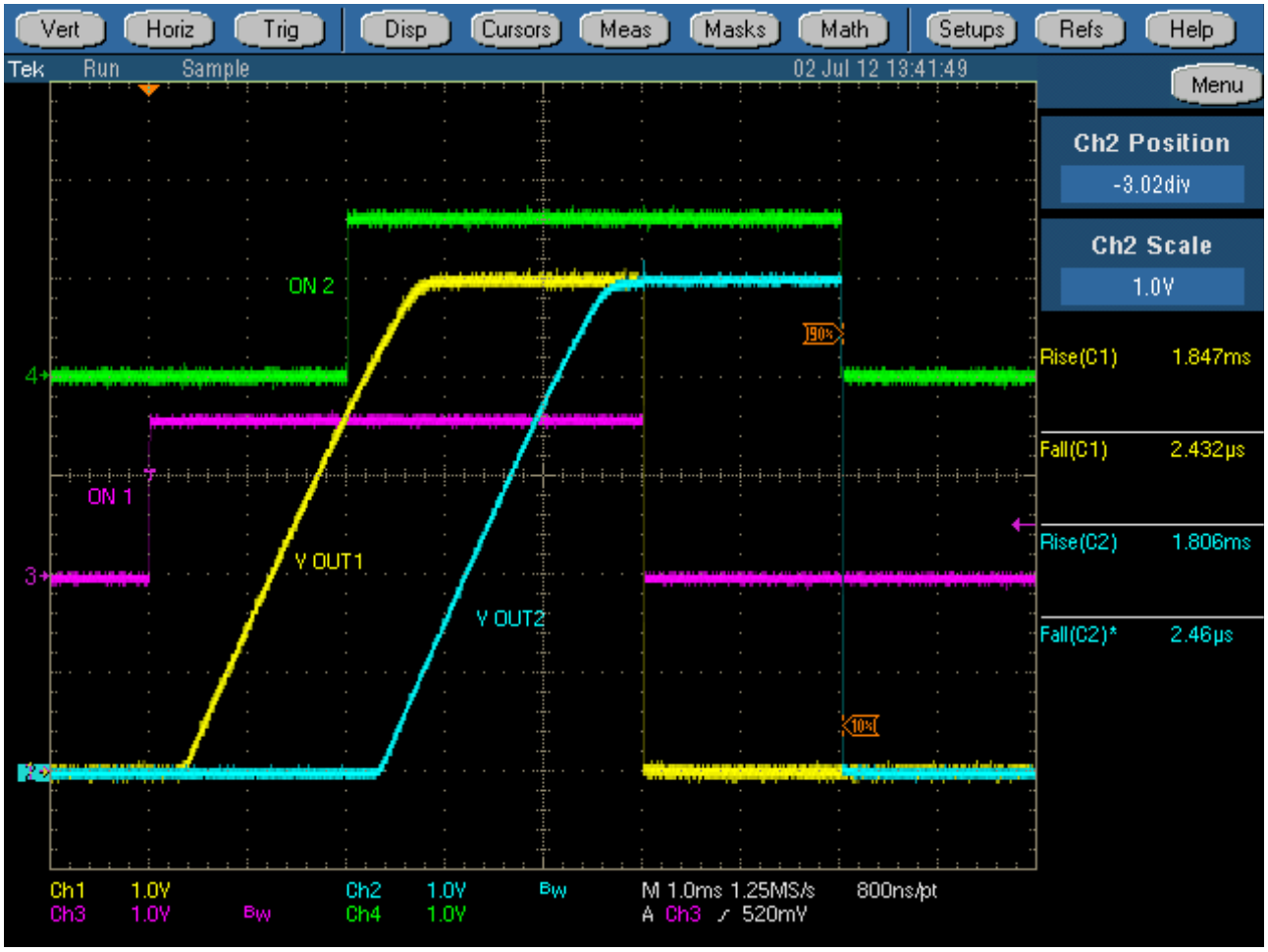


Figure 7. TPS22966EVM-007 t_R and t_F with VIN=5V, CT=1nF and Load =10Ω.

6.2 6A Operation

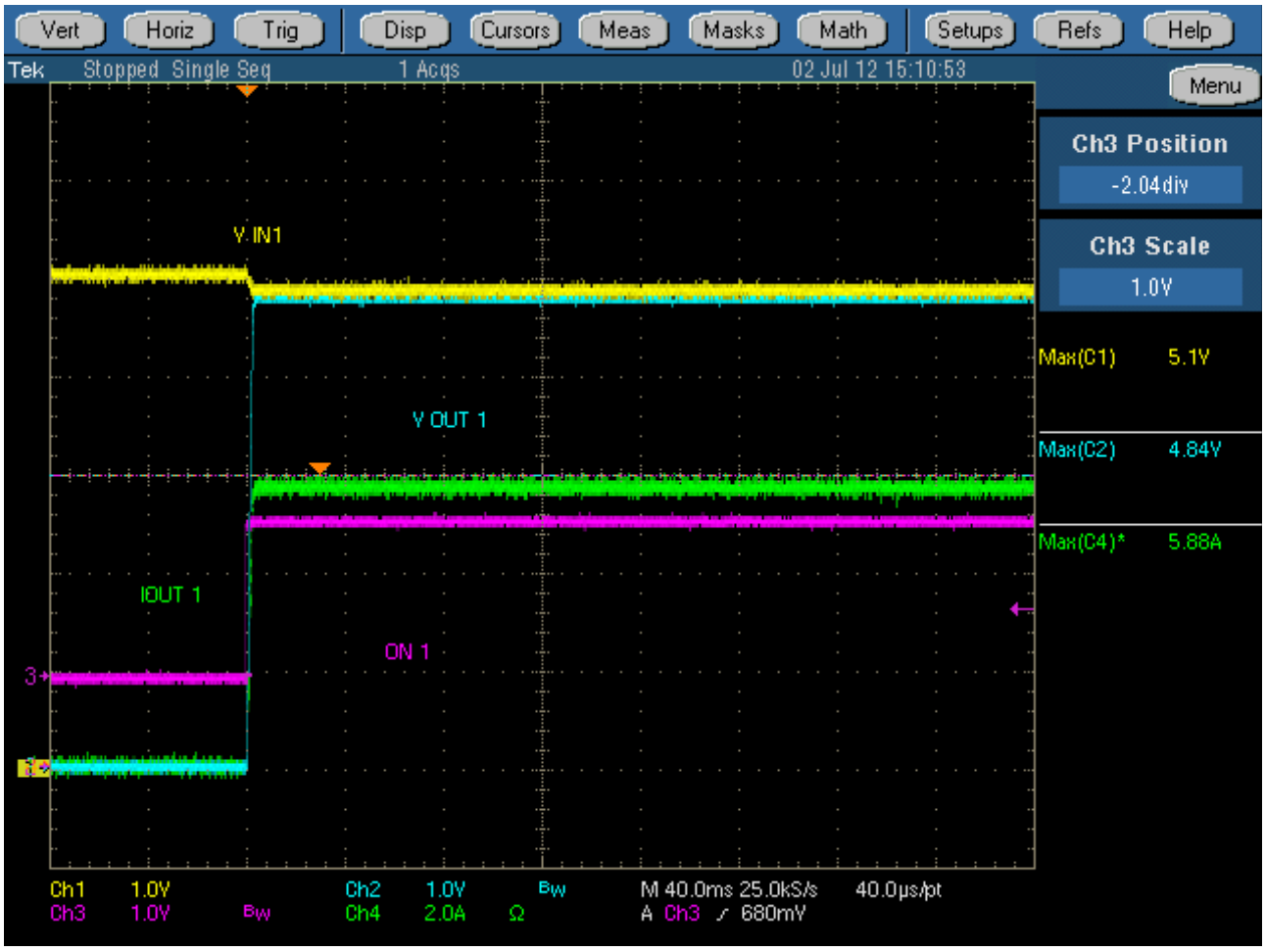


Figure 8. TPS22966EVM-007 Turn-ON and Operation at 6A.

6.3 R_{ON} vs Input Voltage

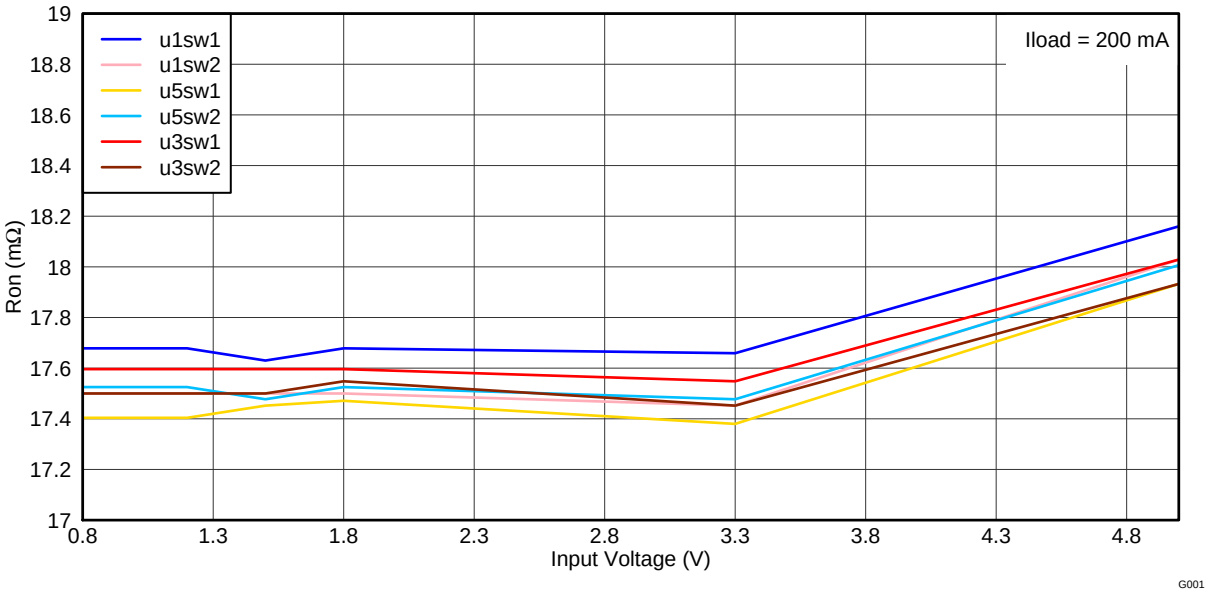


Figure 9. TPS22966EVM-007 R_{ON}

6.4 R_{ON} vs Temperature

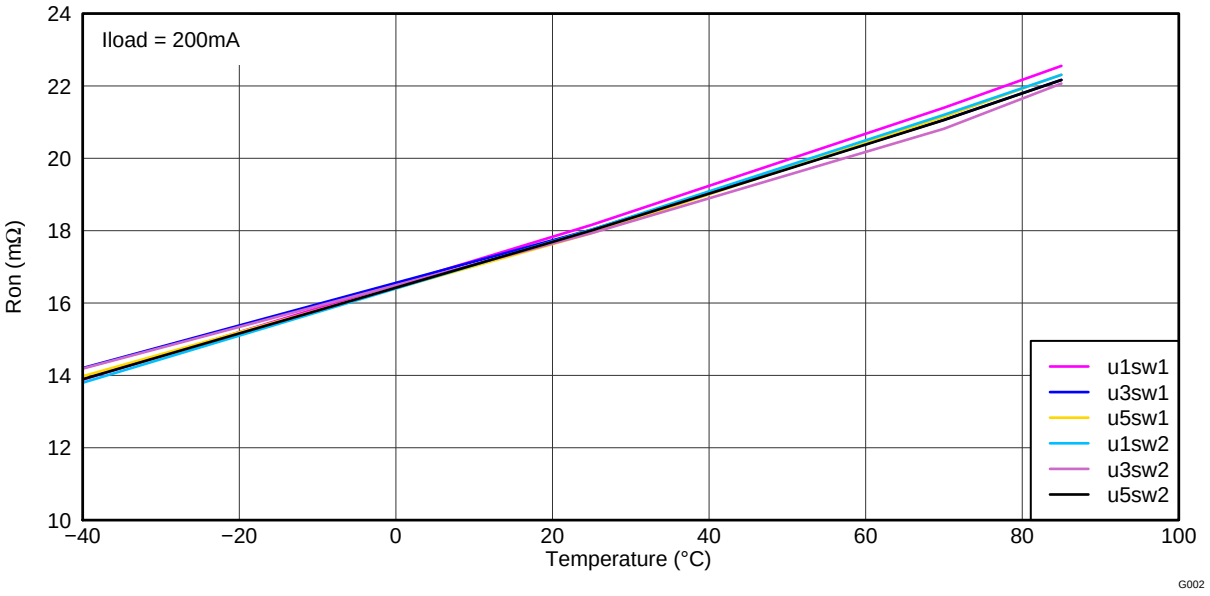


Figure 10. TPS22966EVM-007 R_{ON} vs Temperature

6.5 t_R vs CT Capacitor Value

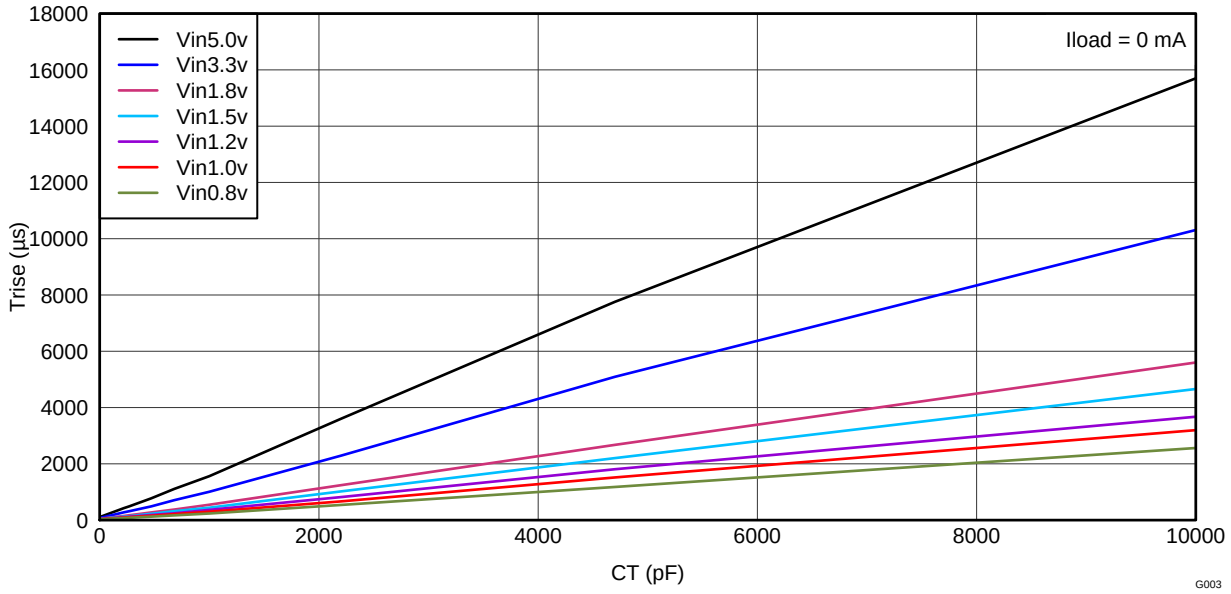


Figure 11. TPS22966EVM-0077 t_R vs CT cap

7 Bill of Materials

Table 3 is the EVM componets list according to the schematic shown in Figure 1.

Table 3. EVM Components List

Count	RefDes	Value	Description	Size	Part Number	MFR
0	C1, C2, C7, C10	DNP	Capacitor, Ceramic, 25V, X7R, 20%	603	Std	Std
3	C11, C12, C13	0.01µF	Capacitor, Ceramic, 16V, X7R, 20%	603	Std	Std
2	C3, C4	1µF	Capacitor, Ceramic,16V, X7R, 20%	603	Std	Std
2	C5, C8	0.1µF	Capacitor, Ceramic, 25V, X7R, 20%	603	Std	Std
2	C6, C9	1nF	Capacitor, Ceramic, 25V, X7R, 20%	603	Std	Std
1	JP1	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
12	JP2, JP3, JP4, JP5, JP6, JP7, JP8, JP9, JP10, JP11, JP12, JP13	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
0	R1, R2, R3, R4	DNP	Resistor, Chip, 1/16W, x%	805	Std	Std
12	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12	5010	Test Point, Red, Thru Hole Compact Style	0.125 x 0.125 inch	5010	Keystone
4	TP13, TP14, TP15, TP16	5011	Test Point, Black, Thru Hole Compact Style	0.125 x 0.125 inch	5011	Keystone
4	J1, J2, J3, J4	ED120/2DS	Terminal Block, 2-pin, 15-A, 5.1mm	0.512 inch	ED120/2DS	OST
1	U1	TPS22966DPU	IC, 6-A Dual Load Switch With Controlled Turn-On	PWSON	TPS22966DPU	TI
1	--		PCB, 2.98 In x 2.22 In x 0.062 In		HVL007	Any
1			Shunt, Black	100-mil	929950-00	3M

Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.
2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.

Revision History

Changes from Original (August 2012) to A Revision	Page
• Changed DCN to DPU for Value and Part Number in line item 12 of BOM	15

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

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For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

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This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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http://www.tij.co.jp

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EVALUATION BOARD/KIT/MODULE (EVM)
WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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