

LM5160 Fly-Buck (Isolated Buck) User's Guide

User's Guide



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LM5160 User's Guide

1 Introduction

The LM5160NDNTFBKEVM evaluation module (EVM) helps designers evaluate the operation and performance of the LM5160 in the Fly-Buck™ (isolated buck) configuration. The Fly-Buck topology is derived from the synchronous buck topology by replacing the buck inductor with a coupled inductor (transformer) to produce both primary (non-isolated) and secondary (isolated) outputs. This user guide details the specification of the EVM and includes complete application schematic, bill of materials (BOM), setup instructions, and performance curves. 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.

2 Background

The application schematic is designed to operate from a 24 V nominal bus with the input voltage ranging from 18 V to 32 V. It is capable of supplying 12 V with the secondary load rated to 400 mA at the isolated output. The nominal switching frequency is 300 kHz. The high side and low side MOSFETs are integrated in the LM5160 and LM5160A. The EVM is designed to demonstrate a small solution size in the WSON-12 lead-less package for low power isolated bias applications.

Table 1. Default Board Specification with LM5160

INPUT	FREQUENCY	VOUT1	ISOLATED V_{OUT}	I_{OUT}
$V_{IN} = 18\text{ V} - 32\text{ V}$	300 kHz	8 V	12 V	0 – 400 mA

The EVM can also be arranged with an alternate configuration shown in [Table 2](#) using some simple modifications. The changes in the BOM for the alternate configuration is shown in [Table 4](#). This configuration is optimized for lower power, high efficiency application.

Table 2. Alternate Configuration with LM5160

INPUT	FREQUENCY	VOUT1	ISOLATED V_{OUT}	I_{OUT}
$V_{IN} = 18\text{ V} - 32\text{ V}$	160 kHz	10 V	15 V	0-200 mA

3 Setup

This section describes the connectors and test-points on the EVM as well as how to properly connect, setup and use the LM5160NDNTFBKEVM with the LM5160.

3.1 Input/Output Connector Description

J1 – Output is the isolated output voltage for the converter. The terminal block provides V_{OUTISO} (+) and isolated ground (-) connection to allow the user to attach the EVM to a load.

J2 – Output is the primary non-isolated regulated output voltage for the converter. The terminal block provides VOUT1 (+) and ground (-) connection to allow the user to attach the EVM to a load.

J3 – Input is the power input terminal for the converter. The terminal block provides input V_{IN} (+) and ground (-) connections to allow the user to attach the EVM to a power supply.

TP1 – (SW1) allows the user to connect a scope probe to observe the primary side switching node of the converter.

3.2 Operation

For proper operation of the Fly-Buck converter, gradually increase the input voltage applied across J3. The load on the secondary output (**J1**) with primary output (**J2**) unloaded, should not exceed 400 mA which corresponds to 30 Ω . If the primary is loaded, the combined load on the two outputs should not exceed 600 mA. The coupled inductor (transformer) **T1** utilized in this board is optimized for small solution size and is not rated for the peak current limit of LM5160. If short circuit protection is required, **T1** should be replaced with a coupled inductor (flyback transformer) with primary side saturation current rating greater than the peak current limit of LM5160.

When the input voltage exceeds approximately 18 V, the primary and secondary outputs (**J2** and **J1**) power up to approximately 8 V and 12 V respectively.

The frequency of operation is set using the R_{ON} resistor (R7)

$$f_{SW} = \frac{V_{OUT1}}{1 \times 10^{-10} \times R_{ON}} \quad (1)$$

The primary output voltage can be set with the feedback divider resistors R8 and R9, using the following equation:

$$V_{OUT1} = \left(1 + \frac{R8}{R9}\right) \times 2 \text{ V} \quad (2)$$

The secondary output is related to the primary output voltage by the transformer turns ratio:

$$V_{OUTISO} = V_{OUT1} \times \frac{N2}{N1} - V_F \quad (3)$$

where $N2/N1$ is the turns ratio and V_F is the forward voltage drop of the secondary rectifier diode. There is some additional drop because of the leakage inductance and resistance of windings.

4 Board Layout

Figure 1, Figure 2, and Figure 3 show the board layout for the LM5160DNTFBKVM PCB. The WSON package offers an exposed thermal pad for enhanced thermal performance. The IC must be soldered properly to the copper landing on the PCB for optimal performance. The EVM is a two layer board.

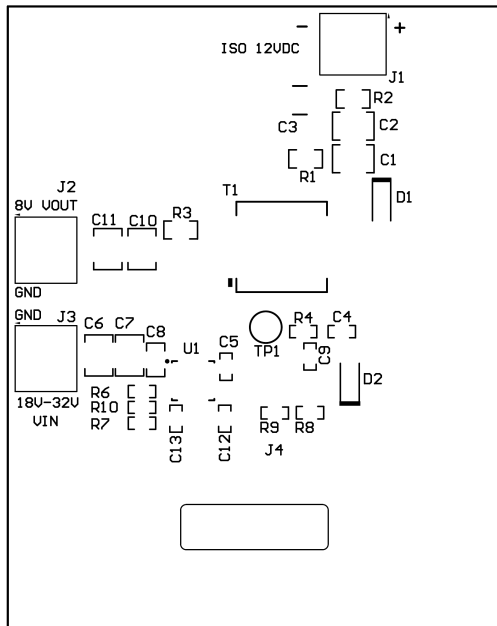


Figure 1. Top Assembly Layer

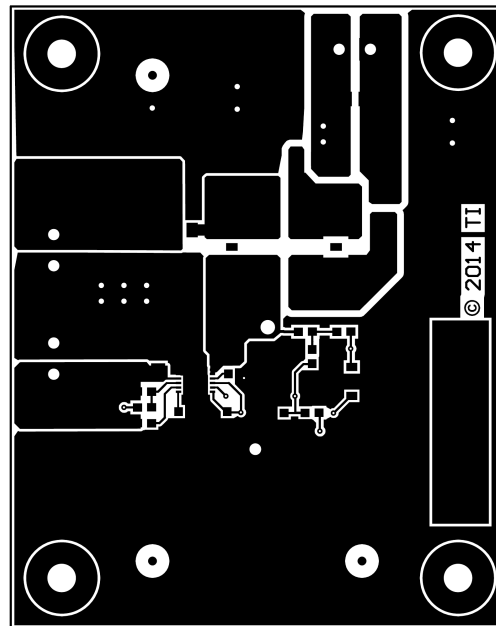


Figure 2. Top Copper

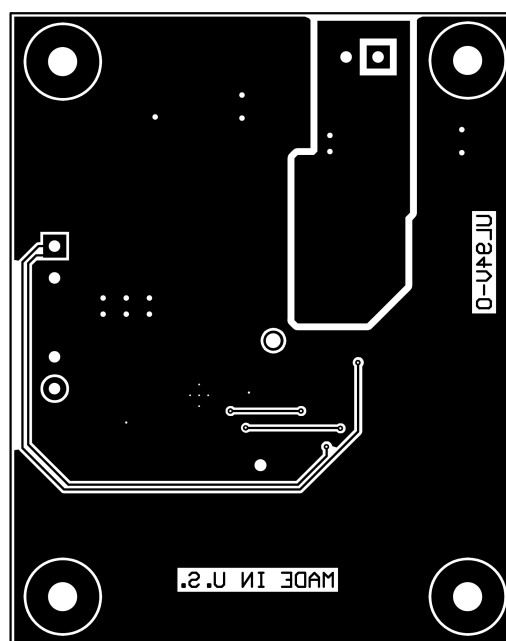


Figure 3. Bottom Copper

5 Schematic

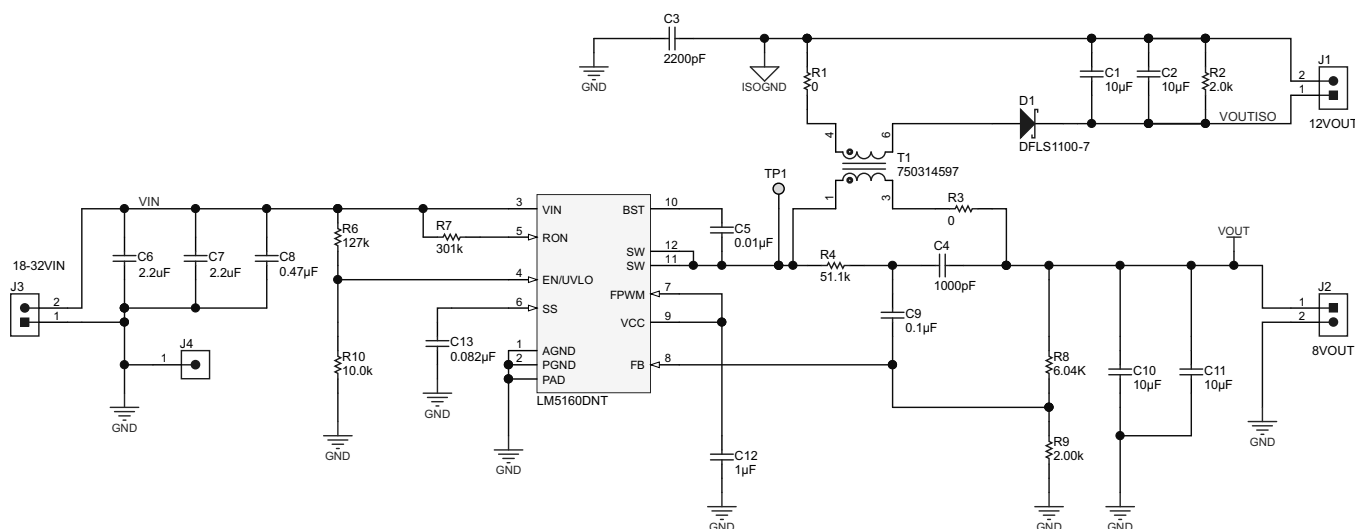


Figure 4. LM5160 Fly-Buck EVM Schematic

Figure 5 below shows the Fly-buck configuration using LM5160A with the VCC being powered from the VOUT (8VOUT, Primary) through diode D2 for improved efficiency requirements. When evaluating the LM5160A, the designer can use the standard LM5160DNTFBKEVM by simply replacing the LM5160 IC with the LM5160A. No other components on board need to be replaced or removed. In the standard EVM, when used with the LM5160, the placeholder for diode D2, as given in Figure 1, must remain unpopulated under all cases. For more information about the difference between the LM5160A and the LM5160, please refer to the LM5160 Datasheet ([SNVSA03](#)).



Table 3. LM5160DNTFBKEVM Bill of Materials for 300 kHz Configuration

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Table 4. Bill of Materials for Alternate Configuration

COUNT	REF DES	DESCRIPTION	SIZE	MFR	PART NUMBER
4	C1, C2, C10, C11	CAP, CERM, 10 μ F, 35 V, $\pm$ 10%, X7R,	1210	MuRata	GRM32ER7YA106KA12L
1	C3	CAP, CERM, 2200 pF, 2000 V, $\pm$ 10%, X7R	1812	TDK	C4532X7R3D222K
1	C4	CAP, CERM, 1000 pF, 16 V, $\pm$ 10%, X7R	603	MuRata	GRM188R71C102KA01D
1	C5	CAP, CERM, 0.01 μ F, 16 V, $\pm$ 10%, X7R	603	MuRata	GRM188R71C103KA01D
2	C6, C7	CAP, CERM, 2.2 μ F, 100 V, X7R, 10%	1210	Murata	GRM32ER72A225KA35K
1	R8	RES, 8.2 k Ω , 1%, 0.1 W, 0603	603	Standard	Standard
1	R7	RES, 698 k Ω , 1%, 0.1 W, 0603	603	Standard	Standard
1	C4	CAP, CERM, 3300 pF, 16 V, $\pm$ 10%, X7R	603	Standard	Standard
1	R2	RES, 5.1 k Ω , 5%, 0.125 W	805	Standard	Standard
1	D1	Diode, Schottky, 60 V, 1A	PowerDI123	Diodes Inc.	DFLS160-7
1	C8	CAP, CERM, 0.47 μ F, 100 V, $\pm$ 10%, X7R	805	MuRata	GRM21BR72A474KA73L
1	C9	CAP, CERM, 0.1 μ F, 25 V, $\pm$ 5%, X7R	603	AVX	06033C104JAT2A
1	C12	CAP, CERM, 1 μ F, 16 V, $\pm$ 10%, X7R	603	TDK	C1608X7R1C105K
1	C13	CAP, CERM, 0.082 μ F, 16 V, $\pm$ 10%, X7R	603	MuRata	GRM188R71C823KA01D
1	D1	Diode, Schottky, 100 V, 1 A	PowerDI123	Diodes Inc.	DFLS1100-7
1	D2	Diode, Schottky, 30 V, 0.5 A (LM5160A only)	SOD-123	Diodes Inc.	B0530W-7-F(Unpopulated)
3	J1, J2, J3	Terminal Block, 6 A, 3.5 mm Pitch, 2-Pos, TH	7.0x8.2x6.5 mm	On-Shore Technology	ED555/2DS
2	R1, R3	RES, 0 Ω , 5%, 0.125 W	805	Vishay-Dale	CRCW08050000Z0EA
1	R4	RES, 51.1 k Ω , 1%, 0.1 W	603	Yageo	RC0603FR-0751K1L
1	R6	RES, 127 k Ω , 1%, 0.1 W	603	Yageo	RC0603FR-07127KL
1	R7	RES, 301 k Ω , 1%, 0.1 W	603	Vishay-Dale	CRCW0603301KFKEA
1	R9	RES, 2.00 k Ω , 1%, 0.1 W	603	Vishay-Dale	CRCW06032K00FKEA
1	R10	RES, 10.0 k Ω , 1%, 0.1 W	603	Vishay-Dale	CRCW060310K0FKEA
1	T1	Transformer, 60 μ H, SMT, 0.840 A	13.36x8.64x10.16 mm	Würth Elektronik	750314597
1	TP1	Test Point, Multipurpose, Yellow, TH	Testpoint	Keystone	5014
1	U1	IC, PWM, COT Regulator	DNT0012B	Texas Instruments	LM5160DNT

7 Performance Curves with LM5160

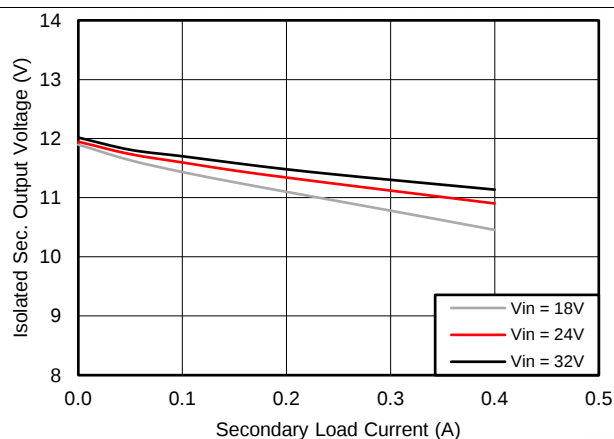


Figure 6. Line and Load Regulation

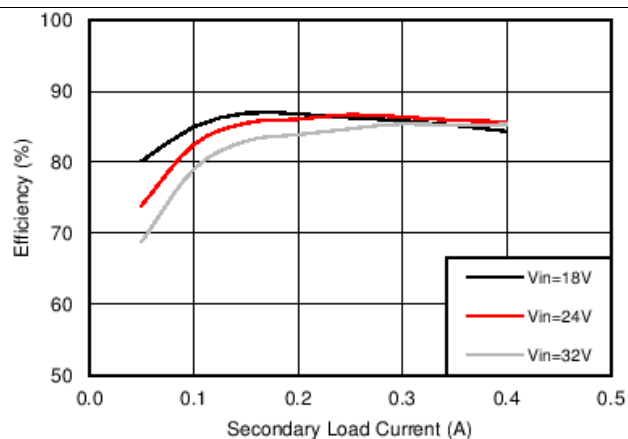


Figure 7. Efficiency vs I_{OUT2} with Default Board Configuration

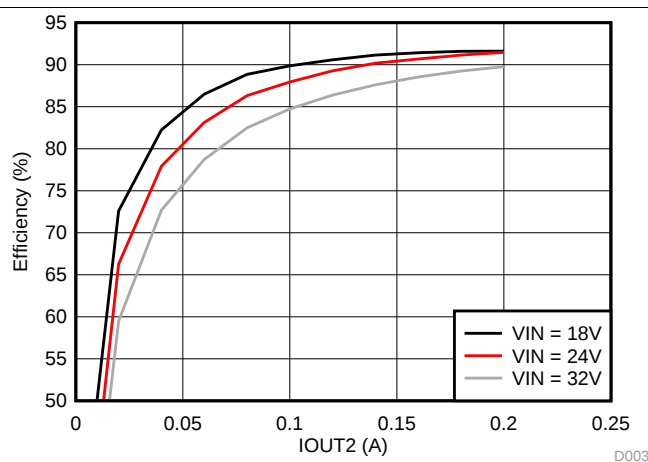


Figure 8. Efficiency vs I_{OUT2} with Alternate Configuration

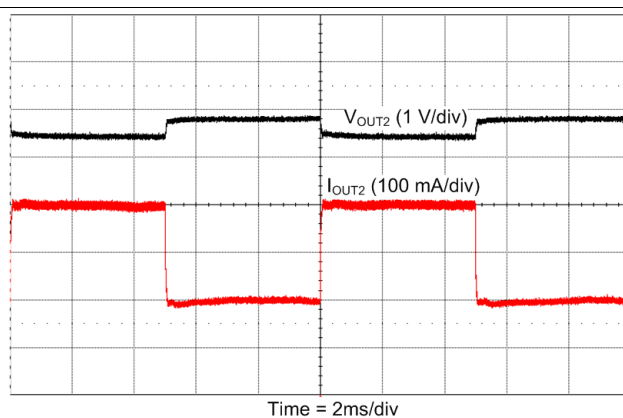


Figure 9. Load Transient at $V_{IN} = 24\text{ V}$
 $I_{OUT2} = 100\text{ mA}$ to 300 mA

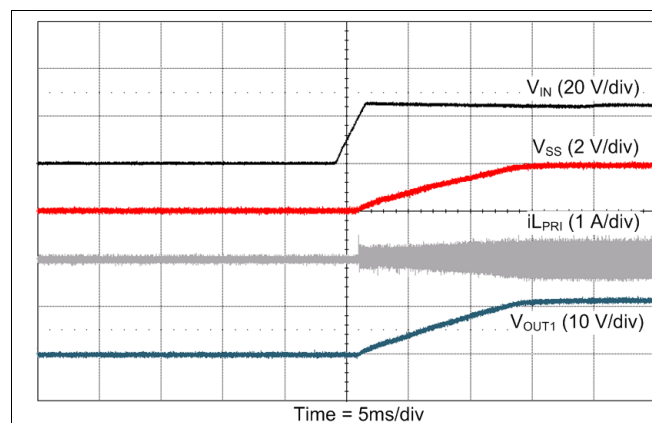


Figure 10. V_{IN} Startup Waveform at $I_{OUT2} = 200\text{ mA}$ and $I_{OUT1} = 0\text{ A}$

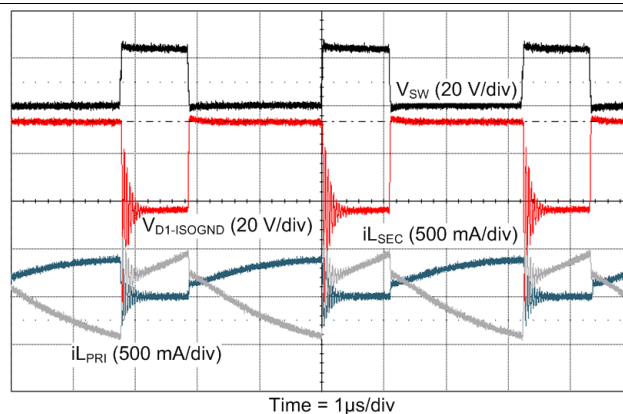


Figure 11. Primary Switch Node at $V_{IN} = 24\text{ V}$ and $I_{OUT2} = 200\text{ mA}$

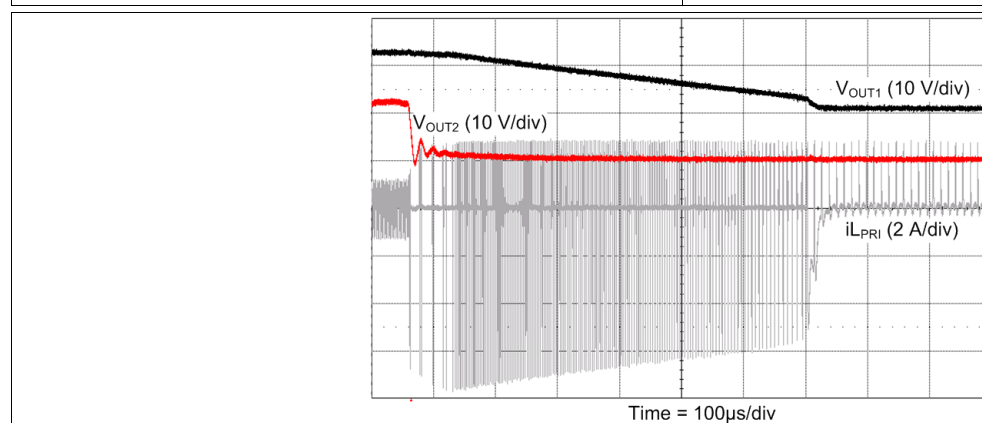


Figure 12. Secondary-side Short at $I_{OUT2} = 600\text{ mA}$ and $I_{OUT1} = 200\text{ mA}$ (Tx: Würth Elektronik #: 744873220)

Revision History

Changes from Original (October 2014) to A Revision	Page
• Added LM5160A to Background	4
• Added new paragraph for LM5160A	6
• Added D2 Schottky Diode information to Bill of Materials	7
• Added D2 Schottky Diode information to Bill of Materials for Alternate Configuration	8

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

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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.*

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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.

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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.

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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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