

LM5160A, LM5160 Buck EVM User's Guide

User's Guide



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LM5160A, LM5160 User's Guide

1 Introduction

The Texas Instruments LM5160DNTBKEVM evaluation module (EVM) helps designers evaluate the operation and performance of the LM5160A / LM5160 synchronous buck regulator IC in a synchronous Buck configuration. It also includes the specification for the board, complete application schematic, bill of materials (BOM), setup instructions, and typical performance curves.

2 Background

The LM5160DNTBKEVM evaluation board provides a fully functional buck regulator, employing the constant on-time (COT) operating principle. This evaluation board provides a 5-V output over an input voltage range of 10 V to 60 V. The circuit delivers load current up to 1.5 A. The application schematic is setup up to operate from a 24 V nominal bus. The nominal switching frequency is approximately 300 kHz. The LM5160 device name is used generically throughout this document and represents both the LM5160 and LM5160A unless stated otherwise. The only difference between the two is the ability to connect an external voltage source to the VCC pin of the LM5160A. The board is designed to demonstrate a small buck solution size for low power wide V_{IN} applications.

Table 1. Board Specification

EVM	INPUT	V_{OUT}	I_{OUT}
LM5160DNTBKEVM	VIN=10V–60V	5V	0–1.5A

3 Setup

This section describes the connectors, the test points and the jumper on the EVM as well as how to properly connect and use the LM5160DNTBKEVM with the LM5160, unless stated otherwise.

3.1 Input/Output Connector Description

J1 – Input is the power input terminal for the converter. The terminal block provides an input V_{IN} (+) and ground (-) connection to allow the user to attach the EVM to a power supply.

J2 – Output is the regulated output voltage for the converter. The terminal block provides a V_{OUT} (+) and ground (-) connection to allow the user to attach the EVM to a load.

TP1 – (EN) allows the user to remotely shutdown/startup LM5160 while operating in the buck mode. EN circuitry is not populated on EVM.

TP2 – (SW) allows the user to connect a scope probe to observe the switch node of the converter.

JP1 – Mode pin allows the user to select between the forced CCM and the DCM operation.

3.2 Operation

For proper operation of the LM5160 Buck converter, the input voltage applied across J1 should be gradually increased. The load on the output (J2) should not exceed 1.5 A. The inductor L1 utilized in this board is optimized for small solution size. The saturation current rating (I_{SAT}) of the inductor should be higher than the LM5160 integrated high side FET peak current-limit threshold of 2.875 A (max.).

The nominal switching frequency can be set using the R_{ON} (R3 in the EVM) resistor as shown by [Equation 1](#):

$$F_{sw} = \frac{V_{OUT}}{R_{ON} \times 1 \times 10^{-10}} \text{ Hz} \tag{1}$$

The output voltage is set by using the feedback divider resistors R7 (R_{FB1}) and R6 (R_{FB2}) in the EVM by using Equation 2:

$$\frac{R_{FB2}}{R_{FB1}} = \frac{V_{OUT}}{V_{REF}} - 1 \tag{2}$$

The EN/UVLO resistors R2 (R_{UV1}) and R1 (R_{UV2}) in the EVM set the input under-voltage lockout threshold and hysteresis according to Equation 3:

$$V_{IN(HYS)} = I_{UVLO(HYS)} \times R_{UV2} \tag{3}$$

and,

$$V_{IN,UVLO(rising)} = V_{UVLO(TH)} \left(1 + \frac{R_{UV2}}{R_{UV1}} \right) \tag{4}$$

3.3 FPWM Mode Selection

Use the FPWM pin to select between the continuous conduction mode (CCM) and the discontinuous conduction mode (DCM) of operation. Table 1 summarizes the LM5160NDTBKEVM Jumper (JP1) settings that are chosen to activate the desired mode of operation. Refer to the LM5160 datasheet ([SNVSA03A](#)) for more detailed information regarding the FPWM mode selection.

Table 2. FPWM Pin Mode

JP1 Shunt Setting	Logic Stage	Description
DCM or Floating (High Z)	0	The FPWM pin is grounded or left floating. DCM enabled at light loads.
FPWM (VCC)	1	The FPWM pin is connected to VCC. Enables CCM at light loads.

4 Board Layout

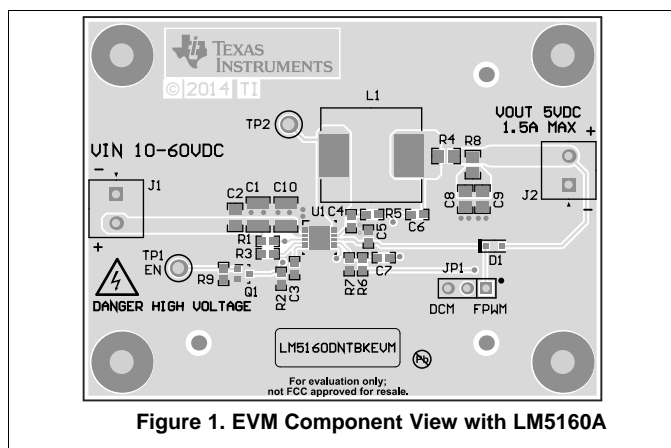


Figure 1. EVM Component View with LM5160A

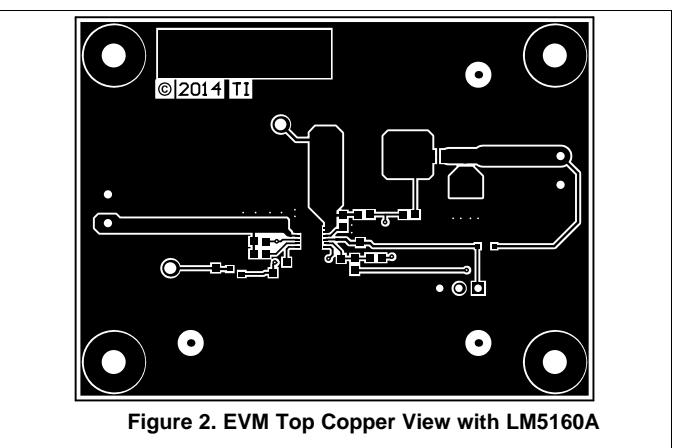


Figure 2. EVM Top Copper View with LM5160A

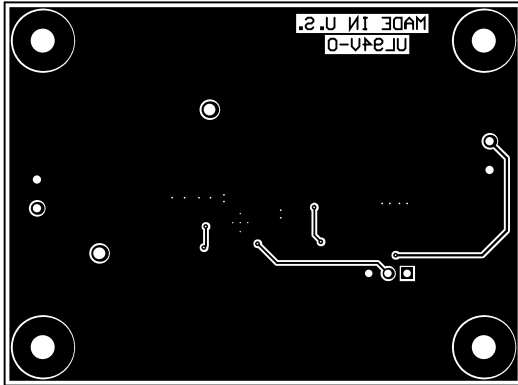


Figure 3. EVM Bottom Copper View with LM5160A

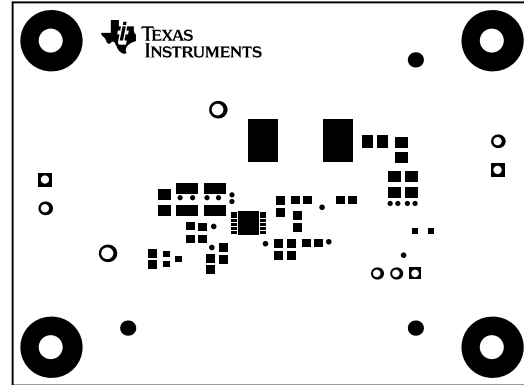


Figure 4. EVM Top Solder Mask with LM5160A

Figure 1 to Figure 4 show the board layout for the LM5160DNTBKEVM PCB. The WSON-12 package allows a compact leadless IC package buck regulator solution. The LM5160DNTBKEVM is a simple two layer board. In this EVM, the necessary feedback ripple voltage (V_{FB}) required for stable COT operation over the entire input voltage range is generated by the inductor current flowing through the resistor, R_{ESR} (R8 as shown in Figure 1). This is the least component, minimum cost ripple configuration. There are placeholders in the EVM (R7, C6, and C7) which can be populated as required, for the minimum ripple injection network. If this external ripple configuration is used, substitute R8 with a 0Ω (0805) resistor. Calculate these component values based on the formulae mentioned under Type 3 ripple configuration in the LM5160, LM5160A Datasheet ([SNVSA03A](#)). See application note [AN-1481](#) for more details for each ripple generation method.

5 Schematic

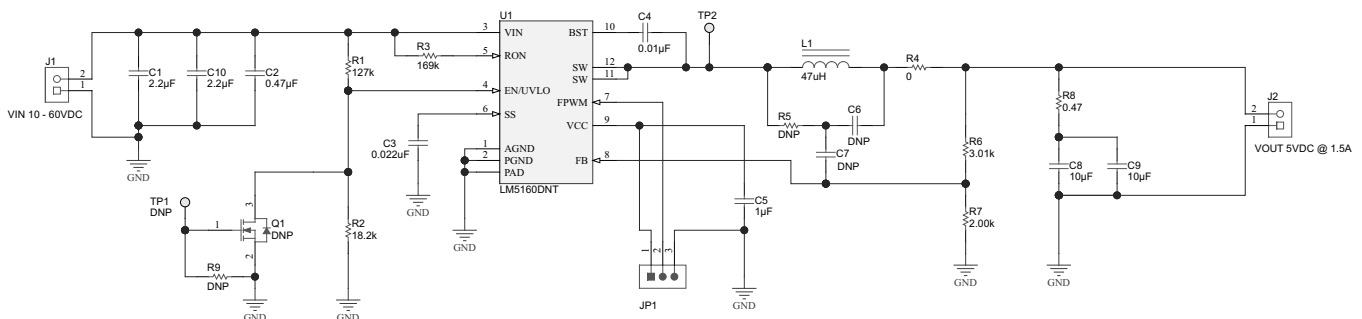


Figure 5. Buck EVM Schematic with LM5160

When/if used with LM5160, the placeholder for D1 as in Figure 1, must remain unpopulated under all cases. When evaluating the LM5160A, the designer needs to use the same standard EVM by replacing the LM5160 IC (when/if populated) with the LM5160A. No other components on board need to be replaced or removed. With LM5160A IC, the designer can use other nominal output voltage (V_{OUT}), set between 9 V and 13 V, to externally drive the V_{CC} for improved efficiency requirement. In that case, the diode in placeholder D1 can be appropriately populated, to the correct voltage ratings. More detail is given in Section 6 in the Bill of Materials. For more information about the difference between LM5160A and LM5160, please refer to the LM5160 Datasheet ([SNVSA03A](#)).

6 LM5160DNTBKEVM Bill of Materials for 300 kHz Configuration

ITEM	DESCRIPTION	MFG. PART NUMBER	PACKAGE	VALUE
C1, C10	Ceramic Capacitor	Murata GRM32ER72A225KA35L	1210	2.2 μ F, 100V, \pm 10%, X7R
C2	Ceramic Capacitor	Murata GRM21BR72A474KA73L	0805	0.47 μ F, 100V, \pm 10%, X7R
C3	Ceramic Capacitor	Murata GRM188R71C223KA01D	0603	0.022 μ F, 16V, \pm 10%, X7R
C4	Ceramic Capacitor	Murata GRM188R71C103KA01D	0603	0.01 μ F, 16V, \pm 10%, X7R
C5	Ceramic Capacitor	Murata GRM188R71E105KA12D	0603	1 μ F, 25V, \pm 10%, X7R
C8, C9	Ceramic Capacitor	Murata GRM21BR71A106KE51L	0805	10 μ F, 10V, \pm 10%, X7R
JP1	Header	Sullins Connector PEC03SAAN		3x1, Tin plated
L1	Inductor	Coiltronics DR125-470-R	10mm x 12.5mm	47 μ H, 2.71A, 0.074 Ω , SMD
R1	Resistor	Yageo America RC0603FR-07127KL	0603	127 k Ω , 1%, 0.1W
R2	Resistor	Vishay-Dale CRCW060318K2FKEA	0603	18.2 k Ω , 1%, 0.1W
R3	Resistor	Yageo America RC0603FR-07169KL	0603	169 k Ω , 1%, 0.1W
R4	Resistor	Yageo America RC0805JR-070RL	0805	0 Ω , 5%, 0.125W
R6	Resistor	Vishay-Dale CRCW06033K01FKEA	0603	3.01 k Ω , 1%, 0.1W
R7	Resistor	Vishay-Dale CRCW06032K00FKEA	0603	2.00 k Ω , 1%, 0.1W
R8	Resistor	Panasonic ERJ-6RQFR47V	0805	0.47 Ω , 1%, 0.125W
U1	Switching Regulator	Texas Instruments LM5160ADNT	WSO-12	
R5	Resistor	Unpopulated	0603	
R9	Resistor	Unpopulated	0603	18.2 k Ω , 1%, 0.1W
C6	Ceramic Capacitor	Unpopulated	0603	
C7	Ceramic Capacitor	Unpopulated	0603	
D1	Schottky Diode (Use with LM5160A only)	Diodes Inc. B0530W-7-F (Unpopulated)	SOD-123	30 V, 0.5 A
Q1	MOSFET	Unpopulated	SOT-323	N-CH, 50V, 0.2A

7 Performance Curves with LM5160A, LM5160

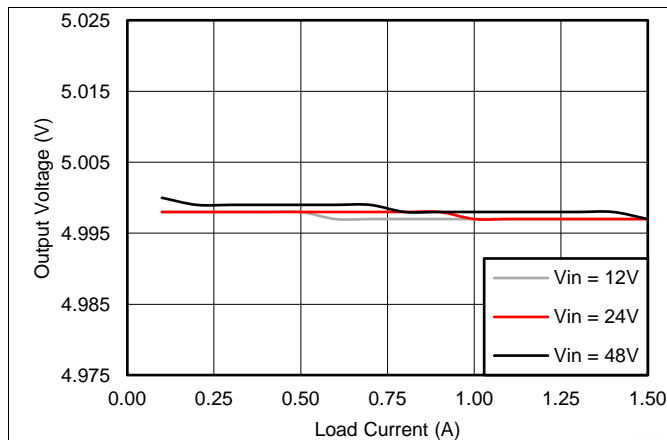


Figure 6. Load Regulation

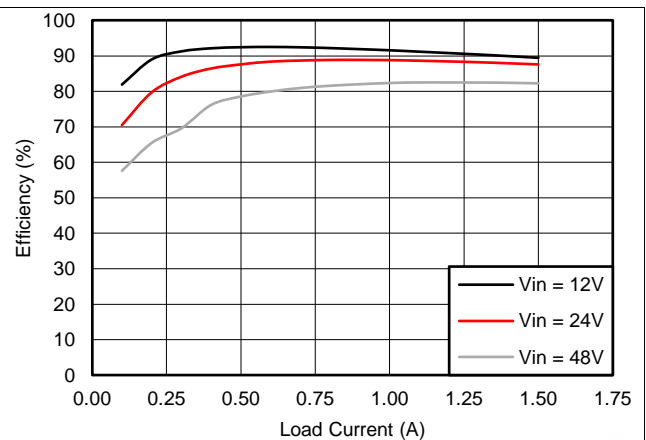


Figure 7. Efficiency vs. I_{OUT}

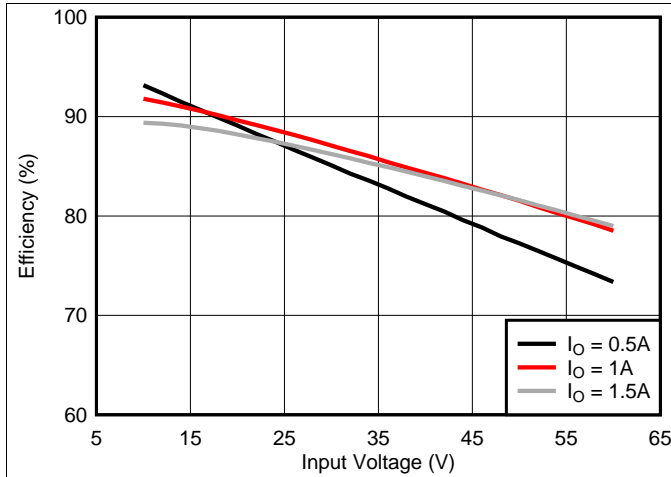


Figure 8. Efficiency vs. V_{IN}

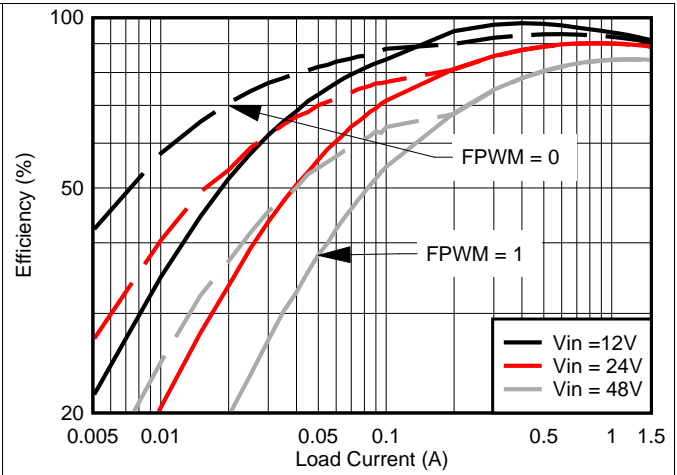


Figure 9. Efficiency DCM vs. CCM at 300kHz

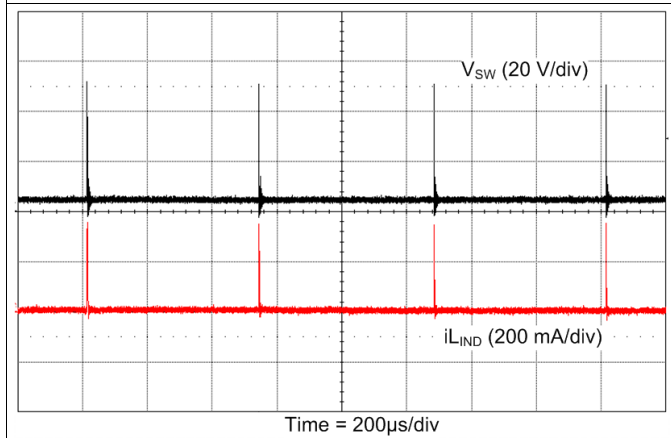


Figure 10. $V_{IN} = 48V$ and FPWM = 0 at no load

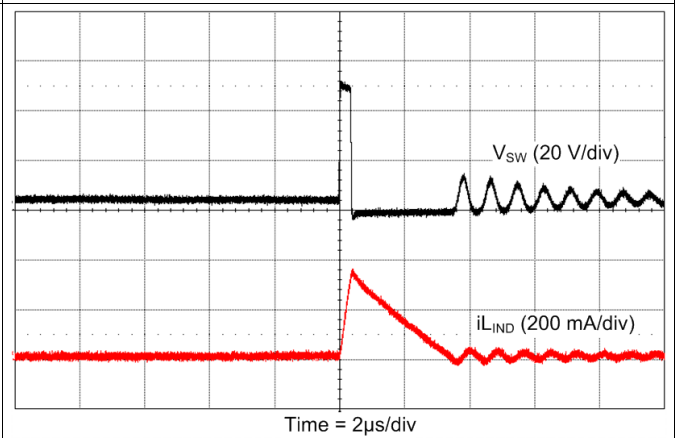


Figure 11. $V_{IN} = 48V$ and FPWM = 0 at no load (Zoomed)

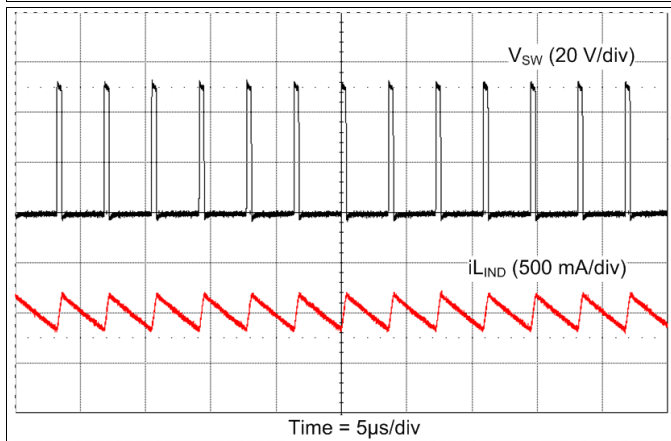


Figure 12. $V_{IN} = 48V$ and FPWM = 1 at no load

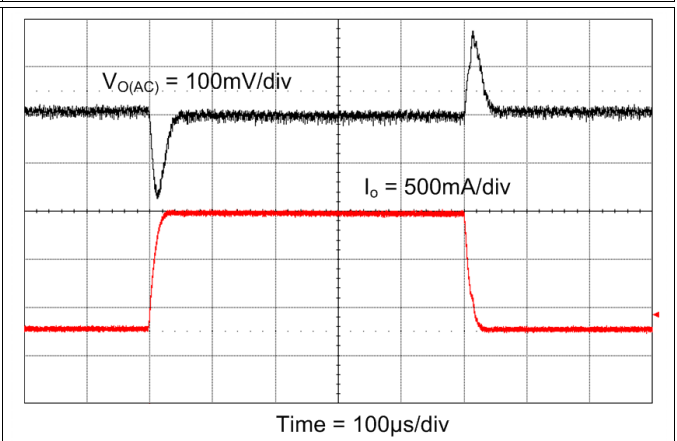


Figure 13. Load Transient ($I_O = 300mA$ to 1.5A)

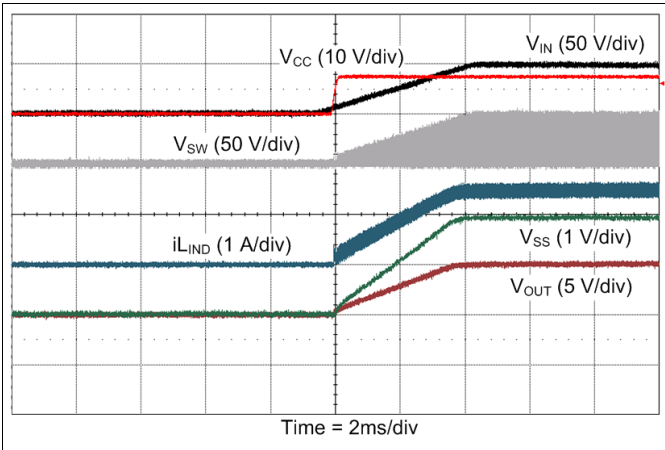


Figure 14. Startup at R_{LOAD} = 3Ω

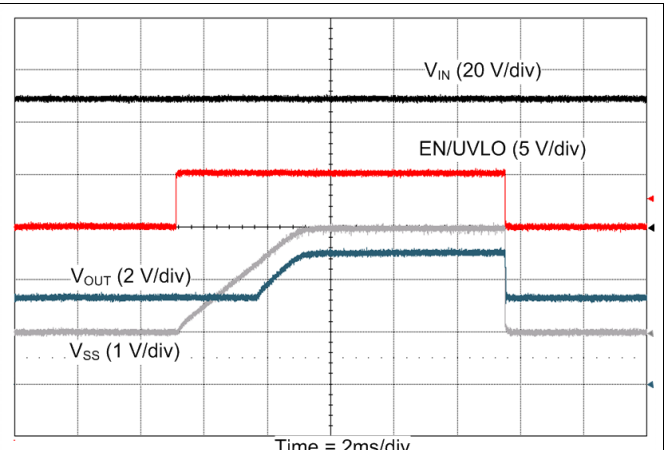


Figure 15. Pre-Bias Startup at R_{LOAD} = 3Ω and V_{IN} = 48V

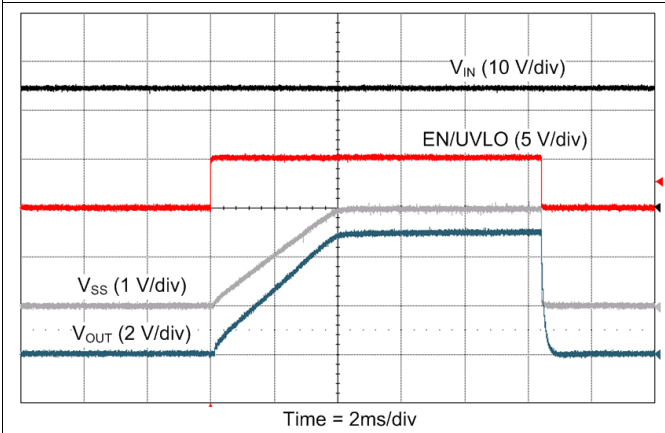


Figure 16. EN/UVLO Startup at R_{LOAD} = 5Ω and V_{IN} = 24V

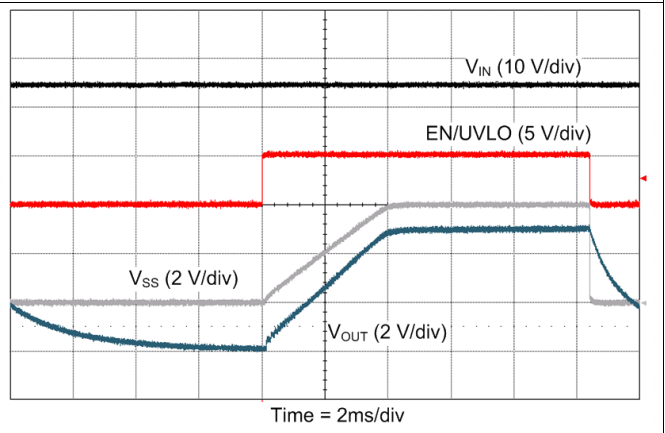


Figure 17. EN/UVLO Startup at R_{LOAD} = 100Ω and V_{IN} = 24V

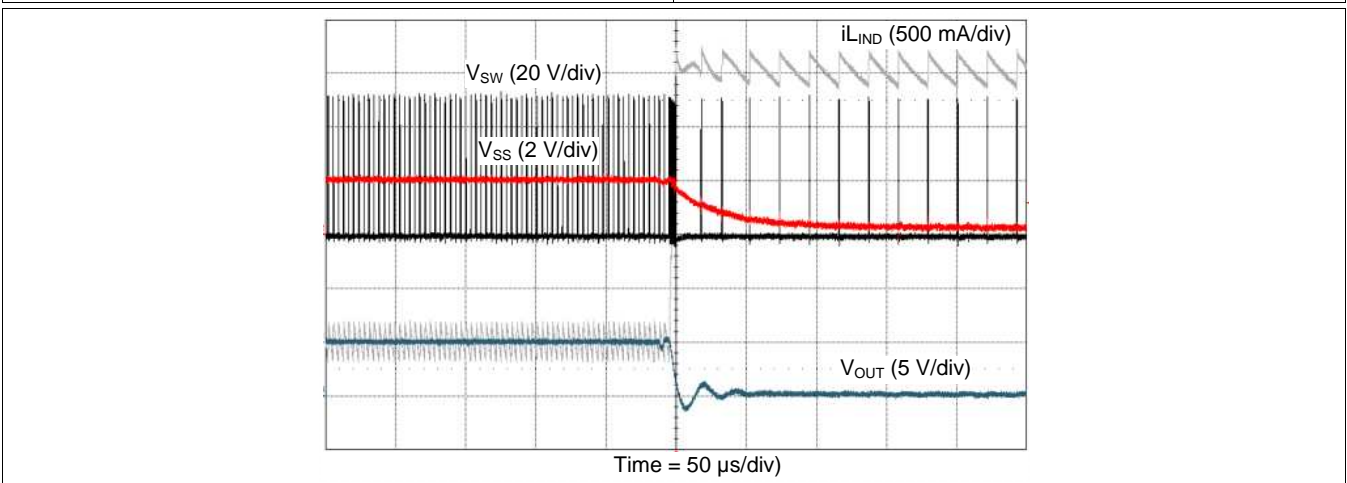


Figure 18. Output Short-Circuit at V_{IN} = 48V

Revision History

Changes from A Revision (February 2015) to B Revision	Page
• Added information for LM5160A EVM	4
• Added updated EVM views with LM5160A	5

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

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 - 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.

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- 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.

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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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4.2 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.

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