ZETEX SEMICONDUCTORS

DN77
Transient and noise protection for Zetex ZXCT series current monitors

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Introduction

Transients are changes in current or voltage which occur in short duration.

Tranients can be both internal and external and may not only damage components but also cause a complete system failure if the circuit doesn't have sufficient protection. Transients can either cause catastrophic failures, partial failures or progressive damage to components over a period of time. Internally generated transients may often be energy stored in inductive or capacitive elements which is then released if operating conditions change. Such a transient is created every time an inductive element is switched within a circuit, for example a motor, contactor or relay. Typical internal transient sources are load dumps, inductive switching or ignition pulses.

The interference source is generally referred to as noise when it is not severe enough to cause catastrophic failures but may interfere, or has the potential to interfere, with normal workings of the system.

The Zetex range of current monitors may need to be protected where such transient noise exists. A number of methods are available to do this and these are explored in this document.

Methods of protection

Prevention

Prevention is always better than cure. Hence preventing the transient in the first place, if this is possible, is better than trying to cope with it. Figure 1 shows the ZXCT1008/9 monitoring current through an inductive load. Without the freewheel diode D1, the inductance of the load would have generated a large voltage spike when the transistor switches off. The inclusion of the diode to clamp this voltage and the way it is connected ensures that the current through the coil and current monitor would decay to zero in a controlled manner and the current monitor never sees any noise.

Output series resistance

One method that is particularly suitable for the Zetex 3-terminal devices is again shown in Figure 1. Since these are current output devices, it means that the output transfer function is not adversely affected by the addition of a protective resistance, R_{LIM}, in series with the output pin provided certain circuit parameters are taken into consideration.

For low to moderate transient voltages this resistance, R_{LIM}, is all that is needed for protection.

This needs to be carefully specified as it needs to be high enough to be functional but not too high to compromise normal operation of the device. At the lower end of its value, it is limited by the maximum current that can be supplied by the device. Whilst at the higher end, the limiting factor is the available circuit compliance. The two limits are determined as follows.

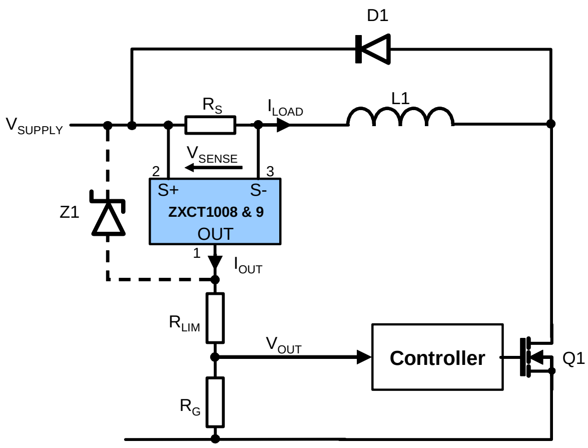

Figure 1 Monitoring current through an inductive load

Equation 1

$$R_{LIM\,(\min)} = \frac{V_{PK} - V_{MAX}}{I_{OUT\,(\max)}}$$

Equation 2

$$R_{LIM\,(\max)} = \frac{R_G\left(V_{SUPPLY\,(\min)} - (V_{DO} + V_{OUT\,(\max)})\right)}{V_{OUT\,(\max)}}$$

where,

V_{PK} = Peak transient voltage to be withstood

V_{MAX} = Maximum operating voltage (20V in most cases)

$I_{OUT(max)}$ = Max continuous output current (25mA for ZXCT1008/9)

$V_{SUPPLY(min)}$ = Minimum supply operating voltage,

V_{DO} = Drop-out voltage

$V_{OUT(min)}$ = Maximum required output voltage

For practical determination of R_{LIM}, since the value has to lie between these two limits, pick a value nearest mid-point between them. The mid-point value for R_{LIM} is calculated from,

Equation 3

$$R_{LIM} = \frac{R_{LIM\,(\min)} + R_{LIM\,(\max)}}{2}$$

Adding a zener diode across the current monitor as shown provides better protection by ensuring that the voltage across it is clamped to a known safe value regardless of the amplitude of the transient voltage or R_{LIM}.

RC filtering

If the noise is of a relatively low level, a simple RC filter could be used for protection as shown in Figure 2 and Figure 3 below. This method could be used for any of the current monitors and these two examples specifically demonstrate this for the ZXCT1050 and generically for all others.

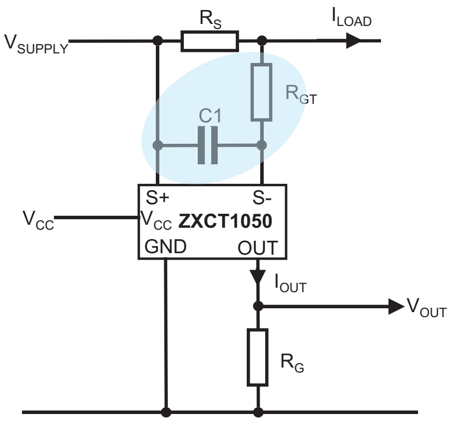

Figure 2 RC noise suppression for ZXCT1050

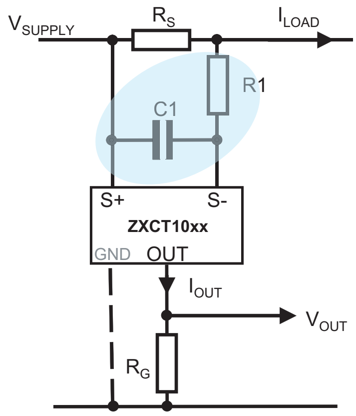

Figure 3 RC noise suppression for a generic current monitor

Notice in Figure 2 that the transconductance resistor is also used as the snubber resistor whilst in most other cases this would be an additional component.

Design example

Consider an application where a 3 Ampere current needs to be measured. 130V transient spikes (Figure 4) are present in the system and a 5V output is required. The supply voltage ranges from 12V to 16V. The device is ZXCT1009 and an output resistance of 10k is required.

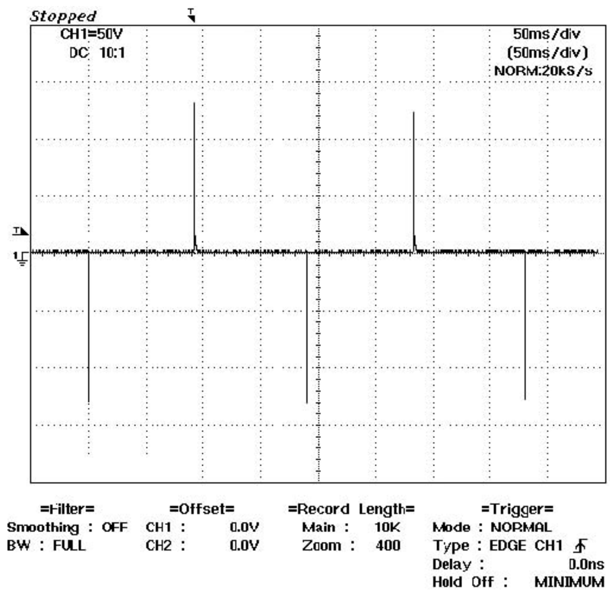

Figure 4 ±130V interference

Solution:

The solution uses the ZXCT1009 as shown in Figure 5 below.

- First determine R_G as follows

Set V_{SENSE} to 100mV (at 3A this would mean a loss of 300mW in R_S)

Hence,

$$R_S = \frac{V_{SENSE}}{I_{LOAD}} = \frac{0.1}{3} = 33m\Omega$$

Therefore,

$$I_{OUT} = G_T \cdot R_S \cdot I_{LOAD} = 0.001 \cdot 0.033 \cdot 3 = 0.99mA$$

Giving,

$$R_G = \frac{V_{OUT(\max)}}{I_{OUT}}$$

- Next determine $R_{LIM(MIN)}$ and $R_{LIM(MAX)}$:

$$R_{LIM(\min)} = \frac{V_{PK} - V_{MAX}}{I_{OUT(\max)}} = \frac{130V - 20V}{25mA} = 4.4k\Omega$$

$$R_{LIM(\max)} = \frac{R_G\left(V_{SUPPLY(\min)} - (V_{DO} + V_{OUT(\max)})\right)}{V_{OUT(\max)}} = \frac{5.05(12 - (2.5 + 5))}{5} = 4.545k\Omega$$

As the two values are very close, either value can be used. Hence R_{LIM} = 4.4k - 4.5k.

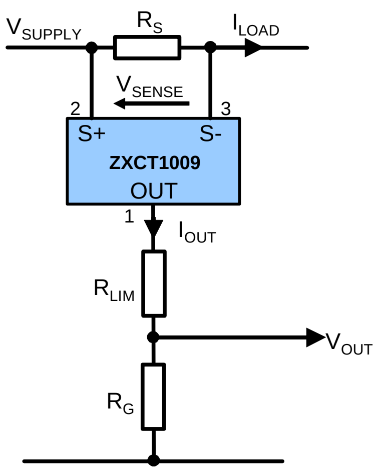

Figure 5 Solution to worked example

Note, that the two values can converge which is also acceptable. If, as can sometimes happen, $R_{LIM(min)}$ is larger than $R_{LIM(max)}$, this would indicate that the maximum output voltage, $V_{OUT(max)}$, required from the circuit is too high for the set of circumstances. This can be corrected by doing any or all of the following.

- Reduce $V_{OUT(max)}$ this means lowering the value of R_G.
- Increase minimum supply voltage $V_{SUPPLY(min)}$.
- Reduce I_{OUT} (note that, in cases where the transconductance is internally fixed, this can only be done by reducing R_S which will result in an increase in error which may not be desirable).

Conclusion

Protection of current monitors from transients and external noise can be easily achieved with the addition of a few components.

Recommended further reading

1. AN39 - Current Measurement Applications Handbook
2. AN45 - High voltage current monitoring using the ZXCT series in power supplies

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