LSI/CSI

APPLICATION NOTE 101

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THREE AND FOUR PHASE BRUSHLESS DC MOTOR CONTROLLERS USING PULSE-WIDTH MODULATION

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ABSTRACT

This paper describes the five motor circuits which drive brushless DC Motor controllers and are available as standard products from LSI Computer Systems, Inc. The theory of operation of each of the circuits is explained, accompanied by circuit block diagrams. Numerous applications are illustrated and interface circuits for driving high voltage motor windings using bipolar and MOS power transistors are indicated. The first of these five is the LS7261, which is an open or closed loop commutator sequencer. It operates at 7 to 28 Volts and has externally selectable input and output codes for 60˚, 120˚, 240˚ and 300˚ electrical sensor spacing. It has a pulse width modulation for analog speed control and forward/reverse inputs. In addition, this circuit contains positive static braking, overcurrent input, and an output enable control. There are 6 outputs for driving 3 phase or 4 phase motors.

Whereas in the LS7261 the overcurrent causes the outputs to switch on and off directly from the overcurrent sense input, the LS7260 and LS7262 circuitry causes the outputs to switch off immediately upon sensing the overcurrent condition. It only switches back on at a rate determined by the pulse width modulation chopping rate.

The LS7263 is a highly accurate speed regulator operating at 10 to 28V and designed to control the speed of a 3-phase brushless DC motor. The specific circuit is programmed for 3600 RPM applications using a 3.58MHz crystal. Other speeds can be controlled by changing the crystal frequency or by having the circuit reprogrammed by the company. It is presently available for 4 or 8 pole motors and 60˚ and 120˚ sensor separation.

The LS7264 is basically the same as the LS7263 except that it was designed for the 4-phase brushless DC motor.

BRUSHLESS DC MOTOR COMMUTATOR

The advent of brushless DC motors has brought with it the need to integrate its unique circuit control requirements into a flexible, low cost integrated circuit. The ideal circuit should be able to commutate 3 and 4 phase motors. It should have some means of controlling the speed of the motor. It should also have overcurrent protection circuitry, a brake input, a forward/reverse input and be able to accommodate different electrical sensor spacings.

The heart of the LS7261 and the LS7262 commutator circuit is the decoder which senses the Hall effect inputs and creates the proper turn-on sequence of the output devices which are used to drive the motor. In addition, these circuits are able to commutate properly whether the Hall switches are separated electrically by 60˚, 120˚, 240˚ or 300˚. Figure 1 illustrates the commutator circuit block diagram. CS1 and CS2 inputs are used to select the proper decode mode depending on the Hall electrical separations. S_1, S_2, and S_3 designate the Hall inputs. Also indicated are the forward/reverse inputs, the enable input, the brake input, the common input and the output drivers. The speed of the motor can be controlled by the sawtooth oscillator circuitry. The external R-C network was chosen to set the oscillator at approximately 30KHz. The oscillator will ramp within the power supply rails as shown. By adjusting V_{TRIP} to the desired voltage, the comparator output duty cycle can be adjusted to be between 0 and 100%. This output is then applied to the output driver circuitry and causes the outputs to be chopped at the oscillator frequency. Varying the duty cycle will result in output drive signals that can vary from full-off to full-on or to any level in between.

The LS7260 and LS7262 incorporates a flip-flop as part of the overcurrent protection circuitry. An overcurrent condition generates a voltage greater than V_{REF} and resets the flip-flop which disables the output drivers through the And gate. When the overcurrent condition terminates, the next positive sawtooth oscillation edge will enable the drivers

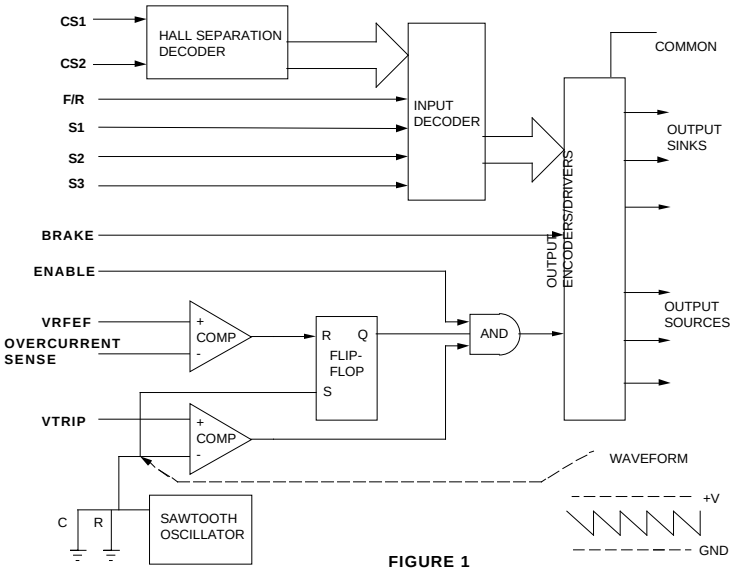

FIGURE 1
LS7261/LS7262 BLOCK DIAGRAM