Application Note

How to Implement Isolated Flyback Feedback on TPS40210 and TPS40211

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ABSTRACT

Flyback is the common isolated topology to simplify a design. There are a few methods for stabilizing feedback. Use primary side regulation if tight regulation output is not required or an optocoupler is not available. Using a TL431 device because TL431 and optocoupler both applied in isolated feedback is a method for isolated feedback on the secondary side. There is need compensation for stable loop commonly implemented in the secondary side. Theoretically, using a selected internal error amplifier is not required. Using this method requires more consideration. These design tips are crucial to enable the system to function.

Table of Contents

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1 Introduction

There are two methods to stabilize feedback.

This article summarizes the implementation method of PSR and SSR, and shows how to consider feedback compensation parameter settings to achieve stable bias IC and good transient response on the primary side regulation. On the secondary side regulation, there are two ways to implement feedback. It is not necessary to use the primary side IC internal error amplifier because of the error amplifier and compensator on the secondary side. Use the internal error amplifier of the primary control device. Make sure the internal error amplifier is the operation amplifier instead of the transconductance amplifier. Consider the optocoupler output connection and setting the gain of the internal error amplifier. Both methods can achieve a stable loop.

Performing a simulation on the PMP40274 board verified these two methods.

2 Primary Side Regulation (PSR)

For PSR flyback regulation, there are three methods to perform output voltage sensing. The first method is to sense the primary side switching node. The second method is to directly sense the third or auxiliary winding voltage. The third method is to sense the third or auxiliary winding rectifier voltage. The first two methods require primary controller device support. The third method is the most popular. Figure 2-1 shows the block diagram. For PSR control, the device must integrate the error amplifier. Otherwise, an external reference and amplifier is required. Make sure to follow required parameters. See Creating a Primary-Side Regulation Flyback Converter using a Conventional Boost Controller for more information.

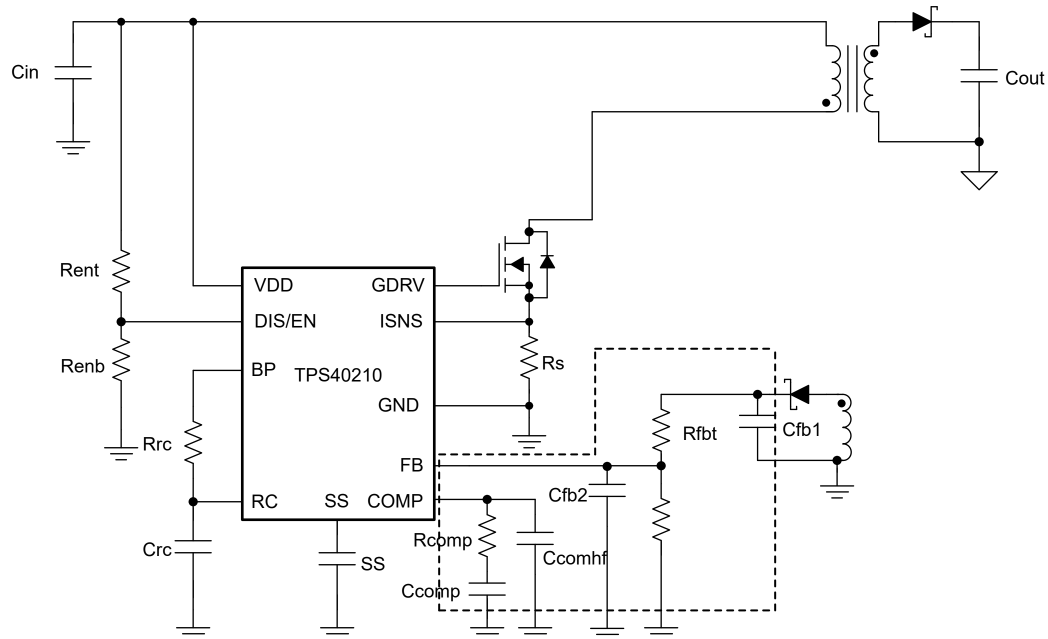

Figure 2-1. Primary Side Regulation Block Diagram

3 Secondary Side Regulation Implementation

3.1 Common Implementation Feedback for Secondary Side Regulation

The TPS40210 device integrates the error amplifier and reference. In non-isolated flyback or boost topology, these features are used. On the secondary side regulation, owing to TL431 on the secondary or discrete amplifier with reference voltage. The TL431 device acts as an error amplifier with reference voltage. The TPS40210 device doesn't require an internal amplifier. FB can connect to ground. Equation 1 shows the comp to output transfer function.

$$\frac{Vcomp}{Vout} = \frac{Rpullup}{Rled} * \frac{CTR*[(1 + SComp*(Rfb1 + Rcomp))]}{S*Rfb1*Comp} * \frac{(1 + SComp*Rpullup)}{1 + S*Copto*Rpullup} \quad (1)$$

Copto is the optocoupler parasitic capacitance (commonly 1nF to 5nF)

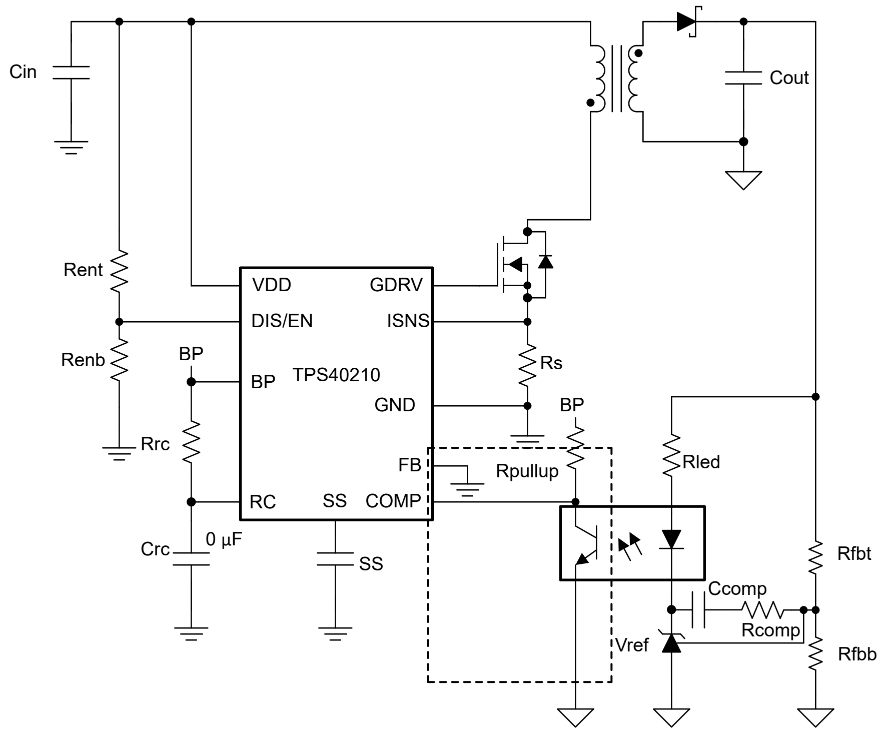

Figure 3-1. Feedback Implementation of Secondary Side Regulation

3.2 Implementing Feedback for Secondary Side Regulation

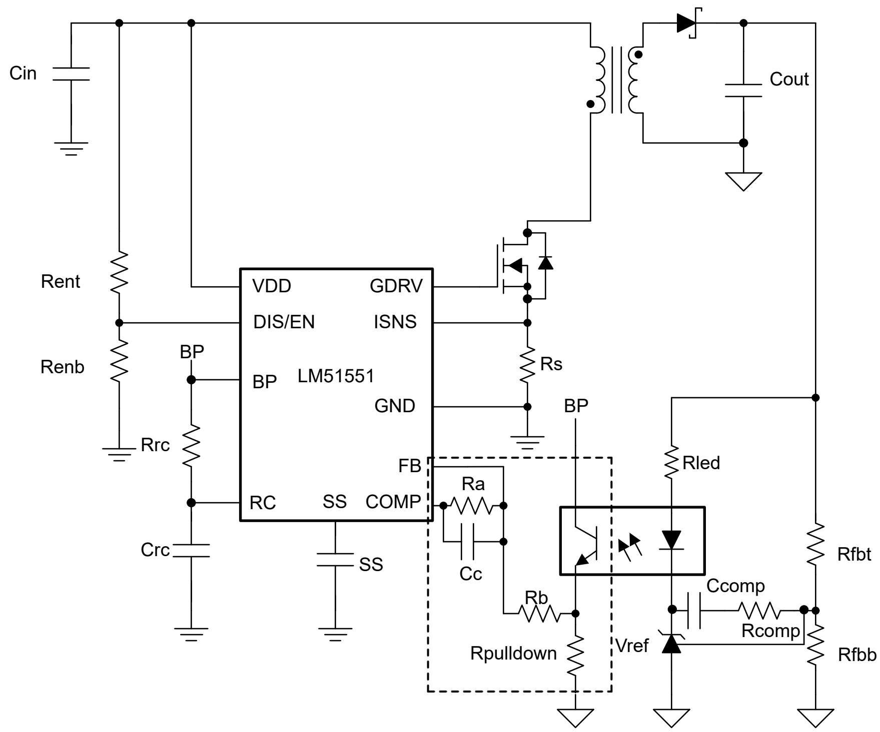

Figure 3-2. Feedback of Secondary Side Regulation Implementation with Primary Amplifier

In the secondary side regulation, use TL431 on the secondary or discrete amplifier with reference voltage. The device can be connected as shown in Figure 3-2. Under this condition, the internal error amplifier is acting inversely proportionally to the amplifier and the optocoupler connector must be pulled down to resistor to ground. Equation 2 shows comp to the output transfer function.

$$\frac{Vcomp}{Vout} = \frac{Ra*Rpulldown}{Rb*Rled} * \frac{CTR*[(1 + SComp*(Rfb1 + Rcomp)]}{S*Rfb1*Comp} * \frac{(1 + SComp*Rpulldown)}{1 + S*Copto*Rpulldown} \tag{2}$$

As shown in Equation 3, the primary gain is the unity gain. The transfer function must be the same as the common method of implementation. The compensation must be the same if there is no pole or zero to add. If Equation 3 is not met, the comp to output transfer function gain is different from the common method of implementation but proportional.

$$Rpullup = \frac{Ra*Rpulldown}{Rb*Rled} \tag{3}$$

With this method, the IC internal error amplifier is the traditional operational amplifier. This type of operational amplifier is a simple voltage to voltage amplification device and requires local feedback between the outputs and inputs for stability. See *Demystifying Type II and Type III Compensators Using Op Amp and OTA for DC/DC Converters* for more information. In other cases, this method is not recommended because most of operational transconductance amplifiers (OTA) only source current. In addition, adjusting the gain of OTA is difficult when implemented as a proportional function. Suitable gain can be set of OTA fitting the internal comp range. The parameters setting is valid only under certain range. This method cannot provide the flexibility compared to fractional operation amplifier. Therefore, this implementation is not applied for the LM3481 and LM5155 series owing to the internal transconductance amplifier.

4 Simulation Results

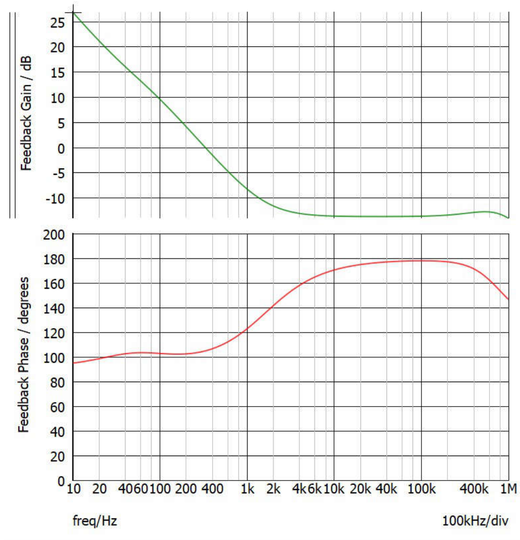

Figure 4-1. Compensator without Amplifier

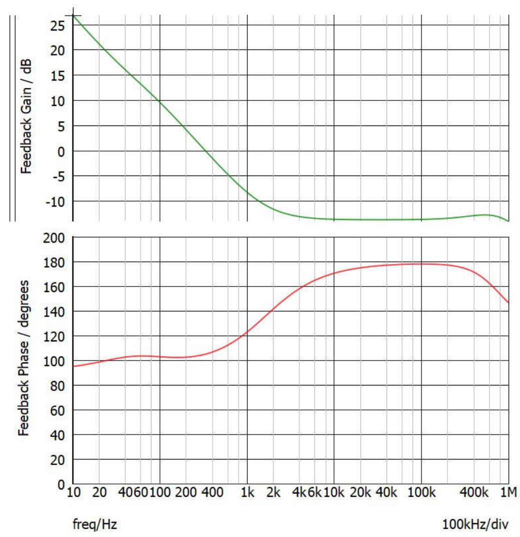

Figure 4-2. Compensator with Amplifier

Compensator without Amplifier and Compensator with Amplifier are the compensator simulation results with and without the primary internal amplifier based on the PMP40274 board parameters. For the compensator without amplifier, the Rpullup resistor is 4kΩ pulled up to BP. The intersection between the Rpullup resistor and BP connects to comp and FB connects to ground. There is no difference for compensator bode plot when meeting Equation 3.

5 Practical Bode Plot Comparison

Figure 5-1 and Figure 5-2 show the experiment results with and without the primary internal amplifier based on the PMP40274 board parameters. For the compensator without the amplifier, the change is the same as the simulation model. Loop bode plot without amplifier has a bandwidth of 7.6kHz, a phase margin of 58°C and a gain margin of -18dB. The loop bode plot with the amplifier has a bandwidth of 3.2kHz, a phase margin of 58°C and a gain margin of -17dB. Only the bandwidth is slightly different, however, each bode plot has good phase margin and gain margin.

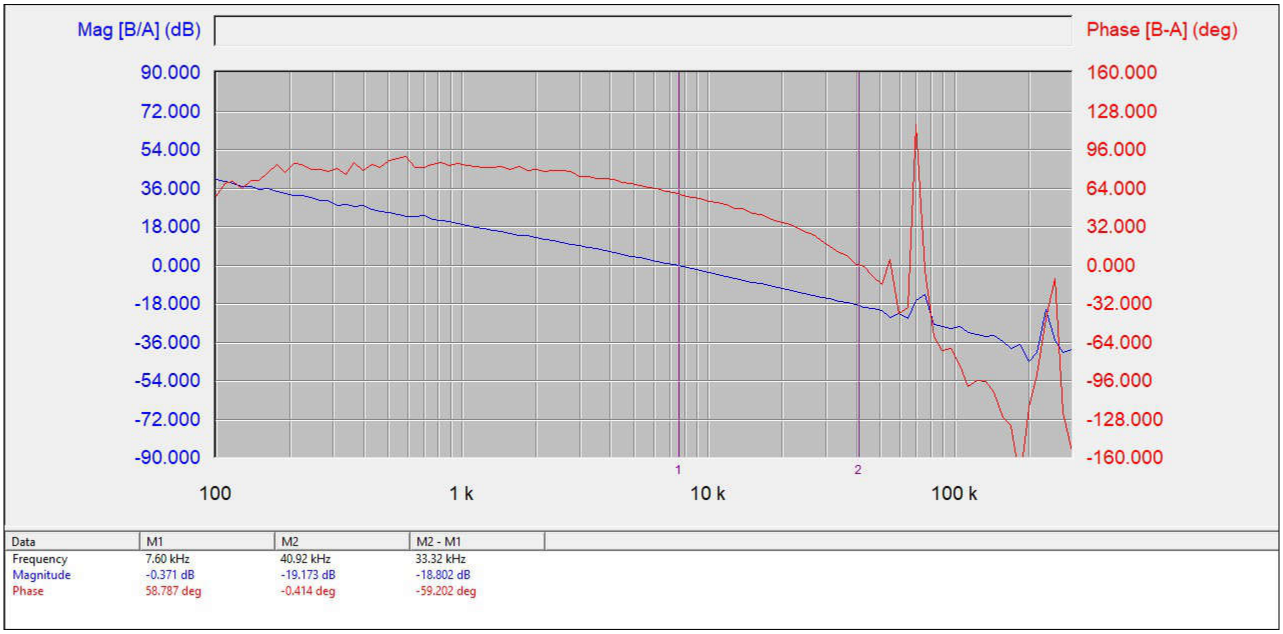

Figure 5-1. Loop Bode Plot without Amplifier

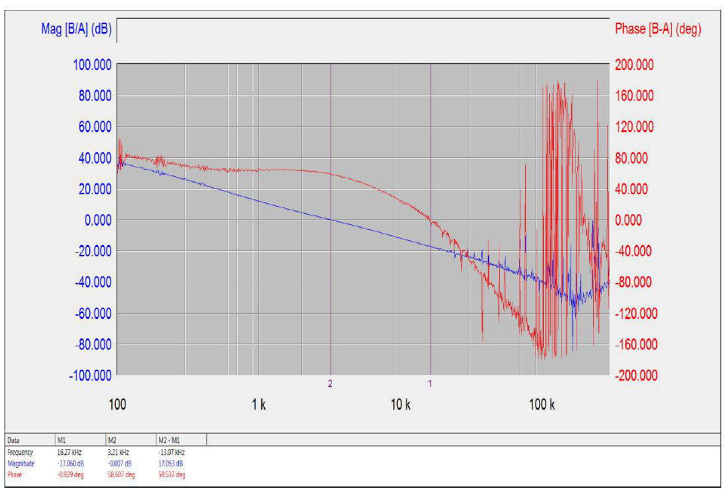

Figure 5-2. Loop Bode Plot with Amplifier

6 Summary

Flyback feedback implementation is not complicated. However, there are best practices. Consider setting feedback filter to achieve stable bias IC and good transient response on the primary side regulation. On the secondary side regulation, there are two methods to implement feedback. It is not necessary to use the primary side IC internal error amplifier because of the error amplifier and compensator on the secondary side. The other method is to use the internal error amplifier of the primary control IC. When using this method, make sure that the internal error amplifier is the operation amplifier instead of transconductance amplifier. Consider the optocoupler output connection and set the suitable gain of internal error amplifier. Both methods can achieve stable loop. A simulation and practical experiment performed on the PMP40274 board verify these two methods.

7 References

- Texas Instruments, *Creating a Primary-Side Regulation Flyback Converter using a Conventional Boost Controller*, seminar.
- Texas Instruments, *LM51551-Q1 2.2MHz Wide Input Nonsynchronous Boost, SEPIC, Flyback Controller*, data sheet.
- Texas Instruments, *How to Design an Isolated Flyback Using LM5155*, application note.
- Texas Instruments, *PMP40274 24Vin, 5V6A Power Module Reference Design*, product page.
- Texas Instruments, *TL431 Adjustable Precision Shunt Regulator*, data sheet.