APPLICATION NOTE AN-126

Powered by CITA technologies

Relay Driver

Keywords: **Relay, Driver, Inductive, Load**

Specifications Reference: **None**

Scope: **BPSX, BPWX and BPH Modules**

Reference Application Notes: **AN-441: Zero Crossing**

Introduction:

The relay driver is a typical and often used application for the "Vo" output of a Bias power supply, particularly in products where Bias supplies all of the power required by the product. Although many designers have used open-collector transistors or MOSFETs for these purposes, experience with proper coil suppression can be lacking. Erratic operation and shortened product life are symptoms of improper or non-existent suppression. This application note has been written in response to a number of application problems resulting from improper/non-existent relay coil suppression.

Background:

When electromagnetic relays in particular, and inductive loads in general, are rapidly de-energized, the collapse of the magnetic field results in a significant voltage transient. This is due to the inductance attempting to discharge the stored energy when the current flow stops. A 12VDC relay may generate ten times its rated voltage during turn-off. This large voltage transient can cause semiconductor breakdown, create EMI, degrade switch contacts and destroy components.

A number of suppression choices exist: bilateral transient suppressor diodes, a reverse-biased rectifier diode in series with a zener diode, metal-oxide-varistors, a reversed-biased rectifier diode in series with a resistor, a resistor only, reversed-biased rectifier diodes, a resistor-capacitor "snubber" or a bifilar wound coil with the second winding used as the suppression device.

Application:

Although the use of coil suppression is necessary to ensure at least one aspect of product reliability, there can be problems if it is improperly designed. Relays are normally designed without regard for the dynamic impact of suppressors. As a result, design verification of switching life (for normally-open contacts) is obtained with an un-suppressed relay coil and specifications for rated electrical life are usually based on that premise.

The successful "breaking" of a DC load requires the relay contacts to open with reasonably high speed. A typical relay will have an accelerating motion of its armature toward the de-energized position during drop-out. The velocity of the armature at the instant of contact opening plays a significant role in the relay's ability to avoid welding its contacts. The armature must have enough inertia and/or force to break any light welds made during the "make" of a high current resistive load (or one with a high in-rush current). It is the velocity of the armature that is affected by coil suppression. The suppressor provides a conducting path allowing the stored energy in the relay's magnetic circuit to decay more slowly than if un-suppressed, thus reducing armature velocity; risking the welding of the relay contacts.

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Based upon the impact on armature motion, and optimizing for normally-open contacts, the best suppression method is to use a reversed-biased rectifier diode in series with a zener diode. This is done such that their anodes (or cathodes) are common and the rectifier diode prevents normal current flow. This suppressor will have the least effect on relay dropout dynamics, since the relay transient will be allowed to go to a predetermined voltage level and then permit current to flow with a low impedance. This results in the stored energy being quickly dissipated by the suppressor. This is normally a low-cost method and the only design precaution is to select a zener with an appropriate breakdown voltage and impulse power specifications adequate for the relay in its application.

Many engineers use a rectifier diode alone to provide the transient suppression for relay coils. While this is cost effective and fully eliminates the transient voltage, its impact on relay performance can be problematic. Unexplained, random "tack welding" can occur with this approach. To illustrate the impact of various coil suppression on the relay response time, consider the following data that was recorded using an automotive ISO type relay with a 55 ohm coil and with 13.5VDC applied to the coil (source Tyco Industries).

Supression Technique	Drop-out time (mSec)	Theoretical transient (Volts)	Recorded Transient (Volts)
Unsupressed	1.5	n/a	n/a
Diode & 24V zener	1.9	-24.8	-25
Diode	9.8	-0.8	-0.7

Table 1

With the suggested suppression techniques based on normally-open contact performance, a qualifying comment concerning the normally-closed contacts; when the primary load is on the normally-closed contacts (and a small load or none on the normally-open), it may be desirable to use a rectifier diode alone as the relay suppression (or perhaps a rectifier diode and a lower voltage zener diode, or possibly a low value of series resistor). The retarded armature motion that adversely impacts normally-open contact performance will typically improve normally-closed contact performance. The improvement results from less contact bounce during closure of the normally-closed contacts. This results from the lower impact velocity created by the retarded armature motion and has been utilized in the past to improve normally-closed contact performance on certain relays.

Application:
Bias recommends only the following suppression approaches:

1. Bilateral transient suppressor diodes that is similar in V-I characteristics to two zener diodes connected anode-anode (or cathode-cathode).
2. A reverse-biased rectifier diode in series with a zener diode such that their anodes (or cathodes) are common and the rectifier diode prevents normal current flow.
3. A reversed-biased rectifier diode.

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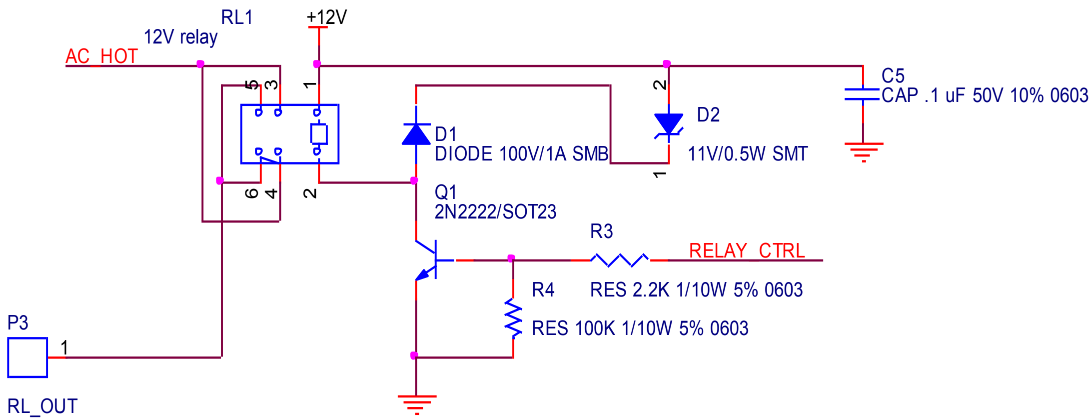
Although some may suggest suppression of either the relay coil (or load) or the switch (transistor or MOSFET) is acceptable, it is preferred to have the suppression in parallel to the coil/load as it is best to deal with transients at their source. So called "clamped MOSFETs" packaged as such or in integrated "inductive load drivers" may be used. However, parallel coil/load suppression must be used as well.

The following relay drive protection circuit is designed for use with the Bias products identified in Scope



12V Relay circuit (For reference only)

Figure 1

Notes to Figure 1:

1. Q1 can be either a MOSFET or transistor.
2. D1/D2 voltage should be 7 to 10 volts less than the reverse breakdown voltage of Q1.
3. Clamped MOSFETS (e.g. OnSemi NID9N05CL, Diodes, Inc. ZXMS6006DG/SG) will self protect, but will not eliminate problems.
4. Leads connecting D1, D2 and RL1 should be as short as possible.
5. Figure 1 is for reference only based on relay with 12VDC coil

Restrictions:

1. This approach is harmonized with Bias Power power supplies identified in Scope and the unique characteristics of the Bias Power Vo output, no applicability or suitability with other power supplies is expressed or implied.
2. Results not guaranteed, testing has confirmed this circuit, your results may differ, testing for conformance still required. Variations in test methods, layout, adjacent components and devices may alter results.

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