# PMP15034 Test Results

## System Description

The reference design circuit introduces high precision, bi-direction current solution used in battery test system (BTS). The block diagram of the circuit is shown in Figure 1. The LV side voltage ranges from 1V to 5V and HV side voltage ranges from 12V to 15V. In real application, the LV side is connected to the battery and the HV side is connected to a voltage bus that has the capability to sink or source current. The DIR stands for the direction signal that determine if the battery is charged or discharged. When DIR is logic high, the TPS611781 operates and TPS54821 shutdowns, so the battery energy is discharged to the HV which is 15V at this condition; when DIR is logic low, the TPS54821 operates and TPS611781 shutdowns, so the battery is charged by the energy from the HV which is 12V at this condition. The ISET is voltage signal to set the charge/discharge current. The current is approximately 6A if the voltage in ISET is 3V. A voltage applied in VSET will set the regulation voltage of the LV side.

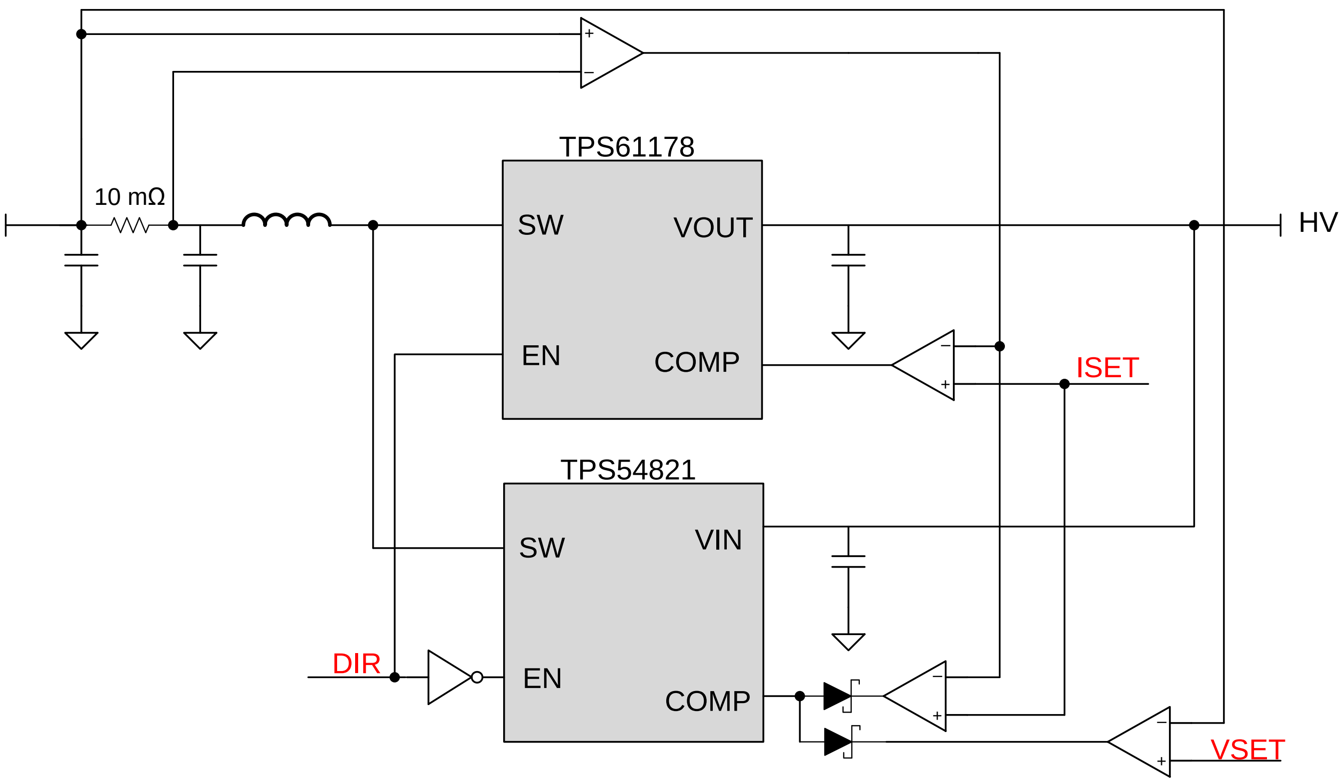


**Figure 1: Block Diagram of the PMP15034**

## Design Theory

The TPS61178x is a 20V, full integrated boost converter. Details about the operating principle of the TPS61178x can be found in its datasheet. The schematic of TPS61178x is shown in Figure 2:

- The TPS611781 is a force PWM device, which allows negative inductor current. While TPS61178 integrates power save mode that turns off the synchronic MOSFET if inductor current is zero. If <100mA discharge current for the battery is required, TPS611781 is the right device. Otherwise, TPS61178 can be selected.

- The TPS61178x triggers under-voltage lockout if the voltage in its VIN pin is lower than 2.7 V. So the VIN pin is powered by VBUS in Figure 2. It is suggested that the voltage at VIN pin is at least 2V lower than VBUS.

- The switching frequency is set to 200KHz to increase the efficiency and maximum duty cycle as the minimum on time of low side MOSFET is fixed to 135 ns

- The R9, R11 and FB pin are used to set the VBUS voltage not higher than 16V. Please note that the FB pin must be higher than 0.36V at normal operation condition.

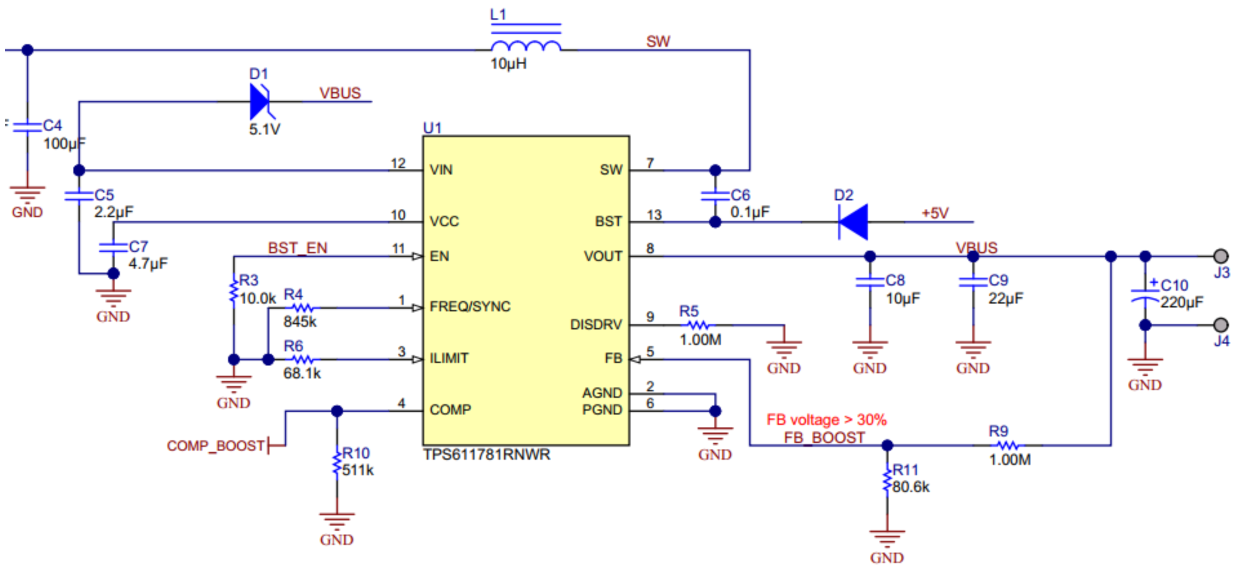


Figure 2: Schematic of TPS61178x

The TPS54821 is a 4.5-V to 17-V input, 8-A output BUCK converter. The schematic is shown in Figure 3:

- The VSENSE pin and its resistor divider are used to set the maximamum voltage of the BUCK converter

- The converter is disabled by pulling the SS pin to low voltage instead of EN. Otherwise, the TPS54821's internal MOSFET would faultly switch if TPS611781 is operating.

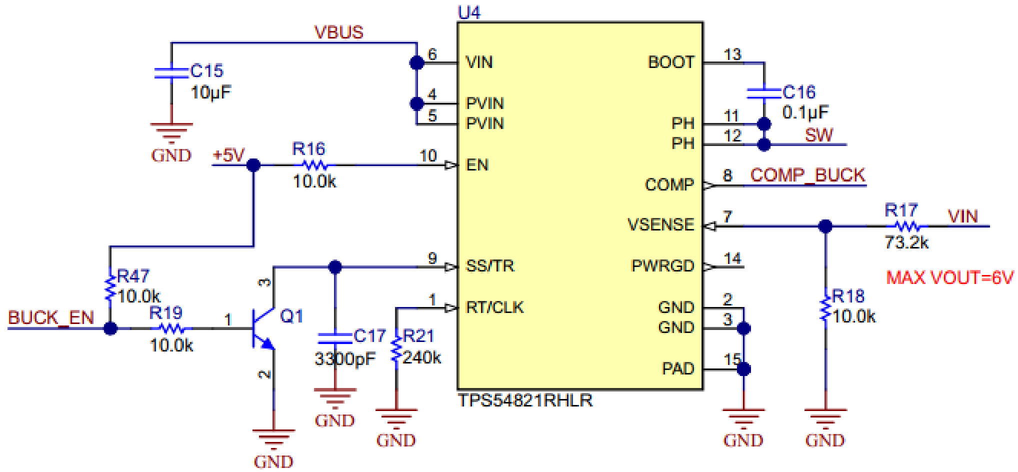


Figure 3: Schematic of TPS54821

The current control circuitry for the TPS611781 and the TPS54821 is shown in Figure 4. The INA188 is used to sense the voltage across a 5mohm resistor, and then amplifies the signal approximately 101 times. The battery voltage is sensed through an amplifier in the node of the battery.

The proportional- integrated method is used to control the battery charging or discharging current and the battery voltage.

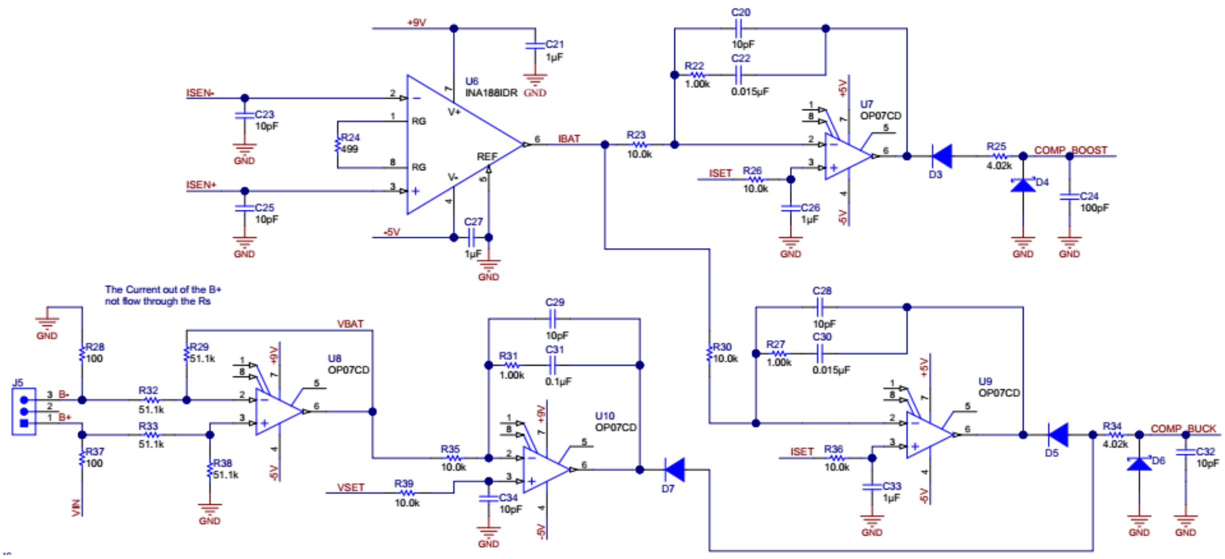


**Figure 4: Current and Voltage Control Circuitry**

## Test Result

In the reference design, the current accuracy relates to the current sensing resistor, the current amplifier INA188 and the offset of the OP07CD. To achieve good current control accuracy, the designed circuit should be calibrated. When TPS611781 operates, the output current is 1.0017A if ISET=0.5109V; and the output current is 5.0046 A if ISET=2.5498V.  From these two data, the gain and offset can be calculated as following:

$$gain = \frac{IOUT2 - IOUT1}{ISET2 - ISET1} = \frac{5.0046 - 1.0017}{2.5498 - 0.5109} = 1.96327$$

$$OffSet = IOUT1 - gain \cdot ISET1 = 1.0017 - 1.96327 \times 0.5109 = -0.00133$$

Using the gain and offset, the setting current and actually output in bench test are shown in table 1

**Table 1: Reference Current Vs Actual Current at TPS611781 Operation**

| | | | | | | |
|---|---|---|---|---|---|---|
| Reference Current (A) | 0.09683 | 0.49066 | 0.99522 | 1.98176 | 3.99646 | 5.99683 |
| Actual Current (A) | 0.0980 | 0.4910 | 0.9956 | 1.9820 | 3.9970 | 5.9980 |

Using the same method to calibrate the current at TPS54821 operation, the bench test result is shown in table 2

**Table 2: Reference Current Vs Actual Current at TPS611781 Operation**

| | | | | | | |
|---|---|---|---|---|---|---|
| Reference Current (A) | 0.09912 | 0.50027 | 0.99998 | 2.00197 | 4.00357 | 6.00813 |
| Actual Current (A) | 0.0999 | 0.5011 | 1.0001 | 2.0023 | 4.0025 | 6.0075 |

The Figure 1 shows the full scale (FS) accuracy of the reference design at TPS611781 and TPS54821 operating condition.

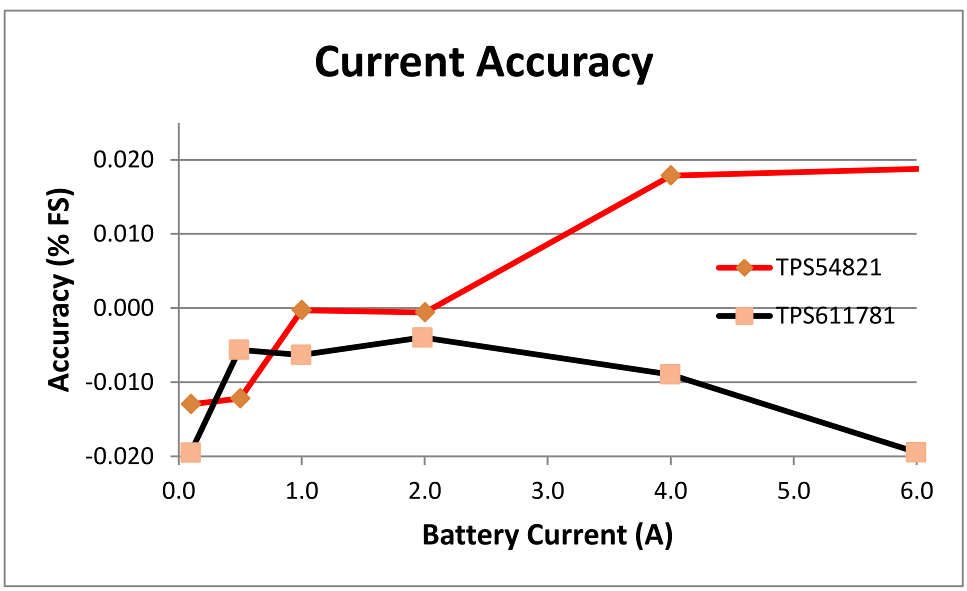


Figure 1: Battery Charge and Discharge Current Accuracy

When TPS611781 is operating at 6 A, the thermal performance is shown Figure 2, where the TPS611781 case temperature is 75.8°C, and the inductor temperature is 63.4°C.

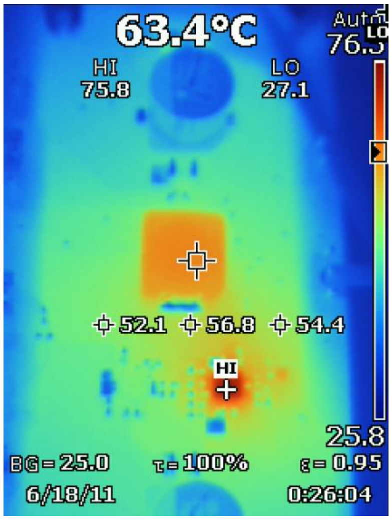


Figure 2: TPS611781 Thermal at 6A operation

While the TPS54821 is operating at 6 A, the thermal is shown in Figure 3, where the case temperature is 67.3 °C and inductor temperature is 62°C

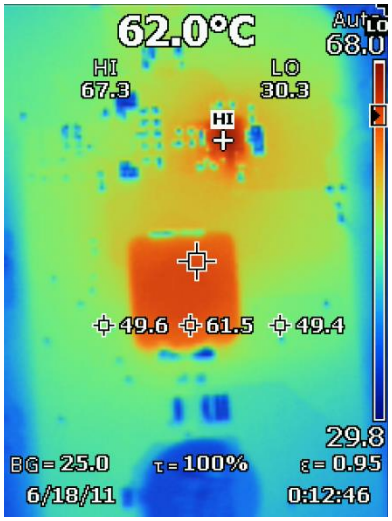


Figure 3: TPS54821 Thermal at 6A operation

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