Application Report
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USB Type-C™ Monitor Power Budge Control With INA233 Power Sensing

Shang-Heng Hsieh, Vincent Chen

ABSTRACT

USB Type-C™ applications are becoming more and more popular in the consumer monitor design. This application report discusses how to design the monitor system power budget with an INA233 power sensing function. A USB Type-C monitor uses > 150-W AC/DC adaptor to provide the monitor system power. One monitor USB Type-C port power source capability can support up to 100 W. If there are two USB Type-C ports on the monitor and each USB Type-C port can support up to 100 W, then, dynamically adjusting the USB Type-C port power source capability is one method to implement under input power limitations.

The INA233 device detects the monitoring of voltage, current, power, and energy with an I2C bus. A typical application and block diagram of the INA233 device is shown in Figure 1. The INA233 can monitor the input power either on monitor 19-V input from an AC/DC adaptor or on each USB Type-C V_{BUS}. An MCU or scalar inside the monitor can read back the energy information and change the power on each PD controller, thus providing a profile for the power budget of each USB Type-C port.

Figure 1 is the monitor power budget control block diagram.

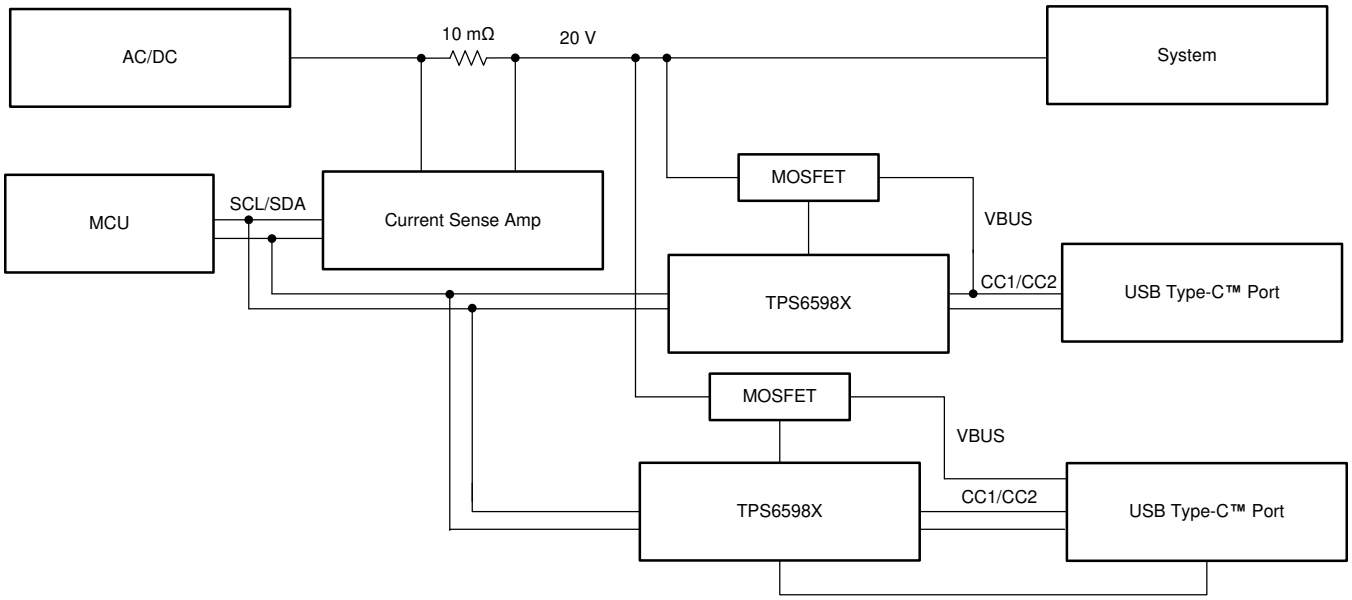

Figure 1. Monitor Power Budget Control Block Diagram

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Trademarks

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1 Example On Monitor Power Budget

Table 1 shows the example on the USB Type-C monitor with limited power budget. Two USB Type-C ports provide 130-W power to the external power sink devices such as a notebook, cellphone, and earbuds. However, the total power with the main board and back light power is greater than the AC/DC adaptor capability. Hence, making the power budge control is an intelligent method to make this possible.

Table 1. Examples of a USB Type-C™ Monitor With a Limited Power Budget

Input AC/DC Power Supply	150 W
USB Type-C, port A	90 W (20 V, 4.25 A)
USB Type-C, port B	60 W (20 V, 3 A)
Main board and backlight	45 W

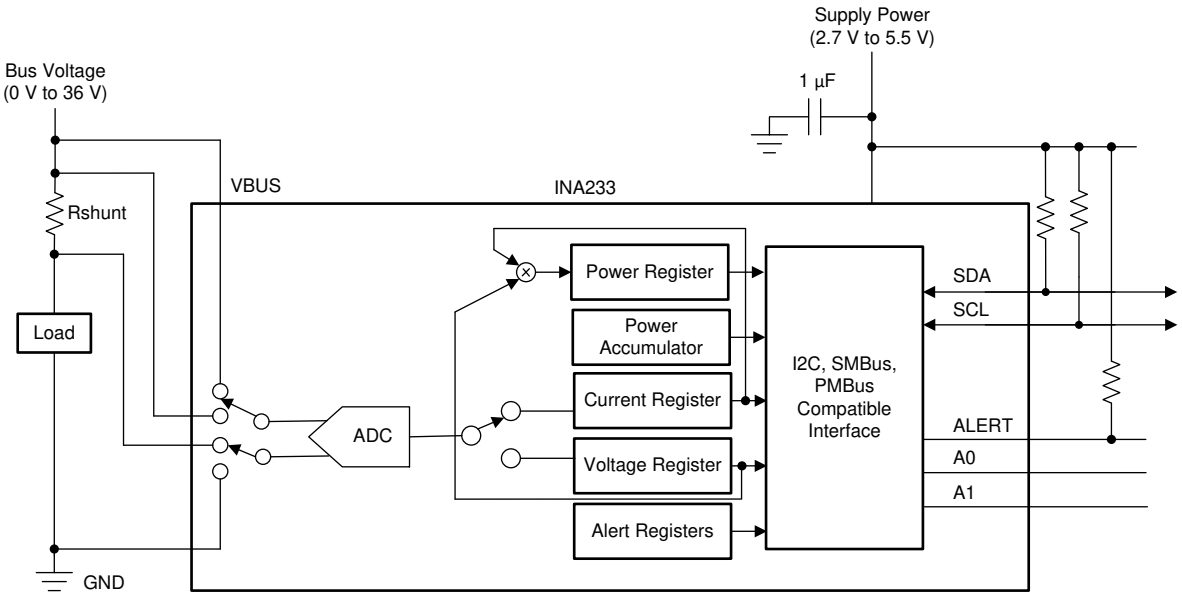

Figure 2. INA233 Block Diagram

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The MCU can read back the INA233 energy registers to acquire the total power consumption on the VBUS. The INA233 VBUS is wired directly to the bus voltage (+19-V node) instead of to the bottom side of the shunt resistor. If the VBUS is wired to the bottom side of the shunt resistor, there will be errors in the bus voltage and power measurements due to the voltage drop across the shunt.

Place a 2.2R series resistor matching R748 between the bottom of Rshunt (R740) and the bottom of the input capacitor (C743). Otherwise, the input resistance is imbalanced and large errors will be seen due to mismatched common-mode rejection and input bias current.

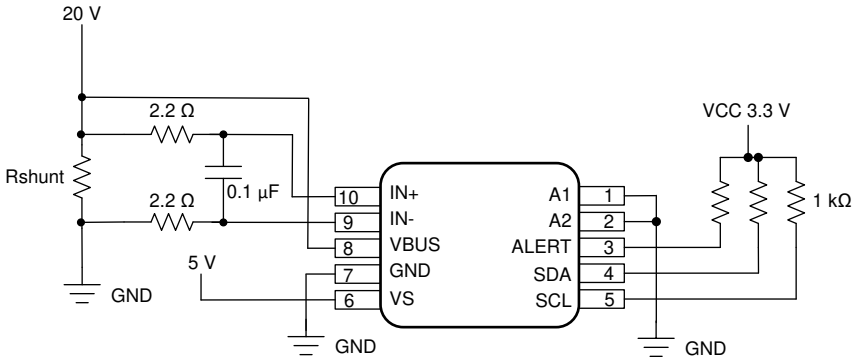

Figure 3. INA233 Input Filter Design

2 Shunt Resistor Design Selection

In this design, the 10-mΩ current shunt resistor was selected. According to the shunt voltage input range specification found in the electrical characteristics section of the data sheet, the maximum measurable shunt voltage is 81.9175 mV.

$$-81.95\ \text{mV} \geq \text{Shunt voltage input voltage} \geq 81.9175\ \text{mV} \tag{1}$$

If selecting a 10-mΩ shunt resistor, the maximum current the device can read for your given shunt is:

$$\frac{0.8192\ \text{V}}{0.01\ \Omega} = 8.19\ \text{A} \tag{2}$$

If the design needs to support a larger current, use a lower shunt resistance.

$$\text{Shunt resistor} \leq \frac{(\text{Maximum Shunt voltage input range})}{(\text{Maximum desired measured current})} \tag{3}$$

3 Example of INA233 Register Setting

Table 2 lists the INA233 register settings.

Table 2. INA223 Register Settings

Register Address	Description	Register Value
0xD4	MFR_CALIBRATION	0x0200
0x4A	IOUT_OC_WARN_LIMIT	0x2710
0xD0	MFR_ADC_CONFIG	0x4427
0xD2	MFR_ALERT_MASK	0x00FB

The *INA233 High-Side or Low-Side Measurement, Bidirectional Current and Power Monitor With I2C-, SMBus-, and PMBus-Compatible Interface Data Sheet* recommends avoiding possible rounding errors which can maximize m. In the following sections, the steps are summarized so that it is clear for designer reference. If the register PEAD_POUT 96h read back value is 0xC80, here is the calculation method to show how to change from a binary number to a real-world power number.

Calculate current_LSB: (typically calculated from the maximum expected current; however, it is calculated from CAL in this case)

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$$Current_{LSB} = \frac{0.00512}{(CAL \times R_{Shunt})} = \frac{0.00512}{512 \times 0.01} = 50\ mA$$

where

- CAL = 0x0200 = 512
- R_{Shunt} = 0.01 Ω

(4)

Calculate m for power:

$$m = \frac{1}{(25 \times Current_{LSB})} = \frac{1}{25 \times 0.005} = 40$$

(5)

Decimal shifts to the right result in negative values for R and shifts to the left result in positive values; the number of shifts is the absolute value of R. Here are the examples for shifting m to obtain R.

```
If 1000×m1>32767>100×m1, then R1=-2, new m2 = m1×100
Else if 100×m2>32767>10×m2, then R2=-1, new m3 = m1×10
Else if 10×m3>32767>m3, then R3 = 0
```

…

From the previous information, we can get m2 = m1 × 100 = 40 × 100 = 4000 < 32767.

So m2 = 4000, R1 = –2

Calculated for the real-world value: x:

Y = 3200

$$x = \frac{1}{m} \times \left(Y \times 10^{-R} - b\right) = \frac{1}{4000} \times \left(3200 \times 10^{2} - 0\right) = 80\ W$$

(6)

4 References

- Texas Instruments, *INA233 High-Side or Low-Side Measurement, Bidirectional Current and Power Monitor With I2C-, SMBus-, and PMBus-Compatible Interface Data Sheet*
- Texas Instruments, *INA233EVM Evaluation Board and Software Tutorial User Guide*

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