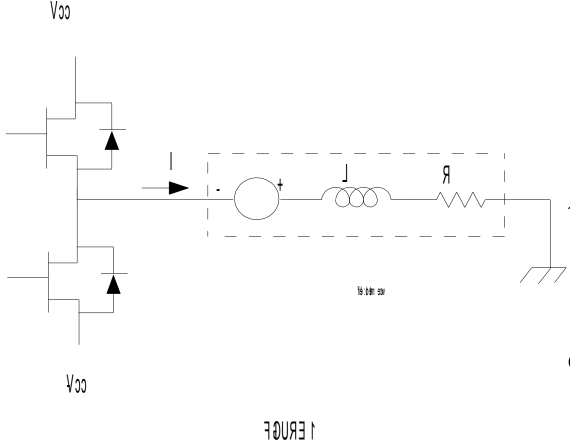

To: File, wpfiles| tiedwns\motor4.wp6

From: Jon Hagen
Date: Mar. 5, 1999
Subject: Switching converter for servo motor control

For simplicity, assume we are dealing with an internally commutated dc motor with inductance L and resistance R. For bidirectional operation, we need to be able to drive current in either direction. In addition, we need to be able to accept the energy produced by the motor during regeneration. If we use two power supplies, the simple totem pole circuit of Figure 1 will suffice.

The voltage generator inside the motor block represents the back EMF, non-zero when the motor is turning.

Case 1. Positive current (and therefore positive torque).

1a. The motor is moving in the direction of the torque.
The back EMF is negative, tending to decrease the current. A net positive voltage must be applied to the motor. To do this, the top transistor and the bottom diode operate as a step-down (buck) converter. A 50% duty cycle applies a net voltage of zero. For any duty cycle, while the transistor is on, energy flows *into* the motor and while the transistor is off, and the diode is conducting, energy flows *out* of the motor.

1b. The motor is moving in the direction opposite to the torque.
The back EMF is positive, tending to increase the current. At low speeds, the back EMF will help to maintain the required current; the operation described in 1a will simply operate with a lower duty cycle. At some speed the required net voltage will be zero. Here the duty cycle will be 50%. At this point no net power is being supplied to the motor. Its back EMF is producing all the current needed to maintain the desired torque. As the speed is increased further, the duty cycle must become less than 50% to maintain the desired torque. Since the current comes more of the time from the negative supply than from the positive supply, there is a net average power supplied by the motor to the outside world, i.e. regeneration.

Case 2. Negative current (and therefore negative torque).
Same explanation as above, except that the lower transistor is pulsed.

When only one power supply is available, a four-transistor H-bridge circuit is used (Figure 2).

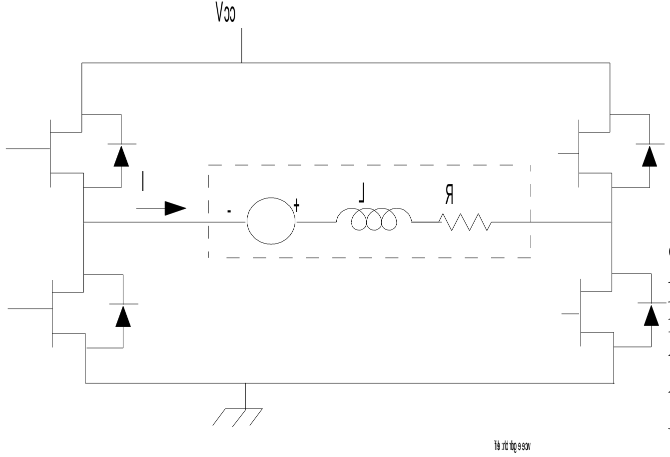

FIGURE 2

Consider again the case of positive current (and therefore positive torque). As long as net power must be supplied to the motor, the top left transistor is pulsed while the lower right transistor is held on. In this operation, the upper left transistor and lower left diode operate as a step-down (buck) converter. As the external power requirement goes to zero, the duty cycle in this circuit goes to zero. When power must be taken from the motor (regeneration), the bottom left transistor is held on while the bottom right transistor is pulsed. In this situation, the bottom right transistor and the upper right diode operate as a step-up (boost) converter.