*Jasper Li*

# *TI Designs: PMP9775 Reference Guide*
# *PMOLED Display Power Supply with TPS61046*

TEXAS INSTRUMENTS

## TI Designs

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## Circuit Description

A PMOLED display is mostly used in the wearable device because of its low power consumption and low cost. This reference design is to demonstrate the TPS61046's application in powering a PMOLED display. It includes a MCU MSP430G2230, boost converter TPS61046 and a 32 x 128 pixel PMOLED display. The display shows a picture programed by the MCU when the reference design is powered up.

## Design Resources

| | |
|---|---|
| Design Page | All Design files |
| TPS61046 | Datasheet |
| MSP430G2230-EP | Datasheet |

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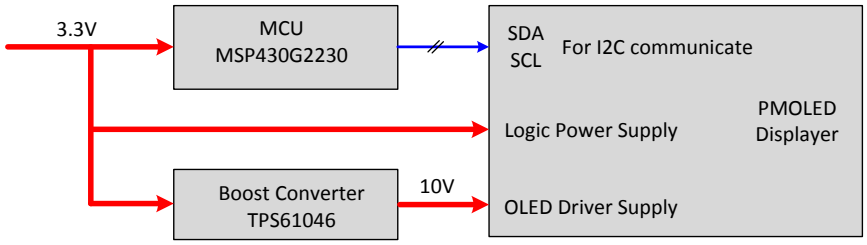


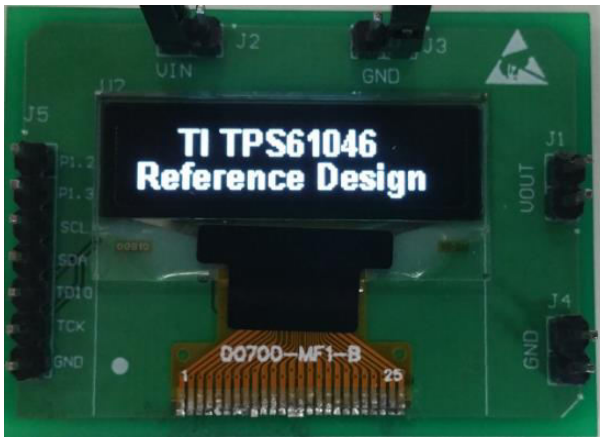


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# 1 Introduction

The Reference Design (RD) is to demonstrate one of the TPS61046's applications in powering a PMOLED display which is mostly used in the wearable device. The TPS61046 is a highly integrated boost converter specially designed for this application. Its true shutdown feature disconnects the input and output when the device is disable. This feature helps to reduce the current consumption to 100nA when the display is off. The TPS61046's input voltage ranges from 1.8 V to 5.5 V and output voltage up to 28 V.

In the following chapters, the operation principle of the RD is described firstly. Then the output voltage waveforms in different conditions are measured. Finally, the schematic, BOM and PCB are provided.

# 2 Design Description

The RD's block diagram is shown in the Figure 1. The input voltage is set to 3.3V for the MCU and the PMOLED display logic power supply. In real application where the system is powered by lithium-ion battery, the battery voltage can power TPS61046 directly, while a LDO or BUCK converter should be added to steps down the battery voltage to 3.3 V for the MCU and the display logic power supply. The part number of the display is VGM128032A5W01 from Visionox.

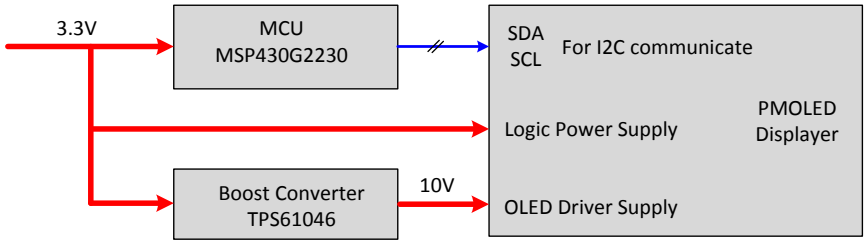



**Figure 1: Block Diagram of the Reference Design**

The output voltage of the TPS61046 is set to 10 V for the display's driver supply according the display's datasheet. The initialization and screen content of the display is programmed by the MCU through I2C communication line.

After the RD is powered, the MCU enables the boost converter and the display, and the display will show the content programmed by the MCU, as in Figure 2.

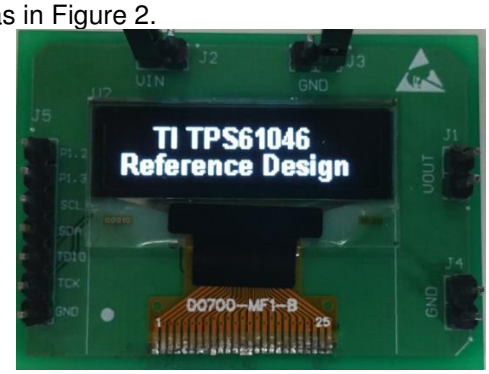



**Figure 2 PMOLED Display**

## *2.1 Boost Converter Solution*

The schematic of the boost converter solution based on the TPS61046 is shown in Figure 3. The detail operating principle, pin functions and electrical characteristics of the TPS61046 are described in the datasheet (SLVSCQ7).

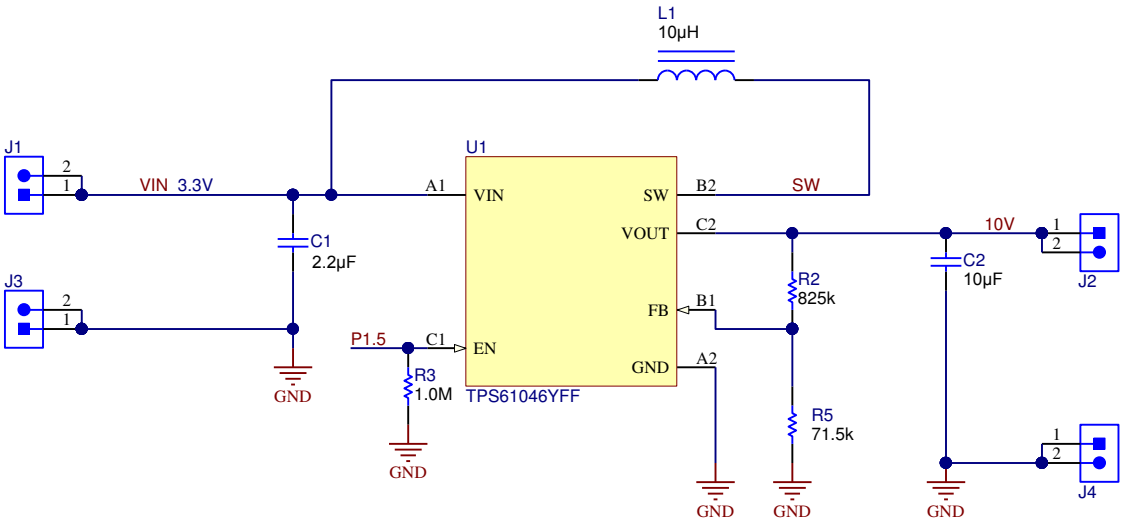



**Figure 3 TPS61046 Boost Converter Schematic**

The current requirement of the PMOLED display in "Normal Mode" can be calculate by formula (1), which $Pt_{MAX}$ is the maximum output power when all pixels is on. The "NORMAL MODE" is defined in the datasheet of VGM128032A5W01 as "driving voltage 10V, Contrast setting 0x35, Frame rate104Hz, and Duty setting 1/32".

$$I_{OUT} = \frac{Pt_{MAX}}{V_{OUT}} = \frac{130mW}{10V} = 13mA \quad (1)$$

The maximum input current of the boost converter can be calculated by formula (2), where η is efficiency of the boost converter.

$$I_{IN\_MAX} = \frac{I_{OUT} \cdot V_{OUT}}{V_{IN} \cdot \eta} = \frac{130mW}{3.3V \times 0.8} \approx 49mA \quad (2)$$

The minimum input peak current of TPS61046 is 600mA, higher than the input current requirement. So the TPS61046 is good for the application.

The 10µH inductor 1239AS-H-100M (size 2.5x2x1.2 mm) from TOKO is used for the boost converter. A inductor with larger inductance and small ESR help to improve the efficiency but could result in larger size and higher cost.

The value of the input and output capacitors can be selected following the "Recommended Operating Condition" table in the TPS61046 datasheet. Care must be taken in evaluating a ceramic capacitor's effective capacitance, because the effective capacitance of a ceramic capacitor could significantly decrease under the increase of dc bias voltage.

A 2.2-µF capacitor with 1.7-µF effective capacitance at 3.3V is selected for the input capacitor, and 10-µF capacitor with 2-µF effective capacitance at 10V is selected for the output capacitor.

## 2.2 MCU Solution

The schematic of the MCU MSP430G2230-EP is showed in Figure 4. The MSP430G2230 is an ultra-low-power mixed signal microcontroller with four I/O pins and a built-in communication capability using synchronous protocols (SPI or I2C) and a 10-bit A/D converter. In the reference design, the P1.2 and P1.5 I/O pins are used to control the display and the boost converter. The P1.6 and P1.7 pins are configured to the I2C function for communication with the display.

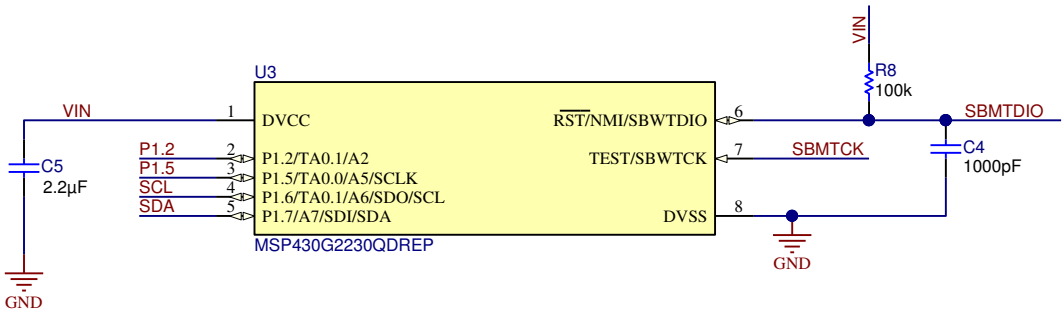



**Figure 4 Schematic of the MCU**

# 3 Bench Test Result

Figure 5 shows the waveform of the TPS61046's output voltage and output current when the PMOLED display is set to "NORMAL MODE" and shows "TI TPS61046 Reference Design" as in Figure 2.

From Figure 5, the TPS61046 output voltage is stable and output ripple is approximate 20mV.

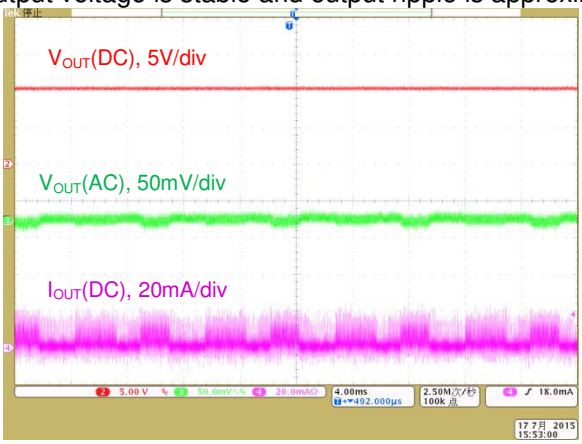



**Figure 5 Output Waveform at Displaying Designed Content**

Figure 6 shows the waveform of TPS61046's output voltage and current when all pixels of the PMOLED are on at "NORMAL MODE". The output current of TPS61046 is approximate 10mA, and the peak to peak ripple of output voltage is lower than 20mV.

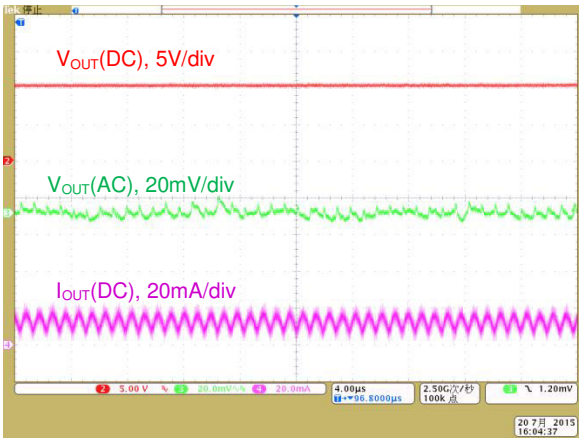



**Figure 6 Output Waveform at All Pixels On**

The efficiency of the TPS61046 at VOUT=10V, VIN=3V, 3.6V, 4.0V condition is shown in Figure 7. The data is measured with the inductor 1239AS-H-100M (size 2.5x2x1.2 mm) from TOKO.

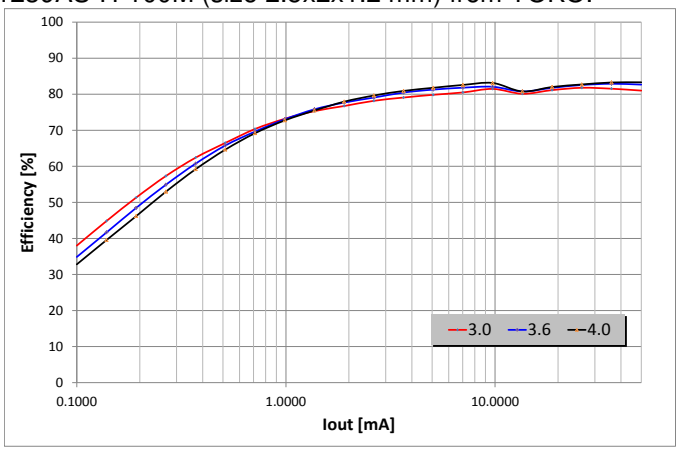



**Figure 7 Efficiency of TPS61046**

# 4 Schematic, Bill of Materials and PCB Layout

## *4.1 Schematic*

The schematic of the whole reference design is shown in Figure 8. Some components are not installed and are placed for debugging. The R7 is to change the PMOLED's I2C address. The C7 and C9 are tantalum capacitors which can replace the ceramic capacitor C6 and C8 if the ceramic capacitor generates high acoustic noise.

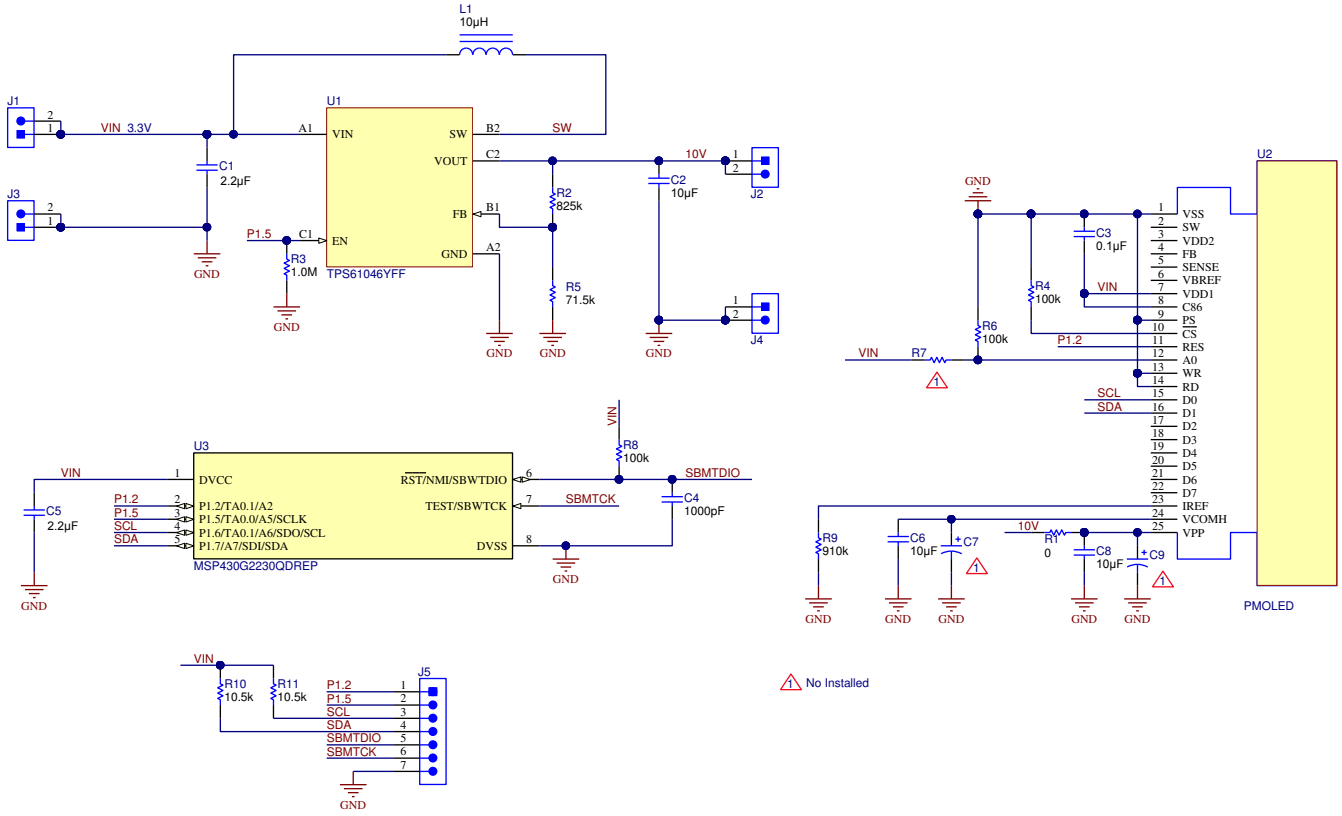



**Figure 8 Schematic of the Reference Design**

## 4.2 Bill of Material

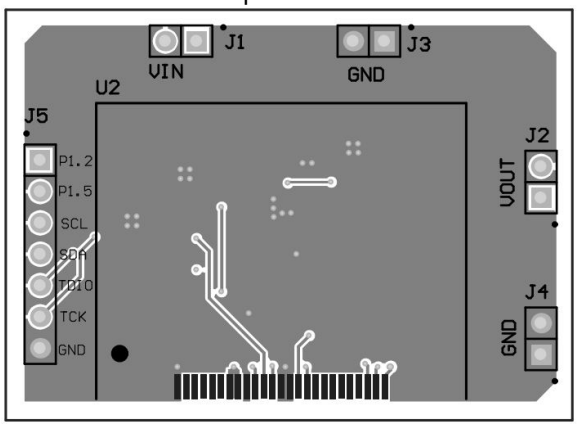
The bill of material (BOM) of the reference design is listed at table 1.

Table 1 Bill of Material

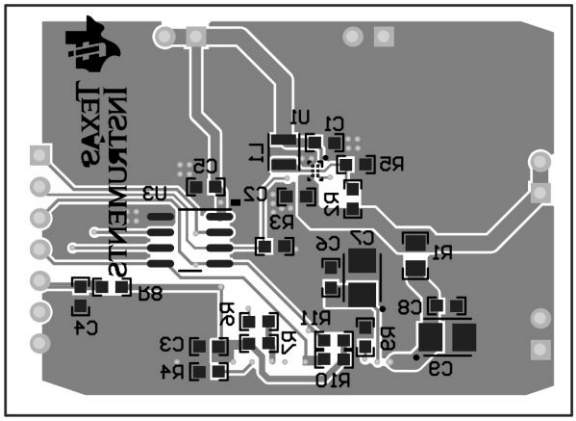
| Designator | Quantity | Value | Description | Package | PartNumber | Manufacturer |
|---|---|---|---|---|---|---|
| C1, C5 | 2 | 2.2uF | CAP, CERM, 2.2 µF, 10 V, +/- 10%, X5R, 0603 | 0603 | GRM188R61A225KE34D | MuRata |
| C2, C6, C8 | 3 | 10uF | CAP, CERM, 10 µF, 25 V, +/- 20%, X5R, 0603 | 0603 | GRM188R61E106MA73 | MuRata |
| C3 | 1 | 0.1uF | CAP, CERM, 0.1 µF, 6.3 V, +/- 10%, X7R, 0603 | 0603 | GRM188R70J104KA01D | MuRata |
| C4 | 1 | 1000pF | CAP, CERM, 1000 pF, 50 V, +/- 10%, X5R, 0603 | 0603 | GRM188R61H102KA01D | MuRata |
| C7, C9 | 2 | 4.7uF | CAP, TA, 4.7 µF, 16 V, +/- 10%, 0.8 ohm, SMD | 3528-21 | T495B475K016ZTE800 | Kemet |
| L1 | 1 | 10uH | Inductor, Shielded, Ferrite, 10 µH, 1 A, 0.4 ohm, SMD | 2.5x1.2x2mm | 1239AS-H-100M | Toko |
| R1 | 1 | 0 | RES, 0, 5%, 0.125 W, 0805 | 0805 | CRCW08050000Z0EA | Vishay-Dale |
| R2 | 1 | 825k | RES, 825 k, 1%, 0.1 W, 0603 | 0603 | CRCW0603825KFKEA | Vishay-Dale |
| R3 | 1 | 1.0Meg | RES, 1.0 M, 5%, 0.1 W, 0603 | 0603 | CRCW06031M00JNEA | Vishay-Dale |
| R4, R6, R7, R8 | 4 | 100k | RES, 100 k, 1%, 0.1 W, 0603 | 0603 | CRCW0603100KFKEA | Vishay-Dale |
| R5 | 1 | 71.5k | RES, 71.5 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-0771K5L | Yageo America |
| R9 | 1 | 910k | RES, 910 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-07910KL | Yageo America |
| R10, R11 | 2 | 10.5k | RES, 10.5 k, 1%, 0.1 W, 0603 | 0603 | CRCW060310K5FKEA | Vishay-Dale |
| U1 | 1 | | 28-V Output Voltage Boost Converter, YFF0006AAAA | YFF0006AAAA | TPS61046YFF | Texas Instruments |
| U2 | 1 | | 128×32 dot matrix monochrome OLED display module | | VGM128032A5W01 | visionox |
| U3 | 1 | | MIXED SIGNAL MICROCONTROLLER, D0008A | D0008A | MSP430G2230QDREP | Texas Instruments |

## 4.3 Layout

The PCB layout of the reference design evaluation board is showed in Figure 9. The display is on the top layer, and the boost converter, MCU and their external components are on the bottom layer.




(a) Top Layer of the Reference Design PCB




(b) Bottom Layer of the Reference Design PCB

**Figure 9 Layout of the Reference Design**

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