Circuit design of feedback based on TL431 in fly-back converter

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Introduction of TL431

TL431 by Texas Instruments (TI) and Motorola’s 2.5 ~ 36V adjustable precision shunt regulator. Its excellent performance, low cost, the typical dynamic impedance of the device 0.2Ω, can be used in single precision or precision linear regulators, switching power supply, in many applications can use it instead of Zener diodes. In addition, TL431 can constitute a voltage comparator, the supply voltage monitors, time delay circuit, precision current source and so on.

TL431 they use a DIP-8 or TO-92 package, pinout are shown in Figure 1. 3 pins are: the cathode (CATHODE), anode (ANODE) and the reference terminal (REF). The figure, A is the anode, is required to use ground; K for the cathode, subject to the current limiting resistor connected to the positive power supply; UREF is the output voltage UO of the configuration side, an external resistor divider; NC is empty feet.

The equivalent circuit by the TL431 can be seen below, Uref an internal 2.5V reference, connected to the inverting input of op amp. Shows the characteristics of the op amp, and only when the REF terminal (inverting input) voltage is very close to Uref (2.5V), the transistor will have a stable in the non-saturation current through, and with small changes in voltage REF, through the VT transistor current changes from 1 to 100mA. Of course, the figure is by no means the actual internal structure of the TL431, it can not simply replace it with this combination. However, if in the design, analytical applications TL431 circuit, this block diagram of the open thinking, understanding the circuit is very helpful.

TL431 mentioned earlier contains a 2.5V internal reference voltage, so when the end of the introduction of the REF output feedback, the device from the cathode to the anode through a wide range of streaming, control the output voltage. The circuit shown in Figure 2, when the resistance R1 and R2 to determine when the partial pressure of both the introduction of Vo feedback, if Vo increases, the amount of feedback increases, TL431 shunt will increase, which in turn led to decreased Vo . Obviously, the depth of the negative feedback circuit must equal the reference voltage at the Uref stable, then Vo = (1 + R1/R2) Vref.

Choose different values of R1 and R2 can be from 2.5V to 36V output voltage range of any in particular, when R1 = R2 when, Vo = 5V. Note that, the choice of resistance TL431 must ensure the necessary conditions of work, that is, the current through the cathode is greater than 1 mA.

General Optocoupler PC817

Features:
1. Current transfer ratio CTR: IF = 5mA, VCE = 5V 50% when the minimum
2. Isolation between input and output high voltage Viso (rms): 5.0 KV
Ordinary optical coupler can only transmit digital signals (signal), not suitable for analog signal transmission. Linear optical coupler is a new type of optical isolation device that can transmit continuously varying analog voltage or current signals, such as changes in the strength of the input signal will produce a corresponding optical signal, so that the phototransistor turns on the degree of different voltage or current output also will be different.

PC817 optocoupler feedback can not only play a role can also play a role in isolation. Its internal block diagram as shown.

➢ Use with TL431 and PC817

Switching power supply regulator using TL431 and feedback usually PC817, such as the output voltage do not ask, you can also use the voltage regulator diode and PC817, Here I come to the following description of the typical application circuit TL431, PC817 co-ordination problems. Circuit as follows:

The value of R13, R13 taken the value is not arbitrary, to consider two factors:
1) TL431 reference input current, generally the current 2uA so, in order to avoid the end of the current impact of the partial pressure ratio and to avoid the effect of noise, and generally flows through the resistor R13 of the current more than 100 times, so the resistance less than 2.5V/200uA = 12.5k.
2) the standby power requirements, if required, to meet the "12.5K try to take the case of large value.

TL431 dead current 1mA, which is close to zero current R6, but also to ensure that 431 has 1mA, so R3 = 1.2V/1mA = 1.2K to. In addition consideration is power consumption, R17 is to ensure that the current size of the dead, R17 will happen can not, when the output voltage is less than 7.5v should be considered must be used, because here is to provide a TL431 R17 since the death of District current, then the LED turns on when voltage is less than useful, if the light-emitting diodes can be conducted, to provide adequate dead TL431 current, if Vo is low when the calculation method to R17 = (Vo- Vk) / 1mA (where Vk = Vr-0.7 = 1.8v); when Vo = 3.3V R17 from the dead when the angle of the critical current maximum R17 = (3.3-1.8) / 1mA = 1.5k, from the current limit TL431 the perspective of protecting the critical minimum of R17 = (3.3-1.8) / 100mA = 15Ω. When Vo high time, that is greater than the Vk + Vd Vo of the time, that is about 7.5v above, TL431 dead required LED current can be conduction through the provision of, so this is not R17.

The value of R6 client made to ensure the required high voltage control of current, presumably by PC817 (U1-B), the CTR = 0.8-1.6, obtained lower limit of 0.8, requiring the maximum flow through the LED current = 6/0.8 = 7.5 mA, so the value of R6 = (15-2.5-1.2) / 7.5 = 1.5K, light emitting diode can withstand the maximum current at 50mA or so, TL431 is 100mA, so we take the maximum current flowing through R6 is 50mA, R6 (15 -2.5-1.3) / 50 = 226 ohms. To meet these two conditions: 226 <R6.

Some increase in the circuit design to enhance low frequency gain circuit, using a resistor and a capacitor in series with the control side and output side to suppress low frequency (100Hz) ripple and improve the output regulation, the static error, male power is to enhance the phase To be placed in front to increase the frequency bandwidth of the phase margin, the rest depends on the specific location of the power part in the design phase at how much the bandwidth, the frequency of resistance and capacitance is lower, the higher the increase phase, of course, only 90 degrees maximum, but its frequency is very low, low-frequency gain will also reduce the general on the bandwidth of 1 / 5 of the early phase increased to about 78 degrees.

U1-A flow of current Ic of the current should be between the 2-6mA, the switch will be linear pulse-width modulation, so the current Ic PC817 transistor should be in the range of changes. The Ic is controlled by the diode current If we adopted the Vce PC817 If the relationship with the curve (Figure 3) can correctly determine the PC817.

![Figure 3](image-url)

It can be seen from Figure 3, when the PC817 diode forward current at 3mA If so, the transistor radio set in the 4mA current Ic is about change and set-emitter voltage Vce in a wide range of linear change. Meet the control requirements. So you can determine the election PC817 diode forward current If is 3mA. Look TL431 requirements.
Knowledge from the technical parameters of TL431, Vka changes in the 2.5V-37V, Ika can 1mA to 100mA from a wide range in the changes within the general election to 20mA, either stable jobs, but also provide part of the dead load. Therefore, choose only 3-5mA or so on it.

After several relations identified above, the value of resistance like that of several established. According to the performance of TL431, R11, R13, Vo, Vr has a fixed relationship: \[ Vo = \left(1 + \frac{R11}{R13}\right) Vr \]
Where, Vo is the output voltage, Vr is the reference voltage, Vr = 2.50V, first take the value of R13, for example, R13 = 10k, according to the value of Vo can be calculated on the R11.

Again determine the R6 and R17. Described by the former, PC817’s If taken 3mA, first take the value of R6 470Ω, then the voltage drop across the Vr6 = If * R6, technical manuals from the PC817 know, the diode forward voltage drop typical 1.2V Vf , you can determine the voltage drop on R17 Vr17 = Vr17 + Vf, and know that the current flowing through R17 Ir17 = Ika-If, therefore the value of R17 can be calculated: \[ R17 = \frac{Vr17 + Vf}{Ika - If} \]
Based on the above calculation can know TL431 cathode voltage Vka, Vka = Vo’-Vr17, where Vo ‘values than the large 0.1-0.2V to Vo.

As an example, Vo = 15V, take R13 = 10k, R11 = (Vo/Vr-1) R13 = (12/2.5-1) * 10 = 50K; take R6 = 470Ω, If = 3mA, Vr6 = If * R6 = 0.003 * 470 = 1.41V; Vr17 = Vr1 + Vf = 1.41 +1.2 = 2.61V;
Take Ika = 20mA, Ir17 = Ika-If = 20-3 = 17, R17 = Vr17 / Ir17 = 2.61/17 = 153Ω;
TL431 cathode voltage Vka, Vka = Vo’-Vr17 = 15.2-2.61 = 12.59V
Results: R6 = 470Ω, R17 = 150Ω, R11 = 10KΩ, R13 = 50K.