

# LM3670 Evaluation Board

National Semiconductor  
Application Note 1348  
Netnarin Joy Taylor  
October 9, 2008



## Introduction

The LM3670 evaluation board is a working demonstration of a step down DC-DC converter. This application note contains information about the evaluation board. For further information on buck converter topology, device electrical characteristics, and component selection please refer to the datasheet.

## General Description

The LM3670 converts high input voltages to lower output voltages with high efficiency through an inductor based switching topology. Automatic intelligent switching between PWM low-

noise and PFM low-current mode offers improved system control. LM3670 is available in both fixed output voltage options (1.2V, 1.5V, 1.6V, 1.8V, 1.875V, 2.5V, 3.3V) and adjustable voltage options range from 0.7V to 2.5V. The LM3670 is available in a SOT23-5 package.

## Operating Conditions

- $V_{IN}$  range:  $2.5V \leq V_{IN} \leq 5.5V$
- Recommended load current:  $0mA \leq I_{OUT} \leq 350mA$
- Ambient temperature ( $T_A$ ) range:  $-40C$  to  $+85C$
- Junction temperature ( $T_J$ ) range:  $-40C$  to  $+125C$

## Typical Application

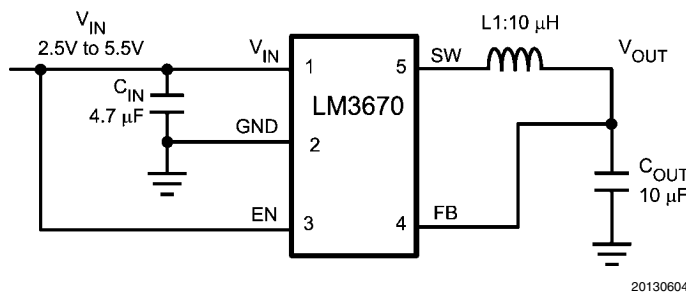


FIGURE 1. Fixed Output Voltage--Typical Application Circuit

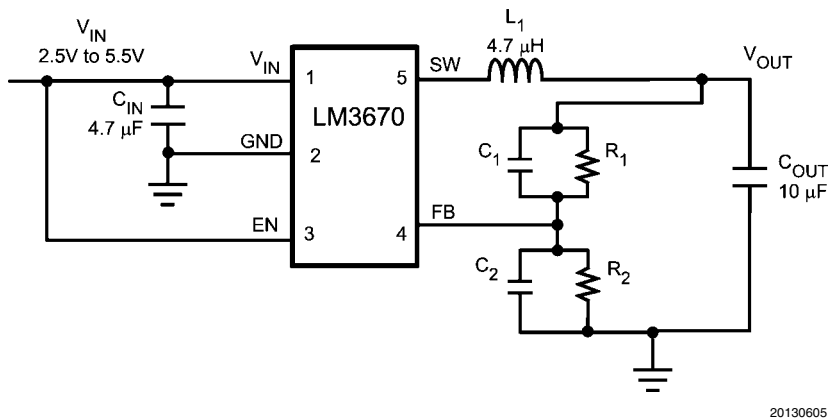


FIGURE 2. Adjustable Output Voltage—Typical Application Circuit

## Output Voltage Selection for LM3670MF-ADJ

The output voltage of the adjustable parts can be programmed through the resistor network connected from  $V_{OUT}$  to  $V_{FB}$  to GND. The resistor from  $V_{FB}$  to GND ( $R_2$ ) should be at least  $100k\Omega$  to keep the current sunk through this network well below  $15\mu A$  quiescent current level (PFM mode with no switching) but large enough that it is not susceptible to noise. If  $R_2$  is  $200k\Omega$ , and given the  $V_{FB}$  is  $0.5V$ , then the current through the resistor feedback network will be  $2.5\mu A$  ( $I_{FB} = 0.5V/R_2$ ). The output voltage formula is:

$$V_{OUT} = V_{FB} \left( \frac{R_1}{R_2} + 1 \right)$$

$V_{OUT}$ : output voltage (V)

$V_{FB}$ : feedback voltage (0.5V typical)

$R_1$ : feedback resistor from  $V_{OUT}$  to  $V_{FB}(\Omega)$

$R_2$ : feedback resistor from  $V_{FB}$  to GND ( $\Omega$ )

For the fixed output voltage parts the feedback resistors are internal and  $R_1$  is  $0\Omega$ .

The bypass capacitors  $C_1$  and  $C_2$  (labeled  $C_4$  and  $C_5$  on Evaluation Board) in parallel with the feedback resistors are chosen for increased stability. Below are the formulas for  $C_1$  and  $C_2$ .

$$C_1 = \frac{1}{2 * \pi * R_1 * 10 \text{ kHz}}$$

$$C_2 = \frac{1}{2 * \pi * R_2 * 10 \text{ kHz}}$$

TABLE 1. Adjustable LM3670 Configurations for Various  $V_{OUT}$

| $V_{OUT}$ (V) | $R_1(k\Omega)$ | $R_2(k\Omega)$ | $C_1(pF)$ | $C_2(pF)$ | L ( $\mu H$ ) | $C_{IN}$ ( $\mu F$ ) | $C_{OUT}$ ( $\mu F$ ) |
|---------------|----------------|----------------|-----------|-----------|---------------|----------------------|-----------------------|
| 0.7           | 80.6           | 200            | 200       | 150       | 4.7           | 4.7                  | 10                    |
| 0.8           | 120            | 200            | 130       | none      | 4.7           | 4.7                  | 10                    |
| 0.9           | 160            | 200            | 100       | none      | 4.7           | 4.7                  | 10                    |
| 1.0           | 200            | 200            | 82        | none      | 4.7           | 4.7                  | 10                    |
| 1.1           | 240            | 200            | 68        | none      | 4.7           | 4.7                  | 10                    |
| 1.2           | 280            | 200            | 56        | none      | 4.7           | 4.7                  | 10                    |
| 1.24          | 300            | 200            | 56        | none      | 4.7           | 4.7                  | 10                    |
| 1.24          | 221            | 150            | 75        | 120       | 4.7           | 4.7                  | 10                    |
| 1.5           | 402            | 200            | 39        | none      | 10            | 4.7                  | 10                    |
| 1.6           | 442            | 200            | 39        | none      | 10            | 4.7                  | 10                    |
| 1.7           | 487            | 200            | 33        | none      | 10            | 4.7                  | 10                    |
| 1.875         | 549            | 200            | 30        | none      | 10            | 4.7                  | 14.7 (10    4.7)      |
| 2.5           | 806            | 200            | 22        | 82        | 10            | 4.7                  | 22                    |

## Powering the LM3670 for Bench Measurements

When powering the LM3670 with a bench power supply, it is recommended to place a  $100\mu F$  tantalum capacitor across the  $V_{IN}$  and GND supply terminals of the bench power supply. This capacitor will reduce the input spike caused by the power

supply and long power cables. The combination of the power supply and inductance within the power cables produce a large voltage spike that may damage the device. In addition, consideration must also be looked at the enable pin of the device. The enable should never be taken high, until minimum guaranteed operating voltage of  $2.7V$  is reached. The enable pin should also never exceed the input voltage.

## Connection Diagram and Package Mark Information

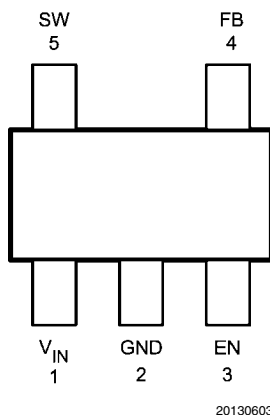
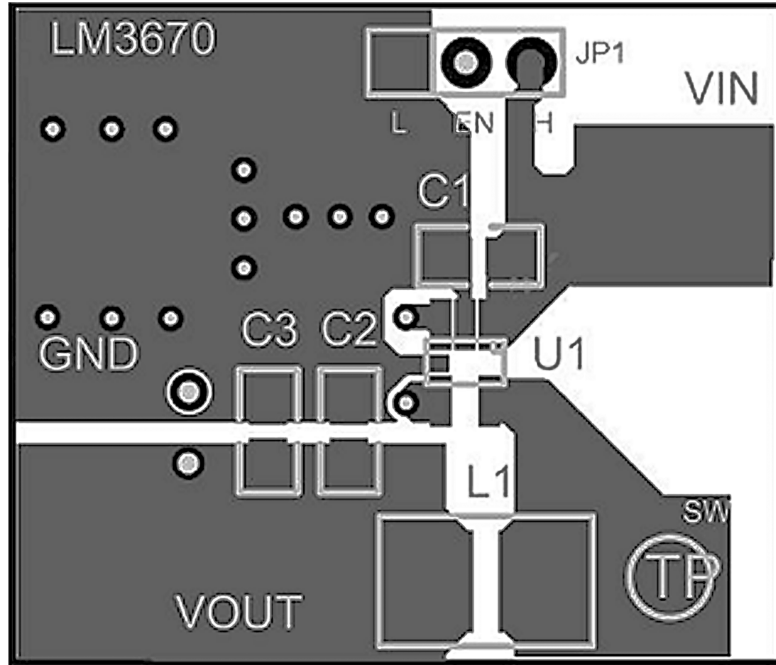


FIGURE 3. SOT23–5 Package-Top View

## Pin Descriptions

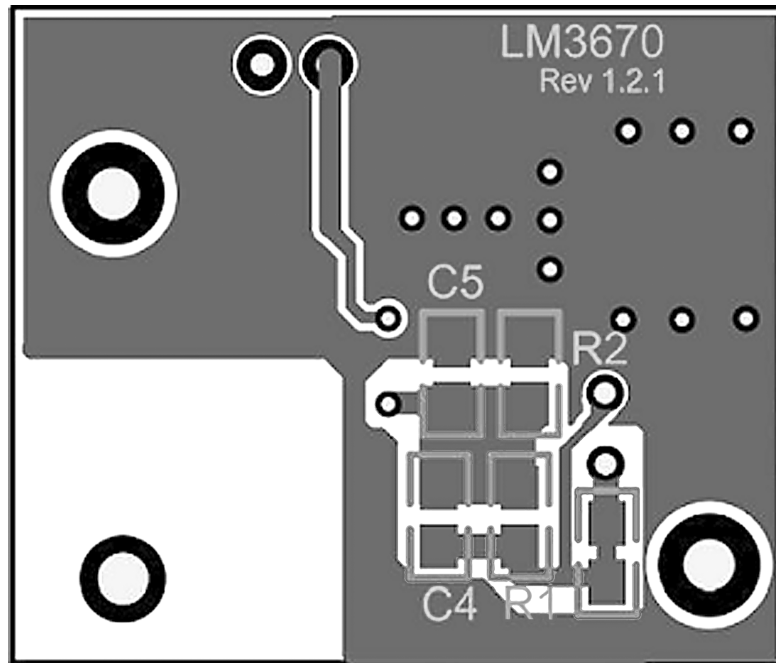
| Pin # | Name            | Description   |
|-------|-----------------|---|
| 1     | V <sub>IN</sub> | Power supply input. Connect to the input filter capacitor   |
| 2     | GND             | Ground pin  |
| 3     | EN              | Enable input  |
| 4     | FB              | Feedback analog input. Connect to the output filter capacitor   |
| 5     | SW              | Switching node connection to the internal PFET switch and NFET synchronous rectifier. Connect to an inductor with a saturation current rating that exceeds the 750 mA max. Switch Peak Current Limit Specification. |

# Evaluation Board Layout



20130608

FIGURE 4. Top Layer



20130609

FIGURE 5. Bottom Layer

## BOM For Common Configurations

|                                       | Manufacture        | Manufacture #  | Description                               |
|---------------------------------------|--------------------|----------------|---|
| <b>LM3670 - 1.8V &amp; 3.3V FIXED</b> |                    |                |   |
| C1 (input C)                          | Taiyo Yuden        | LMK316BJ475ML  | 4.7 $\mu$ F,10V,20%,1206                  |
| C3 (output C)                         | TDK                | 3216X5R0J106M  | 10 $\mu$ F,6.3V,20%,1206                  |
| C2 (aux output C)                     |                    |                |   |
| L1 (inductor)                         | Coilcraft          | DO1608C-103    | 10 $\mu$ H inductor, 1.1A sat             |
| R1 ( $V_{OUT}$ to $V_{FB}$ )          | Vishay             | CRCW08050R00F  | 0 $\Omega$ , 0805                         |
| C4 ( $V_{OUT}$ to $V_{FB}$ )          |                    |                |   |
| R2 ( $V_{FB}$ to GND)                 |                    |                |   |
| C5 ( $V_{FB}$ to GND)                 |                    |                |   |
| <b>LM3670 - 1.2V ADJUSTABLE</b>       |                    |                |   |
| C1 (input C)                          | Taiyo Yuden        | LMK316BJ475ML  | 4.7 $\mu$ F,10V,20%,1206                  |
| C3 (output C)                         | TDK                | 3216X5R0J106M  | 10 $\mu$ F,6.3V,20%,1206                  |
| C2 (aux output C)                     |                    |                |   |
| L1 (inductor)                         | Coilcraft          | DO1608C-472    | 4.7 $\mu$ H inductor, 1.5A sat            |
| R1 ( $V_{OUT}$ to $V_{FB}$ )          | Vishay             | CRCW08052803F  | 280 k $\Omega$ , 0805, 1%                 |
| C4 ( $V_{OUT}$ to $V_{FB}$ )          | Vishay             | VJ0805Y560KXXA | 56 pF, 0805, 10%                          |
| R2 ( $V_{FB}$ to GND)                 | Vishay             | CRCW08052003F  | 200 k $\Omega$ , 0805, 1%                 |
| C5 ( $V_{FB}$ to GND)                 |                    |                |   |
| <b>LM3670 - 1.5V ADJUSTABLE</b>       |                    |                |   |
| C1 (input C)                          | Taiyo Yuden        | LMK316BJ475ML  | 4.7 $\mu$ F,10V,20%,1206                  |
| C3 (output C)                         | TDK                | 3216X5R0J106M  | 10 $\mu$ F,6.3V,20%,1206                  |
| C2 (aux output C)                     |                    |                |   |
| L1 (inductor)                         | Coilcraft          | DO1608C-103    | 10 $\mu$ H inductor, 1.1A sat             |
| R1 ( $V_{OUT}$ to $V_{FB}$ )          | Vishay             | CRCW08054023F  | 402 k $\Omega$ , 0805, 1%                 |
| C4 ( $V_{OUT}$ to $V_{FB}$ )          | Vishay             | VJ0805A390KXAA | 39 pF, 0805, 10%                          |
| R2 ( $V_{FB}$ to GND)                 | Vishay             | CRCW08052003F  | 200 k $\Omega$ , 0805, 1%                 |
| C5 ( $V_{FB}$ to GND)                 |                    |                |   |
| <b>LM3670 - 2.5V ADJUSTABLE</b>       |                    |                |   |
| C1 (input C)                          | Taiyo Yuden        | LMK316BJ475ML  | 4.7 $\mu$ F,10V,20%,0805                  |
| C3 (output C)                         | Taiyo Yuden        | JMK316BJ226ML  | 22 $\mu$ F,6.3V,20%, 1206                 |
| C2 (aux output C)                     |                    |                |   |
| L1 (inductor)                         | Coilcraft          | DO1608C-103    | 10 $\mu$ H inductor, 1.1A sat             |
| R1 ( $V_{OUT}$ to $V_{FB}$ )          | Vishay             | CRCW08058063F  | 806 k $\Omega$ , 0805, 1%                 |
| C4 ( $V_{OUT}$ to $V_{FB}$ )          | Vishay             | VJ0805A220KXAA | 22 pF, 0805, 10%                          |
| R2 ( $V_{FB}$ to GND)                 | Vishay             | CRCW08052003F  | 200 k $\Omega$ , 0805, 1%                 |
| C5 ( $V_{FB}$ to GND)                 | Vishay             | VJ0805A820KXAA | 82 pF, 0805, 10%                          |
| <b>COMMON TO ALL</b>                  |                    |                |   |
| $V_{IN}$ banana jack - red            | Johnson Components | 108-0902-001   | connector, insulated banana jack (red)    |
| $V_{OUT}$ banana jack - yellow        | Johnson Components | 108-0907-001   | connector, insulated banana jack (yellow) |
| GND banana jack - black               | Johnson Components | 108-0903-001   | connector, insulated banana jack (black)  |

# Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:

| Products                       |  | Design Support          |  |
|--------------------------------|--|-------------------------|--|
| Amplifiers                     | <a href="http://www.national.com/amplifiers">www.national.com/amplifiers</a>   | WEBENCH                 | <a href="http://www.national.com/webench">www.national.com/webench</a>             |
| Audio                          | <a href="http://www.national.com/audio">www.national.com/audio</a>             | Analog University       | <a href="http://www.national.com/AU">www.national.com/AU</a>                       |
| Clock Conditioners             | <a href="http://www.national.com/timing">www.national.com/timing</a>           | App Notes               | <a href="http://www.national.com/appnotes">www.national.com/appnotes</a>           |
| Data Converters                | <a href="http://www.national.com/adc">www.national.com/adc</a>                 | Distributors            | <a href="http://www.national.com/contacts">www.national.com/contacts</a>           |
| Displays                       | <a href="http://www.national.com/displays">www.national.com/displays</a>       | Green Compliance        | <a href="http://www.national.com/quality/green">www.national.com/quality/green</a> |
| Ethernet                       | <a href="http://www.national.com/ethernet">www.national.com/ethernet</a>       | Packaging               | <a href="http://www.national.com/packaging">www.national.com/packaging</a>         |
| Interface                      | <a href="http://www.national.com/interface">www.national.com/interface</a>     | Quality and Reliability | <a href="http://www.national.com/quality">www.national.com/quality</a>             |
| LVDS                           | <a href="http://www.national.com/lvds">www.national.com/lvds</a>               | Reference Designs       | <a href="http://www.national.com/refdesigns">www.national.com/refdesigns</a>       |
| Power Management               | <a href="http://www.national.com/power">www.national.com/power</a>             | Feedback                | <a href="http://www.national.com/feedback">www.national.com/feedback</a>           |
| Switching Regulators           | <a href="http://www.national.com/switchers">www.national.com/switchers</a>     |                         |  |
| LDOs                           | <a href="http://www.national.com/ldo">www.national.com/ldo</a>                 |                         |  |
| LED Lighting                   | <a href="http://www.national.com/led">www.national.com/led</a>                 |                         |  |
| PowerWise                      | <a href="http://www.national.com/powerwise">www.national.com/powerwise</a>     |                         |  |
| Serial Digital Interface (SDI) | <a href="http://www.national.com/sdi">www.national.com/sdi</a>                 |                         |  |
| Temperature Sensors            | <a href="http://www.national.com/tempsensors">www.national.com/tempsensors</a> |                         |  |
| Wireless (PLL/VCO)             | <a href="http://www.national.com/wireless">www.national.com/wireless</a>       |                         |  |

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

## LIFE SUPPORT POLICY

**NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION.** As used herein:

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2008 National Semiconductor Corporation

For the most current product information visit us at [www.national.com](http://www.national.com)



**National Semiconductor Americas Technical Support Center**  
Email: [support@nsc.com](mailto:support@nsc.com)  
Tel: 1-800-272-9959

**National Semiconductor Europe Technical Support Center**  
Email: [europe.support@nsc.com](mailto:europe.support@nsc.com)  
German Tel: +49 (0) 180 5010 771  
English Tel: +44 (0) 870 850 4288

**National Semiconductor Asia Pacific Technical Support Center**  
Email: [ap.support@nsc.com](mailto:ap.support@nsc.com)

**National Semiconductor Japan Technical Support Center**  
Email: [jpn.feedback@nsc.com](mailto:jpn.feedback@nsc.com)