



S550 Mustang Charging System - A Primer

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Traditional vehicle charging systems involved a battery, generator and voltage regulator. While these core components are still present in the S550, there are some logical advancements with improved capabilities. This primer will provide a general overview of the charging system and how it operates.

An electron is one particle of an atom which carries a negative (-) electrical charge.

Electron flow is the direction electrons take while traveling through an electrical circuit.

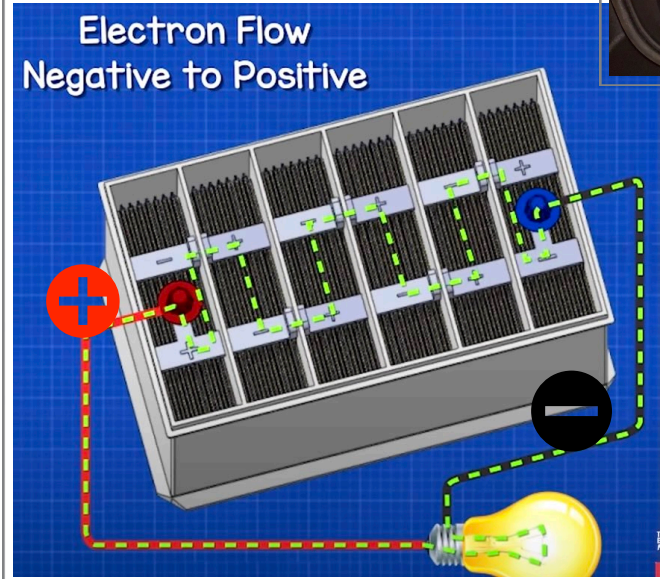
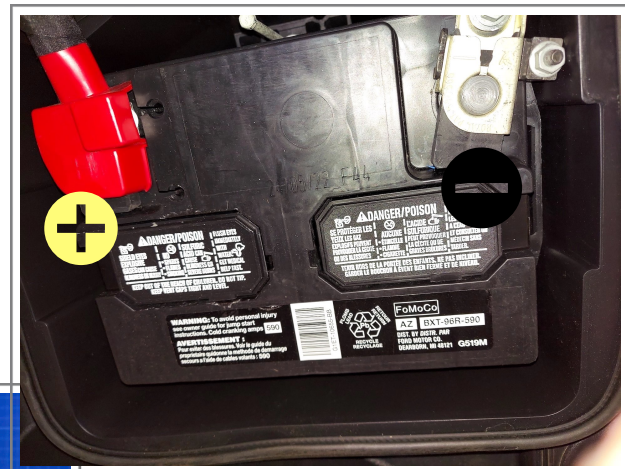
Conventional current flow is always opposite of electron flow. If electrons are traveling from North-to-South, Conventional current flow is from South-to-North.

An Ampere or Amp is the measure of the amount of electrical flow past a given point at a particular time. Current and Amps are synonymous. Current or amps could be measuring the amount of electron flow or charge carrier flow.

Voltage is a measure of electrical pressure, a difference in electrical potential and form of doing work. The higher the voltage, the greater the pressure.

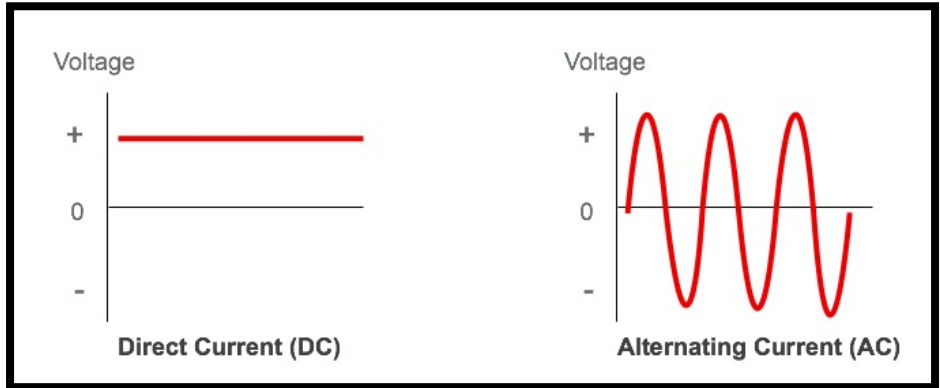
Battery (Lead-Acid)

A battery is a device which stores chemical energy, designed to produce electricity on demand. This section will be focussing on lead-acid batteries, comprised of a case, lead plates and an acid solution.



Inside the case of a vehicle battery are a series of cells. Inside each cell are lead plates. The plates and cells are attached in-series, ultimately producing about +12 Volts of Direct Current (DC) or VDC. One can think of each cell as one battery in itself, the cells then chained together to produce an overall unit; it's much like placing multiple batteries in-series in a flashlight.

This graphic shows the differences in waveforms between DC and AC. While the DC voltage in the picture displays positive voltage, DC can easily be negative. A lead-acid battery in a vehicle will measure positive (+) voltage.



There is no inherent advantage of using positive (+) or a negative (-) system. Engineers will select one or another for a particular application.

DC voltage is of constant amplitude and polarity. AC voltage constantly varies in amplitude and polarity. Most vehicle systems use positive DC.

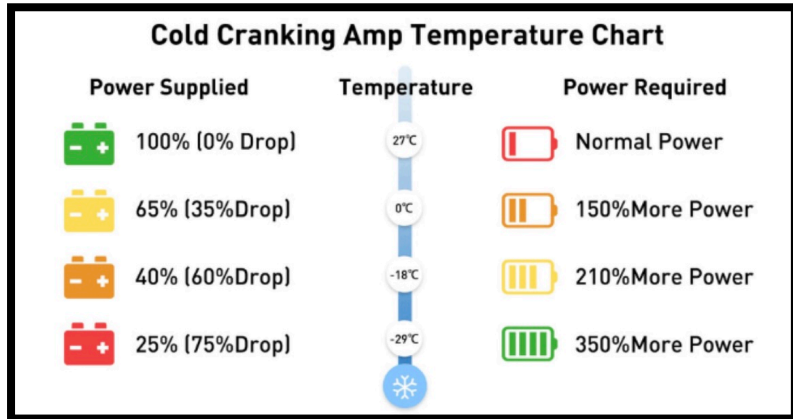
Logically and physically, one half of the battery is positive, the other negative. The positive end terminal is often marked with a “+” and a red protective cap. The negative end terminal is sometimes marked with a “-“. I’ve never seen a “-“ terminal with a cap, but if you do see one, it’d probably be black.

Virtually all modern vehicle systems are +12 VDC. The amperage of the recommended battery can vary by vehicle and engine type. A battery’s Cold Cranking Amp (CCA) rating gives you an idea of the power a battery can generate in specific conditions.

“CCA measures your battery's ability to start your vehicle in cold temperatures. Specifically, the amount of amperage a battery can supply at zero degrees (-17.8 C) for 30 seconds while sustaining a voltage of at least 7.2 volts. In other words, a CCA rating tells you how well your battery can work in the hardest possible conditions for a car battery.”

Supplied Power	Temperature	Power Required
100% (0% Drop)	27°C / 81F	Normal Power
65% (35% Drop)	0°C / 32F	150% More Power
40% (60% Drop)	-18°C / 0F	210% More Power
25% (75% Drop)	-29°C / -20F	350% More Power

A vehicle's biggest draw on the battery will be when starting. Peak Summer and peak Winter temperatures can put excessive stress on any battery. It would not be unusual to require 250-300 amps of power to start a 5.0L. As a reference, most home service panels are rated at 100-150 amps. Small as they are vehicle batteries can generate tremendous amounts of current.



When sourcing new or replacement batteries, most owners go a bit above the minimum recommended CCA, for additional reserve. There's no specific amount over. But certainly not under the recommended CCA.

At this point, a safety PSA. When working on anything electrical, isolate that system. In the case of the home panel, turn-off the breaker fuse, or the entire panel. If the S550 or other vehicle, disconnect the negative (-) terminal, the source of the electrons. The few moments to do that can spare you and the vehicle any damage. People lose their footing. Tools slip. The only assured way of protecting yourself is to remove the source of electricity.

There is no actual distinction between breaking the negative (-) or positive (+) terminal. You are disconnecting the loop either way. However, I do believe removing the negative cable gives one some advantages. First, the (-) post is the source of electrons, and electron flow. Second, there could be charged devices in-between the negative terminal and the positive, devices which will continue to accept electrons if the (+) side of the device completes the circuit (possibly by you or a tool in an accident).

A detailed explanation of battery construction and the energy conversion process is available in the Links section.

The outside of the battery case has two terminals, a positive (+) and a negative (-). The (+) terminal is a cathode, the negative, an anode. One good way to remember is caThode and aNode, as in posiTive and Negative.

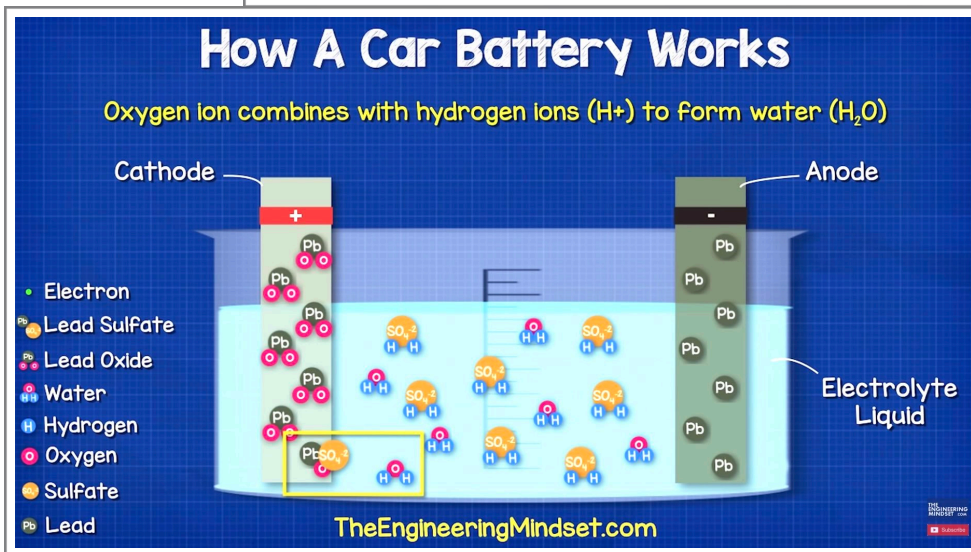
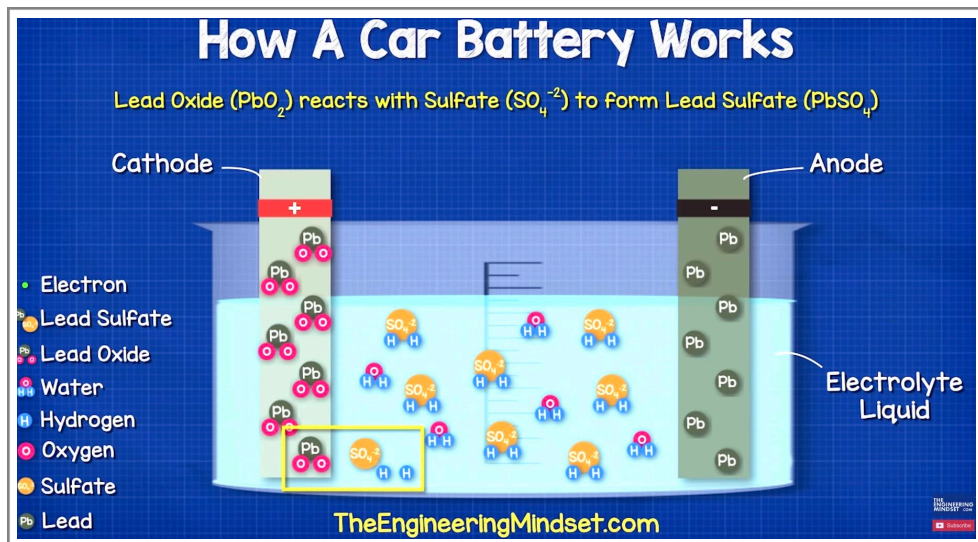
The aNode (-) terminal post and internal plates are lead. The caThode (+) post and internal plates are lead oxide. The (+) and (-) plates and terminals are never in direct contact with one another but close to one another.

Chemical oxides (in this case, the (+) terminal and plates) are molecules with oxygen; Oxides can also be reducers; they donate electrons. When discharging, the lead oxide releases oxygen (an atom heavy with electrons), producing water and sulfate (a mineral salt) as by-products. Metal oxides act as catalysts, facilitating or accelerating chemical reactions to occur.

The electrolyte is a sulfuric acid, water solution, 1/3 sulphuric acid, 2/3 water. The battery electrolyte enables the transfer of electrons and ions from one part of the battery to another. Electrolytes allow electrical or charge flow inside a battery.

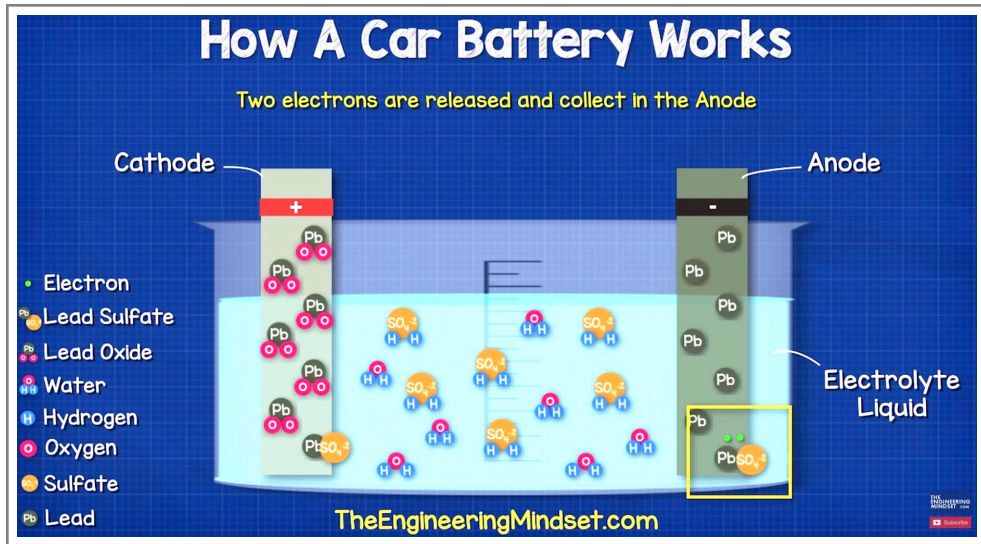
The terminals and associated plates cause the sulphuric acid to separate into hydrogen ions and sulfate ions. The hydrogen ions remain suspended in the fluid electrolyte.

The sulfate ions that reach and attach to the (+) lead oxide terminal and plates ejects oxygen ions from those parts.

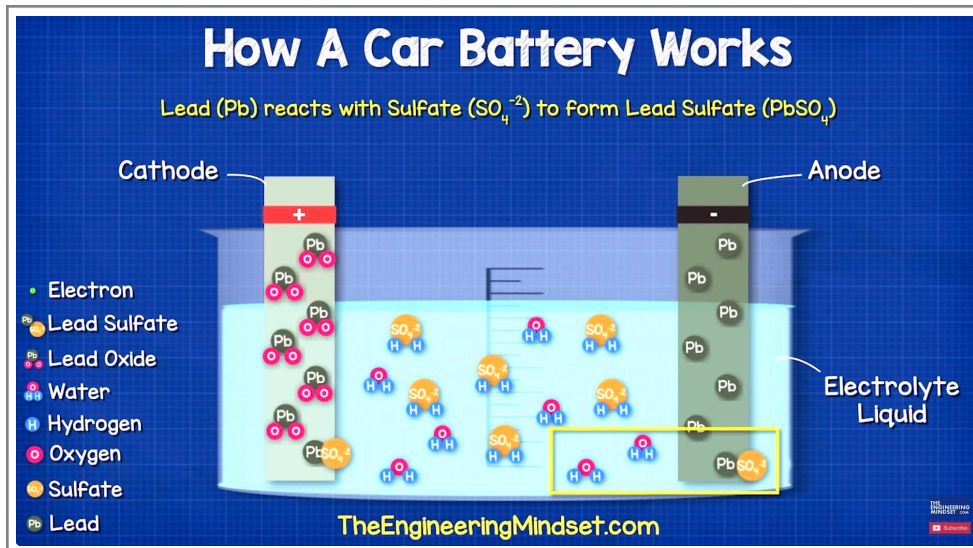


The ejected oxygen ions combine with the suspended hydrogen ions, creating water (more than what was originally in the solution).

The sulfate that reaches and attaches to the (-) lead terminal and plates ejects two electrons into the (-) plates and terminal. As with the (+) terminal and plates, a layer of sulfate builds on the surface.



Notice how one terminal becomes more positive, the other, more negative, as the process continues. A differential of potential, a form of work, has been created

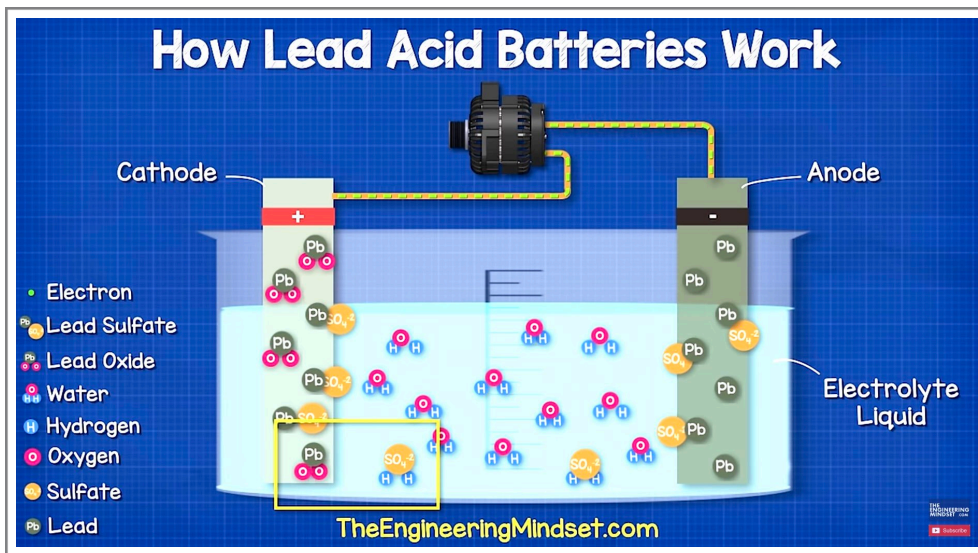
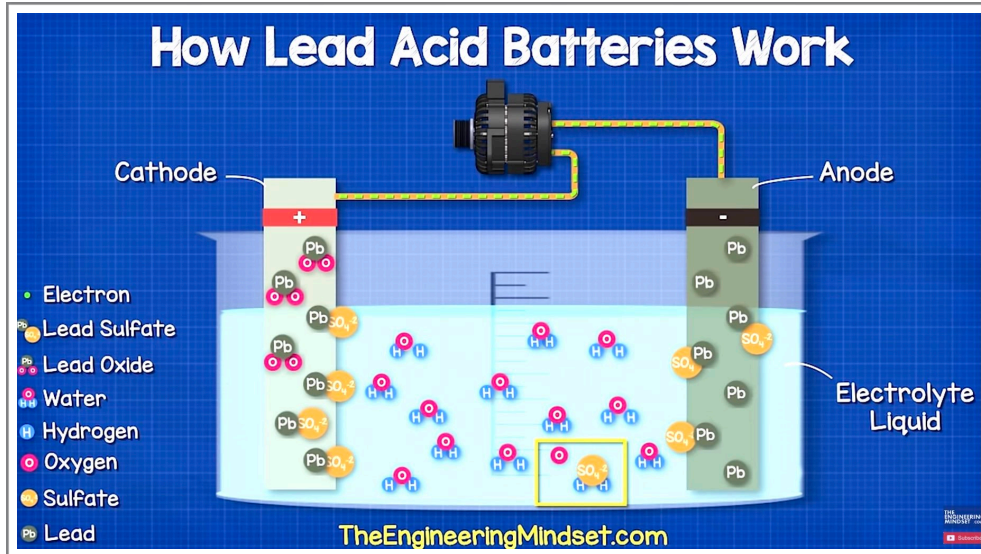


At rest, a battery is a static, chemical store of energy. While there is some electricity available, it will not flow and the battery will not create more until a circuit and load are attached.

Ultimately, the battery can become completely discharged. The electrolyte solution has a much greater concentration of water. The terminals and plates, sulfate build-up, the terminals becoming more similar.

The process described above is routinely reversed, one of the key jobs of the alternator.

When running, the alternator can produce and send electrons back through the negative terminal. The entering electrons repel the existing electrons, dissolving the sulfate, putting it all back into the electrolyte solution.



At the same time, the positive portion of the alternator circuit is increasing the amount of electrical charge on the cathode, repelling and dissolving the positively-charged sulfate.

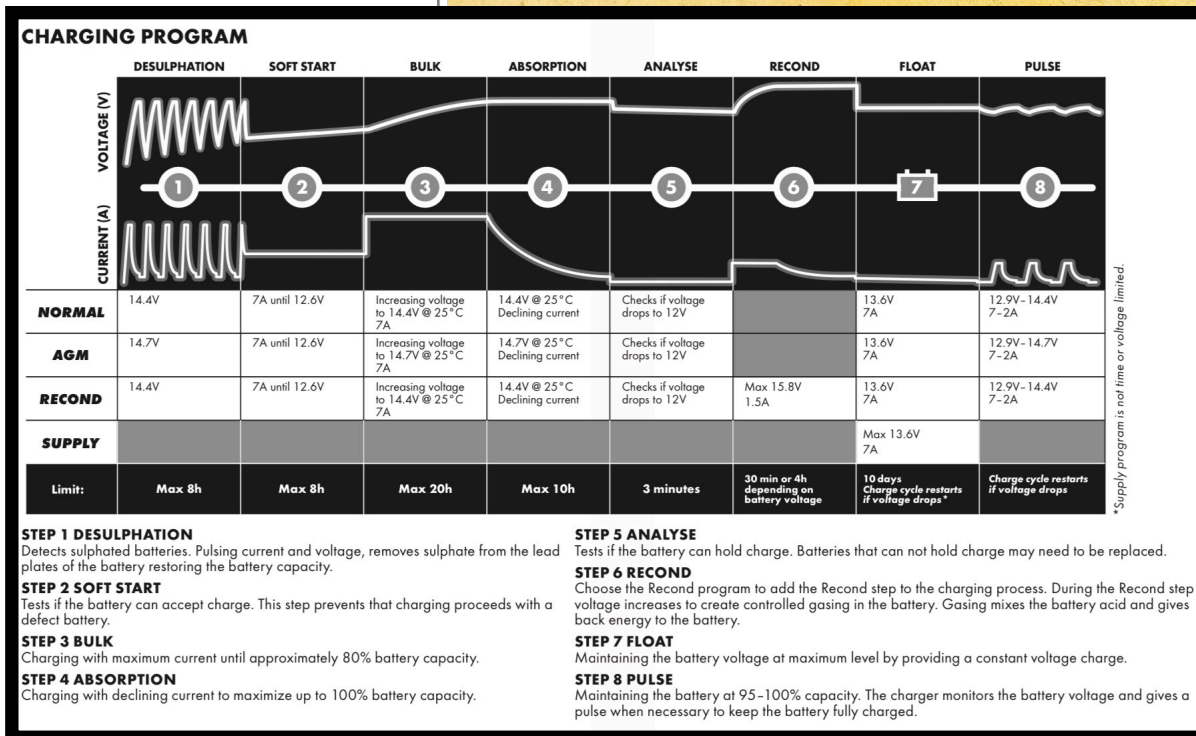
Once back in the solution, the sulfate ions recombine with the hydrogen ions, ejecting the oxygen. The electrolyte is becoming more acidic.

The freed oxygen ions gravitate to the lead oxide on the (+) terminal.

Battery Maintainer

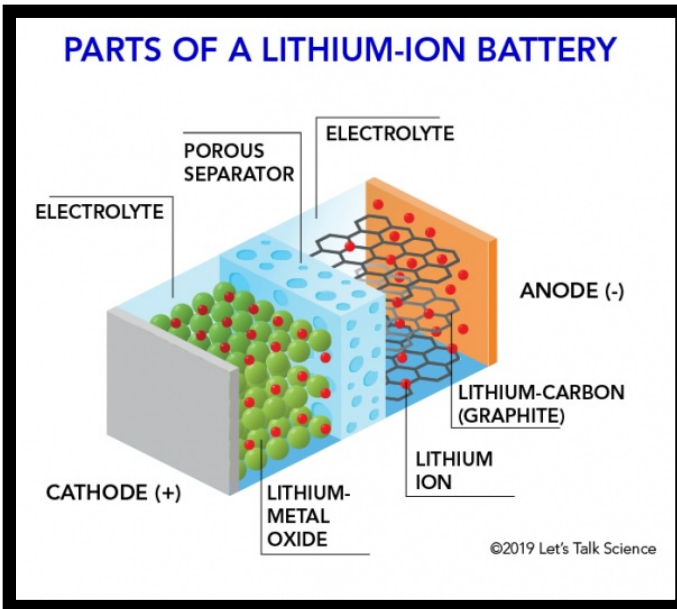
In describing the chemical reactions, sulfates were discussed. Routinely taking a vehicle on short trips is detrimental to the battery and the vehicle's charging system. It takes a lot of power to start a car, and time for the generator to replenish the battery. During short, consecutive drives, the generator will work harder. Sulfates will develop which might not be cleared sufficiently before the next start. If heavy enough, sulfates do not later dissolve, but break up and fall to the bottom of the battery case, permanently weakening the battery.

If the car does not see extended drives often, or is not driven often, a battery tender can enhance the life of the battery and lessen the strain on the generator. Tenders are designed with battery maintenance and longevity in mind. They have specific routines to keep at battery at peak performance.



Battery (Lithium Ion)

Lithium is an element which is widely available, light in weight and energy dense. Lithium Ion (Li-ion) batteries have an anode (-), cathode (+), electrolyte and generate electricity. Lithium Ion batteries are not as common in ICE vehicles as traditional lead-acid ones, and their material composition is different. But the same general components and principles are the same. Different types of Li-ion batteries can have different component materials. The following will describe activities in one type of battery.



The negative section of a lithium battery holds lithium in a graphite lattice. This arrangement keeps the lithium stable until needed. "Intercalation" is a term used to describe a reversible insertion of a molecule held in a layered structure.

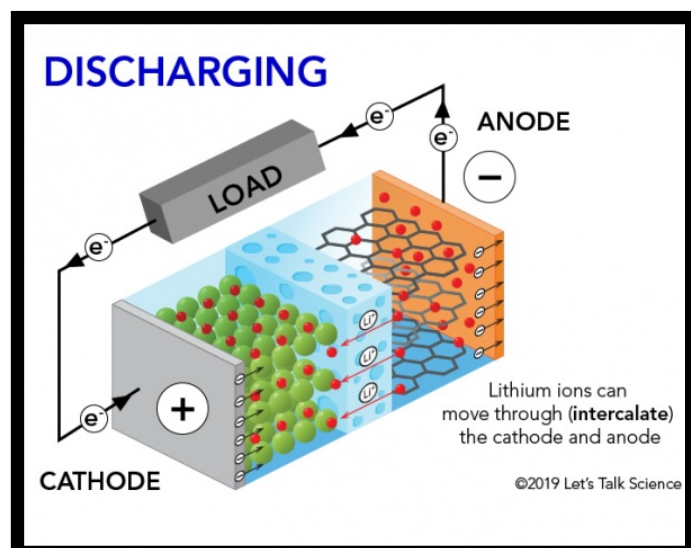
The cathode of a Lithium battery is made of a cobalt, oxygen oxide. The cobalt atoms have given up the electrons in their outer shell to the oxygen and are looking for replacements. The cobalt lattice leans (+).

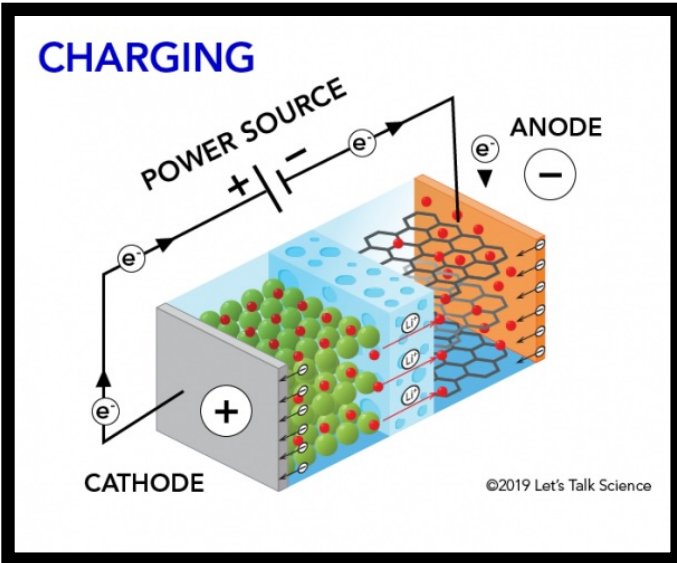
The electrolyte in a Li-ion battery operates a bit different than a lead-acid one: it blocks any free electrons from crossing directly into the (+) lattice, while allowing lithium ions free movement across. Electrons in the (-) lattice can only exit the negative terminal and flow through a circuit load.

The electrolyte in a Li-ion battery

There is also a separator, preventing the lattice on either side from touching the other and causing a short circuit.

When discharging a Li-ion battery, electron flow is away from the anode and into the electrical circuit. The lithium ions stay in the battery structure, pass through the electrolyte barrier, are attracted to and enter the cobalt lattice. Electrons recombine with those ions after passing through the circuit.





When charging a lithium battery, electrons are pumped from a power source, towards the anode lattice. The positive side of that same power source is strong enough to break the electrons away from their lithium atoms, “sucking” them back in and pushing them towards the anode. At the same time, those additional positive forces repel ions back towards the electrolyte. The ions are attracted to the gathering of electrons at the anode, move to and re-attach.

Some S550 owners have changed their factory lead-acid battery to an Antigravity Li-ion battery. The advantages are space and weight savings. The units are a direct replacement. There are some caveats when considering a lithium battery.

Specific to the Antigravity unit, they have under-voltage protection. As parasitic drains lower the voltage of the Li-ion unit, the battery has intelligence to disconnect itself. The feature acts like a breaker, preventing the owner from having a dead battery.

Under voltage protection maintains a “self-jump” feature is so the owner does not have to jump-start the battery. Jump-starting a heavily-discharged battery is not safe. Li-ion units need to be brought back up slowly. Jump-starting could damage the unit. Antigravity has battery-specific help guides and more details at their web site.

With respect to battery tenders, these need to be designed to maintain a lithium unit. Using a high-powered charger or non-Li-ion tender could damage the battery.

Antigravity batteries have their own, internal Battery Management System (BMS). We’ll discuss Ford’s BMS later. Using FORScan, many Mustang owners will disable the Ford BMS and use the Antigravity BMS exclusively.

Battery Management System

Engineers who design batteries are well-aware of certain operating conditions (extreme hot, extreme cold, taxing loads, over-charging, under-charging) which can shorten a battery's useful service life. Ford's Battery Management System (BMS) is installed to keep the battery at its optimum for as long as possible. While monitoring conditions, BMS and the car make adjustments to the charging system in support of the battery and its health.

12V Battery Voltage	Volts Per Cell	State of charge
12.7	2.12	100%
12.5	2.08	90%
12.42	2.07	80%
12.32	2.05	70%
12.2	2.03	60%
12.06	2.01	50%
11.9	1.98	40%
11.79	1.96	30%
11.58	1.93	20%
11.31	1.89	10%
10.5	1.75	0%

In a new car, Ford's battery State of Charge (SoC) goal is 80%. A one hundred percent charge is not optimum. While your oven has a self-cleaning feature which operates at the device's maximum possible temperature, the oven's service life will be reduced every time that feature is used. BMS is attempting to do the same. Keeping a long-term 100% charge accelerates internal

degradation of battery components.

From repeated uses and expected degradation, a battery will need a greater or longer charge than previously. BMS keeps track of all this and adjusts the alternator and charging circuits accordingly.

The charging and discharging of any battery will physically wear it out. Materials will degrade. Even when kept at their best, not all sulfates will be released. Over time, the battery has more and more difficulty maintaining a charge and producing the designed current flow.

This writer is pro-active, replacing lead-acid batteries every five years, even if they do still present well.

BMS is akin to the Oil Life Monitor (OLM); it knows how long the battery has been in the car, how often charged and discharged and adjusts the car's charging routine accordingly. Once the battery is replaced, the Owner needs to reset the BMS, to let the car know a new battery is present.

BMS resets are easy. There's a link to the procedure in this document's appendix.

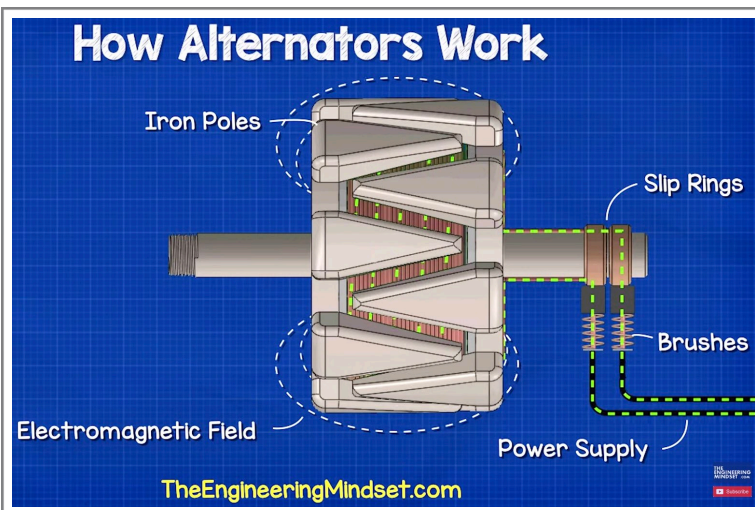
Alternator

A generator is a device that converts mechanical energy into electricity.

An alternator is a generator that produces Alternating Current (AC).

The S550 uses an alternator, but the car needs DC voltage and current. The alternator contains three main components to produce and output DC.

Animated videos giving detailed information on generators is in the Links section.

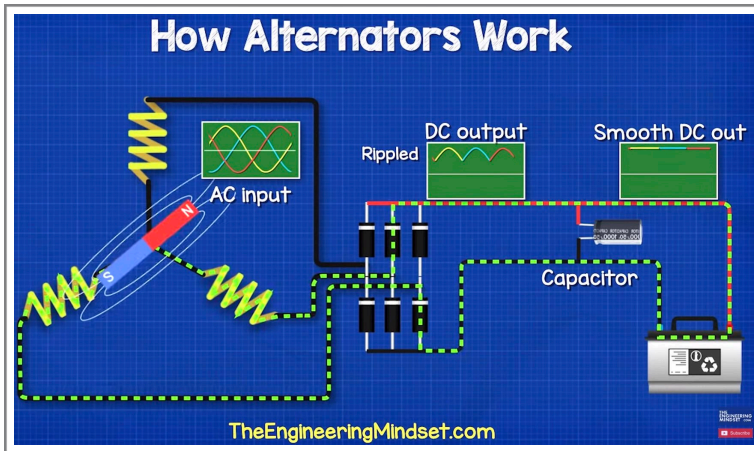


Inside the alternator is a electromagnetic rotor (magnet) and stator coil (pickup coil). This rotor is powered by the battery with a small amount of VDC. The rotor spins inside the stator coils. Once the engine is running, electromagnetic induction produces an AC signal.

Electromagnetic Induction is the production of ElectroMagnetic Force (EMF) when there is relative motion between a magnetic field (rotor) and a conductor (stator coils).

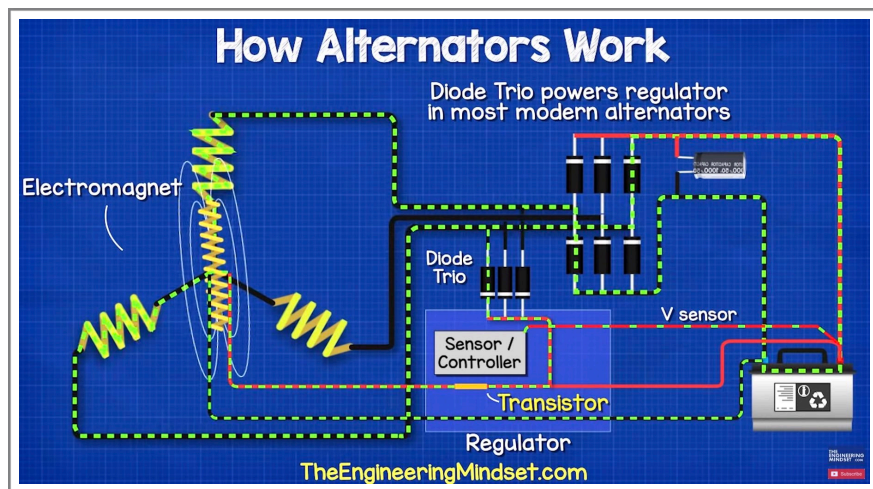
The initial output of an alternator is VAC. A second component of an alternator produces VDC: the rectifier.





The rectifier is comprised of multiple diodes. A diode is a semi-conductor which allows current movement in one direction only. If oriented correctly, three diodes can capture and orient three-phase AC to produce VDC.

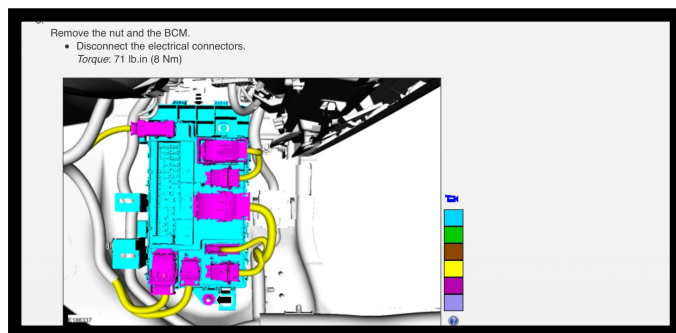
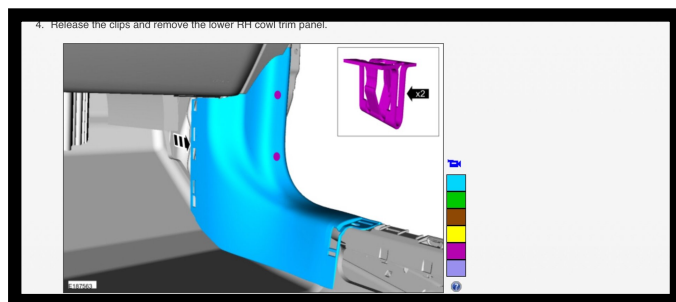
Finally, the alternator has a third major component: the regulator. As the engine's RPMs increase or decrease, so will the output voltage and current of the alternator, something we don't want. The regulator ensures the signal is always of the correct amperage and steady voltage.



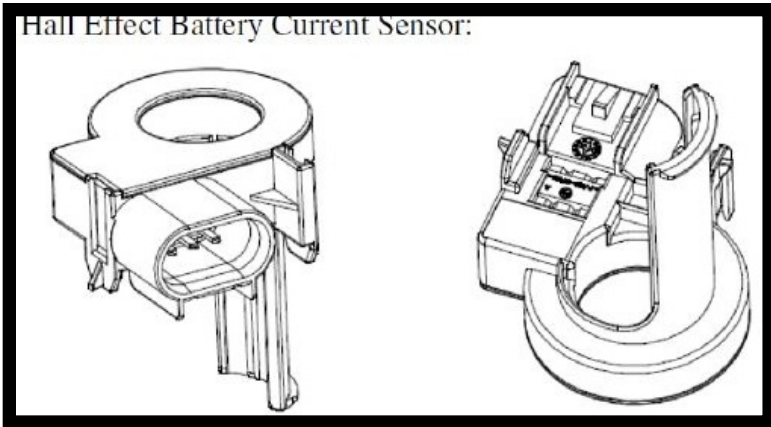
Charging Strategy

The Body Control Module-A (BCM), interior of car, near passenger side footwell, monitors and maintains the battery State of Charge (SoC). Battery charging and monitoring done by Ford's, "Electrical Energy Management", system.

A battery's SoC will be measured and charging system algorithms updated when the car is off. This process can take up to eight hours to ensure the highest accuracy.



Hall Effect Battery Current Sensor:



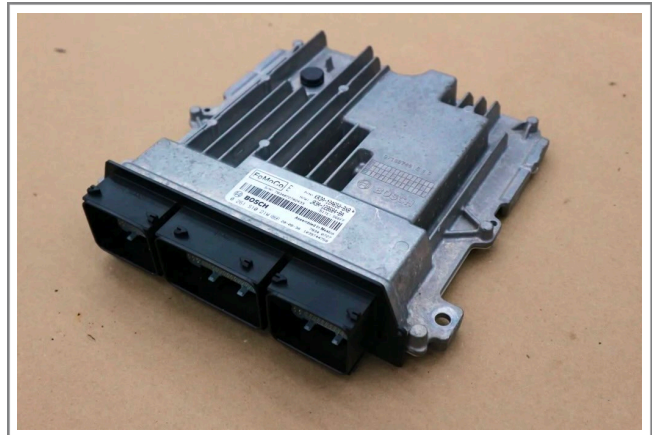
The battery is monitored via a Hall effect sensor located on the vehicle's negative battery cable. The Hall effect, "is the production of a potential difference (the Hall voltage) across an electrical conductor that is transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current."

By monitoring the Hall voltage present in the sensor, the BCM can determine at what rate the battery is charging and discharging, as well as its SoC. The presence of this sensor on the cable identifies how some electrical installations which go straight to the (-) post of the battery can confuse and interfere with the BMS.

When jump starting the vehicle, Ford recommends, at the disabled vehicle, attach the recovery negative jumper cable to the engine or a chassis mount. Not to the (-) battery terminal directly.

Load Shedding Strategy

The Powertrain Control Module (PCM) (located under the hood and near the fuse panel) controls the generator and its output. In addition to the regulated voltage output of the alternator, there is a GENERator COMMunication (GENCOM) circuit; this is the method the PCM uses to direct the generator to provide a given output. In addition to generator load, the PCM receives alternator error and status conditions via the GENERator MONitor (GENMON) circuit. Both circuits use Pulse Width Modulation (PWM) signals to convey information. Ford uses the term, "Smart Charge", for how the PCM controls the alternator. The PCM reports any system faults to the BCM-A.



During engine cranking, the PCM turns off the alternator to reduce load and increase engine cranking speed. Once running, the PCM increases alternator output to meet requirements. If the PCM senses the battery is discharging, the PCM will increase alternator output and possibly engine speed to charge the battery and prevent battery drain.

When programming modules, Ford recommends connecting an external charger, tender or running the engine while doing so. If not, there is the potential to drain a battery to a given level where load shedding will occur, the update will stop and information will be corrupted.

When the car is off, if the BCM determines the battery has discharged to concerning levels, the BCM will begin to disable the audio and navigation systems.

When the engine is running and the BCM or Power Steering Control Module (PSCM) voltage is low, load shedding will occur. Climate controlled seats, heated mirrors, steering wheels and rear window defrost functions could all be disabled.

Ford vehicles have three strategies, each more aggressive, which engage as needed: Load shed 1, Load shed 2 transient and Load shed 2 continuous.

Load shedding also helps explain why, when a driver has a failing battery that needs to be replaced, some features of the vehicle do not work correctly, if at all.

Acronyms

ABS - Anti-Lock Brake System
ACK - ACKnowledgment (See CAN message format, ISO 11898)
ACM - Audio Front Control Module (DACMC, Radio, CD, Speakers)
AM - Amplitude Modulated
ANC - Active Noise Cancelling
APIM - Accessory Protocol Interface Module (SYNC, steering controls, radio, NAV)
BCM - Body Control Module
BCMA - BCM (Interior, right side, near floor)
BCMB - BCM (Trunk, right side, near wheel well)
BECMB - Battery Energy Control Module B (RCM, SRS. Turns off fuel in crash.)
BLIS - Blind Spot Information System
BMS - Battery Management System
CAN - Controller Area Network (See also LIN)
CCA - Cold Cranking Amps
CCM - Cruise Control Module
CIP - Consumer Interface Protocol
CPA - Connector Position Assurance (SRS, airbag connector tabs)
CRC - Cyclic Redundancy Check (See CAN message format, ISO 11898)
DAB - Digital Audio Broadcasting
DACMC - Digital Audio Control Module-C (ACM, Radio, CD, Speakers)
DCSM - Dual Climate Seat Module (Seating Climate Control)
DCT - Dual-Clutch Transmission (Paired, electronically-controlled manuals)
DDM - Driver Door Module (Keyless Entry)
DIAG1 - A physical link, connecting LHD and RHD DLC/GWMs
DIAG2 - A physical link, connecting LHD and RHD DLC/GWMs
DLC - DataLink Connector (OBDII, GWM, both LHD and RHD)
DSM - Driver Seat Module (Seat Memory, Power)
DSP - Audio Digital Signal Processor (DSP) Module
DTC - Diagnostic Trouble Code. The fault code/s, seen by a OBDII scan tool
ECM - Engine Control Module (PCM)
ECU - Engine Control Unit (PCM)
EOF - End Of Frame (See CAN message format, ISO 11898)
EMF - ElectroMotive Force
EMI - Electro-Magnetic Interference
FCIM - Front Controls Interface Module (Center Console Push-Button Controls)
FCDIM - Front Controls Display Interface Module (FCIM Outputs)
FDIM - Ford Display Module (Screen Outputs)
FM - Frequency Modulated
GENCOM - Generator Communications
GENMON - Generator Monitoring
GSM - Gear Shift Module (GT500 Only)
GWM - GateWay Module (DLC, OBDII, LHD and RHD)
HS-CAN - High-Speed Controller Area Network (1,2,3 and 4)

Acronyms (cont.)

HSWM - Heated Steering Wheel Module
HUD - Head-Up Display Module
HVAC - Heating, Ventilation, Air Conditioning
ICM - Information Center Module
ID - Identifier (See CAN message format, ISO 11898)
IPC - Instrument Panel Cluster
IPMA - Image Processing Module A (Camera, Lane Departure)
ISO - International Organization for Standardization (See CAN message, ISO 11898)
LHD - Left-Hand Drive (DLC, GWM, LHD and RHD OBDII linked via DIAG1 and 2)
LIN - Local Interconnect Network (low-cost, low-speed, low-reliability CAN supplement)
LVDS - Low Voltage Differential Signaling
MRCMA - Movable Roof Control Module, Primary (Convertible Roof)
MRCMB - Movable Roof Control Module, Secondary (Convertible Roof)
MS-CAN - Medium-Speed Controller Area Network
OBDII - On-Board Diagnostics, Gen 2 (DLC, GWM)
OCS - Occupant Classification System (Passenger Seat Only)
OCSM - Occupant Classification Systems Module (Passenger Sitting Detect)
OLM - Oil Life Monitor
PAM - Parking Assist Control Module (Backup Assist, Parking Assist)
PCM - Powertrain Control Module
PDM - Passenger Door Module (Keyless Entry)
PMI - Programmable Module Installation
PSCM - Power Steering Control Module
PWM - Pulse Width Modulation
RCM - Restraint Control Module (Seatbelt, SRS, Crash Detect)
RHD - Right-Hand Drive (DLC, GWM, LHD and RHD OBDII linked via DIAG1 and 2)
RPM - Revolutions Per Minute
RTM - Radio/Remote Transceiver Module (keyless entry, TPMS, remote start)
SCCM - Steering Column Control Module (High Beams, Turn Signals)
SCME - Seat Climate-controlled Module - E
SDL - Smart Device Link (Infotainment connectivity protocol, apps, systems)
SIM - Subscriber Identity Module
SoC - State of Charge
SODL - Side Obstacle Detection Control Module LH (BLIS)
SODR - Side Obstacle Detection Control Module RH (BLIS)
SOF - Start Of Frame (See CAN message format, ISO 11898)
SRS - Supplemental Restraint System
SUMB - Vehicle Dynamics Control Module (VDM, Magneride)
TCM - Transmission Control Module (In GT500, a dedicated unit, attached to trans)
TCU - Telematics Control Unit
TCU - Transmission Control Unit (In GT500, a dedicated unit, attached to trans)
TPMS - Tire Pressure Monitoring System
TTS - Text To Speech
VAC - Voltage Alternating Current

Acronyms (cont.)

VDC - Voltage Direct Current

VDM - Vehicle Dynamics Control Module (Magneride)

VIN - Vehicle Identification Number

VIP - Vehicle Interface Protocol

VPWR - Vehicle PoWeR (PCM manages power needs)

VQM - Voltage Quality Module ("smoothes" voltage to components)

Links and Site References

Alternator

Alternator Animated Video Tutorial

<https://www.youtube.com/watch?v=jdSKlg80DjU>

Antenna

Antenna (Roof) And What They Do

<https://www.mustang6g.com/forums/threads/job-1-vs-job-2-shark-fin-roof-antenna-and-what-they-do.146941/>

Antenna (Shark Fin) PN#

<https://www.mustang6g.com/forums/threads/shark-fin-antenna-part.146564/>

APIM

APIM - YouTube Video Showing APIM and its location

<https://www.youtube.com/watch?app=desktop&v=fI03A9IbYaA>

Links and Site References

Battery

Battery, Lead-Acid, Animation Video Tutorial

<https://www.youtube.com/watch?v=VnPRX5zQWLw>

Battery, Lithium-Ion, Brief Explanation

<https://letstalkscience.ca/educational-resources/stem-explained/how-does-a-lithium-ion-battery-work>

BCM

BCM Location, Diagrams, with Steps on How to Replace (BCMA and BCMB)

<https://www.mustang6g.com/forums/threads/bcm-replacement-help.119035/>

<https://www.mustang6g.com/forums/threads/2018-gauge-cluster-retrofit.74133/page-27>

BCM Partial Pinout, to include Fog Lights

<https://www.mustang6g.com/forums/threads/anyone-have-the-pinout-wiring-diagram-for-2018-up-fog-running-light-assembly.132859/>

BLIS

BLIS, A Step-By-Step Guide To Installing

<https://www.mustang6g.com/forums/threads/step-by-step-guide-to-enabling-blind-spot-information-system-blis-and-cross-traffic-alert-cta.107623/>

BMS

BMS, Characteristics of Lead Acid Batteries

<https://www.pveducation.org/pvcdrom/lead-acid-batteries/characteristics-of-lead-acid-batteries>

BMS, The Concept of Ford's Service

<https://lockdownsecurity.forumbee.com/t/m2gvh9/ford-trucks-bms-battery-monitoring-systems>

BMS: How to Reset in the S550 Mustang

<https://www.mustang6g.com/forums/threads/bms-reset-no-tools-required.151602/>

Links and Site References

CAN

CAN Tutorials, both Document and Video (See also LIN)

<https://dewesoft.com/blog/what-is-can-bus>

<https://www.csselectronics.com/pages/can-bus-intros-tutorials>

<https://www.ti.com/lit/an/sloa101b/sloa101b.pdf>

<https://www.youtube.com/@CSSElectronics-CAN-Logger-X000/videos>

CAN in Ford, Explained In Detail, with Logical Drawings

https://www.fofusion2.com/ford_fusion_communications_network_system_operation_and_component_description_description_and_operation-2613.html (Site explains which module uses which CAN)

<https://www.fordgt500.com/threads/can-bus-2020-2022-gt500.205590/>

<https://www.mustang6g.com/forums/threads/the-how-to-disable-the-data-link-to-ford-thread.146863/page-5#post-3007057>

Links and Site References

DCT

DCT Operation (Also see TCM below)

<https://www.youtube.com/watch?v=t8aGgSbtoJE>

Links and Site References

GWM

GWM Location with Dash Harness Connector Layout, HSWM

<https://www.mustang6g.com/forums/threads/2018-gauge-cluster-retrofit.74133/page-27>

Links and Site References

LIN

LIN Tutorial (See also CAN)

<https://www.youtube.com/watch?v=TresvW4dxlc>

LVDS

LVDS Tutorials

<https://www.allaboutcircuits.com/technical-articles/the-why-and-how-of-differential-signaling/>

<https://resources.system-analysis.cadence.com/blog/msa2021-the-advantages-of-differential-signaling>

<https://hardwarebee.com/understanding-lvds-low-voltage-differential-signaling/>

Links and Site References

MRCMA

MRCMA Detailed Document with CAN explanations and Logical Diagrams

https://www.mustang6g.com/forums/attachments/sm_22-pdf.436431/

Links and Site References

PCM

P CM, 10R80 Harness Connectors and Connections

<https://www.mustang6g.com/forums/threads/looking-for-trans-pcm-connector-pinout-10r80.147871/>

P CM Control Pack Reference (5.0, 5.2, Harness and Connectors)

<https://performanceparts.ford.com/download/instructionsheets/FordInstShtM-6017-504V.pdf>

<https://www.mustang6g.com/forums/threads/leaked-2019-gt500-5-2l-supercharged-engine-wiring-cad-diagram-from-ford.95772/>

P CM, Fuel Pump Schematic

<https://www.mustang6g.com/forums/threads/fore-wiring-2018-gt.114303/>

P CM Ignition Coil Schematic (5.0)

<https://www.mustang6g.com/forums/threads/dtc-code-p0354.145419/>

P CM Location, Where to Find PCM, Codes Needed by Tuners

<https://www.ortizperformance.com/post/locating-your-vehicle-s-pcm-code-1996-2021-mustangs>

<https://lmr.com/products/ford-mustang-ecu-computer-code-location>

P CM Pinout, with Specific Pin Function

<https://www.mustang6g.com/forums/threads/pcm-pinout-info-for-v6-mustang-and-v8-2016.136824/>

P CM Wiring, Detailed Schematic (2.3L)

<https://www.mustang6g.com/forums/threads/looking-for-a-wire-from-the-ecu.107905/>

Links and Site References

SODL/R

SODL SODR modules (Detailed Guide, with Photos)

<https://www.mustang6g.com/forums/attachments/step-by-step-guide-to-enabling-blis-and-cta-pdf.294019/>

SRS

Supplemental Restraint System Tutorial (Ford)

<https://www.repairerdrivennews.com/wp-content/uploads/2023/12/On-Target.pdf>

<https://fordcrashparts.com/wp-content/uploads/2020/12/On-Target-2020-Vol.-4-FINAL-12-7-20.pdf>

Supplemental Restraint System- YouTube Video Showing RCM and its location

https://www.youtube.com/watch?v=-VjR8bxT_HU

Supplemental Restraint System- YouTube Video Showing OCSM and its location

<https://www.youtube.com/watch?v=KYgyc7oLLtl>

Supplemental Restraint System - YouTube Video Showing APIM and its location

<https://www.youtube.com/watch?app=desktop&v=fI03A9IbYaA>

SYNC Update Thread

SYNC

<https://www.mustang6g.com/forums/threads/official-ford-sync3-3-4-release.145436/>

Links and Site References

TCM

TCM (GT500) (Also see DCT Operation above)

<https://www.motortrend.com/how-to/whats-inside-tremecs-new-seven-speed-dual-clutch-transmission-new-shelby-gt500-mustang/>

<https://www.mustang6g.com/forums/threads/what-is-this-part-number.157159/> (GSM-specific)

TCU

TCU Location (Telematics Control Unit) (location and logical)

<https://www.mustang6g.com/forums/threads/4g-modem-disabling-instructions.146860/>

<https://www.mustang6g.com/forums/threads/the-how-to-disable-the-data-link-to-ford-thread.146863/page-17#post-3028021>

