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Linear Voltage Fan Speed Control Using Microchip's TC64X Family

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INTRODUCTION

Pulse Width Modulation (PWM) fan speed control methodology pulse-width modulates a fan's full-rated power supply voltage at a low frequency, typically 30 Hz. A typical PWM circuit, consisting of a transistor in series with a fan, can be small and inexpensive because it is either fully on or completely off. This efficient control methodology affords a very wide speed-control range (typically 10% to 100% of full speed) because the fan motor is exposed to its full-rated voltage during the active portion of the PWM cycle.

PWM control works with standard, two-wire Brushless DC (BDC) fans of various sizes. However, very large fans (with operating currents of 0.5A or more) can sometimes produce an unwanted acoustic noise component when operated with PWM control. In most cases, this is remedied by slowing the edges of the output switching transistor with the addition of a small capacitor. In the most severe cases, this may not be sufficient, which forces the user to consider linear voltage speed control.

Linear voltage speed control operates by continuously varying the DC supply across the fan. The lower the voltage, the slower the fan operates. While this methodology eliminates the acoustic noise issue described earlier, it creates other problems. For example, the output device must be operated as a linear amplifier (instead of a switch), so its size and cost must be increased and may require heatsink mounting. Also, most fans cannot be operated at less than half the full-rated supply voltage, thereby limiting the fan speed control range to only 50% to 100% of maximum. With the inherent limitations of linear voltage speed control in mind, this application note describes a low-cost technique for operating the TC642/646/648 PWM Fan Managers in linear voltage speed control mode.

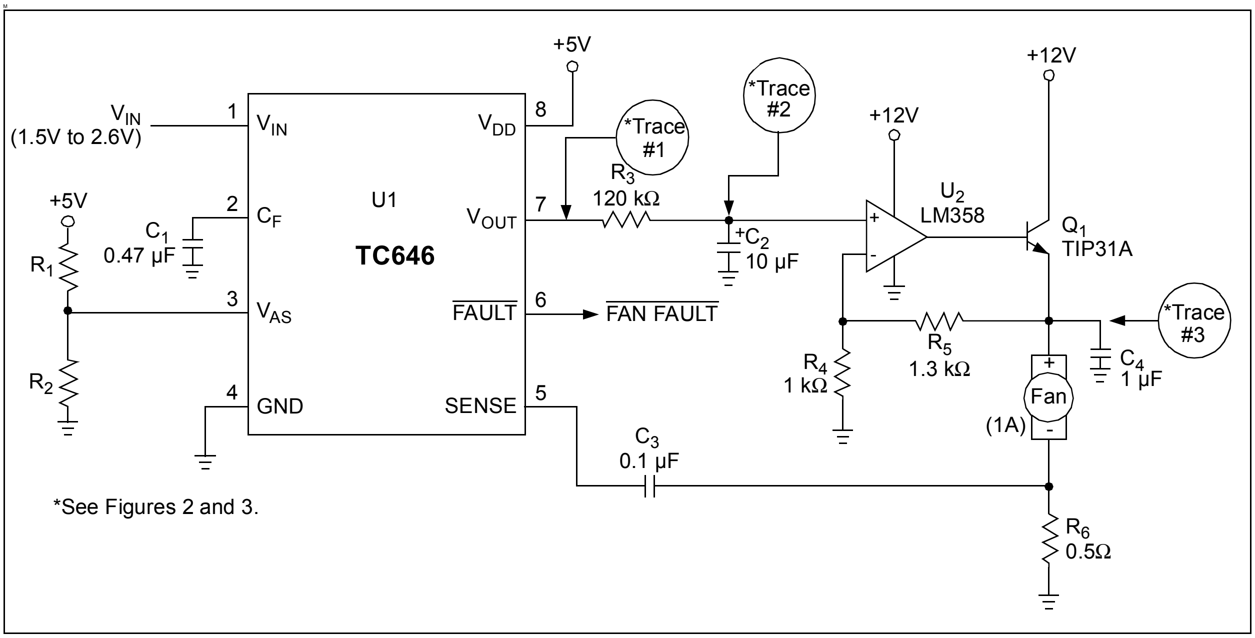

FIGURE 1: Linear Voltage Speed Control Circuit.

MICROCHIP'S TC64X FAN MANAGERS

The TC642/646/648 Fan Managers are stand-alone, PWM output fan speed controllers/monitors that operate with any standard two-wire BDC fan. They control fan speed using a low frequency PWM, modulated by a 1.25V to 2.65V typical input signal. This is usually provided by a thermistor or other low-cost temperature sensor. The TC642 and TC646 have built-in fan fault detection circuits that monitor the fan current waveform for commutation pulses. On-board circuitry compares the presence (or absence) of these pulses to the fan's operating state to determine if a fault condition is present. For more information, please consult the TC642 (DS21444), TC646 (DS21446) and TC648 (DS21448) datasheets.

LINEAR VOLTAGE SPEED CONTROL CIRCUIT

Figure 1 shows the circuit implementation for a linear voltage speed control/fan fault detector using the TC646 fan manager with auto-shutdown. All the features of the TC646 (including fan fault detection) remain intact. Compared to the TC646 circuit recommended in the datasheet, the circuit of Figure 1 adds a low-cost, single-supply Operational Amplifier (Op Amp) (such as an LM358), gain-setting resistors R_4 and R_5 and a PWM averaging circuit consisting of R_3 and C_2. As is the case with all linear voltage fan speed control schemes, series-pass transistor Q_1 must have sufficient power and current-handling capability to support the fan of choice. Depending on the voltage and current of this fan, Q_1 may require a heatsink. The remaining circuitry components (i.e., values of R_1, R_2, R_6, and C_3) are consistent with the recommended circuit configuration in the TC646 datasheet (DS21446).

The PWM output waveform from the TC646 is averaged by R_3 and C_2. The averaged PWM signal is applied to a simple, non-inverting voltage amplifier consisting of Op Amp U_2 and resistors R_4 and R_5. Transistor Q_1, biased by the feedback loop around U_2, provides the output current necessary to drive the fan. As shown in Figure 2, the PWM signal (trace 1) is averaged (trace 2), resulting in the DC drive level applied to the fan (trace 3). Notice the PWM duty cycle in Figure 2 is 50.2%, resulting in a fan drive voltage of 6.1V (fan running at approximately half-speed). Figure 3 shows the effects of increasing PWM duty cycle to approximately 75%, causing a corresponding increase of the fan drive voltage to 8.7V.

The circuit configuration and values shown in Figure 1 will support 12V fans to a maximum operating current of 2A, (with the Q_1 mounted on the appropriate heatsink). Higher voltage and/or higher current fans can be supported using the appropriate operational amplifier/transistor combination.

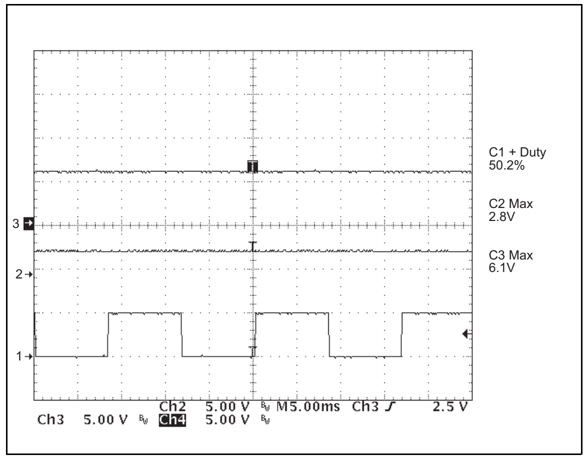

FIGURE 2: *Waveform at 50% Duty Cycle.*

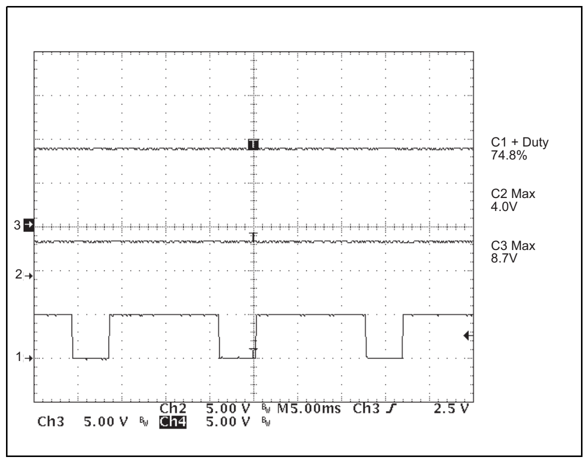

FIGURE 3: *Waveform at 75% Duty Cycle.*

SUMMARY

The TC64X family of BDC Fan Managers can be operated in a linear voltage speed control mode with the addition of a few inexpensive components. In some cases, this speed control methodology is recommended for large fans and limits acoustic noise that would otherwise result from PWM speed control.

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