NASA TECH BRIEF

Ames Research Center

Driver Circuit for Inductive Loads

The problem:

To design a circuit which can drive inductive loads such as are presented by the solenoids of cold-gas thrust valves used in rocket attitude control systems. Since the fine adjustment of attitude requires that the thrust valves deliver very small increments of gas on command, the very rapid on-off valve operation makes it impractical to diode-clamp the turn-off transient voltage of the valve coil.

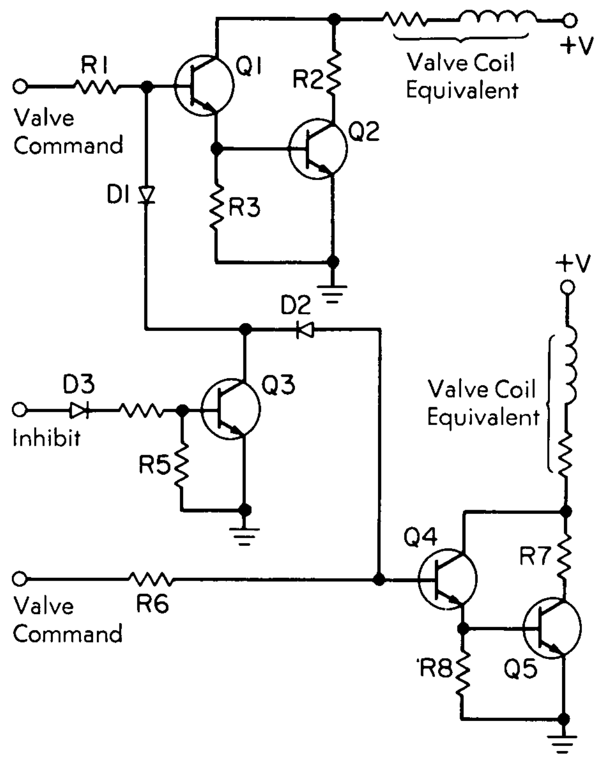
The solution:

A circuit based on the use of power transistors which do not display second breakdown under valve loading.

How it's done:

The figure shows two valve driver circuits controlled by an inhibit circuit. Each drive circuit supplies power to its valve solenoid when about +3 volts appear at the valve command terminal and turns off power when about +0.5 volt appears at the terminals. The drive circuits are inactivated by an inhibit signal of the order of +12 volts.

Transistors Q1 and Q2 are in a Darlington configuration for power gain; resistor R2 allows Q2 to saturate completely, and R3 provides a leakage path to ground. Both Q1 and Q2 are off when a negative or zero volt input appears at the input terminal leading to the base of Q1, and since no valve current flows, the valve is in the off position. When a positive input command of more than one volt is applied, both Q1 and Q2 turn on and the resulting current turns on the valve. The current through the valve increases exponentially, and typically has a 10-millisecond time-constant. Now, if the transistor drive circuit is turned off abruptly, a voltage is induced across the inductor of a magnitude and duration which keeps the collector current flowing in Q2, thus driving it into avalanche and high power dissipation,



i.e., the so-called second breakdown where the base no longer controls normal collector characteristics. Physically, second breakdown is caused by very localized current concentrations, resulting in the uncontrollable generation and multiplication of carriers, with a sudden reduction of collection impedance.

(continued overleaf)

Because the duration of this phenomenon exceeds the thermal time constant of the small area in which current is flowing, the transistor is damaged.

The usual methods for preventing damage of transistors connected to inductive loads use "free wheeling" diodes, Zeners, or combination of Zeners and diodes; however, these methods increase the time required for a solenoid to unload its magnetic field when current is interrupted.

The solenoid driver circuit depicted in the figure performs successfully because Q2 (and Q5) is selected from a small group of transistors which have adequate instantaneous power dissipation and which do not readily exhibit second breakdown. Peak voltages, power dissipations, heat sink requirements, and thermal stability considerations can be obtained by theoretical analysis; the effectiveness of the circuit is proven by tests of the assembled components.

Note:

Requests for additional information may be directed to:

Technology Utilization Officer
Ames Research Center
Moffet Field, California 94035
Reference: TSP 72-10268

Patent status:

No patent action is contemplated by NASA.

Source: Walter A. Cooke of
Lockheed Missiles & Space Company
under contract to
Ames Research Center
(ARC-10073)