STATE OF SOLID STATE

A switch-mode power supply controller

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THE GROWING POPULARITY OF THE switch-mode or switching-type power supplies has—in the last six or seven years—led to the development of more specialized component-types than any other electronic circuit since the early days of radio. It has involved the development of special types of rectifier diodes, inductors, and a wide variety of dedicated IC's.

Switching power supplies

Before taking a look at the Signetics NE5561 switch-mode power supply controller IC that we're covering this month, let's take a look at Fig. 1 and see what a switching power supply is all about. Basically, a switch-mode power supply can be thought of as a type of series voltage-regulator in which the pass (series) transistor has been replaced by a solid-state switch and a series inductor.

The switch-mode power supply controller—enclosed by dashed lines—has four major sections: a precision free-running multivibrator or clock, an electronic power-switch, a pulse-width modulator (PWM), and an error amplifier.

The *multivibrator* supplies the clock frequency and any timing signals required by the exterior circuit design or application. It drives one input gate of the PWM and, in some applications, provides the switching drive-voltage in transformer-type flybacks and DC-to-DC converters. The *electronic switch* is closed and opened (switched between saturation and cutoff) at a rate and duty cycle that keeps the supply's output constant.

The *pulse-width modulator* accepts signals from the clock multivibrator and the error amplifier. Its output is a pulse train whose duty cycle is determined by the output of the error amplifier in the feedback path between the power supply output and the PWM. The *error amplifier* compares the voltage tapped from the power supply output with a precision reference-voltage, and develops an error voltage based on the difference between the input signals.

The error voltage varies the switching-pulse duty cycle (the ratio of the on-time to the total time period) as a function of the input voltage and the output load conditions. The switch's on-time is increased if the sample voltage tapped from the supply output is low compared to the reference voltage. If the output sample is higher than the reference voltage, the error voltage narrows the switching pulse, decreasing the switch on-time.

Commutating diode D1 is also called the "catch" or "free-wheeling" diode. Its action is similar to that of a damper diode in TV-flyback power supplies. The abrupt turn-off of the switch causes the choke's magnetic field to collapse and develop a counter electromotive force (emf) that tends to keep current flowing through the choke. During that period, D1 conducts, permitting the counter-emf current to maintain the charge on C1.

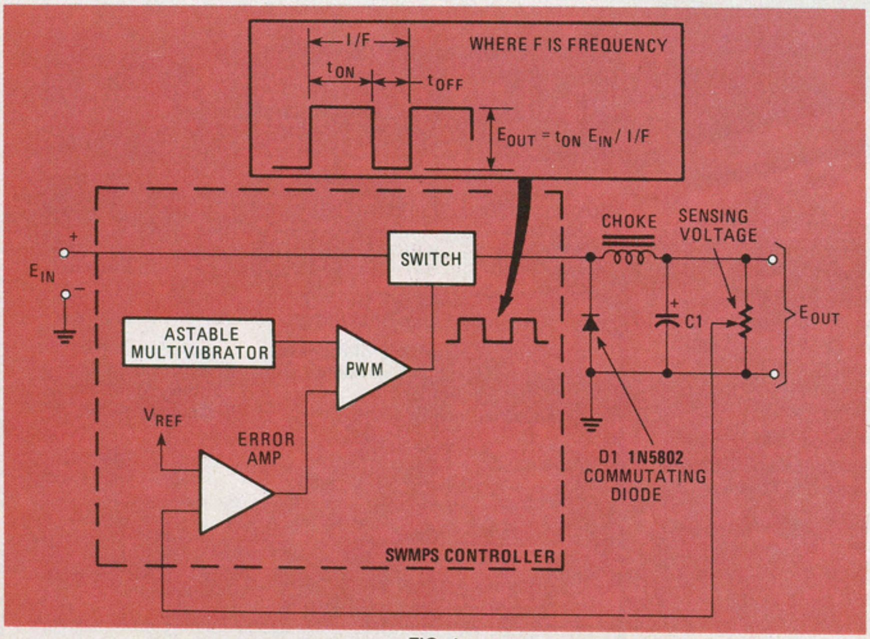

FIG. 1

The NE5561

Small DC-motors have been used for years in automotive and aircraft applications, and are finding many new uses as more and more electronic and computer controls are added.

The circuit in Fig. 2 shows how the Signetics NE5561 switch-mode power supply controller can be used in a DC motor-control application. The circuit is efficient and does not present the heat and power-dissipation problems that are inherent in linear speed-controllers.

The NE5561 provides constant motor-speed through pulse-proportional drive based on feedback from a tachometer that is driven by the motor. A switching circuit consisting of transistor Q1 and commutating diode D1 delivers the programmed pulse energy to the motor. The motor drive-current is in the form of constant-frequency, variable-width power pulses.

The heart of the NE5561 is the sawtooth generator that drives the PWM and the SET terminal of an R-S flip-flop latch. The oscillator frequency, determined by R_tC_t, is set at 20 kHz, a frequency high enough to eliminate the audio noise associated with lower-frequency switching drives. The output of the DC tachometer is proportional to the motor speed and should be 2.7 volts per 1000 rpm. The tachometer output is applied as negative feedback to the input of the error amplifier through a voltage divider that delivers 3.75-volts DC to ensure servo lock.

Duty cycle control

The motor-speed controller feeds a chain of 12-volt pulses to the motor. The duty cycle of the pulses is directly proportional to the load-torque demand. The circuit can be modified for torque-limiting by feeding a derivative of the motor return current (typical current drawn might be 0.3-amp no-load, and 0.6-amp full-load) back into the CURRENT SENSE terminal, pin 6.

An external method of preventing the

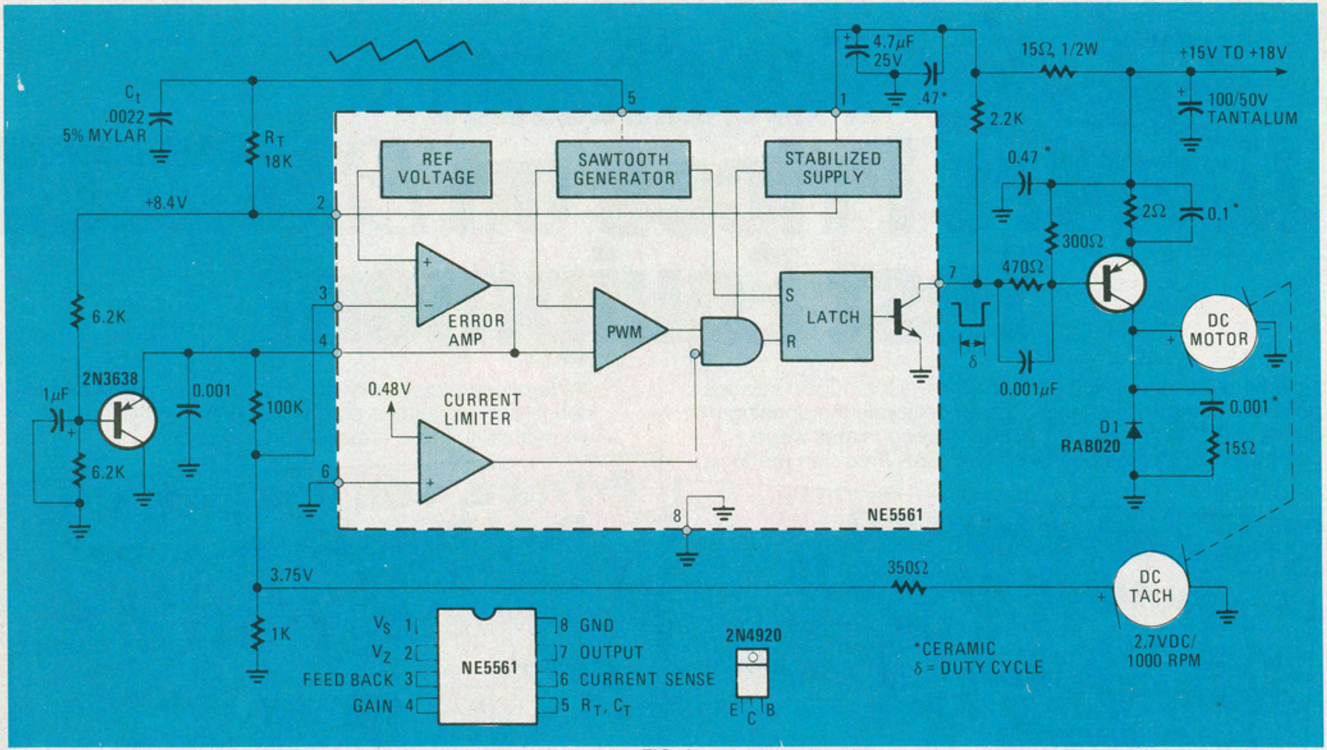

FIG. 2

duty cycle from immediately rising to its maximum is required at the initial start-up of most circuits driven by the NE5561. Without cycle-limiting, at initial turn-on, the DC feedback voltage at pin 3 of the IC is zero. That causes the error amplifier's output to go high and force the PWM to its maximum duty cycle.

This circuit was taken from the NE5561 data sheet. For additional information and some interesting power-supply circuits, refer to that data sheet and *Switch Mode Power Supply Circuits*, from Signetics Corp., PO Box 409, Sunnyvale, CA 94086. **R-E**