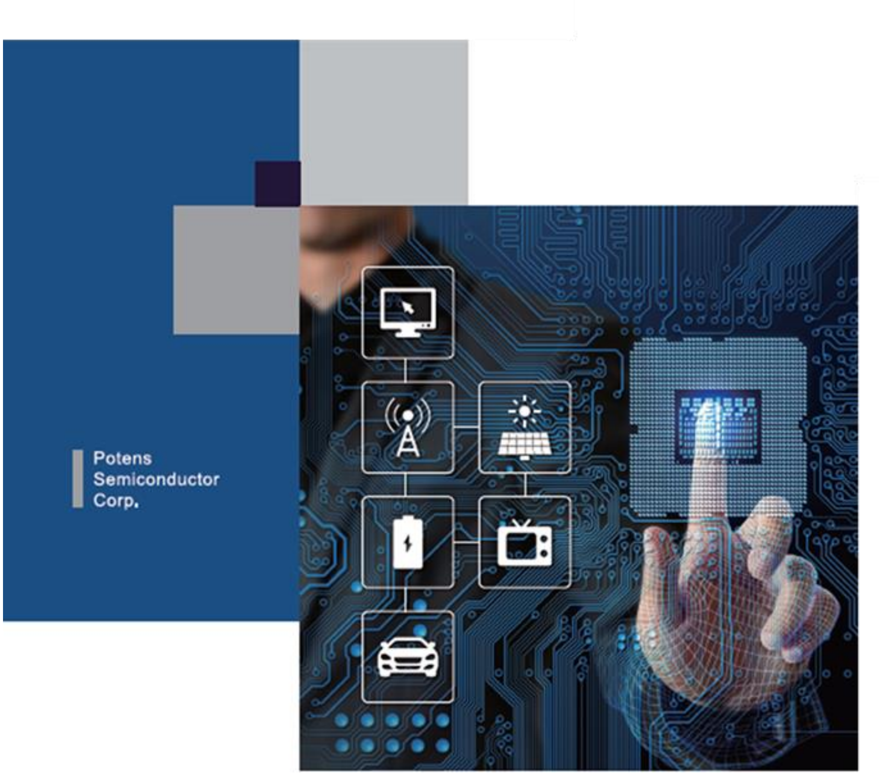
# Application Information

## Boost Converter Evaluation Board with PIS3481




Enhancing everyday life

# Table of Contents

# 1. Introduction

This document provides the features, operations, board setup procedure, and boost converter design parameters and basic information to designing with the boost converter design (DK2-23) using the PIS3481 DC/DC controller and the 65V MOSFET from Potens Semiconductor Corp [1].

## 1.1 Circuit Diagram

The PIS3481 is the PWM control IC for the boost converter. Fig. 1 shows the power stage circuit, control and feedback circuit for the boost converter. The main circuit is including power inductor, diode, input/output capacitor, MOSFET(PDC6986X-5) and PIS3481 [2]. For this evaluation board, the input voltage is 12V, the output voltage is 15V, and the output current is 5A and the switching frequency is ~400kHz.

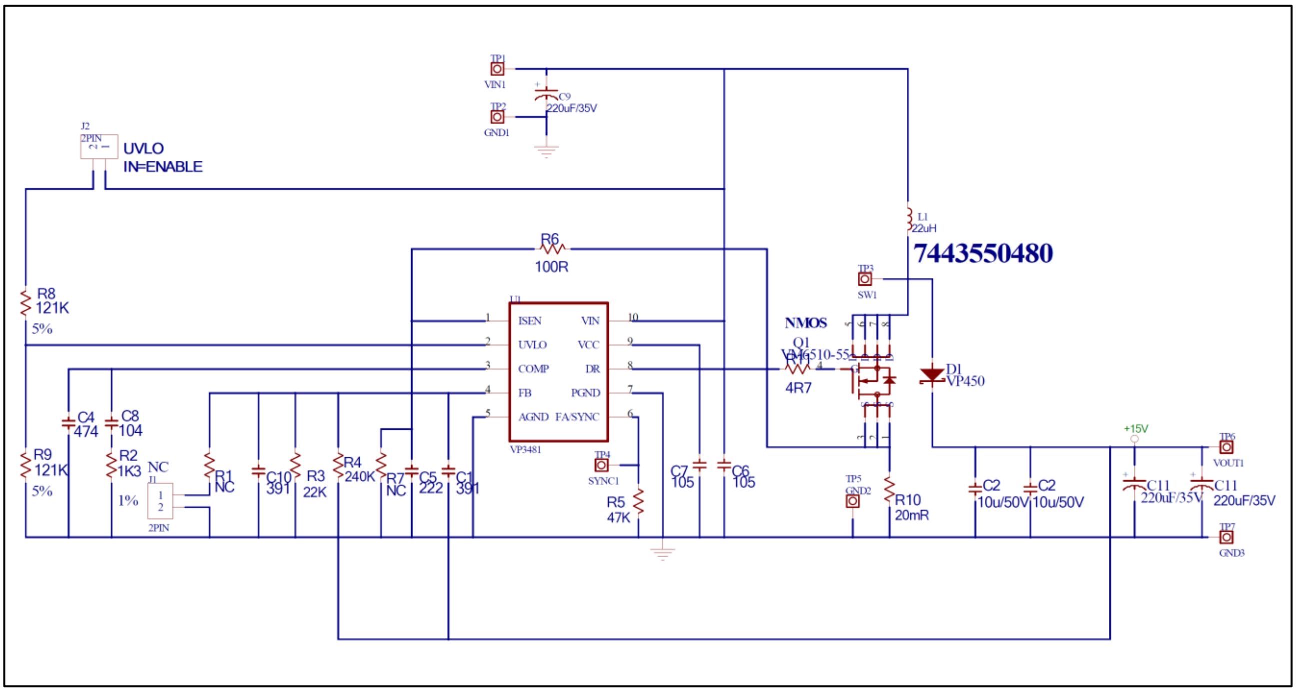



Fig. 1 The circuit diagram of DK2-23 boost evaluation board

## 1.2 Specifications

Table 1 is the main parameters of the DK2-23evaluation board.

## 1.3 Evaluation Board

Figure 2 shows the top side of the DK2-23evaluation board.

Table 1. DK3-23evaluation board specifications

| Parameter | Value |
|---|---|
| Input voltage | 12Vdc |
| Output voltage | 15Vdc |
| Output current | 5A |
| Total output power | 120W |

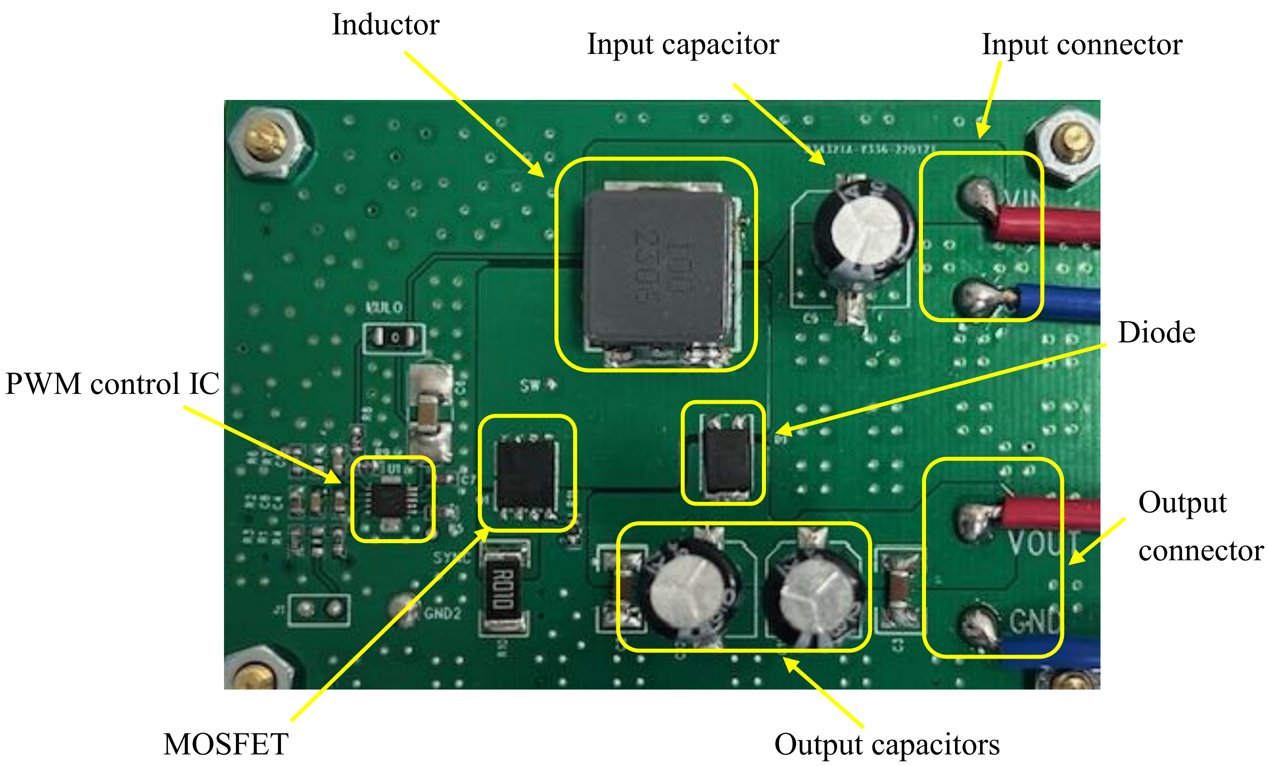



Fig. 2 the top side of the DK2-23 boost converter evaluation board

1.4 Test Setup

The evaluation board test setup is as follows:

Step 1. Input connector connects to DC source (Voltage setting:12Vdc)

Step 2. Output connector connects to DC load

Step 3. Power on the DC source (12Vdc)

Step 4. Adjust output loading (0A~5A)

# 2. Design Considerations

From the volt-second balance principle, the duty cycle of input and output voltage relation for boost convert design is derived as below:

$$V_{OUT} = \frac{V_{IN}}{1-D} \quad (1)$$

where $V_{OUT}$ is output voltage, $V_{IN}$ is input voltage and $D$ is duty cycle. Let the converter operates in continuous current mode for the low ripple current requirement. The duty cycle for input voltage is 12V and output voltage is 15V is derived as:

$$15V = \frac{12V}{1-D} \Rightarrow D = 0.2 \quad (2)$$

The switching frequency is set as 400kHz. The frequency adjust resistor $R_5$ can be derived as:

$$R_5 = \frac{22\times10^6}{f_S} - 5.74 = \frac{22\times10^6}{400k} - 5.74 = 49.26\Omega \quad (3)$$

where $f_S$ is switching frequency. Assumes operation in continuous conduction mode, the power inductor selection is shown as:

$$L > \frac{D\times(1-D)\times V_{IN}}{2\times I_{OUT}\times f_S} \quad (4)$$

The output current is 5A. Hence, the power inductor selection is as following:

$$L > \frac{0.2\times(1-0.2)\times12}{2\times5\times400k} \Rightarrow \mathrm{L} > 0.5\mu\mathrm{H} \quad (5)$$

Choosing 10μH (TMPC1205HP-100MG-D) for the minimum current ripple of the power inductor, the current ripple can be derived as [3]

$$\Delta i_L > \frac{D\times V_{IN}}{2\times L\times f_S} \Rightarrow \Delta i_L > \frac{0.2\times12}{2\times10\mu\times400k} \Rightarrow \Delta i_L > 0.3A \quad (6)$$

The output voltage is set by resistor divider ($R_3$ and $R_4$) and we choose $R_3 = 22k$ and $R_4 = 240k$ for the 15V output voltage, the output voltage relation can be derived as

$$V_{OUT} = V_{FB} \times \left(1+\frac{R_4}{R_3}\right) \Rightarrow V_{OUT} = 1.275 \times \left(1+\frac{240k}{22k}\right) = 15.18V \qquad (7)$$

where $V_{FB}$ is feedback voltage. The feedback voltage is shown in Table 2.The current sense resistor for maximum current protection can be expressed as:

$$R_{SEN} = \frac{V_{SENSE}-(D\times V_{SL})}{\frac{I_{OUT(max)}}{1-D}+\frac{D\times V_{IN}}{2\times f_S\times L}} \Rightarrow R_{SEN} = \frac{0.19-(0.2\times 0.09)}{\frac{6.5}{1-0.2}+\frac{0.2\times 12}{2\times 400k\times 10\mu}} = 0.02\Omega \qquad (8)$$

where $I_{OUT(max)}$ is maximum output current for current limit (set as 6.5A), $V_{SENSE}$ is current sense threshold voltage and $V_{SL}$ is internal compensation ramp.

.

Table 2. Electrical characteristics of PIS3481

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{FB}$ | Feedback voltage | $V_{COMP}$=1.4V, 3V<$V_{IN}$<40V | --- | 1.275 | --- | V |
| | | $V_{COMP}$=1.4V, 3V<$V_{IN}$<40V -40℃<TJ<125℃ | 1.256 | --- | 1.294 | |
| $V_{SENSE}$ | Current sense threshold voltage | | 100 | 170 | 190 | mV |
| $V_{SL}$ | Internal compensation ramp | $V_{IN}$=5V | --- | 90 | --- | mV |

# 3. Test Results

The test equipment and experimental results of the DK2-23 boost evaluation board applying PWM control IC PIS3481are shown as following subsection.

## 3.1 Test Equipment

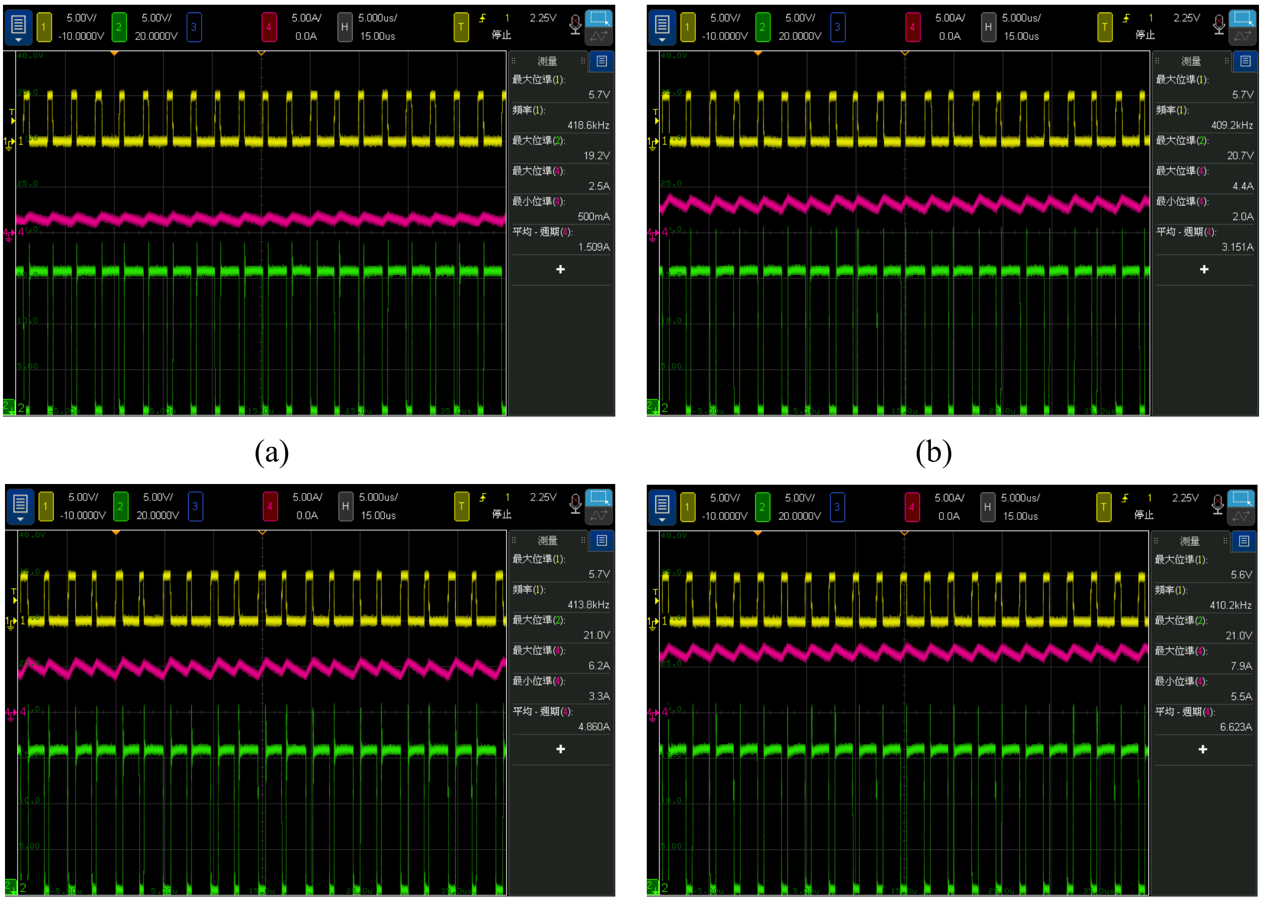
The table 3 shows the test equipment.

Table 3. List of the test equipment

| Test equipment | Model |
|---|---|
| DC Power Supply | ITECH IT6874A |
| Electronic load | ITECH IT8700 |
| Power meter | YOKOGAWA WT310 |
| Oscilloscope | Angilent DSO-X 6004A |

3.2 Test waveforms

Fig. 3 (a)-(d) shows the steady state waveforms at 25%, 50%, 75%, 100% load and the switching frequency is ~400kHz. Channel 1 is Vgs of MOSFET, Channel 2 is Vds of MOSFET and Channel 4 is inductor current.



(a) (b) (c) (d)

Fig. 3 The steady state waveforms (a) 25% load (b) 50% load (c) 75% load (d) 100% load

3.3 Efficiency

The efficiency results are shown in Fig. 9.

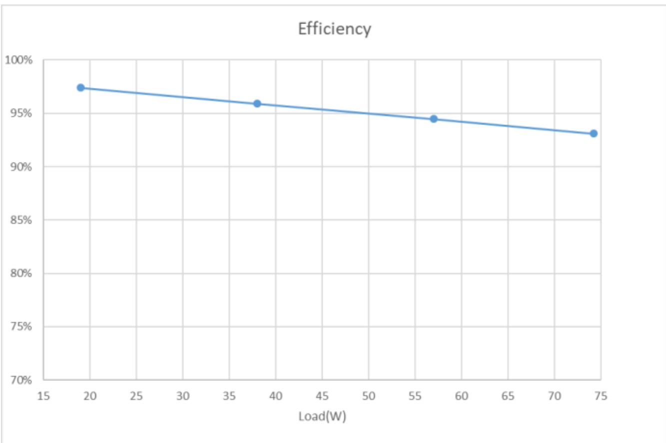



Fig. 4 the efficiency of boost converter

# 4. Reference

[1] Potens Semiconductor, “High Efficiency DC/DC Controller,” PIS3481 datasheet.

[2] Potens Semiconductor, “65V N-channel MOSFET,” PDC6986X-5 datasheet. https://www.potens-semi.com/upload/product/PDC6986X-5.pdf.

[3] TAI-TECH Advanced Electronics, “Hi-current Power Inductor,” TMPC1205HP-100MG-D datasheet. https://www.tai-tech.com.tw/product?mcls=&cls=1490671070&cls2=1490671070&cls3=1490672517&pid=1491962309

# 5. Appendix

The bill of materials for the DK2-23evaluation board is shown in Table 4.

Table 4. Bill of materials

| Location | Description | Qty |
|---|---|---|
| C11 C12 | EC, 220uF/50V | 2 |
| C2 C3 | Capacitor, 1206 22u/50V | 2 |
| C4 | Capacitor, 0603 330pF | 1 |
| C5 | Capacitor, 0603 2.2nF | 1 |
| C6 C7 C13 | Capacitor, 0603 1uF | 3 |
| C8 C14 | Capacitor, 0603 0.1uF | 2 |
| C9 | EC, 100uF/50V | 1 |
| D1 | VP6020 | 1 |
| L1 | 10uH, TMPC1205HP-100MG-D | 1 |
| Q1 | NMOS, PDC6986X-5 | 1 |
| R1 R7 | Resistor, NC | 2 |
| R10 | Resistor, 2512 20mR | 1 |
| R11 | Resistor, 0603 4R7 | 1 |
| R2 | Resistor, 0603 1.3K | 1 |
| R3 | Resistor, 0603 12K | 1 |
| R4 | Resistor, 0603 130K | 1 |
| R5 | Resistor, 0603 91K | 1 |
| R6 | Resistor, 0603 470R | 1 |
| R8 | Resistor, 0603 120K | 1 |
| R9 | Resistor, 0603 62K | 1 |
| U1 | PWM IC, PIS3481 | 1 |