Application Report

Implementing Output Voltage Offset in the TPS40322

ABSTRACT

Changing output voltage on the fly may be needed in some particular applications such as running turbo mode or low-power mode. Some systems may require different supply voltages for each operation mode to achieve best performance. This application report describes how to adjust the TPS40322 regulated output voltage (V_{OUT}) on-the-fly by implementing the TPL0102-100 (100-kΩ end-to-end resistance, 256-taps digital potentiometers).

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1 Introduction

This application note introduces a method to implement the TPS40322 device, changing the output voltage on-the-fly by sending an I2C command to set the TPL0102-100 digital potentiometer.

2 Circuit Description

This section provides the system block diagram, FB network circuit, and calculations for VOUT settings.

Figure 2-1 illustrates the system block diagram.

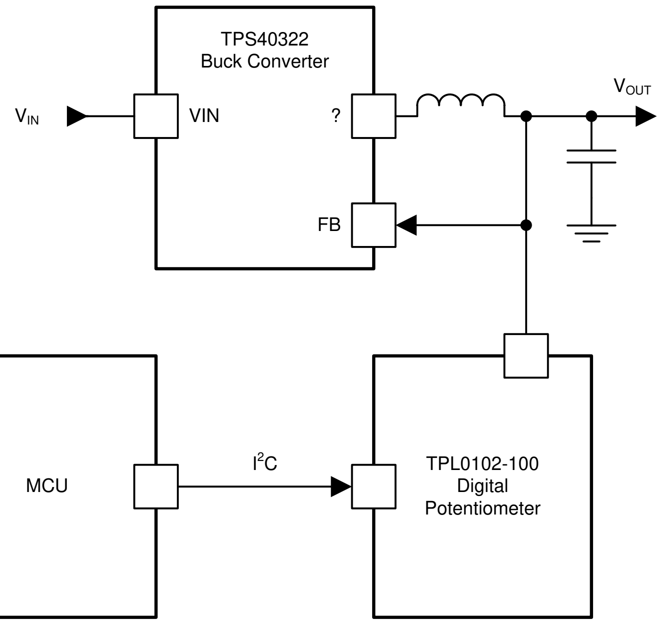

Figure 2-1. System Block Diagram

2.1 Calculation for VOUT Settings

Figure 2-2 shows the FB network circuit.

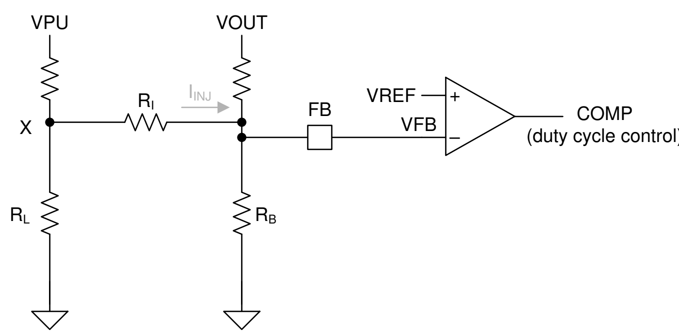

Figure 2-2. FB Network

Converter DC regulation forces V_{FB} = V_{REF} = 0.6 V. Therefore, the divider is injecting current i_{INJ} into the FB node to offset the output voltage.

1. Calculate VOUT as a function of i_{INJ}

   KCL at FB node:

$$\frac{V_{OUT} - V_{FB}}{R_T} + i_{INJ} = \frac{V_{FB}}{R_B} \quad (1)$$

   Rearrange and simplify as Equation 2 shows:

$$V_{OUT} = V_{FB}\left(1 + \frac{R_T}{R_B}\right) - i_{INJ} \times R_T \quad (2)$$

2. Solve for i_{INJ}

$$i_{INJ} = \frac{V_x - V_{FB}}{R_i} \quad (3)$$

   KCL @ X to solve for Vx:

$$\frac{V_{PU} - V_x}{R_H} = \frac{V_x}{R_L} + \frac{V_x - V_{FB}}{R_i} \quad (4)$$

   Rearrange and simplify as Equation 5 shows:

$$V_x = \frac{V_{PU} \times R_L \times R_i + V_{FB} \times R_L \times R_H}{R_H \times R_i + R_L \times R_H + R_L \times R_i} \quad (5)$$

3. Substitute:

$$V_{OUT} = V_{FB}\left(1 + \frac{R_T}{R_B}\right) - \left(\frac{V_x - V_{FB}}{R_i}\right) \times R_T \quad (6)$$

   where V_x equals Equation 5.

These calculations are integrated in the *TPS40322 Resistor Divider Vout Offset Calculator* tool.

3 Setup TPL0102-100 EVM

R_H and R_L in Figure 2 are presenting the R_{HW}, R_{WL} of the TPL0102 device. An I2C master connects to the TPL0102 and is required to get control the R_{HW}, R_{WL} of the TPL0102. Figure 3-1 shows a connection example which uses the TI EV2400 tool as a I2C master to set the R_{HW}, R_{WL} values via the bqStudio GUI.

3.1 Connection Block Diagram

This section details the hardware equipment and setup.

Hardware Equipment:

- PC or laptop
- EV2400
- TPL0102 EVM
- DC power supply

Hardware Setup:

1. Insert header caps in J1, J2, and J3 to set A2, A1, and A0, respectively. The board is shipped with the following settings: A2 = 0, A1 = 0, and A0 = 1.
2. Connect the I2C bus of the host(EV2400) to the board via connector J14 (pins marked SCL, SDA). Also connect the GND pin on J14 to GND of the host processor.
3. Apply the positive supply voltage 2.7 V–5.5 V(VDD) to center pin of J4. Apply GND to lowest pin of J4.
4. Apply the negative supply voltage (VSS) to J5. The board is shipped with a header cap that connects VSS to GND.
5. Write to the TPL0102 data registers per protocol in the *TPL0102 Two 256-Taps Digital Potentiometers With Non-Volatile Memory Data Sheet*.
6. Measure resistance between H, W, L terminals as appropriate on headers J8–J13.

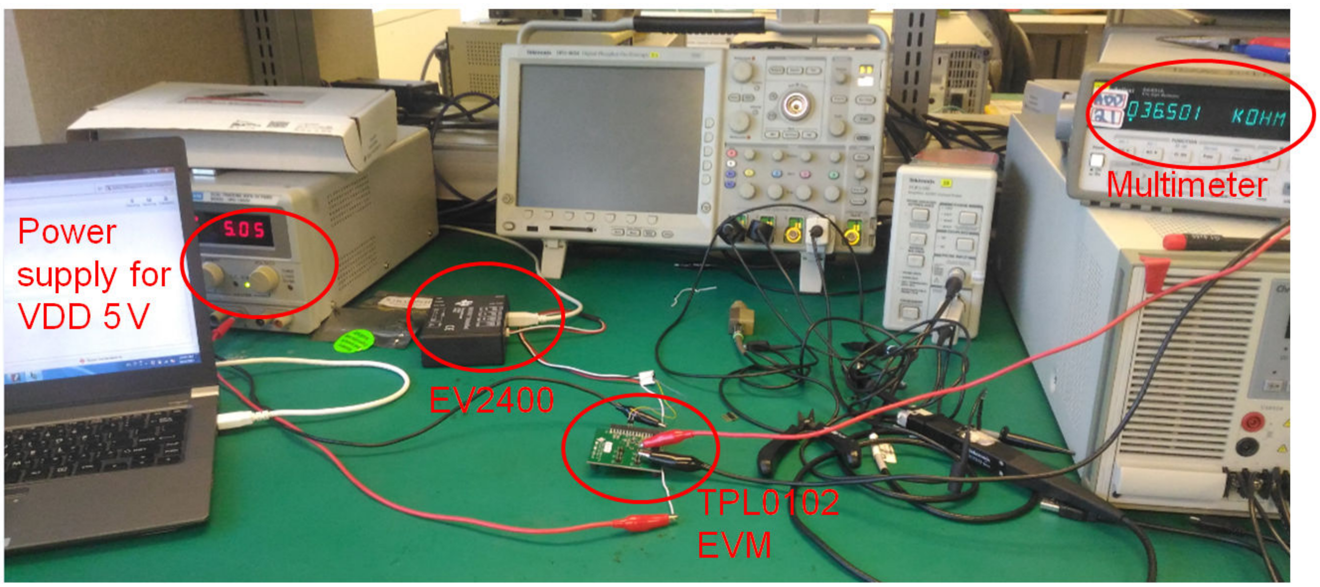

Figure 3-1. Hardware Setup

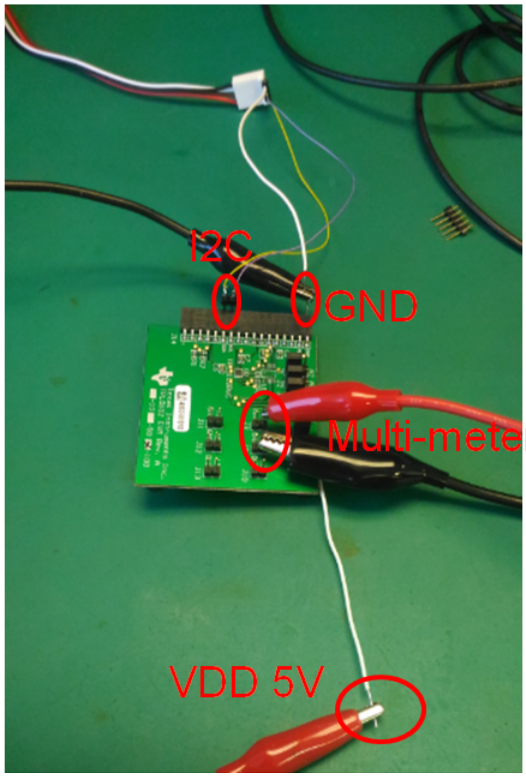

Figure 3-2. TPL0102 EVM Board Connection

3.2 Software GUI Setup

Utilize the bqStudio GUI for read/write the I2C commands to I2C slave device. Use the following procedure to set up the bqStudio GUI to control the TPL0102-100EVM and adjust as a variable resistor. Figure 3-5 second (fourth) Figure 3-6

1. Open BqStudio, select *Charger*, and click the *Next* button

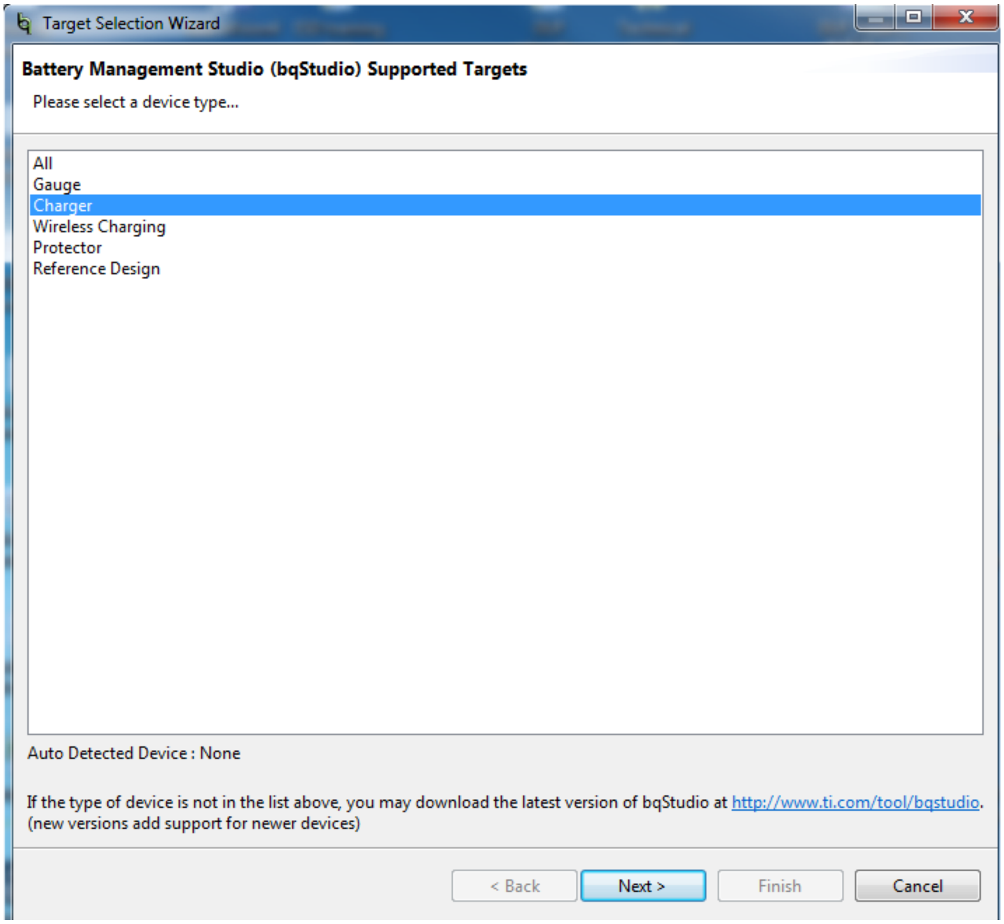

Figure 3-3. Charger Device Type

2. Select the *bq24773.bqz* target and click the *Finish* button

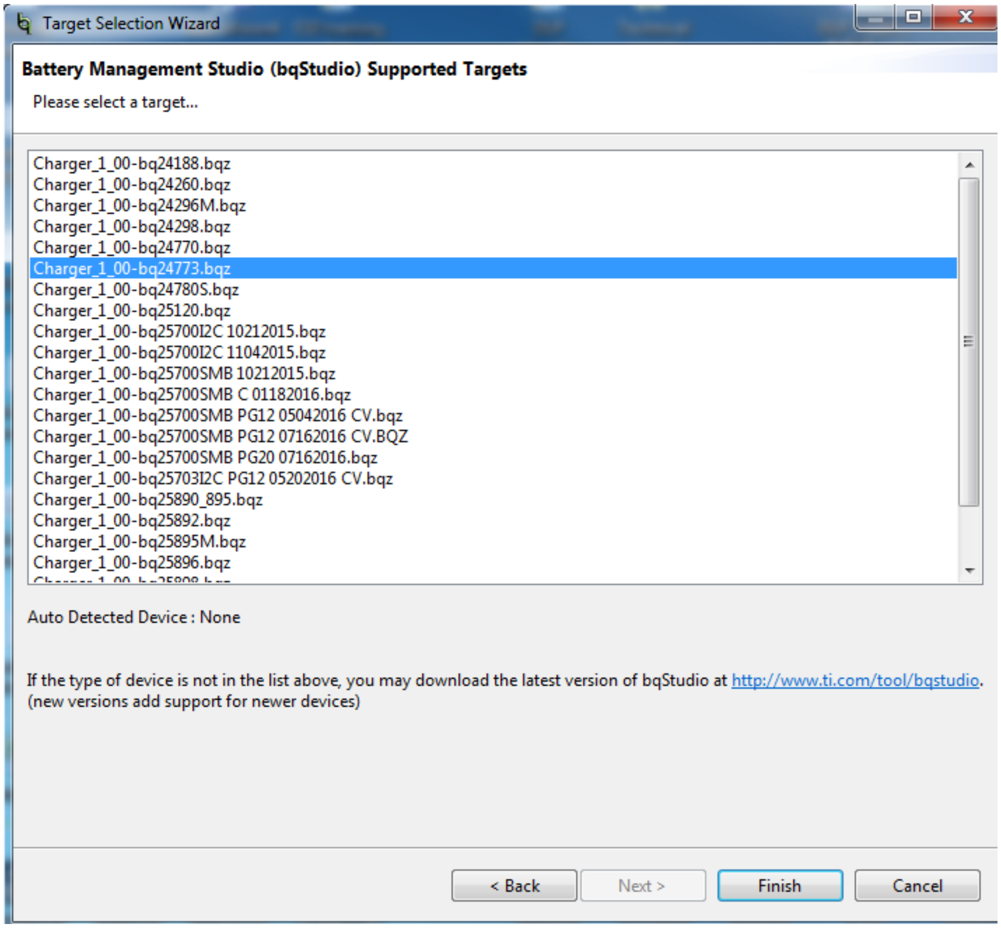

Figure 3-4. bq24773.bqz Target

3. Select the *Advanced Comm* tab

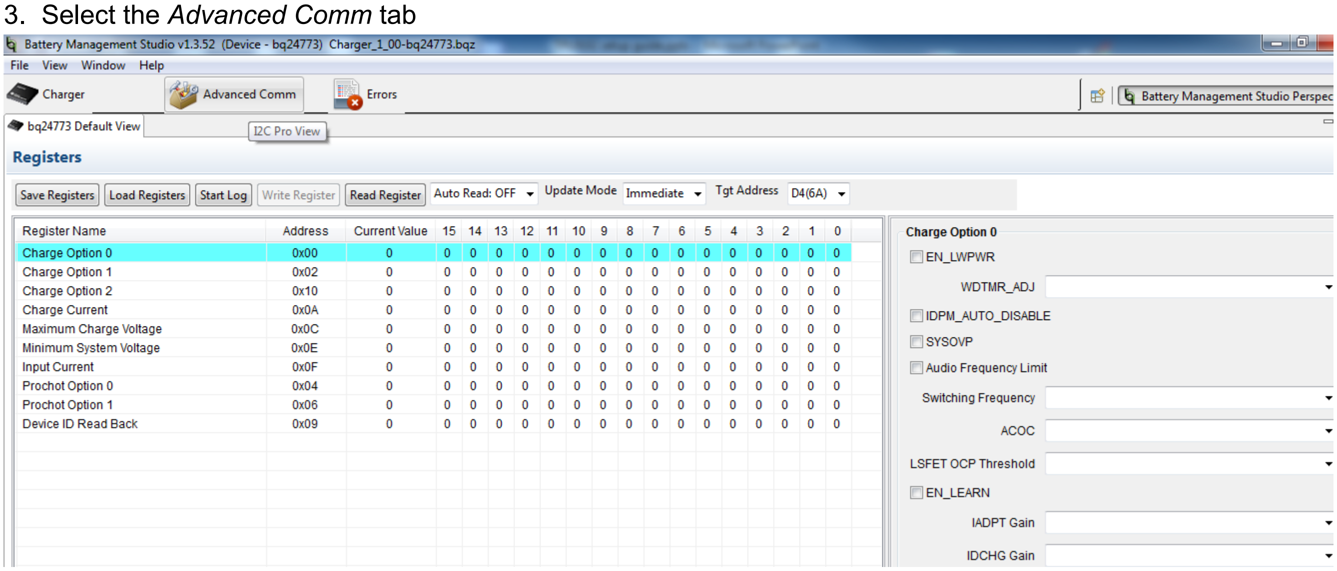

Figure 3-5. Advanced Comm tab

4. Read/Write I2C command to TPL0102-100 EVM

illustrates using the *Advanced Comm* tab to set the device address to 0xA0h and read/write 1 byte data from and to the register 0x00h for accessing the Wiper Resistance Register of Potentiometer A.

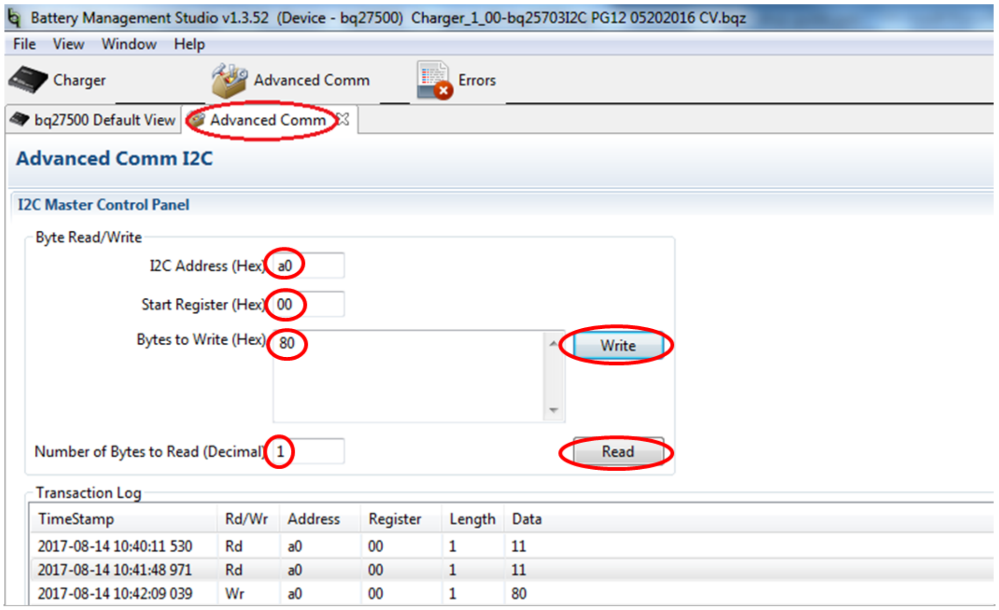

Figure 3-6. Byte Read/Write Settings

4 Conclusion

1. Typically the absolute value of a silicon resistor divider may not very accurate (approximately ±20%), but the ratio is very accurate. Use some parallel resistors with the TPL0102 to control the absolute values.
2. The TPL0102 device probably changes the resistance quickly. It would be better to have some capacitance in the circuit to slow down the Vref step change, so regulator does not overshoot.