Fan Controller Overview

Texas Instruments fan controller ICs provide a complete solution for monitoring and controlling 2-wire, 3-wire, and 4-wire brushless DC (BLDC) chassis fans. A key feature of the fan controller is its tachometer, or TACH, input pins and its PWM (pulse-width modulated) output pins. The TACH input measures the time between pulses generated by the fan, which determines the rotational speed (RPM) of the fan. The PWM output regulates the speed of the fan by varying the duty cycle supplied to the fan.

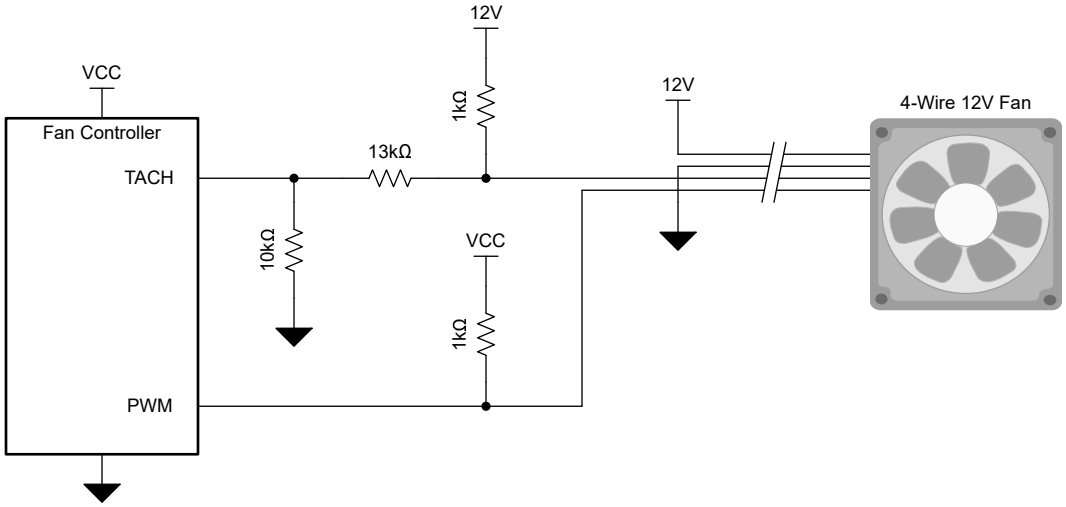

Figure 1. Fan Controller with 4-Wire 12V Fan

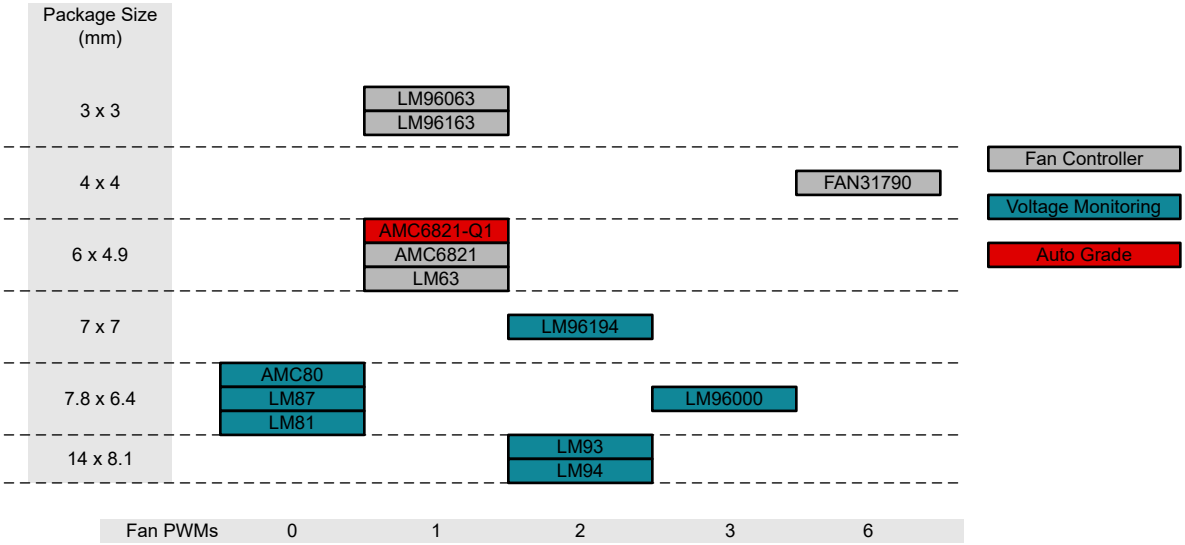

Figure 2. Fan Controller Portfolio

Texas Instruments offers fan controllers ranging from single-fan designs to multi-channel controllers. The FAN31790 supports up to six independently controlled PWM outputs with six corresponding TACH inputs. When PWM outputs are not required, the device can instead monitor up to 12 TACH inputs. The FAN31790 can be

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configured to regulate fan speed in RPM (revolutions per minute.) The FAN31790 has no temperature sensor, and cannot adjust fan speed to match the thermal conditions on its own.

The AMC6821 and its automotive-grade variant support a single 4-wire fan and include a closed-loop RPM control algorithm. An RPM target can be configured in the AMC6821, and it will attempt to restart the fan as well as trigger alarm outputs when there is a detected fan fault. The AMC6821 features both local and remote temperature channels. It is able to adjust fan speed according to the current remote temperature and a configured linear ramp rate. This is described as Linear RPM in Table 1.

Several devices support local and/or remote temperature monitoring, allowing fan speed to be adjusted automatically based on measured temperature. In the Fan Control column of Table 1, devices which adjust fan speed according to a look-up table are listed as TBL. The LM94 family of devices support both proportional/integral control as well as lookup table, and are listed as PI/TBL. The number of remote temperature channels is listed in the Temp# columns. A few of the fan controllers can also monitor system power supplies such as 12V, 5V and 3.3V. The presence of these voltage monitoring channels is noted in the ADC column.

Table 1. Fan Controller Portfolio

Device	Temp #	PWM	TACH #	ADC	Fan Control	Size (mm)	Comments
FAN31790	0	6	6+		RPM	4 × 4	Six-channel PWM output fan controller
LM96000	2	3	4	x	Linear	7.8 × 6.4	Voltage and remote/local temp monitor; PWM temperature control
LM96194	5	2	4	x	PI/TBL	7 × 7	Dual-Fan;4-Remote with Voltage Monitor; ß Comp; PWM PI control
LM94	4	2	4	x	PI/TBL	14 × 8.1	Voltage and remote/local temp monitor; PWM LUT Control; ß Comp
LM93	2	2	4	x	Table	14 × 8.1	Voltage and remote/local temp monitor; PWM LUT Control
AMC6821-Q1	1	1	1		Linear RPM	4.9 × 6	Automotive version of AMC6821
AMC6821	1	1	1		Linear RPM	4.9 × 6	Single Fan, Closed loop based on temperature or set RPM
LM96063	1	1	1		Table	3 × 3	QFN-10, single fan controller with closed loop LUT control; 2 Alert
LM96163	1	1	1		Table	3 × 3	QFN-10, single fan controller with closed loop LUT control; 2 Alert
LM63	1	1	1		Table	4.9 × 6	SOIC-8, single fan controller with LUT closed loop control
AMC80	0	0	2	x		7.8 × 6.4	Voltage supervisor with local temperature and TACH inputs
LM96080	0	0	2	x		7.8 × 6.4	Voltage supervisor with local temperature and TACH inputs
LM87	2	0	4	x		7.8 × 6.4	Voltage and remote/local temp monitor; Linear output and TACHs
LM81	0	0	2	x		7.8 × 6.4	Voltage and local temperature monitor with linear output and TACHs

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Speed Control for 3-Wire Fans

Table 2. Fan Wiring Pin-Out

Pin	2-Wire Fan	3-Wire Fan	4-Wire Fan
1	V+	V+	V+
2	GND	GND	GND
3		TACH	TACH
4			PWM

For 4-wire fan applications, the fan controller's PWM output can be directly connected to the fan's PWM control input (fourth wire). Since the PWM output is open-drain, a pull-up resistor must be provided. In most cases, the fan's PWM input presents a high impedance load, resulting in negligible current requirements from the fan controller output.

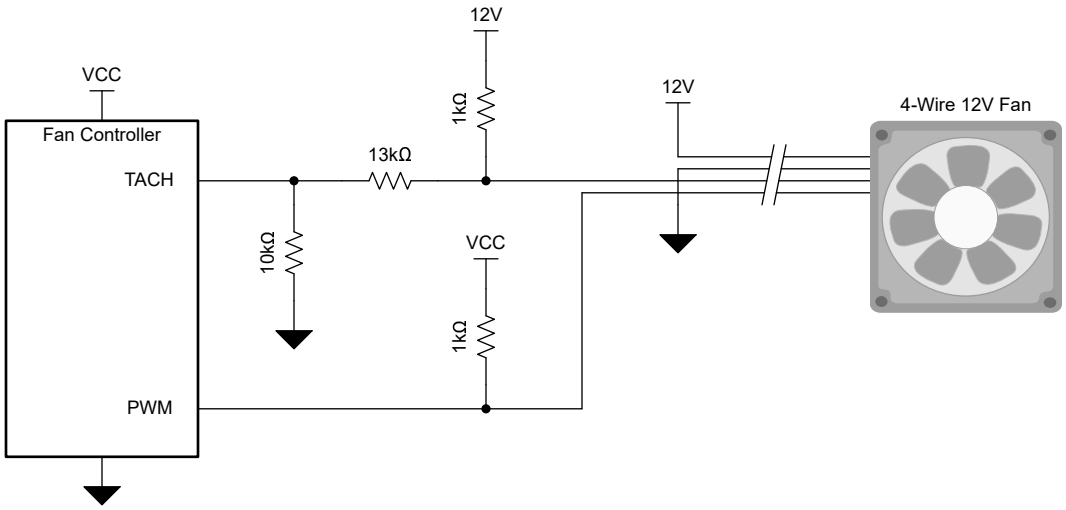

Figure 3. Fan Controller with 4-Wire 12V Fan

When using a 3-wire fan, the fan controller's PWM output cannot directly switch the motor supply wires. In this example, the typical application circuit uses an NMOS FET as a low-side switch in the fan's ground return path. Similarly, a PMOS can be implemented as a high-side switch for the fan's power pin. Most fan controllers offer PWM inversion to support these variations.

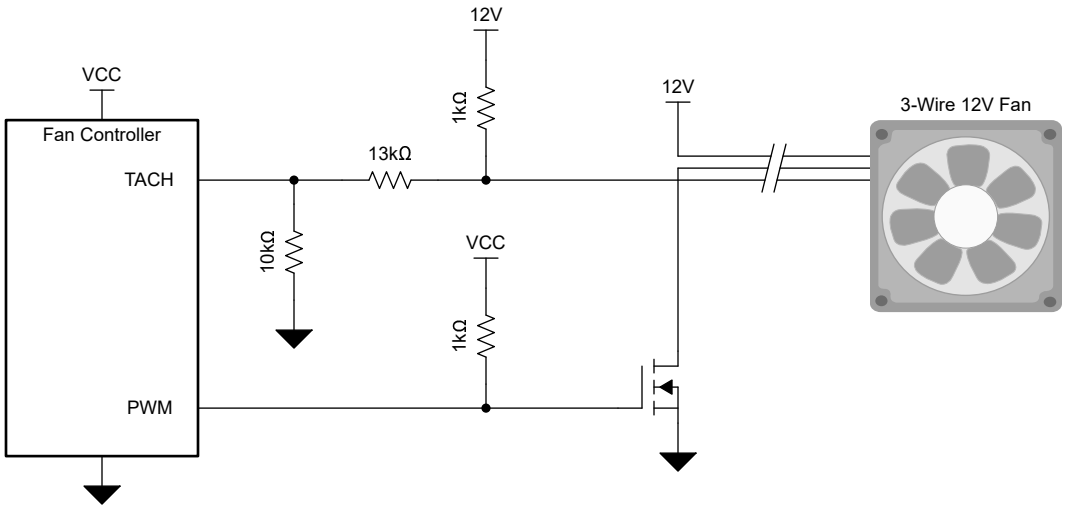

Figure 4. Fan Controller with 3-Wire 12V Fan

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In both 3-wire and 4-wire applications, the minimum value of the PWM pin's pull-up resistor must not exceed the current rating (IOL) of the PWM pin. The current rating is commonly stated as the test condition in the VOL specification.

Support for 12V Fans and Beyond

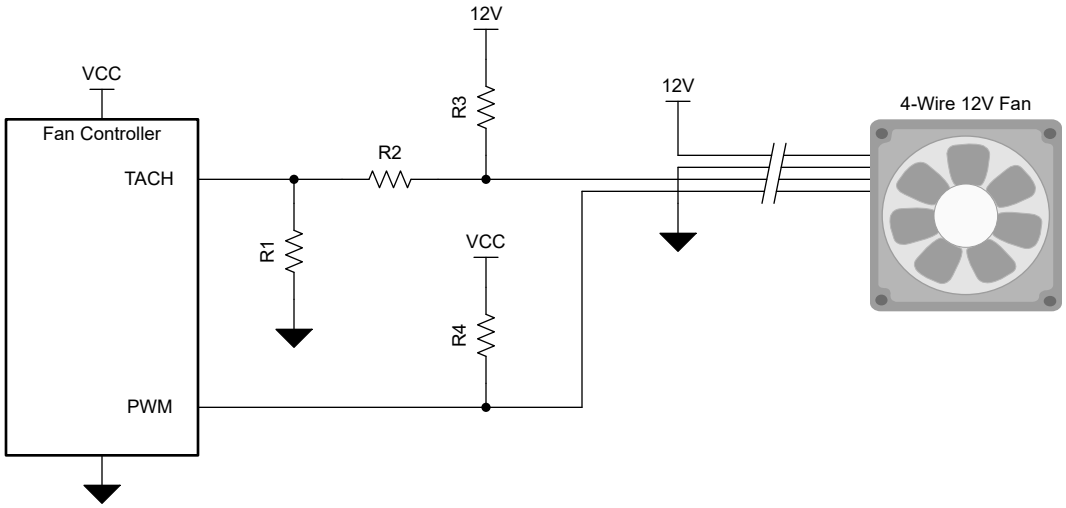

Figure 5. Fan Controller Resistor Network

Most fan controllers have an absolute max voltage rating of 6V. When the fan tachometer signal is pulled up to a voltage greater than the controller's input voltage rating, a resistor divider circuit is needed to protect the fan controller's TACH input from exceeding the absolute max rating. The tachometer output from the fan is typically an open-collector (or open-drain) output that requires a pull-up resistor. It's customary to connect this pull-up to the same voltage as the fan power. Even if the tachometer pull-up can be connected to a lower voltage, using the resistor divider provides protection against unexpected operating conditions and is therefore the recommended implementation for higher-voltage fan applications. The equation for the resistor divider is as follows.

$$Vih < \left[Vfan \times \frac{R1}{R1 + R2 + R3}\right] < Vmax \quad (1)$$

$$12V \times \frac{10k}{10k\Omega + 13k\Omega + 1k\Omega} = 5V \quad (2)$$

$$Vih(2.1V) < 5V < Vmax(6V) \quad (3)$$

When connecting PWM to a 4-Wire fan that exceeds the absolute max voltage, the PWM pull-up resistor is still commonly connected to the same VCC as the fan controller. This is because the 4-wire fan has a FET or BJT inside it to control the power switching. This allows the PWM input to switch on and off according to logic-level voltages. When using a fan that needs more voltage or current handling capability at its PWM input, the same NMOS low-side switch used for 3-Wire fans should be employed with a pull-up resistor.

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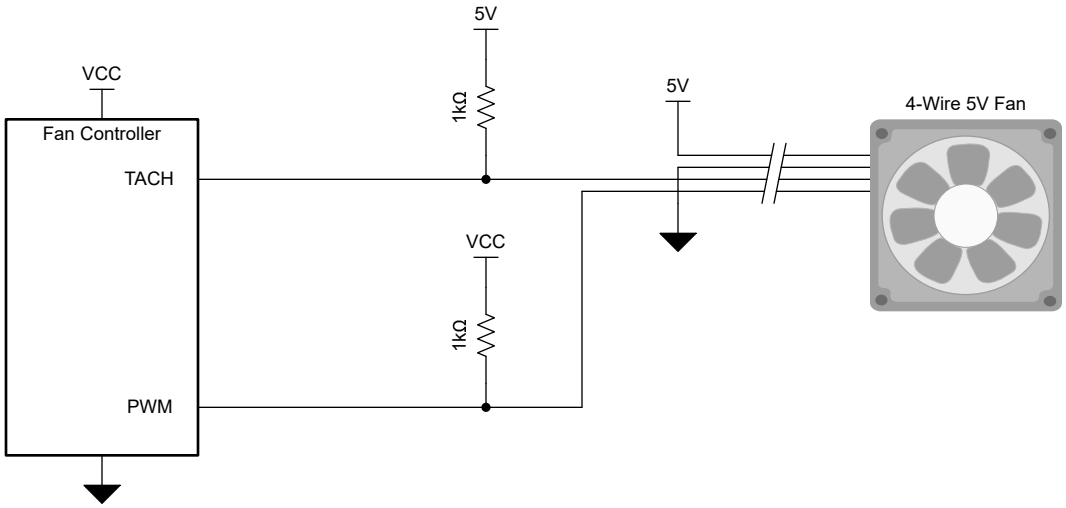

Figure 6. Fan Controller with 4-Wire 5V Fan

When a 5V or lower voltage fan is used that does not violate the absolute max rating of the fan controller, the resistor divider circuit can be omitted.

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