iW3616(7) BIsense Resistor Selection Guide Rev. 1

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1.0 Introduction

iW3616 and iW3617 are the third generation phase-cut dimmable LED driver controllers. Their two-stage architecture provides smooth dimming experience and minimizes the output current ripple. Its power factor correction (PFC) stage uniquely utilizes the bipolar power transistor (BJT) as the main power switch. The BJT also performs the bleeding function when it works with a phase-cut dimmer. iWatt's patented BJT current gain detection technology allows the BJT safe operation in the linear mode.

Figure 1 shows a typical application circuit with iW3616. The PFC stage includes boost inductor L3, main switch Q2, rectifier D3, boost output capacitor C3 and current sense resistor R6. The boost current sense signal is directly connected to the BIsense pin (Pin 3) of the controller. During the initial power-on, there is a 30ms dimmer detection time. Q2 works in linear mode to load the dimmer with constant current. In order to operate Q2 safely, the DC current gain of Q2 is measured before applying the driving current. Once the dimmer detection completes, Q2 operates in switching mode or linear mode depends on the input condition.

If there is no dimmer detected, the boost converter operates in power factor correction mode. Q2 works as a power switch. If a phase-cut dimmer is detected, then Q2 works in both the switching mode and the linear mode depending on the dimming status. Because the current gain of the BJT varies by temperature, the driving current needs to adapt to this gain variation in order to provide consistent bleeding current. iW3616 and iW3617 have a built-in gain detection algorithm to measure the gain and control the bleeding current to within the BJT safe operating range. In the LED driver design, the BJT bleeding current can be optimized by the selection of the BIsense resistor. The BIsense resistor impacts the dimming control, the boost switching over-current protection and the Vcc loading. This guide discusses the BJT control methodology and how to select the BIsense resistor.

This design guide first explains the current gain detection and bleeding current control. Then the BIsense resistor selection section calculates the BIsense resistor based on the bleeding function requirements, as well as discuss the impacts to over-current protection threshold and Vcc loading.

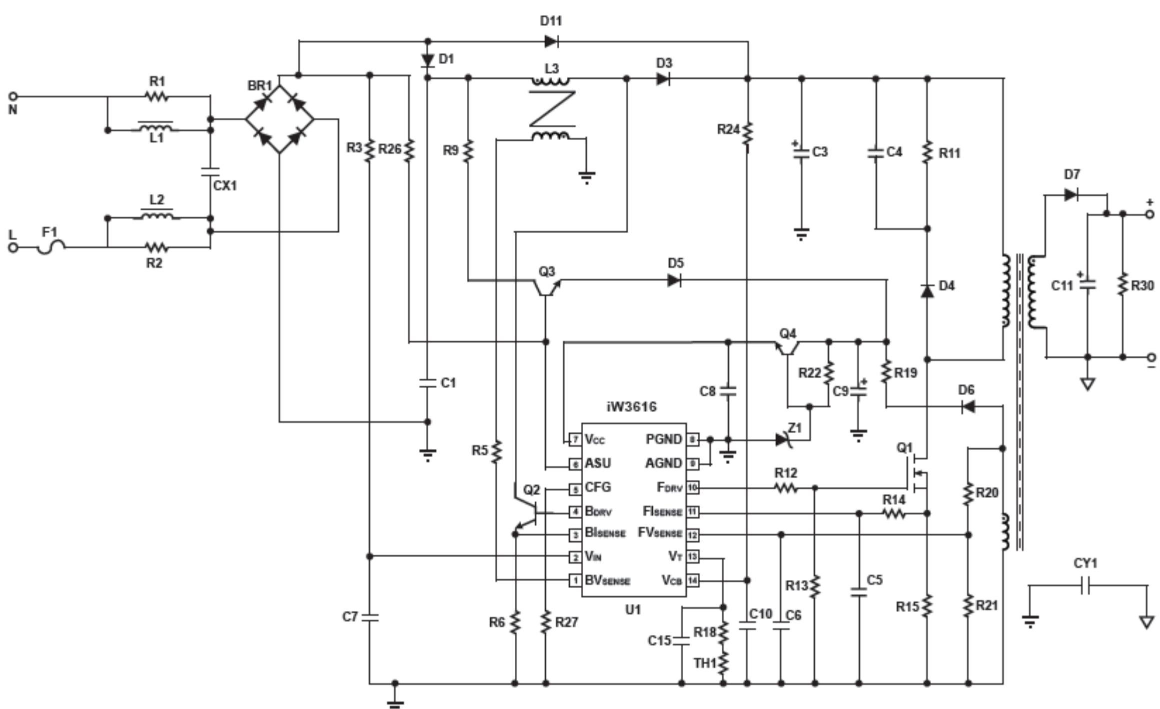


Fig. 1 Typical Application Schematic

2.0 BJT Gain Detection

Figure 2 shows the BJT control diagram. The BJT driver sends out the Q2 base drive current Ib based on the drive command. The current sense resistor R6 is connected between the emitter of Q2 and ground. The emitter current sense voltage BIsense is compared with the window comparators with thresholds of Vreg_th(Hi) and Vreg_th(Lo) for current gain detection. During the detection time, the control logic continuously increases or reduces the base drive current such that the emitter current sense voltage can settle between Vreg_th(Hi) and Vreg_th(Lo).

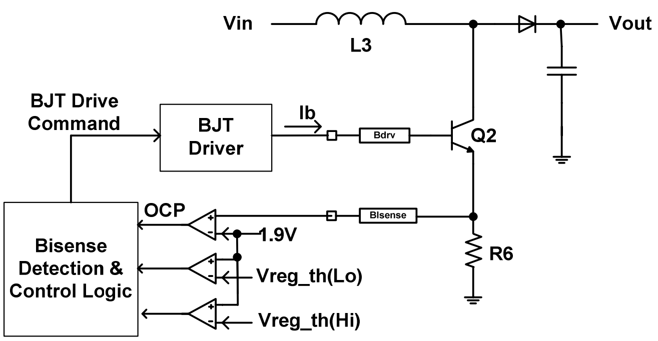
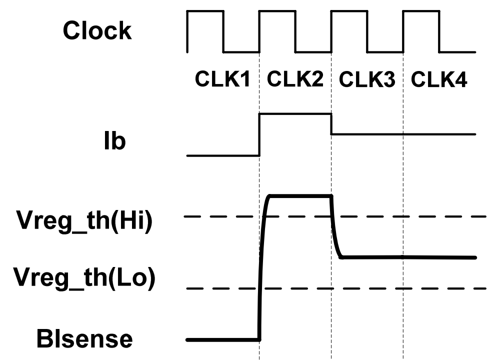


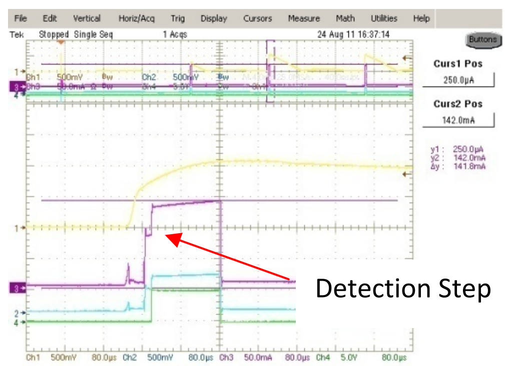
Fig. 2 BJT control blockdiagram

Figure 3 shows an example of the BJT gain detection process. The clock period is 16us. Assume in CLK1 Ib current is low, the current sense BIsense falls below Vreg_th(Lo). The control logic decides to increase the Ib current in CLK2. During CLK2, Figure 3 illustrates an example that Ib is too high and the BIsense rises above Vreg_th(Hi). In CLK3, the control logic further reduces the drive current with a smaller step and the BIsense falls within the threshold window of Vreg_th(Hi) and Vreg_th(Lo). Since BIsense settles within the target window of Vreg_th(Hi) and Vreg_th(Lo), in CLK4, the control logic no longer increases or reduces the Ib current. The BJT gain is then known to the controller. It is equal to $(V_{BIsense}/R6)/Ib - 1$. Two notes:

1) In this calculation, the controller does not attempt to know the exact current gain value. Only the target Ib current is recorded. Therefore, the user can adjust R6 to change the controller's target bleeding current level.
2) The BJT drive current is recorded when the BIsense voltage settles between Vreg_th(Hi) and Vreg_th(Lo). Although it is possible to find more accurate value, it is not required for the proper operation of iW3616 and iW3617 circuits.



(a) Illustration diagram



(b) Waveform

Ch1: Vin sense ; Ch2: BIsense; Ch3: Ie

Fig. 3 BJT gain detection

The current gain detection process is initiated under three conditions:

1) During the power-on dimmer detection time, the gain detection process is initiated when the Vin sense voltage rises above 0.14V.
2) If a leading edge dimmer is detected, the gain detection process is initiated for every half AC cycle. The process starts when the rising edge of the Vin sense goes above 0.14V.
3) If a trailing edge dimmer is detected, the gain detection process is initiated for every 32 half AC cycles. The process starts when the rising edge of the Vin sense goes above 0.21V.

3.0 BIsense Resistor

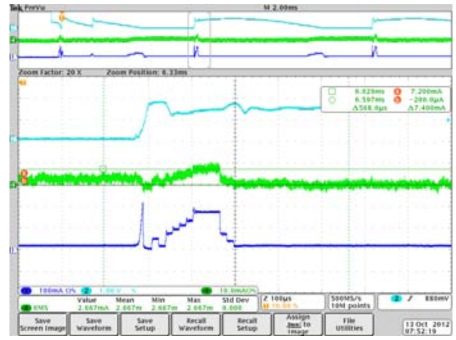
For proper dimming operation, the target detection current is typically set to 100-200mA. For example, if the desired target detection current is 160mA, assuming 3616-01 is used (Vreg_th(Hi) is 0.92V and Vreg_th(Lo) is 0.68V), the average targeting voltage is (0.92+0.68)/2 = 0.8V; R6 can be calculated as 0.8V/160mA = 5ohm. The typical BIsense values for iW3616 and iW3617 based on 160mA targets are calculated in Table 1.

Table 1 Typical BIsense resistor selection

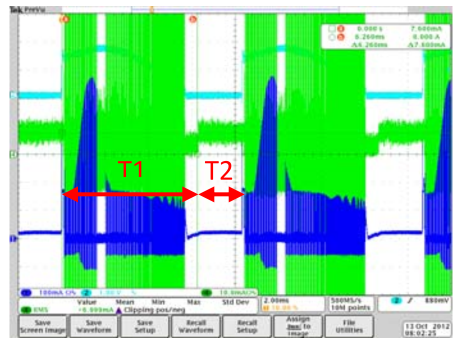
Part#	Vreg_th(Hi) (V)	Vreg_th(Lo) (V)	R6 (ohm)
iW3616-00	0.46	0.34	2.5
iW3616-01	0.92	0.68	5
iW3617-00	0.31	0.22	1.6
iW3617-01	0.46	0.34	2.5

Figure 4 shows a typical leading edge dimmer operation waveforms. Figure 4 (a) shows the gain detection process during the initial power-on. The base drive current steps up gradually until the emitter current sense reaches the detection window. The settling current is 158mA. The base current is determined to be 7.2mA. Therefore, the BJT current gain can be calculated as 158mA/7.2mA – 1 = 21. The BIsense resistor value impacts the BJT base drive current during the dimmer bleeding time. The base drive current during the bleeding time is pre-determined to be either 2/5th of or equal to the detection current. Figure 4 (b) shows the detailed bleeding drive current and timing. Time duration T1 starts from the phase-cut rising edge until 75% of the period time. During T1, the base drive current is set to be 2/5th of the drive current that was recorded from the gain detection value. Time duration T2 starts after T1 finishes and ends at the next phase-cut rising edge. During T2, the base drive current is set to be equal to the drive current from the gain detection result. In this case, the base drive current in T1 and T2 are 2.9mA and 7.2mA respectively.

BIsense resistor can be selected to increase or reduce the bleeding current. The controller only detects the current gain by the emitter current sense. Increasing BIsense resistance, R6, can reduce the bleeding base drive current. For example, if an iW3616-00 is used and the applicaitn design uses 3.75 ohm for R6 instead of 2.5ohm, then the detection current will drop from 160mA to 120mA. The base drive current will be lowered by the same ratio.



(a)



(b)

Fig. 4 Bleeding with Leading Edge Dimmer
Ch1: Emitter current; Ch2 Vin sense; Ch4: Base current

One benefit to lowering the base drive current is to reduce the Vcc power consumption during deep dimming. In deep dimming, the Vcc voltage is low and can get to be close to the Vcc UVLO threshold. If the Vcc voltage drops below the UVLO threshold, the LED driver will turn off. This easily causes on/off flickering. Therefore, it is helpful to reduce the base drive current if this happens.

Another consideration is the Boost over-current protection (OCP) threshold. The OCP threshold is fixed at 1.9V. If BIsense resistor is too high, then the peak boost operating current is limited. This will impact the power factor correction and THD performance at no dimmer. Therefore, the BIsense resistor value should not be too high to trigger OCP during normal operation.

4.0 Summary

In summary, when selecting the BIsense resistor the dimming requirements, OCP threshold and Vcc power consumption should be considered. Table 1 provides a typical BIsense resistor values which can be used as a starting point to begin with a design.

Trademark Information

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