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1. Switch-Mode Power Supply Controller

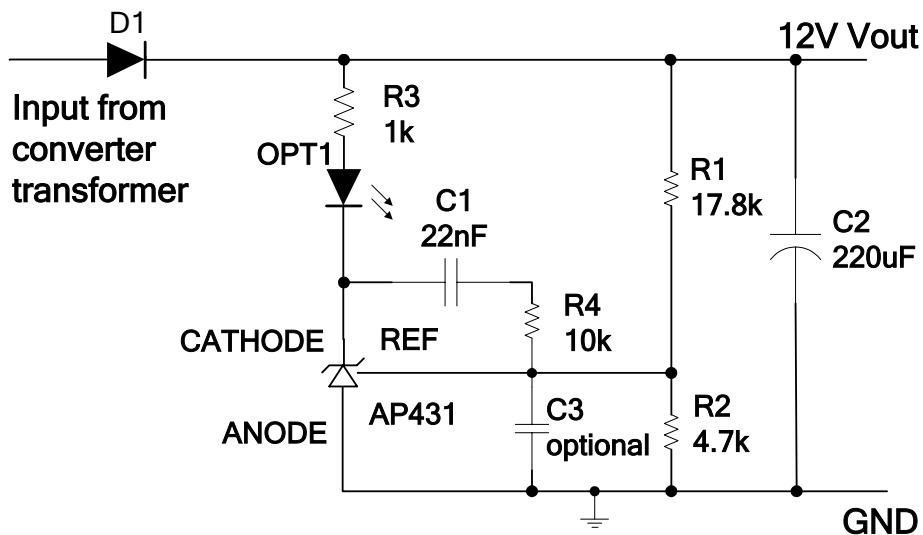


Figure 1: SMPS control/feedback loop

The circuit shown in Figure 1 is commonly used in the control loop of switch-mode power supplies. The output voltage is sensed via R1/R2 by the AP431 and the IC controls the current passing through an opto-coupler and hence feeds back output voltage status to the switching regulator. The minimum supply voltage at which this popular circuit can be used is set by the minimum cathode voltage of the regulator IC plus the forward voltage drop of the opto-coupler LED. With AP431's minimum cathode voltage of 2.5V, and 1.2V voltage drop of the opto-coupler, the circuit is not viable below 4V output voltage.

The capacitor C1 is not required for correct operation of the AP431. It has been included as it is frequently needed to stabilize the overall control loop of the switch-mode power supply.

2. AP431 Vref Minimum Operating Voltage

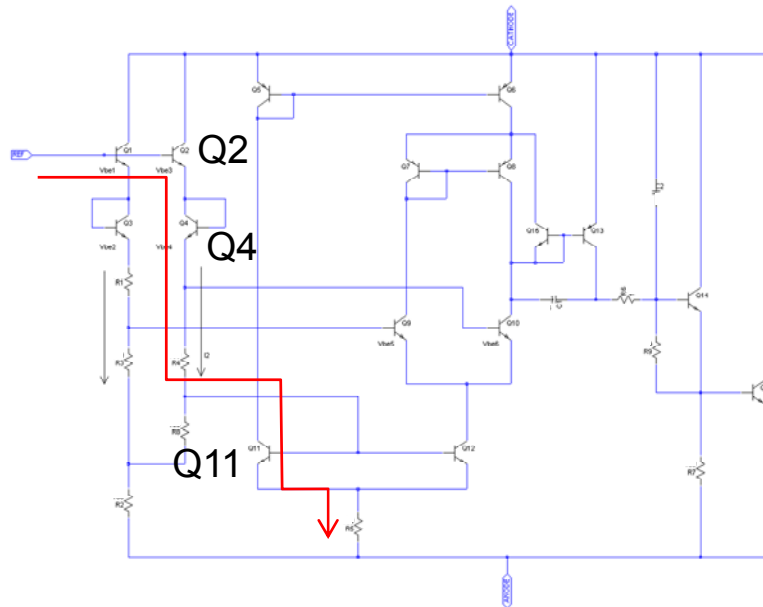


Figure 2: AP431 schematic

- 2.1 The simplified schematic of AP431 is illustrated in fig.2. The path of Q2, Q4, Q11 creates an internal bias circuit for IC normal operations. If REF voltage is below $3 \cdot V_{be}$ (by Q2, Q4, and Q11), the internal biasing circuit ceases to operate. Therefore, the minimum required REF voltage for normal regulation is $3 \cdot V_{be}$, typically 2.1V at room temp.
- 2.2 For stable operation in switch-mode power supply with 12V output(fig. 1), output ripple voltage is around 100mV ripple voltage. REF voltage is regulated to 2.5V with about 20mV ripple voltage. Since REF voltage is over than 2.1V, the control circuit works normally to regulated output to target voltage.

Application Note

AP431 Signal Response In Switch-Mode Power Supply

3. AP431 Response for Coupling Signal

- 3.1 For some undesirable conditions that couple REF to below the minimum operating voltage, i.e., 2.1V, such as by large external pulses, power supply system could encounter slow response, and eventually result in system shutdown by UVP protection.
- 3.2 In the test circuit in fig. 3, V_{pulse} of around 4V magnitude causes REF voltage to drop below 2V, resulting in undesirable slow response on V_{KA} . The circuit returns to normal regulation (i.e., V_{KA} returns to 7V) when REF voltage recovers to over 2.1V. (Figure 4)
- 3.3 Possible solutions to prevent or alleviate the above undesirable situations are listed below:
- 3.3.1 Add cap 1nF to REF pin for filtering. (Figure 5). The transient voltage coupled to REF pin can be greatly reduced by the low pass filtering.
- 3.3.2 Reduce feedback resistors R1/R2 from 30k/20k to 15k/12k (Figure 6), can similarly reduce voltage swing coupled to V_{ref} .
- 3.3.3 Reduce R3 resistor value from 3.9k to 100 to support more current to Cathode node for faster loop response (Figure 7).

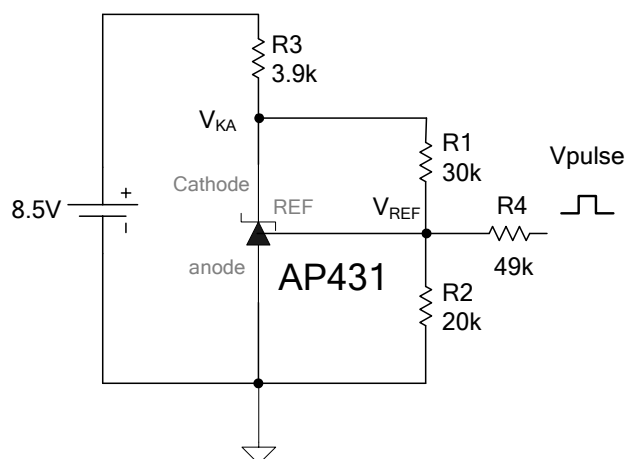


Figure 3: AP431 test circuit for signal response

Application Note AP431 Signal Response In Switch-Mode Power Supply

V_{KA} : AP431 Cathode to anode voltage

V_{REF} : REF voltage

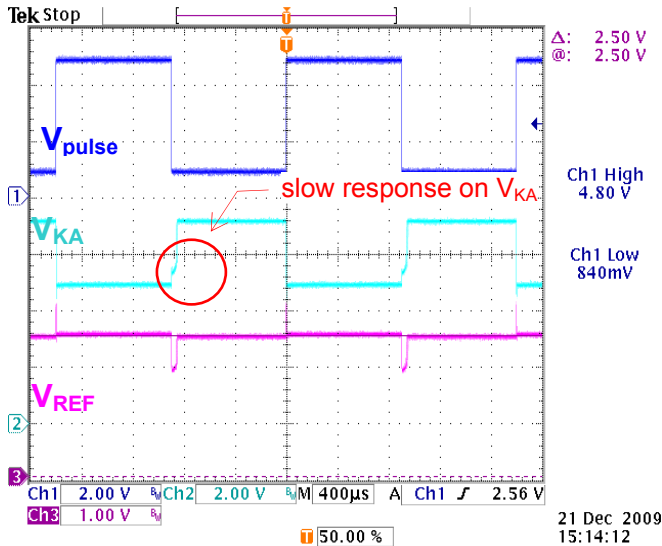


Figure 4: AP431 V_{ka} response to V_{pulse} input

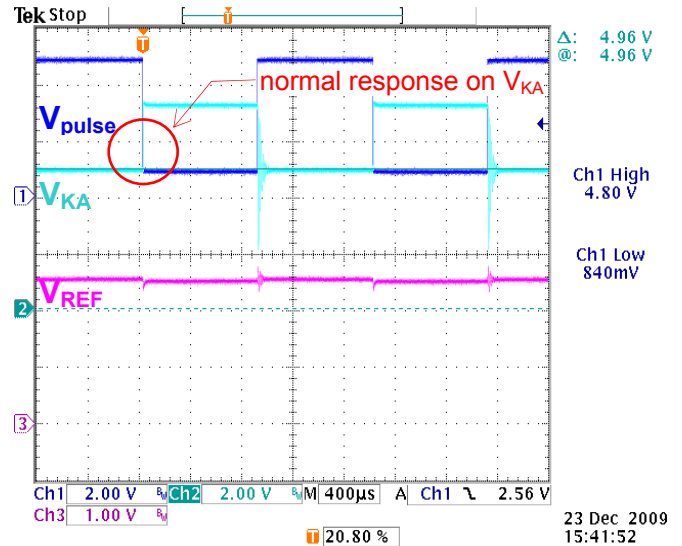


Figure 5: REF pin is added with 1nF

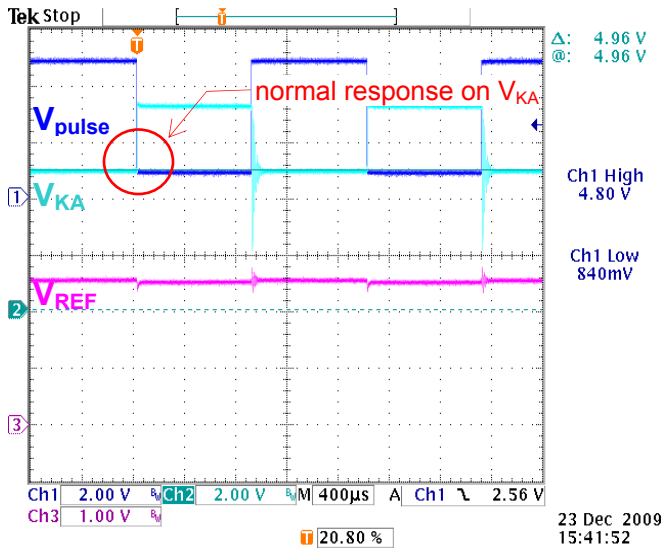


Figure 6: $R1/R2=15K/12K$

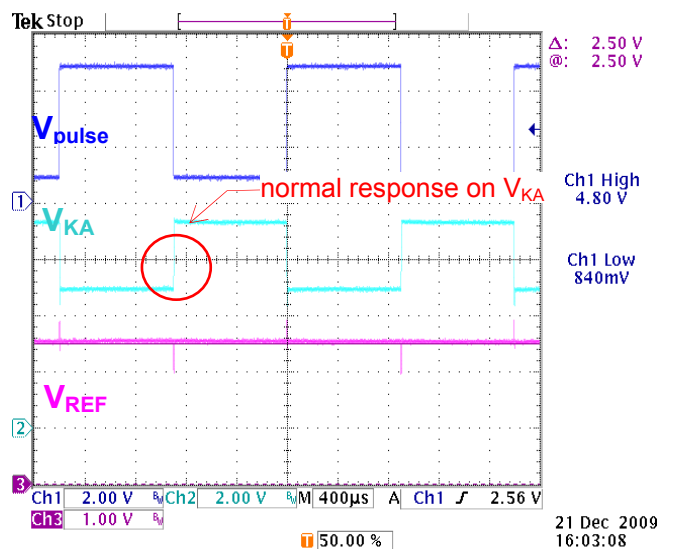


Figure 7: $R3=100$

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