MACS Service Reports

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Electric Cooling Fan Analytics

The modern internal combustion engine with all its advanced technologies is still grossly inefficient. Even when operating at peak efficiency, it's still only about 30-35 percent efficient as machines go. This translates to approximately 65-70 percent of the heat of combustion lost to the atmosphere. Much of this heat loss is released into the exhaust and cooling systems.

The modern liquid cooled four stroke internal combustion engine (ICE) must still be cooled by heat transfer via the radiator via forced convection. It is considered "forced" because the amount of heat transferred from the coolant in the radiator to the atmosphere is highly dependent on the air flow that is flowing across the radiator fins. While the vehicle is in forward motion, a decent amount of air is passed over the frontal area of the vehicle to provide enough heat transfer to cool the coolant returning to the engine. However, there would be insufficient air flow across the radiator when the vehicle is moving slowly, say in traffic, or while stopped. So, our cooling fan(s) provide a way of supplementing the air flow during these conditions.

What began decades ago as a mechanical fan attached to the water pump with and without a fan clutch, has evolved into a very efficient complex electrical motor control of cooling the modern ICE as well as hybrid electronics. I will spare the history lesson on coolant fan technologies for the purpose of this article.

I would, however, like to spend some time exploring the different ways manufacturers control their cooling fans while explaining important electrical circuit characteristics. Secondly, we will be demonstrating an analytical way of looking at the cooling fan wiring schematics to determine the diagnostic approach necessary to correcting any cooling fan control or operating deficiencies.

Our approach to performing any electrical circuit testing of the cooling fans should always begin with a thorough inspection of the frontal area of the vehicle. Due to the location of the heat exchangers, condenser, sub-condenser, radiator and other fluid coolers, they are subjected to all sorts of road debris encountered. This area creates a "catch all," which results in conditions for air flow restrictions. Air flow restriction diagnostics can be tricky if the technician is not acute to its effects. Example: A 4WD pickup truck may only be overheating while pulling a trailer. The service writer and technician need to know this critical information. It is not every day a condenser/radiator restriction is found to be the cause of overheating, and it may go uninspected. Additionally, if we are in A/C season, these air flow restrictions can cause higher A/C pressures, which will affect air conditioning performance and create reduced passenger comfort. Cooling efficiency in the radiator depends on sufficient air flow passing over the radiator fins to absorb the heat from the hot coolant. A coolant temperature drop between inlet and outlet of the radiator can only be achieved if there is sufficient air flow across the radiator. It is important to realize any obstructions to air flow across these heat exchangers, regardless of how small, can affect air volume and needs to be corrected.

Items to Inspect:

Bugs, road dirt, oil, road construction materials, animal remains, bent cooling fins, air dams, gaskets and fan shrouds.

Any area(s) that are restricted can impede the efficiency of the electric cooling fans, which can result in cooling and air conditioning system performance degradation. Obviously, this will all be determined by the severity of the restriction.

A good visual inspection should include a flashlight test across the entire section of the radiator surface area. With the vehicle off, the light is placed in the engine compartment facing forward. This vehicle has 352,000 miles on it. We can visually see there are minor condenser fin restrictions and surface bugs that need to be cleaned off. A garden hose or low-pressure power washer may be all that is needed to clear any surface debris (Figure 1).


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Figure 1: *A good visual inspection should include a flashlight test across the entire section of the radiator surface area.*

The Modern Electric Cooling Fan

The electric cooling fans on modern engines are usually controlled by the PCM (powertrain control module). The PCM monitors certain parameters such as engine coolant, vehicle speed, A/C on-off status, A/C pressure and others to determine engine cooling fan needs. When the engine temperature gets up to a certain setpoint, the PCM enables either a relay or cooling fan module to turn on the cooling fans. Once the engine temperature is reduced to a lower setpoint, the PCM disables the relay or cooling fan module and the fans turn off. The PCM will also turn on the cooling fans when the A/C is requested. This cycle will keep repeating and be modified as coolant temperature, vehicle speed, and air conditioning requests are changed. See Figure 2.


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Figure 2: *The electric cooling fans on modern engines are usually controlled by the PCM (powertrain control module).*

Many systems use separate modules with many different names to control the cooling fans. Depending on the system, there could be one, two or even three cooling fans on the vehicle. These systems may be controlled with resistors, relays or a combination of the two to control the fans speeds. Based on the complaint, we may be able to narrow down what could be causing a problem and what cannot.

Field Example: If the vehicle overheated and blew the head gaskets, the head gaskets are the end result of the problem, *not the problem*. The technician replaces the head gaskets, installs a new thermostat, fills the system up with the correct coolant and bleeds the cooling system per OE instructions. After running the engine for a few minutes, the technician realizes the cooling fans are not coming on. Now we have an idea of what could have caused the overheating condition and led to the head gasket issue. The technician is now faced with diagnosing the reason *why* the cooling fans are not coming on. So, good troubleshooting practices involve being prepared by becoming familiar with the cooling fan circuit.

Getting a description and operation of the cooling fans should also be on the shopping list of good service ready essentials. When examining the circuit, we notice that both cooling fan motors are grounded at the same location. Upon closer inspection, we notice that the vehicle looks like it has been in an accident in the past. The main ground bolt for the fans is found to be loose, causing the fans to be inoperative. The customer didn't tell the shop owner that the car was recently involved in a frontal collision, never thinking to mention it. However, examining the electrical schematic before even looking at the car eliminated many steps and saved valuable shop time.

Let us analyze some of the various cooling fan circuits and determine the methods manufacturers use to control their speeds. Using some basic tools and test equipment, we will discuss what diagnostic tests can be made to locate any electrical circuit deficiencies that may arise.

Resistor and Relay Control of Cooling Fans

In the beginning, man created resistance. Like most schematics, interpreting the power flow is from the top of the page to the bottom of the page. I call it stages, and it breaks down like this.

1. Where is the voltage originating from? Point of origin-Battery, battery junction box, modules, etc.
2. What is the current path going through? Components, fuses, fusible links, relays, and control devices, etc.
3. Where does it go to? Point(s) of termination. Ground locations.

All circuit examination should include a thorough visual inspection.

Example: 2013 Ford Transit Connect

Look at the names of the components in Figure 3 that make up the cooling fan circuit. Inside the Battery Junction Box (BJB), reading from left to right, we notice we have a:

- Cooling Fan Diode
- F16 30A fuse
- Low Fan Control Relay
- F17 50A Fuse
- High Fan Control Relay
- PCM Power Relay
- F14 10A fuse

Like many wiring diagram conventions, the rectangular dotted line inside the Battery Junction Box (BJB) indicates: Not all wiring or information is shown as drawn. It is incomplete. In this circuit that is okay, because everything

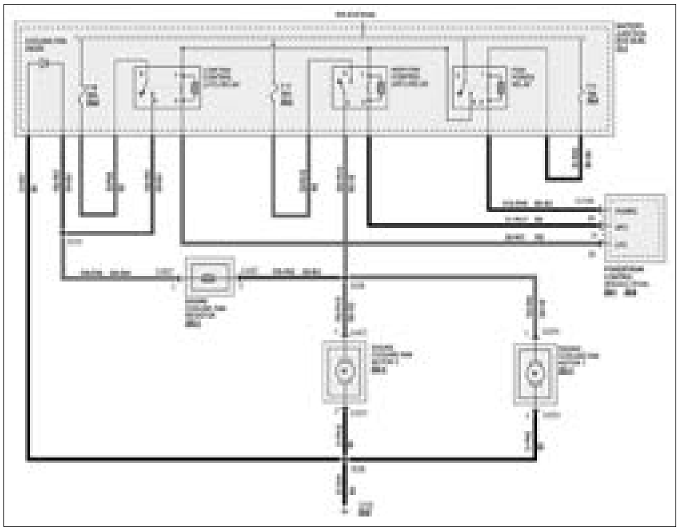

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Figure 3: *Names of the components that make up the cooling fan circuit.*

we need to analyze in the circuit is contained on the page within the schematic diagram. Three fuses, three relays and a diode. These all happen to be in the power supply section of the schematic.

Moving down the page we have:

- Splice 113
- Engine Cooling Fan Resistor
- Splice 108
- Powertrain Control Module
- Engine Cooling Fan Motor 2
- Engine Cooling Fan Motor 1

On the bottom of the page we have:

- Splice 105
- Ground (G-103)

Once we have examined the components and their symbols, it's time to analyze the power flow. We note that inside the BJB at the very top it says: Hot at all times (which is drawn as a double dotted line). Again, reading left to right, this means Fuse F16 30A, Fuse F17 50A, Terminal 3 of the PCM Power Relay and Fuse F14 10A have power to them at ALL times. *Do you see it? Hopefully, you said yes.*

Using either a pencil, pen, highlight markers, or colored pencils (take your pick), we will begin highlighting the low and high-speed fan control power flow for this circuit. This is done before we begin working on the vehicle so that we have a thorough understanding of the circuit wiring (including the wire color code), components, fuses involved and the ground locations. This will help us plan our non-intrusive or intrusive test points within the circuit we may have to make to determine where any malfunctions may be.

I personally cannot work a schematic diagram on a screen. I must print it so I can make my notes, draw any essential detail to power flow and write down my answers to any circuit test measurements I make. My students call this: P.O.P. (it stands for the Peter Orlando Principal!).

NOTE: I continue to use Scotch® tape to piece together any wiring diagrams that are more than one page. This makes it easy to trace my page demarcation from one page to the next.

Low Speed Fan Control Operation

The PCM Power Relay receives power from the F14 10A fuse, which is fed to terminal 1 of the PCM Power Relay. The Power Relay coil terminal 2 receives ground at the PCM on pin 38. Once this relay is energized, power waiting on terminal 3 will latch (close) and travel to terminal 5. With power on terminal 5 of the PCM Power Relay, voltage is now available to terminal 1 of the High Fan Control Relay and terminal 1 of the Low Fan Control Relay. *Do you see it? Hopefully, you said yes*.

To achieve low speed fan control, the Low Fan Control Relay coil terminal 2 must be grounded by the PCM at pin 34 (LFC Circuit). Once the Low Fan Control Relay is energized, current will now flow from terminals 3 to 5 of the relay and exit the Battery Junction box on the GN-BU wire over to Splice 113 and continue through the Engine Cooling Fan Resistor (terminals 1 and2), to Splice 108 and go to both Engine Cooling Fan Motors 1 and 2 (terminal 1). Both cooling fan motors are grounded via the BK wire which terminates at ground location G103. In this case each cooling fan motor will receive less voltage due to the Engine Cooling Fan resistor in series before the motors. The voltage is dropped to approximately 9-10 volts which is how low speed is achieved.

Low Fan Control power flow

OE schematic is drawn with all the power flow arrows indicating direction of current for Low Fan Control (Figure 4).

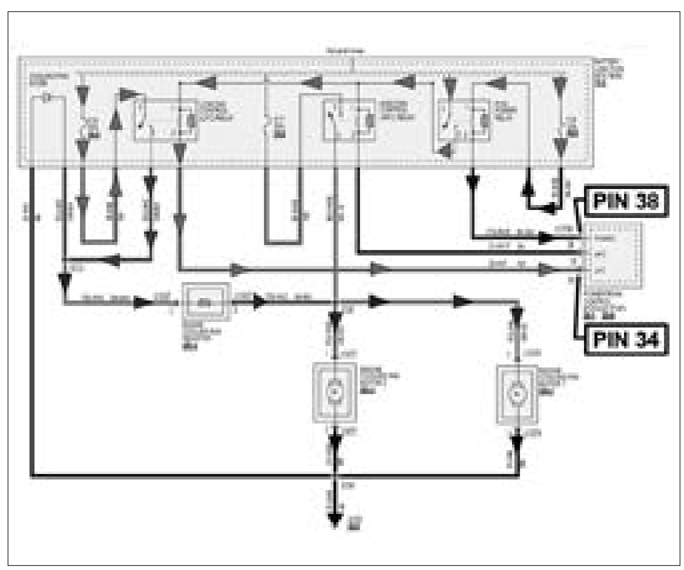

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Figure 4: *OE schematic is drawn with all the power flow arrows indicating direction of current for Low Fan Control.*

Note: There will be voltage at various points in the circuit that have no potential to ground. We are only demonstrating the power flow in the circuit for which current will be flowing.

High Speed Fan Control Operation

The PCM Power Relay receives power from the F14 10A fuse, which is fed to terminal 1 of the PCM Power Relay. The Power Relay coil terminal 2 receives ground at the PCM on pin 38. Once this relay is energized, power waiting on terminal 3 will latch (close) and travel to terminal 5. With power on terminal 5 of the PCM Power Relay, voltage is now available to terminal 1 of the High Fan Control Relay and terminal 1 of the Low Fan Control Relay. *Do you see it? Hopefully, you said yes.*

To achieve high speed fan control, the High Fan Control Relay coil terminal 2 must be grounded by the PCM at pin 18 (HFC Circuit). Once the High Fan Control Relay is energized, current will now flow from terminals 5 to 3 of the relay and exit the Battery Junction box on the RD-YE wire over to Splice 108 and continue to both Engine Cooling Fan Motors 1 and 2 (terminal 1). Both cooling fan motors are grounded via the BK wire that terminates at ground location G103. In this case, each cooling fan motor will receive full charging system voltage so they will be running on high speed. The Engine Cooling Fan resistor is no longer in the circuit.

High Fan Control power flow

OE schematic is drawn with all the power flow arrows indicating direction of current for High Fan Control (Figure 5).

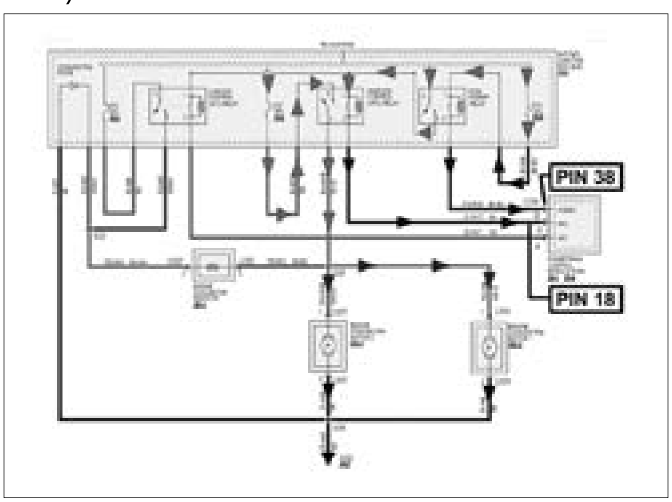

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Figure 5: *OE schematic is drawn with all the power flow arrows indicating direction of current for High Fan Control.*

Cooling Fan Diode

We know the function of a diode is to act as a one-way check valve in the electrical system. Analyzing the schematic, we can see the use of a diode in the Battery Junction Box (BJB). The diode is placed in parallel with the Low Fan Control circuit and, in this case, it is being used for voltage suppression. Much like we have seen spike protection diodes placed across A/C clutches in the past, this cooling fan diode is being used in a similar manner. This is important to the technician for two reasons:

1) In the operation of the circuit, each time the PCM disables the Low Fan Control Relay, the fans will turn off. This can create enough voltage spike in the electrical system to cause issues with low voltage electronics. So, the diode will dissipate this unwanted voltage to ground and prevent that condition.

2) More importantly, look carefully at the placement of the diode, if the diode was shorted, the voltage on the GRN/BLU wire coming from terminal 5 of the Low Fan Control Relay would be shorted directly to ground and blow the F16-30A fuse. If the diode is open, there may a popping noise heard through the audio system of the vehicle associated with the cooling fans turning off or worse, there could be damage to other electronics on board. The technician needs to be aware of these possibilities for diagnostic purposes. Always ask WHY. Why did this component fail? If it failed due to age degradation and simply wore out, fine. However, if something else caused it to fail prematurely, we need to find the cause. If we don't, we may be attempting to fix the result of the failure.

Example: I resurrected this one from the archives. Look at the burned cooling fan resistor and connector from a 2011 Ford Transit Connect. See Figure 6. I wish I were making this up; however this was the THIRD one that was replaced in a months' time. It was July, so guess what the complaint was? "Check the A/C, it's not blowing cold enough." If we do not investigate this one carefully, as one shop found out, we can seriously mis-diagnose a problem, spend a ton of money throwing parts at the problem and not fix anything! Not to mention lose the customers confidence.

Peter Orlando

Figure 6: *Burned cooling fan resistor and connector from a 2011 Ford Transit Connect*

> **Bulletin Issued:** There was a bulletin (TSB-12-1-14) issued for this problem by Ford. The proper fix on the Ford Transit was to look at the amperage on the cooling fans and determine if it was excessive. If it failed a certain amperage threshold, the entire fan assembly needed to be replaced along with the cooling fan resistor and the PCM required reprogramming. Here is the kicker, the Technical Service Bulletin (TSB) is wrong!

They state in the TSB to check the LSF (Low Speed Fan) resistor for an open circuit. Is the LSF resistor open? We have two possible answers to this question: Yes or No. If we said YES, this is what it says to do:

Yes - says to replace the HSF F17 fuse and the LSF resistor (which can cause the HSF F17 to blow) WHAT? HOW? How is that possible?

Again, looking at the schematic, when the PCM supplied the ground for the low fan control relay, it became a Series/Parallel circuit. The Engine Cooling Fan Resistor is in series with BOTH cooling fan motors, which are in parallel with each other after the resistor. Any malfunctions in the cooling fan motors that can cause excessive amperage will take their toll on any portion of that circuit. The F17 Fuse has NOTHING to do with the engine cooling fan resistor. So why didn't the F16 30A fuse blow, Pete? Great question. The amperage was not high enough to blow the fuse; however, it was high enough to cause damage to the cooling fan resistor and its connector.

Cooling Fan Schematic Diagram Comparison

The Low Speed Cooling Fan diagram (2013 Ford Transit Connect) is shown using built-in schematic highlighting tools. This feature makes it a little easier to determine power flow for both low and high cooling fan speed operation. Once the circuit is highlighted, it can be printed out for detailed circuit tests that only involve relevant parts of the circuit in question. See Figure 7.

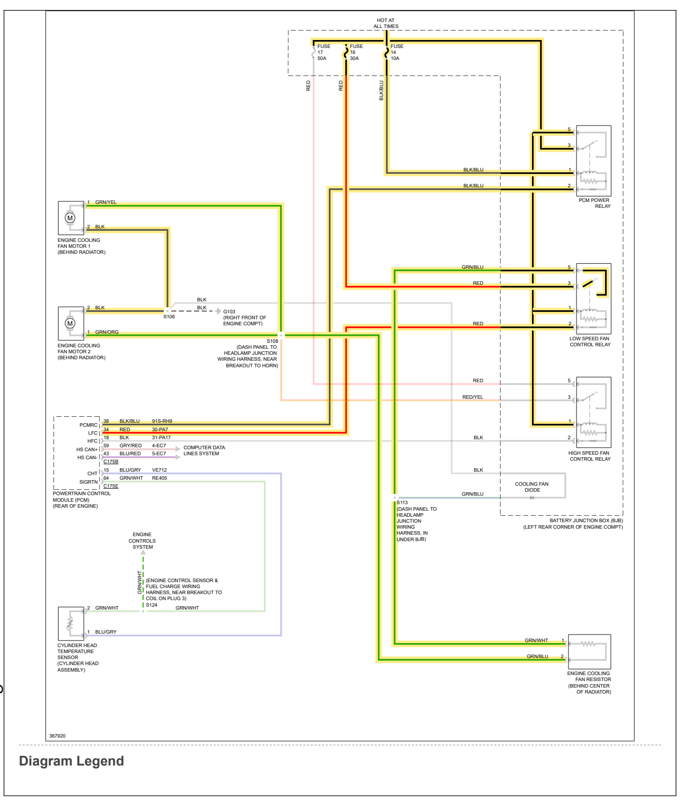

Figure 7: *Built in schematic highlighting feature makes it a little easier to determine power flow.*

Lesson to be learned: When we analyze a circuit using schematic diagrams and understand its operation, we not only see places we can go to perform circuit tests, we begin to troubleshoot differently by thinking in a cause and effect mindset. This has a profound effect on the technician's abilities and enhances their electrical diagnostic skills. We actually see and utilize series, parallel and series-parallel circuit laws. Technicians who possess these skills can spot when service information is incorrect and provide a work-around to reach a satisfactory conclusion. We observe the behavior of electrons in motion and understand what the electrical consequences of too little and too much current flow can mean. It truly is a different way to approach electrical troubleshooting by using critical thinking skills in conjunction with the schematic diagrams.

Example: 2018 Nissan Rogue

Relay Control of Cooling Fans

The use of relays to control electrical circuits has been around for decades. When we do not have a dropping resistor to drive the fans at low speed, we can use relays and a few electrical laws to control the fan speeds. GM has been using relays to control its fans for 30 years. We will examine how Nissan accomplishes control of the cooling fans by placing the two cooling fan motors in series for low speed, then altering the relay arrangement to permit both fans to run independently for high speed. This electrical design is used by many Asian manufacturers and is remarkably close to GM's methods.

Partial Engine Control System Diagram

Figure 8 shows an enlarged view of the Cooling Fan Circuit for a 2018 Nissan Rogue. The entire schematic is interactive and has a highlighting feature built into the diagrams, which allows the technician to select a wire or component. Once selected, that section of the circuit will be highlighted GREEN. A benefit of having the highlight feature is the ability to illustrate the interconnection of the wires and the components to each other. This may help when a diagram is overly complex like this one. In this example, we have the B+ circuit power highlighted from FUSE O (40A) to terminals 1 and 2 of Cooling Fan Motor

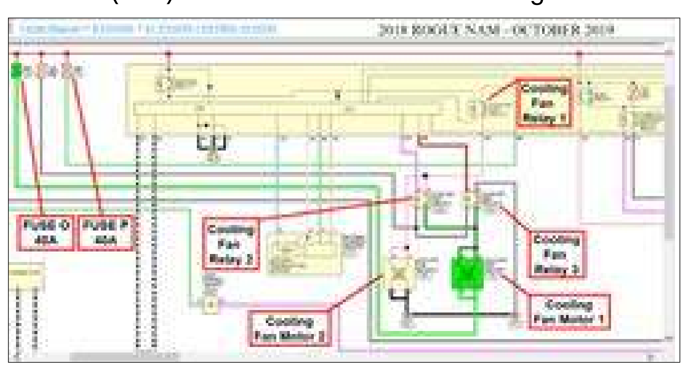

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Figure 8: *View of the 2018 Nissan Rogue cooling fan circuit.*

1. NOTE: The Highlighting feature is NOT a Power Flow feature.

Low Speed Fan Control Operation

The schematic in Figure 9 exemplifies just how important splices can be to the operational characteristics of a circuit. The current flow will be altered by the cooling fan relays to control the cooling fans to best suit the thermal management needs of the engine and interconnected parts that need to be kept cool by the coolant. Each splice has a unique connection that permits the fans to run in series to achieve low speed, connected in parallel to achieve high speed or operate the fans independently. A technician working on any complex controlled systems, like these cooling fans, must understand the operational control functions in order to determine where any circuit deficiencies may be.

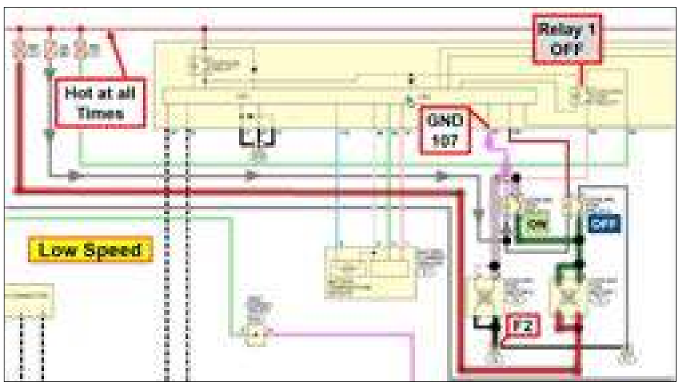

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Figure 9: *Splices are very important to the operational characteristics of a circuit.*

NOTE: The power flow through the circuit above is illustrated to show Low Speed Fan operation.

> **TECH TIP:** Due to the way the circuit is wired, all the current to operate the cooling fans is going through the control relays. A technician must understand that certain component malfunctions, such as blown fuses, and inoperative relays, are going to warrant further circuit analysis of amperage draw of the cooling fan motors. A relay replacement will certainly prematurely fail if the motor is drawing too much current.

Add Some Logic

Let us put some logic on the table. If you have taken any ASE electrical/electronic or transmission exams in the past, then you should be familiar with logic tables. By using logic tables (Figure 10), it helps us understand relay control and the actions taken to control a load, such as a motor or solenoid.

Low Speed Operation - Both Fans in Series	
	Condition
Cooling Fan Relay 1	OFF
Cooling Fan Relay 2	ON
Cooling Fan Relay 3	OFF

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Figure 10: *This logic table is designed to help understand the low speed fan control*

High Speed Fan Control Operation

Figure 11 shows supply voltage and ground for Cooling Fan Relay 1 coil is supplied by the Intelligent Power Distribution Module (IPDM). With continuous B+ power available from the 40A Fuse P, Pin 84 of the IPDM now has power to the switch side of Cooling Fan Relay 1. With the relay energized, power can flow through the relay to pin 85 of the IPDM, which now provides power to Cooling Fan Relay 2 (Pins 2 and 5) and Cooling Fan Motor 2 terminals 1 and 2. Although these two circuits are wired in parallel to each other, they are not running in parallel.

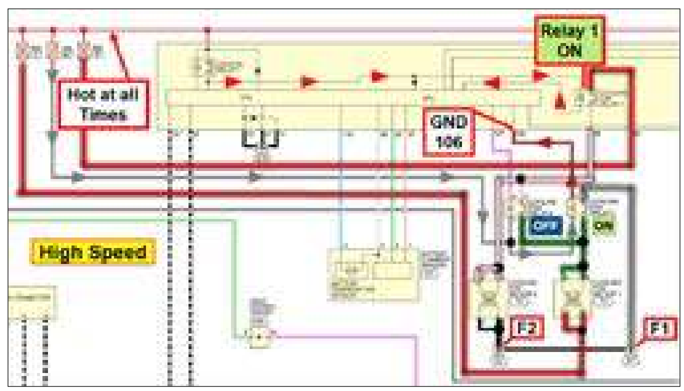

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Figure 11: *Supply voltage and ground for Cooling Fan Relay 1 coil is supplied by the IPDM.*

With Cooling Fan Relay 2 de-energized (OFF), all the voltage potential is routed via the PINK wire to Cooling Fan Motor 2 terminals 1 and 2 through the motor, which has ground supplied at F2. Cooling Fan Motor 2 is now running on high speed due to full battery voltage available to the motor.

The IPDM energizes Cooling Fan Relay 3 by grounding Pin 106. With Cooling Fan Relay 3 energized, Cooling Fan Motor 1 can also run at full speed. Power for Cooling Fan Motor 1 is provided by the 40 A Fuse O to terminals 1 and 2. With Cooling Fan Relay 3 energized, the switch side of the relay closes, which completes the circuit from terminal 3 to 5 of the relay. Terminal 5 of Cooling Fan Relay 3 is connected to ground at F1, which completes the circuit and enables Cooling Fan Motor 1 to operate on high speed. See the logic table in Figure 12.

High Speed Operation - Both Fans in Parallel	
	Condition
Cooling Fan Relay 1	ON
Cooling Fan Relay 2	OFF
Cooling Fan Relay 3	ON

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Figure 12: *This logic table is designed to help understand the high-speed fan control.*

Example: 2010 Ford Flex

Variable Speed Cooling Fan OE Schematic Diagram

The 2010 Ford Flex PCM controls the fan speed and operation using a duty cycle output on the fan control variable (FCV) circuit. The fan controller (located at or integral to the engine cooling fan assembly) receives the FCV command and operates the cooling fan at the speed requested (by varying the power applied to the fan motor). See Figure 13.

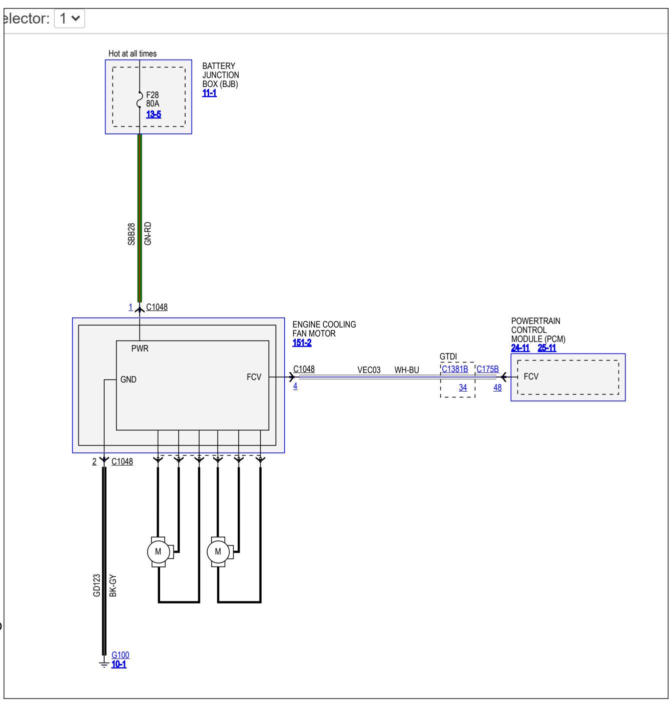

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Figure 13: *2010 Ford Flex PCM controls the fan speed and operation using a duty cycle output.*

The fan controller has the capability to detect certain failure modes within the fan motors. Under certain failure modes, such as a motor that is drawing excessive current, the fan controller will shut off the fans. This information

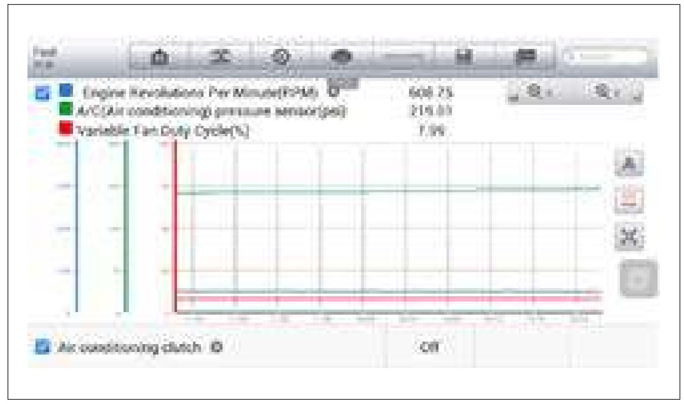

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Figure 14: *Cooling fan with A/C turned OFF.*

is extremely important to the technician. Unlike the 2013 Transit Connect, which will simply blow the fuse if the current climbs above the amperage rating of the fuse for a pre-determined time, the PCM's variable fan control on the Flex will simply shut the fans off if amperage exceeds a certain value for a pre-determined time. That why it's important to get a description and operation of the circuit and determine if any cooling fan parameters are available to see with a system capable scan tool.

NOTE: Fan motor concerns will not set a specific DTC. With the fan motor disconnected from the fan controller, voltage may not be present at the fan controller, however the PCM will display FAULT-YES on the scan tool.

Variable Cooling Fan Control - Scan Tool Parameters

If the scan tool provides access to cooling fan parameters, we will have to navigate to the module (PCM in this example), which provides that data. In this case, to demonstrate a point of reference (Figure 14), I graphed (from top to bottom) engine RPM, A/C pressure sensor and the variable Fan Duty Cycle (%) parameters along with Air Conditioning clutch. You can see, as the A/C was turned

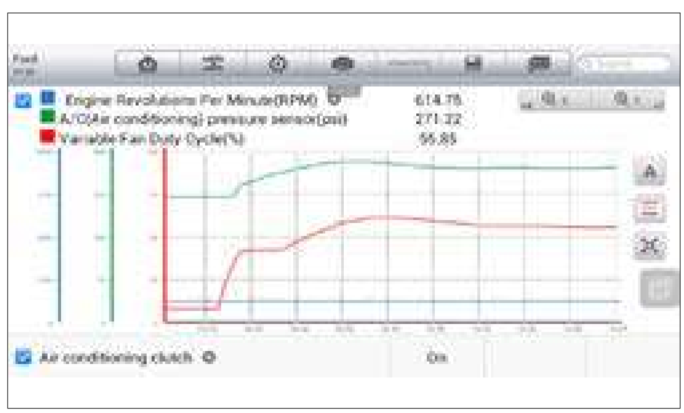

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Figure 15: *Cooling fan with A/C turned ON.*

on (Figure 15), the PCM ramped up the cooling fan speed to a desired setpoint, and when the A/C was turned off, (Figure 16) it ramped it down but never turned them completely off.

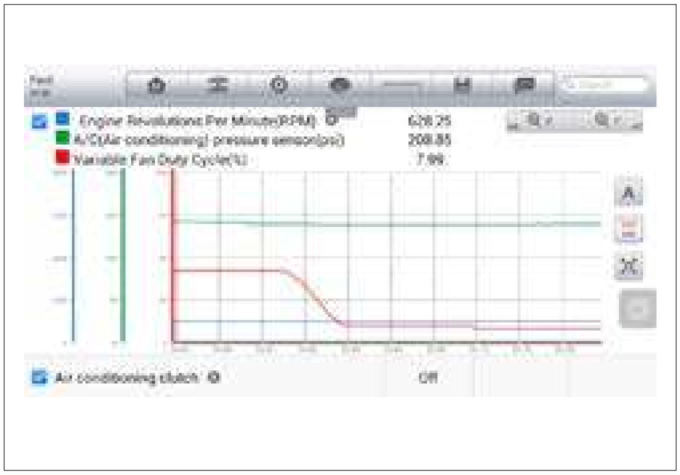

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Figure 16: *Cooling fan runs slower, but still operating, after A/C is turned back OFF*

Scan Tool Active Tests

Bi-directional control of the cooling fans can be done with any OE-capable scan tool. This test provides a quick way to determine if the fans are functional, which can save a lot of diagnostic time. See Figures 17, 18.

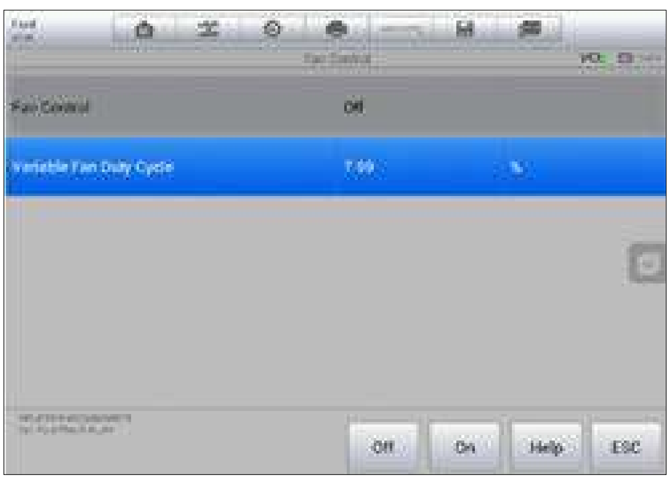

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Figure 17: *Fan control displayed as OFF.*

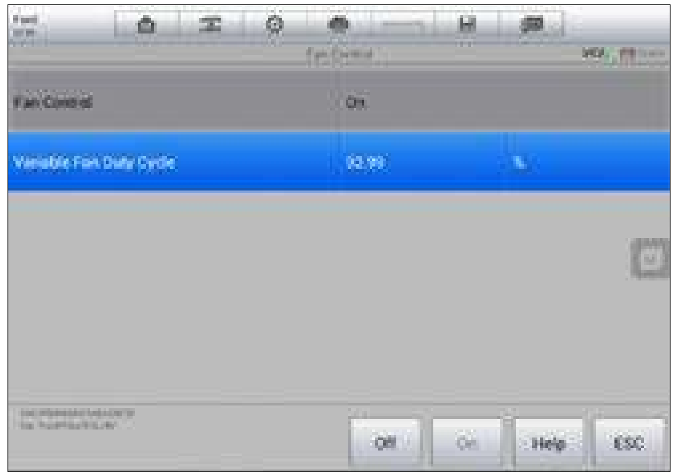

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Figure 18: *Fan control displayed as ON.*

Duty Cycle Testing of Variable Speed Cooling Fans

While the fans are being activated, we can monitor the PCM-Fan Control (WH/BU) wire to determine if the PCM is grounding the signal for the cooling fan control module.

Conclusion

Additional advanced scope level testing can be done to determine the overall health of the cooling fans. Known good test patterns of healthy cooling fan circuits is probably a good place to start if a technician is looking to explore these types of advanced level diagnostics as most manufacturers typically do not provide these advanced level waveforms. Once several scope patterns are analyzed they can be put into the scope's waveform library for later reference.

In summary, the electric cooling fans that are designed to maintain safe operating temperatures for the internal combustion engine (ICE), as well as hybrid electronics, continue to evolve as engine technology evolves. Technicians must continue to advance their skills in electrical troubleshooting by reading, understanding and interpreting all types of schematic diagrams. This helps reduce stress levels when the time comes to begin analyzing circuit types and any circuit deficiencies that may run hot.

Thanks for playing. Stay safe and be well! ❖

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4.	A	B	C	D
5.	A	B	C	D
6.	A	B	C	D
7.	A	B	C	D
8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D

1. Technician A says that OE-installed dye is likely to leave a dye trace by the time a leak occurs. Technician B says that shop-added dye circulates best when the compressor runs at higher rpm. Who is correct?

a. Technician A
b. Technician B
c. Both technicians A and B
d. Neither technician A nor B

2. To trigger an SAE-certified electronic leak detector on an A/C system from which virtually all of the refrigerant has leaked out requires a partial charge of at least _____%.

a. 10
b. 20
c. 50
d. 70

3. Technician A says that forming gas leak detection has the advantage of low cost for the gas. Technician B says that its advantage is minimal global warming impact. Who is correct?

a. Technician A
b. Technician B
c. Both technicians A and B
d. Neither technician A nor B

4. Forming gas leak detection may work best when the A/C system is charged with the gas to _____ psi.

a. 5
b. 20
c. 60
d. 350

5. Ultrasonic leak detection for A/C is among the procedures recommended by _____.

a. Hyundai / Kia
b. Toyota / Lexus
c. Honda / Acura
d. VW / Audi

6. Technician A says that to clear a system of forming gas, it is necessary to pull the system into a deep vacuum. Technician B says to open the valves and let the gas escape to the atmosphere. Who is correct?

a. Technician A
b. Technician B
c. Both technicians A and B
d. Neither technician A nor B

7. Technician A says that finding dye traces may be difficult because the dye is blown off the joint when the vehicle is driven at highway speed. Technician B says that finding the dye traces may be difficult because many joints are buried underhood. Who is correct?

a. Technician A
b. Technician B
c. Both technicians A and B
d. Neither technician A nor B

8. During bulk charging preparation, General Motors encountered refrigerant contamination on some vehicles. Technician A says that this may occur from some cleaning agents or threadlocking compounds. Technician B says that it can be identified with a premium refrigerant identifier. Who is correct?

a. Technician A
b. Technician B
c. Both technicians A and B
d. Neither technician A nor B

9. Technician A says that rodent damage to A/C and other vehicle wiring is most likely caused from food left on the dashboard attracting the rodents. Technician B says that it may occur because many vehicles use soy-based wiring insulation. Who is correct?

a. Technician A
b. Technician B
c. Both technicians A and B
d. Neither technician A nor B

10. Technician A says that a LIN (local interconnect network) is used because of its low cost. Technician B says that it is used because of its high-speed response. Who is correct?

a. Technician A
b. Technician B
c. Both technicians A and B
d. Neither technician A nor B