Electronic Controls for the Pantera.

Project #1 Fan Controller

Designer: Jon Haas [THPNMK03613]

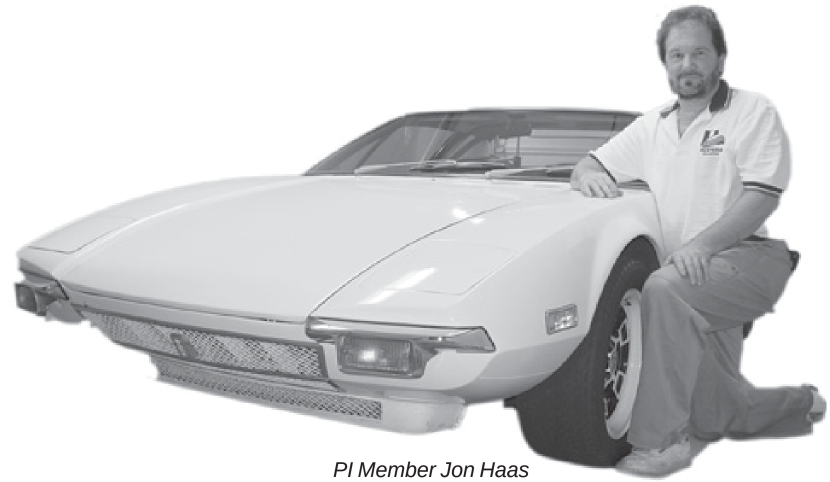
It seems that every topic on improving the cooling system in a Pantera has been written, but none have broached the integration of electronics to provide complete system control. The conventional relay and temperature switch combination has been the default electrical scheme for over 30 years while electronics in current production cars continues to flourish in many areas.

My goal is to improve the overall electrical power management in the Pantera without detracting from the original function and appearance. The first project was to determine what is ideally needed to control the cooling system and design a simple and durable circuit.

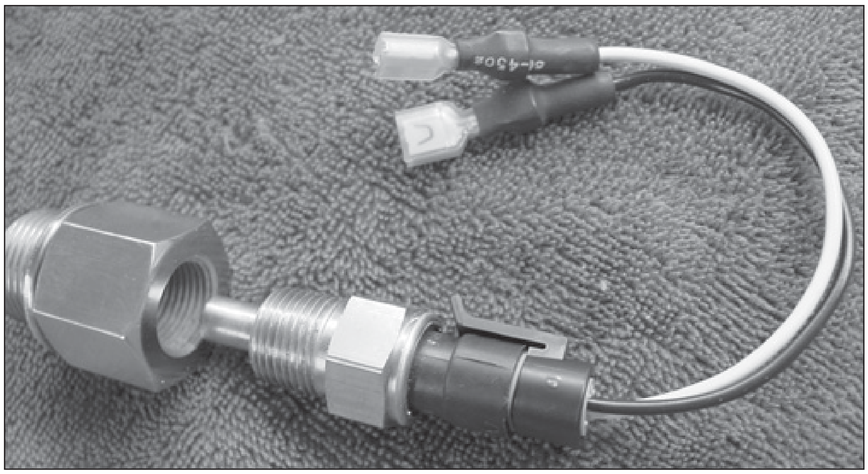
The engine temperature control centers on the mechanical thermostat that varies the volume of coolant flowing through the engine based on the expansion of a medium that opens a valve proportional to the temperature. The engine temperature then depends on the rated temperature of the thermostat, typically 190 degrees F in the Ford 351C. This requires the coolant be maintained at a temperature lower than the 190 degrees in order to control. If the coolant exceeds 190 degrees, the thermostat will be open for maximum flow and engine temperature can elevate beyond 190 degrees. Therefore, the fan control device should be less than 190 degrees in order for the coolant in the radiator to have capacity for removing heat from the engine when circulated.

The design goals for the electronic fan controller:

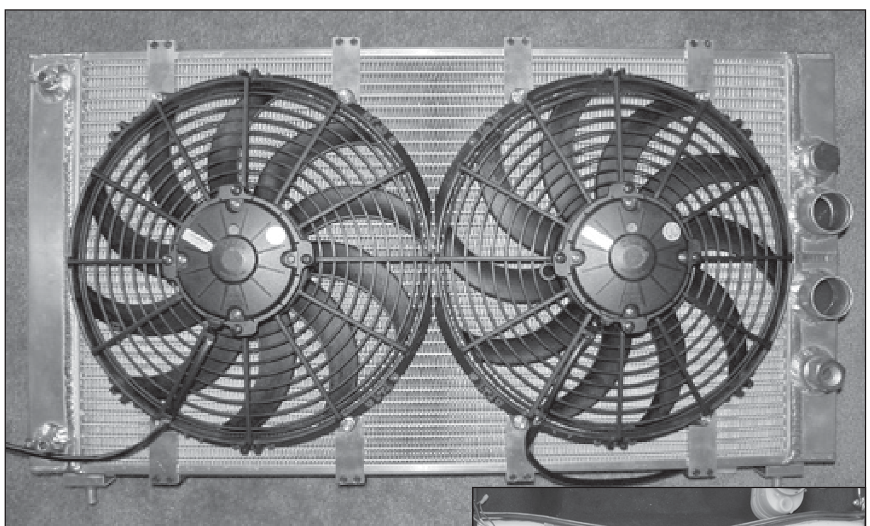
1. Maintain coolant temperature less than 190 degrees F.
2. Modulate the electrical power to the fans in proportion to the temperature of the radiator.
3. Use the existing Pantera wiring where possible.
4. Provide separate and redundant control outputs for each fan.
5. Utilize a readily available and inexpensive temperature sensor.
6. Ramped fan speed during hot engine restart.
7. Delayed fan operation during engine start.
8. Electronic controller size not to exceed the area of the original relays.
9. Amber indicator light in speedometer to indicate either maximum fan speed or fans enabled.

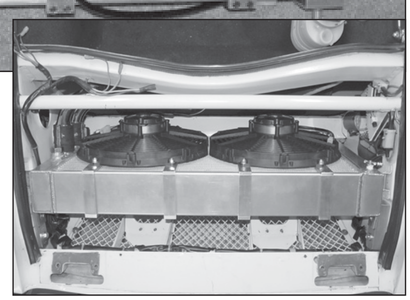


PI Member Jon Haas

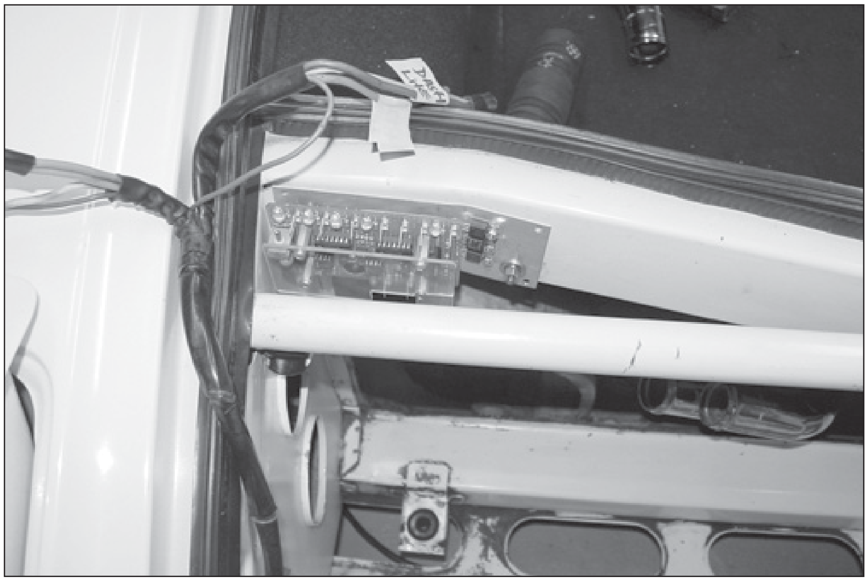


Above: *I chose a GM engine control temperature sensor because the output of the sensor is a variable resistor and the temperature to resistance ratio information is published. It has a brass pipe thread mount and isolated electrical connector. Using a pipe thread to metric adapter bushing, it easily mounts in the Fluidyne sensor port.*

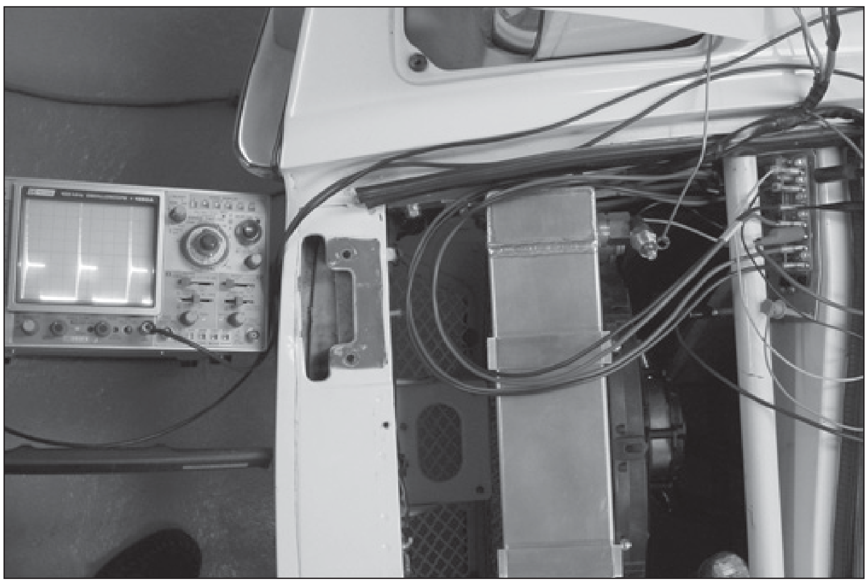




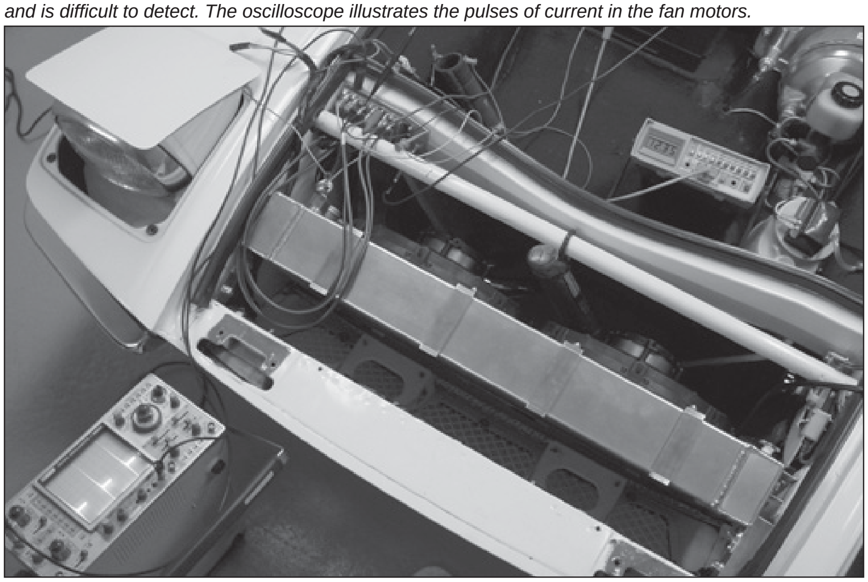
Above and right: *The fans can be of any type but I preferred the highest efficiency and highest airflow. The fans I selected were a pair of Spal, pull-type with 12" diameter, curved blades powered by a brush motor. The Spal fans specify a pull or push fan direction that hints that the motors are designed for a particular rotation direction for maximum efficiency. The motors are rated 13.5 amps at 13 volts each. This rating times 2 fans equals 350 watts, a considerable amount of power to cool any engine.*



Above: *The controller has a mounting footprint to occupy the same location as the original relays. Removal of the original relays and using the same studs to mount the controller allowed convenient connection to the original wiring.*



Above: *The noise of the fan blades moving air typically masks the 10 kHz sound from the fan motors and is difficult to detect. The oscilloscope illustrates the pulses of current in the fan motors.*



Temperature Sensor:

I wanted to use an inexpensive sensor that was readily available from many sources. I chose a GM engine control temperature sensor because the output of the sensor is a variable resistor and the temperature to resistance ratio information is published. It has a brass pipe thread mount and isolated electrical connector. Using a pipe thread to metric adapter bushing it easily mounts in the Fluidyne sensor port. I installed the sensor in the top port of the radiator near the coolant outlet. This will allow measurement of the water temperature that has passed through the radiator.

Fans:

The fans can be of any type but I preferred the highest efficiency and highest airflow. The fans I selected were a pair of Spal, pull-type with 12" diameter, curved blades powered by a brush motor. The Spal fans specify a pull or push fan direction that hints that the motors are designed for a particular rotation direction for maximum efficiency. The motors are rated 13.5 amps at 13 volts each. This rating times 2 fans equals 350 watts, a considerable amount of power to cool any engine. Most electric motors can consume as much as 10 times the running current during the acceleration from zero to full speed. To counter the high start-up current, a ramp-to-speed circuit is used to minimize the current. The ramp has a 500 mS time base and the temperature dictates the final speed.

The reason that this is important to consider is when you start your Pantera after it has been in use. In the conventional scheme, the radiator temperature switches are closed since the engine is still hot, when the starter motor engages the engine it consumes in excess of 100 amps, now add fans accelerating at 130 amps, a total of 230 amps! To alleviate the hot engine starting condition, a time delay is incorporated that is initiated when the ignition switch is turned on. The delay is 6 to 7 seconds before the fans are allowed to turn on regardless of the coolant temperature. After the delay timer has ended then the fans are ramped to speed over the 500 mS range. If the engine does not start, turning off and on the ignition switch resets the delay timer and starts the delay timer for another 6 to 7 seconds allowing a restart of the engine.

Left: *This proportional electrical power is connected to each of the fan motors by separate output connections and electrical devices internal to the controller. This design provides redundancy by making the high power control devices independent.*

Continued on page 24

Continued from page 19

Controller:

The controller has a mounting footprint to occupy the same location as the original relays. Removal of the original relays and using the same studs to mount the controller allowed convenient connection to the original wiring.

The control scheme used in the temperature control loop is a basic proportional control, an increase in temperature results in an increase in fan speed. The range of temperature control is 120 degrees to 190 degrees. Although the temperature sensor can measure lower than 120 degrees, a lower fan speed limit was established to stop the fans from operating at ambient air temperatures and from operating at slow fan speeds where efficiency is poor and would cause undue brush wear. The fan low speed limit is approximately 25% of full speed and represents minimal useful airflow. At temperatures of 190 degrees and above, 100 % of the power is applied to both fan motors. When the 100% power level is achieved, a signal is generated to activate the "fan" light in the tachometer.

The electrical power is in the form of pulses of voltage at the nominal operating voltage of 12 to 13 volts. The temperature of coolant regulates the on-time of the pulse, an increase in temperature equals an increase of on-time of the pulse. The pulse repetition is 10,000 times per second or a 10 kHz frequency. The nature of the windings in the fan motors averages the pulses to a mechanical shaft -speed. The off-time of the pulse allows the unused energy stored in the motor to be returned to the battery,

The noise of the fan blades moving air typically masks the 10 kHz sound from the fan motors and is difficult to detect. The oscilloscope illustrates the pulses of current in the fan motors.

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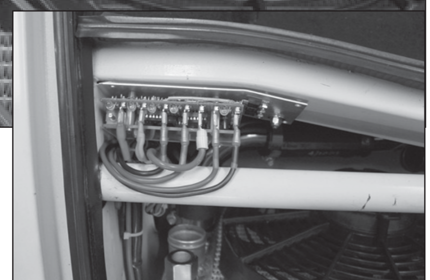
In addition to controlling fan speed there are indicators to aid in determining correct operation. A signal is provided to connect to the amber light on the speedometer to indicate either the fans are on at any level, or the fans are operating at 100% speed. This is operation selectable on the controller. On-board indicators for power on, delay timer complete, maximum fan speed and power from each output to the fans. All connections and indicators are arranged at the top of the controller board for easy access.



Above and right: *On-board indicators for power on, delay timer complete, maximum fan speed and power from each output to the fans. All connections and indicators are arranged at the top of the controller board for easy access.*

Left and above: *The simple added wiring for the fans was run along the bottom and up the side of the internal sheet metal to the controller.*

Wiring:

The original wiring is inadequate for the current demand of modern fans, but some connections are possible without compromising safety. The power lead to the original fans is now used to power only the controller. A 10 AWG wire with an in-line fuse was added from the dash ammeter to the controller for supplying the fan power. The fan leads and temperature sensor leads are connected to the controller. The unused original wiring was left intact but neatly tucked away. The simple added wiring for the fans was run a long the bottom and up the side of the internal sheet metal to the controller.

Results:

The first noticeable aspect was how nice it was to start the Pantera without the fans howling away at full speed with a hot engine. (I look forward to hearing my Pantera start-up) The next noticeable aspect is you never hear the fans turn on, since the fan speed is progressive it is not noticeable during driving and most of the time the fan speed is less than maximum. So far this summer, I never saw the maximum speed light on, so the fan speed has plenty of overhead for hotter days.

Future Improvements:

The 2nd generation controller should have a fan speed bias override to accommodate a front mounted air conditioner condenser. This would be an electrical input to accept a signal from the air conditioning system to fix a minimum fan speed for cooling the condenser. I would propose synchronizing the fan speed override with the compressor and a delayed off-timer to minimize short cycling.

Another output connection for a remote gauge to monitor a voltage that represents the percent of power to the fans. The gauge could be mounted in the engine bay to monitor cooling demand when testing the engine for long periods of time.

Jon Haas