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Electrical Basics

Throughout a vehicle, electricity is supplied through "hot" wires, comparable to the pressurized supply pipes of a plumbing system. At various points along the wires are electrical loads in the form of lights, switches and receptacles. Turning on a light switch is somewhat like opening a faucet to let water run; electricity flows through the hot wire to make the light illuminate. Once the electricity has done its work, its potential drops to zero, just as water loses pressure after flowing through a sink or laundry tub. The electrical system has drains, which are the ground wires that return the electricity to its source, just as a plumbing system has drain pipes through which water runs into the sewer mains or ground.

The lights or equipment, technically called the load, can be compared to a water wheel that remains motionless until a stream of water causes it to turn. A load consists of a resistance, a material that permits the passage of electricity, but only with difficulty and thereby creates heat. Resistance to electricity flowing through a wire can be compared to the resistance given to water flowing through a hose, as if the hose were to be squeezed, it would restrict the flow of water. A load may also be inductive, typically a motor with windings of copper wire, in which the magnetic fields generated by the electrical current creates motion. The tungsten filament of an incandescent bulb or the heating element of an electric heater in a coffee pot would be an example of a resistive load. At any moment, the demand on an electrical system depends on the number of loads in operation and their consumption of energy, just as demands on a water system depend on how many faucets are opened and how wide they are opened.

The mechanics and physical fittings of the system are simple. Electricity moves throughout the vehicle in wires of different sizes, according to the electricity a circuit may have to carry.

Electrical Terms

VOLT is the unit of electrical potential, equal to the difference of electrical potential between 2 points in a circuit. It could be compared to the pressure, or the push, on the water to move it through a pipe.

AMPERE or **AMPS** is the unit used to measure the amount of electrical flow; the number of electrically charged particles called electrons that flow past a given point in a circuit. It is similar to measuring the amount of water flowing through a pipe at any given point. The larger the pipe is, the more water that can flow past one given point per second. Similarly, the bigger the wire is, the more electricity that can flow past a given point.

WATT is the unit of power. It indicates the rate at which a device converts electric current to another form of energy, either heat or motion. Or to put it another way, the rate at which a device converts energy.

The relationship of volts, amperes and watts to one another is expressed in a simple equation that enables you to make any calculations you may need for proper and safe electrical modifications to the vehicle. Volts x Amps = watts. If the current is at 12 volts and a device requires 4 amperes of current, the equation will read 12 volts x 4 amperes = 48 watts.

To figure the current needed for a device rated in watts, turn the equation around: Watts/volts = amperes. For example, if you have a piece of equipment, such as a communications radio, that uses 120 watts: 120 watts/12 volts = 10 amperes.

Control Modules — Red Area

Do not install any components into the control modules or module harness. Connecting into this system may affect control module operation. For example, connecting aftermarket electrical equipment into the brake light circuit or any other circuit which is connected to the PCM, anti-lock brake computer, airbag system or any other vehicle system will cause vehicle malfunction.

Controller Area Network (CAN) Bus

NOTICE:
Wiring faults in the Controller Area Network (CAN) bus may shut down the vehicle and prevent further operation.

Do not splice or connect any equipment to the CAN bus wiring.

General Guidelines For Vehicle Modification

- Provide circuit protection (fuses) for all wiring. The fuse rating should not exceed either the rated wiring current capacity or the total current requirements for all the add-on components on the circuit. Install fuses as close to the point of tapped power as possible.
- Document all revisions to the electrical system and place with the vehicle Owner's Literature. Color code and/or label all revisions or additions to wiring.
- Provide protective covering in all areas that could be damaged during normal equipment installations.
- Disconnect the negative battery cable of vehicles stored on site to reduce the possibility of draining the battery by lights or other equipment.
- Do not allow control panels attached to the instrument panel to protrude into the driver and passenger air bag deployment zones. For additional information, refer to Section 5: Reference Information in this guide.

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- Do not install switches and gauges in the driver or passenger knee impact areas.
- Inspect all Ford gauges, lights and switches for correct operation after instrument panel work is performed.
- Properly secure any relocated or removed wiring while working behind the instrument panel to prevent chafing, squeaks and rattles.
- Provide adequate retention for wiring harnesses so that they are clear of bolts, corners or edges which could abrade the wires during normal vehicle operation.
- Anticipate incorrectly routed wiring situations and protect all wiring from penetration by screws and raw edges.
- Weather-seal all electrical connectors exposed to the elements.
- Do not use quick splice connectors or wire nuts.
- Install the fuse panel so fuses are readily accessible.
- Make sure that connections are easily accessible for assembly and service.
- Make sure submersible connectors do not lose their seals under extreme assembly conditions such as bending wires 90 degrees immediately after the connector.
- Whenever using connectors, use a socket (female) connector on the electrical source side and a plug (male) connector on the electrical load side to reduce the possibility of a short circuit when disconnected.
- Air bag restraint systems must remain intact as received from Ford Motor Company. Before any vehicle modifications are performed, the system must be disarmed by following the instructions provided in the current Workshop Manual.
- Adherence to the above guidelines is not to be construed as approval by Ford Motor Company of any specific revisions or additions to the vehicle's original electrical system.
- Do not modify the cooling system. High voltage vehicle components may be damaged if any cooling system modifications are attempted.
- Do not backprobe, splice or repair the high voltage system (orange) wiring/cables.
- Do not mount to or modify the high voltage system (orange) wiring/cables in any way.
- Do not cut, weld or screw into the HVTB case or penetrate the batteries in any way.
- Provide circuit protection (fuses) for all wiring. The fuse rating should not exceed either the rated wiring current capacity or the total current requirements for all the add-on components on the circuit. Install fuses as close to the point of tapped power as possible.
- Provide protective covering in all areas that could be damaged during normal equipment installations.
- Do not allow control panels attached to the instrument panel to protrude into the driver and passenger air bag deployment zones. For additional information, refer to Section 4: Reference in this guide.
- Do not install switches and gauges in the driver or passenger knee impact areas.
- Provide adequate retention for wiring harnesses so they are clear of bolts, corners or edges which could abrade the wires during normal vehicle operation.
- Properly secure all wiring relocated or removed while working behind the instrument panel to prevent chafing, squeaks and rattles.
- Anticipate mis-routed wiring situations and protect all wiring from penetration by screws and raw edges.
- Weather-seal all electrical connectors exposed to the elements.
- Do not use quick splice connectors or wire nuts.
- Install the fuse panel so fuses are readily accessible.
- Make sure that connections are easily accessible for assembly and service.
- Inspect all Ford gauges, lights and switches for correct operation after instrument panel work is performed.
- Make sure submersible connectors do not lose their seals under extreme assembly conditions such as bending wires 90 degrees immediately after the connector.
- Whenever using connectors, use a socket (female) connector on the electrical source side and a plug (male) connector on the electrical load side to reduce the possibility of a short circuit when disconnected.
- Adherence to the above guidelines is not to be construed as approval by Ford Motor Company of any specific revisions or additions to the vehicles original electrical system.
- Document all revisions to the electrical system and place with the vehicle Owner's Literature. Color code and/or label all revisions or additions to wiring.
- Disconnect the negative battery cable of vehicles stored on-site to reduce the possibility of draining the battery by lights or other equipment.

12 Volt Battery

The 12 volt battery is a standard automotive battery. It is a DC source connected in a negative ground system. The battery case is sealed, with 2 vent holes to release gases. The battery has 3 major functions:

- Storage of electricity for later use
- Voltage stabilizer for the electrical system
- Temporary power source when electrical loads exceed the Direct Current/Direct Current (DC/DC) converter output current.
- Only use the 12 volt (Low Voltage) power point provided in the cargo area on the passenger side under the cargo area floor. NEVER use the High Voltage Hybrid battery to supply power for law enforcement equipment.

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Auxiliary Power Point — 12V

⚠ WARNING:
The nominal high voltage traction battery (HVTB) voltage is 300 volts DC.

⚠ WARNING:
The high voltage traction battery (HVTB) and charging system contains high voltage components and wiring. High voltage cables and wiring are orange in color.

⚠ WARNING:
Before carrying out any vehicle modifications, the high voltage traction battery (HVTB) must be depowered. Failure to follow these instructions may result in severe personal injury or death.

NOTE:
Do not use the power point for operating the cigarette lighter element (if equipped).

NOTICE:
Power outlets are designed for accessory plugs only. Do not insert any other object into the power outlet as this will damage the outlet and blow the fuse. Do not hang any type of accessory or accessory bracket from the plug. Improper use of the power outlet can cause damage not covered by your warranty.

To prevent the fuse from being blown, do not use the power point(s) over the vehicle capacity of 12-VDC/180W.

To prevent the battery from being discharged, do not use the power point longer than necessary when the engine is not running.

DC/DC Converter

The DC/DC converter is an air-cooled component that converts high voltage DC power to low voltage DC power. It is part of the high voltage battery pack and maintains an electrical isolation between the 2 DC power systems. This system converts the high voltage (approximately 300 volts) to low voltage (12 volts) that provides power to the vehicle low voltage battery systems. The PCM controls the operation of the DC/DC converter through an enabled input from the PCM to the DC/DC converter.

Vehicle Component Electrical Loads

Vehicle component electrical loads are shown in the table below. Not all features are powered all the time, so actual vehicle loads on the power supply system will vary.

NOTE:
The electric A/C compressor loads are included with the blower loads.

Component	Amps
Base	
Miscellaneous base loads	16.5
Cooling	
Cooling fan (high speed variable)	27.0
Climate Control	
A/C fan to face — high speed (recirculating air)	25.0
A/C fan to face — M/H speed (recirculating air)	16.0
Heater fan to foot — M/H speed (fresh air)	16.0
Lighting	
Exterior and instrument panel lamps (non-dimmable)	3.5

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(Continued)

Component	Amps
Headlamps — low beam	9.1
Brake lights (with CHMSL)	5.1
Heated Features	
Heated rear window (includes heated mirrors)	18.0
Heated front seat — LH	4.5
Heated front seat — RH	4.5
Other	
Radio	4.0
Typical Vehicle Load = 95-110 Amps	

Typical Police Equipment

Loads for equipment commonly found on police vehicles are shown in the table below. Not all equipment will be operating at the same time, so actual loads on the power supply system will vary.

Component	Amps
Communications radio	5.0-20.0
Light bar	28.0-43.0
LED light bar	6.0
Siren	15.0-30.0
Headlamp flasher	1.0-1.5
LED deck bars/LED visor lights	2.0
Radar	0.8
Receipt printer	3.0
Spotlights (each)	7.8
Alley lights (each)	1.0
Camcorder	2.0

Police Interceptor Utility Hybrid— Rear Power Access

The rear power access point mounted in the cargo area, is a battery access port for police auxiliary equipment. It is capable of supplying 80 amps of battery voltage. Voltage to the positive terminal of the rear power access point is supplied through two 50A, connected to the battery through the power distribution box (PDB) fuses F30 and F31. Battery access is provided by 2 studs contained in an enclosure, behind the passenger second row seat under the cargo area floor. The terminal with the red wire is the battery positive. Remove both fuses in the PDB before removing the cover to the rear power point. Make sure load devices can be turned off and are switched off when reinserting the fuses.

⚠ WARNING:
Under no circumstances should the rear power access point cover be removed without first removing power distribution box (PDB) fuses F30 and F31. Removing the cover without removing the fuses could result in an electrical hazard. Turn off load devices before inserting the fuses. Failure to follow these instructions may result in personal injury.

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1. To access the rear power point, fold back the cargo area floor near the second row seat.

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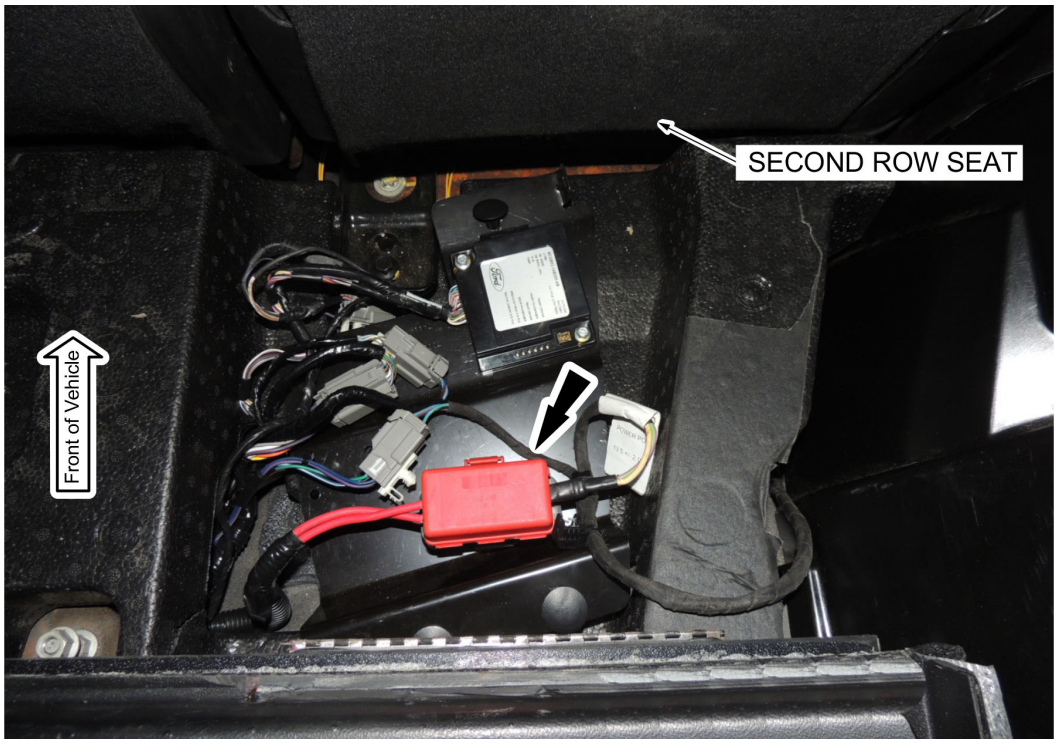
2. Open the cover.



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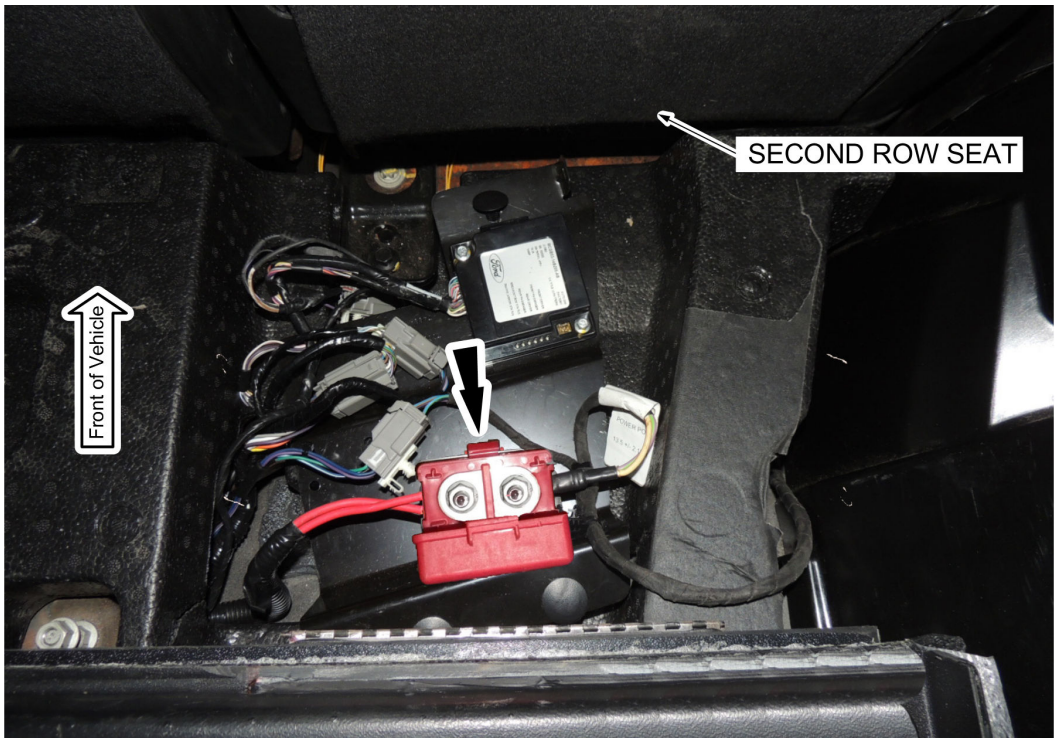

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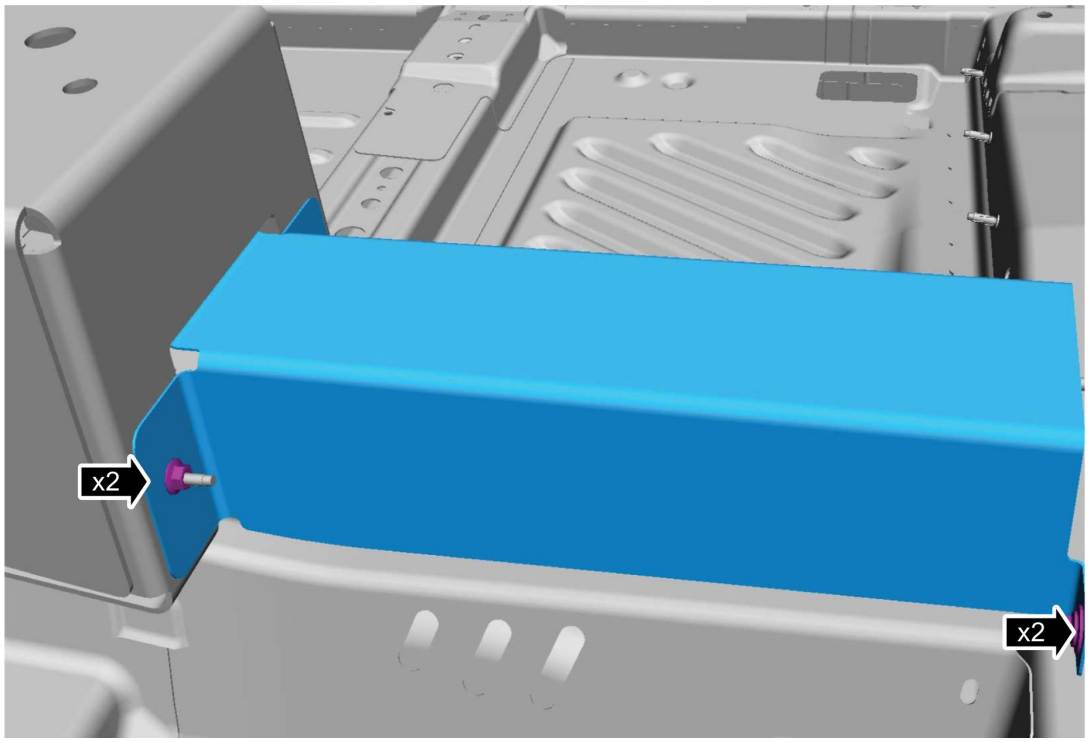
Access to Signals and Power

1. Remove 4 bolts and the rear plate located inbetween the mounting plate and second row seat.
   a. Torque: 40 lb.in (4.5 Nm)



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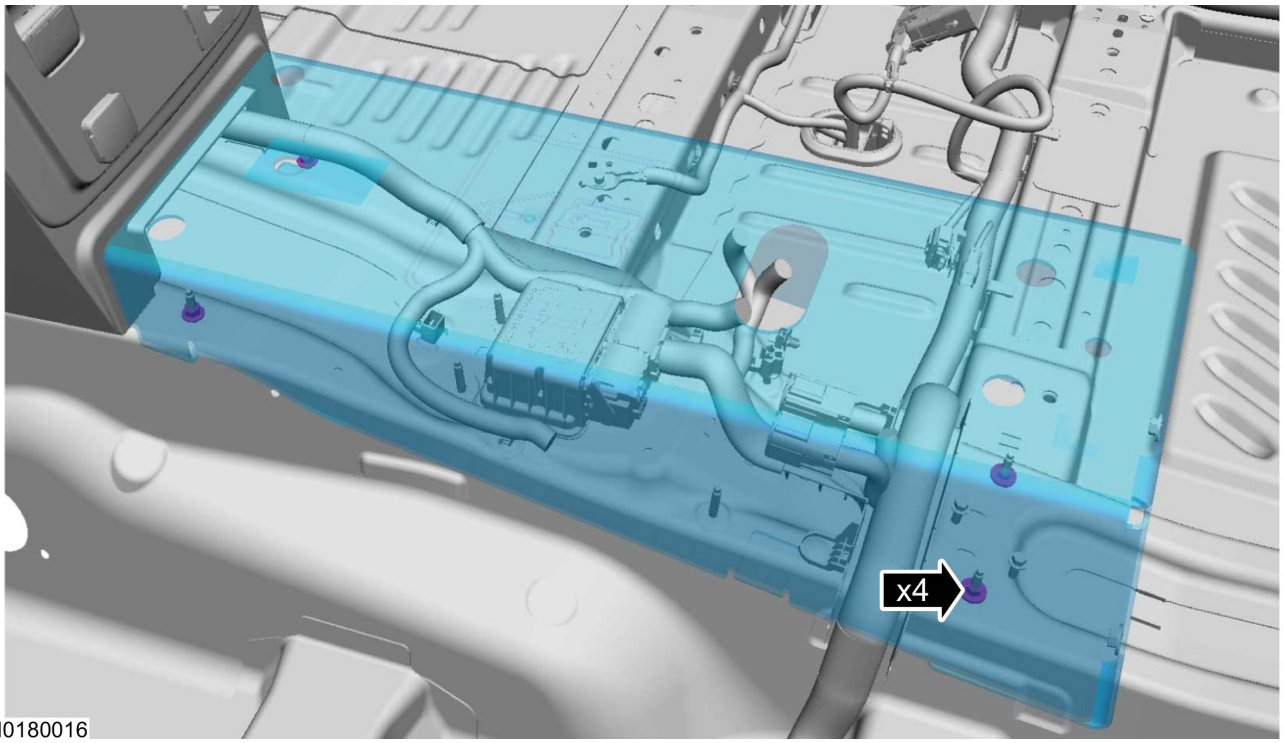
2. Remove the 4 nuts and the center mounting plate.
   a. Torque: 93 lb.in (10.5 Nm)



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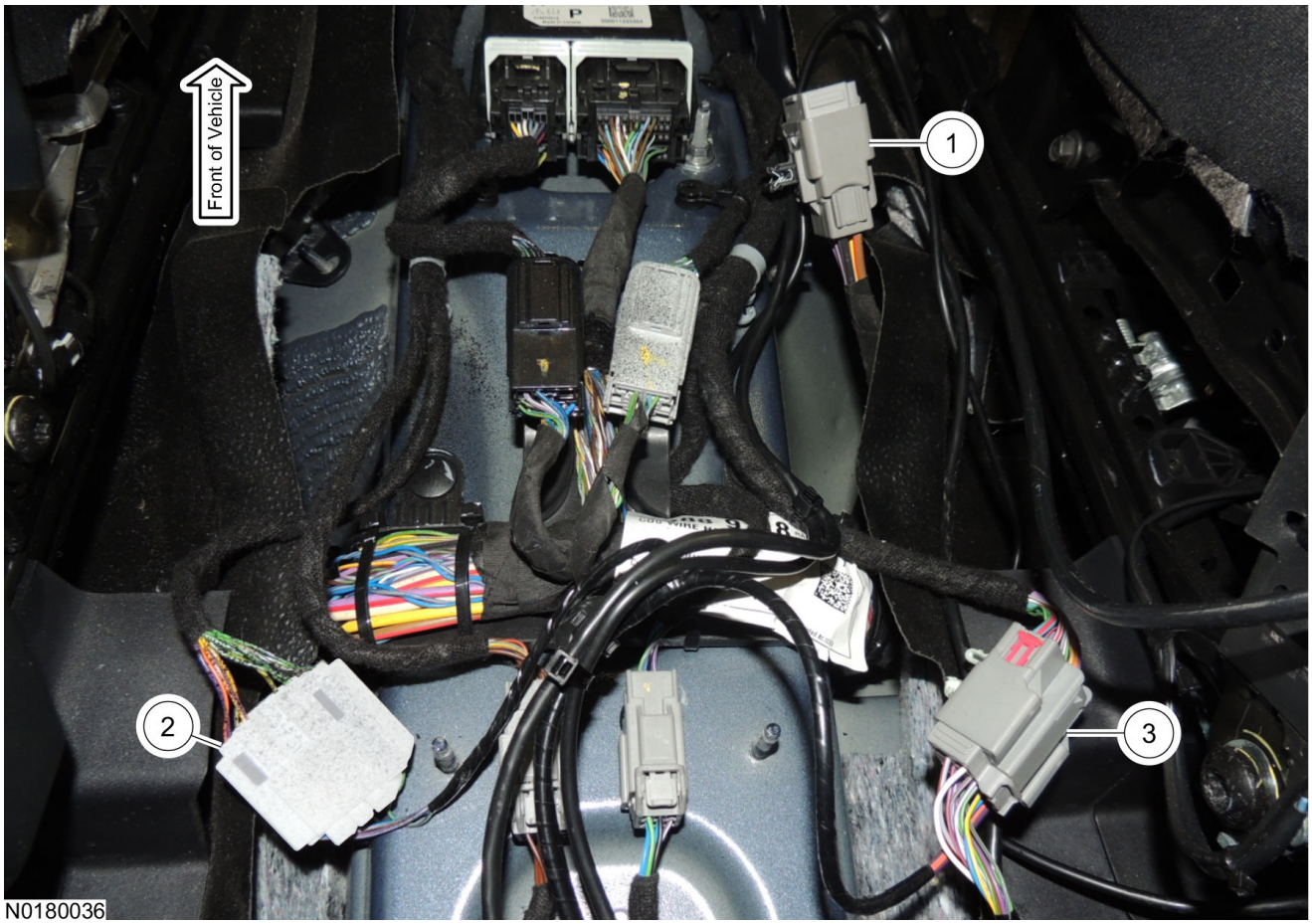

1. Grey 6 pin connector.
2. White 14 pin connector.
3. Grey 14 pin connector.

Connector View For Grey 6 pin Connector

Pin Number	Description	Wire Color
1	B+ (40A)	BU-WH
2	B+ (40A)	YE
3	B+ (40A)	BN-RD
4	Ground	BK-WH
5	Ground	BK-WH
6	Ground	BK-WH

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Connector View For White 14 pin Connector

Pin Number	Description	Wire Color
1	Wig Wag Control	OG
2		
3	B+ feed fused at 15 A max	YE-VT
4		
5		
6	Side LED Synch	GY-OG
7	Dimmer	VT-GY
8	Brake Output	YE-BU
9	Speaker + TDM Grill	BN
10		
11	Battery Saver	YE-GN
12	Horn - Module Side	GN-WH
13	Horn - Switch Side	GN-WH
14	Front LED Pattern	GN-VT

Connector View For Gray 14 pin Connector

Pin Number	Description	Wire Color
1	B+ Feed #1	WH-RD
2	Control Button 1	GY-BN
3	Control Button 2	WH-VT
4	Control Button 3	GN-BN
5	Control Button 4	YE-GY
6	Police Start	BU-BN
7	RN/ST #1	VY-OG
8	B+ Feed #2	BU-RD
9	Vehicle Speed	VT-OR
10	Delay Accessory	VY-GY
11	B+ Feed #3	VT-RD
12		
13	Diver Door Ajar	GN-VT
14	R/S #2	GY-BU

