DOCUMENT
GSM-AUS-CPL.010

DOCUMENT TITLE

AIRCRAFT GENERAL KNOWLEDGE

CHAPTER 8 – ELECTRICAL SYSTEM

Version 1.0
June 2018

CONTENTS PAGE

THE ELECTRICAL SYSTEM

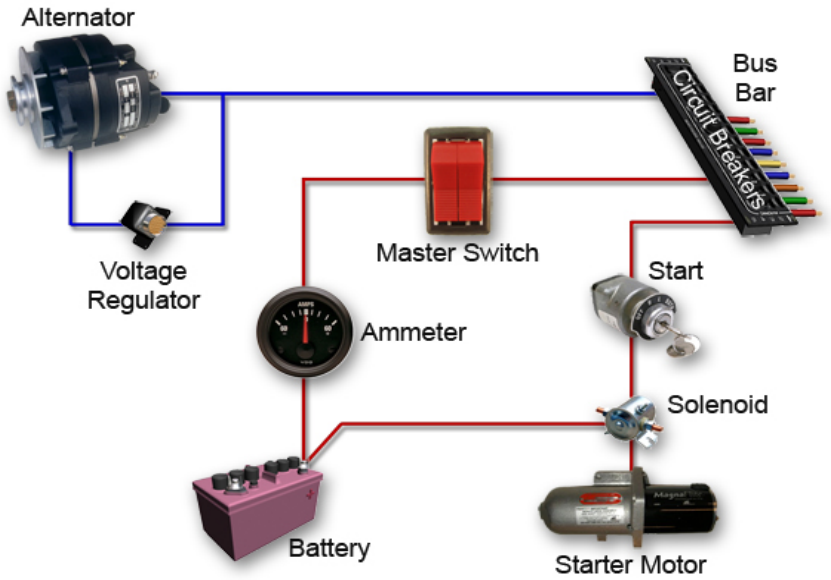
8.1 Introduction

The aircraft is required to have an electrical system to operate a vast array of equipment. This equipment includes but is not restricted to:

8.2 Electrical System Components

A general aircraft electrical system includes the following components:

- Battery
- Alternator or Generator
- Voltage Regulator
- Bus Bar
- Ammeter
- Starter Motor
- Circuit Breakers
- Master switch



Normally aircraft power is from either an alternator or generator which is driven by the engine.

The electrical power is either 28 or 14 volts DC and distributed to the various systems via a bus bar.

Circuit breakers are provided to protect the electrical system in the event of a malfunction.

The pilot uses the ammeter to monitor the electrical system to see whether it is operating correctly or not.

Before and during engine start, when the alternator/generator is not able to provide any current, the storage battery provides the necessary current. After engine start the alternator/generator charges the battery.

The ignition system is not part of the electrical system, as it is a self contained engine driven system.

The aircraft's structure forms the earth return path for the electrical current.

8.2.1 Alternator

An alternator can be considered as an AC generator. It produces Alternating Current (**AC**). Most small aircraft require electricity as Direct Current (**DC**), so the current must then be rectified to DC by the use of diodes.

Unlike the generator the alternator uses an engine driven magnet that rotates between coils (stator) to produce an electrical current. Before the Alternator can produce an output, it needs an exciter voltage from the battery to produce the necessary magnetic field. This is because Alternators use Electro magnets to induce Current, unlike a DC Generator which uses Permanent Magnets.

8.2.1.1 Advantages of an Alternator

- Produces consistent and sufficient power throughout the engine RPM range
- Simple and light construction
- Cheaper to maintain
- Less prone to overload when loads are heavy.

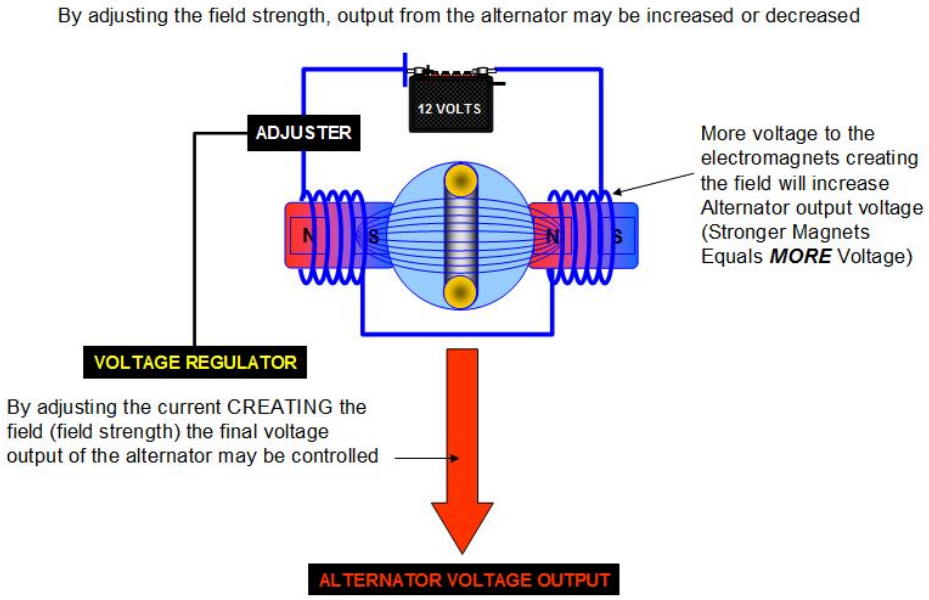
8.2.1.2 Disadvantages of an Alternator

An Alternator requires an initial exciter voltage from the battery to produce a magnetic field, which in turn is needed to produce an electrical output.

8.2.2 Voltage Regulator

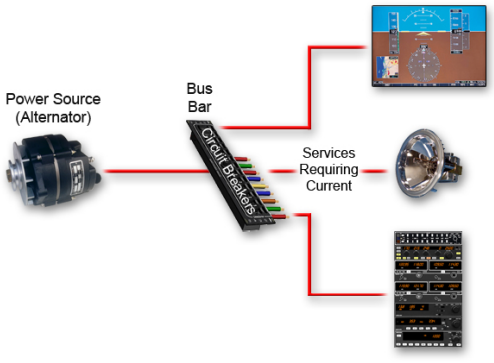
A voltage regulator is simply a regulator within the electrical circuit which ensures that the alternator provides a constant supply to the battery and aircraft electrical demand throughout the engine range. By providing a constant charge the battery and other accessories are protected from damage.

The voltage regulator regulates this charge by controlling the amount of current in the field charge (the windings) of the alternator. If the current in the field charge is high the alternator will produce more charge, while if it is low the alternator will produce less charge. By controlling the amount of current in the field charge the output of the alternator can be controlled.



8.2.3 Bus Bar

The power which has been generated is passed on to the various electrical consuming items by means of bus bars. The bus bar is the means by which the power carried in a single wire can be sub-divided into many wires for distribution to the various circuits. The bus bar is the main component in the distribution system.



Bus bars are often classified in accordance to their importance and a typical aircraft system could have the following bus bars:

- Vital services bus bar
- Essential services bus bar
- Main bus bar.

8.2.4 The Battery

During normal aircraft operation electrical power is supplied by the alternator or generator.

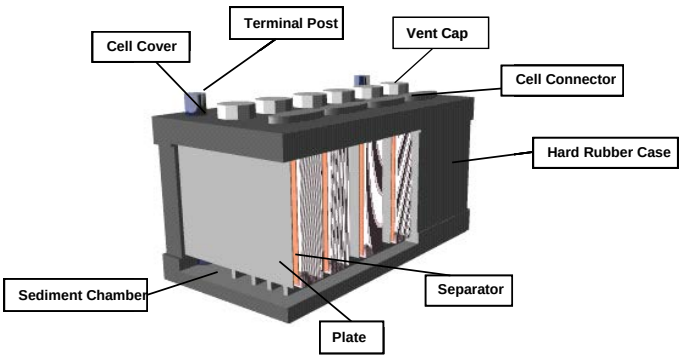
However, an aircraft battery will be required when power is needed to:

- Carry out pre-flight checks
- Start the engines
- Energise alternator field windings
- Supply the aircraft with electrical power in the event of the normal generating system failure.

The most popular types in use are the **Lead-Acid** and the **Nickel Cadmium** batteries. The light aircraft electrical system normally uses a **12 volt** and larger aircraft use **24 volt** Lead-Acid batteries. More complex aircraft would use a Nickel Cadmium battery. These two types of batteries are very different and cannot be interchanged.

The battery is continually charged by the generator/alternator. The charging rate is controlled by a voltage regulator, which stabilises output from the generator/alternator. The generator/alternator voltage output is usually slightly higher than the battery voltage. For example, a 12v-battery system would be fed by a generator/alternator system of approximately 14v. This voltage difference keeps the battery charged.

A lead-acid battery creates an electrical current (amps) by a chemical reaction between lead plates immersed in weak sulphuric acid that acts as an electrolyte. The battery is housed in an acid proof case to prevent corrosion from any spillage of the acid.

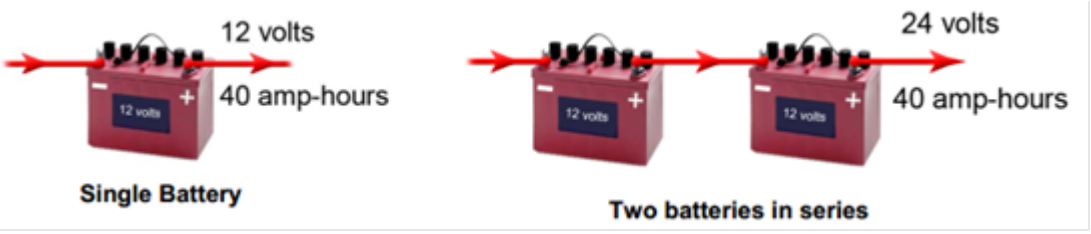


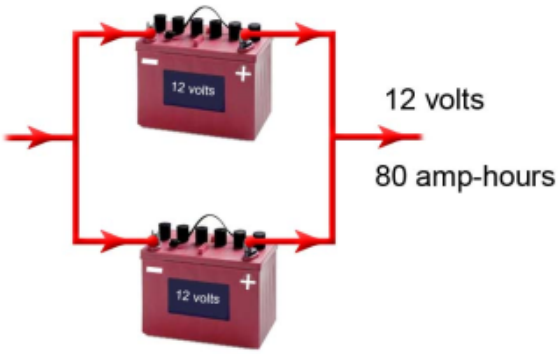
Batteries are rated in **Ampere Hours**, which indicate the number of amps the battery can deliver over a period of hours.

A 45 ampere-hour battery for example, can deliver 1 amp for 45 hours or 5 amps for 9 hours.

Batteries connected in series will increase the total voltage, while batteries connected in parallel, will increase the total ampere-hours.

Note: Batteries that are interconnected must be of the same type, i.e. same voltage and ampere hours.





Battery charge condition can be determined by a hydrometer. This measures the specific gravity (SG) of the electrolyte.

Specific gravity of a fluid is the ratio of the density of a fluid relative to that of water

8.2.4.1 Battery safety precautions

Before engine start, ensure all ancillary equipment is switched off as the large voltage fluctuations during starter engagement can damage sensitive electronic equipment. Ensure the battery is being charged before switching on all of the electrical equipment. The same applies when shutting down the engine—first switch off all electrical equipment.

Charging batteries emit a mixture of hydrogen and oxygen. These are highly flammable and will explode if a flame is brought too close to them. Lighted matches and torches should be kept away from charging batteries.

8.2.5 Ammeter

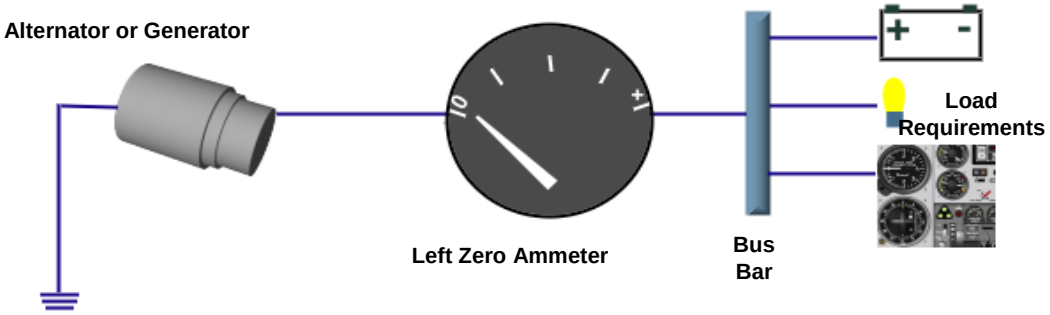
The ammeter is the instrument which measures current flow into or out of the battery. Some aircraft also employ a voltmeter to measure the electro motive force available to deliver the current. (1 volt is required to force 1 ampere of current to flow through a 1 ohm resistor).

There are two types of ammeter used to measure the current flow.

They are the **Left-Zero Ammeter** and the **Centre-Zero Ammeter**.

8.2.6 Left-Zero Ammeter

This ammeter measures only the output of the alternator or generator. It has a graduated scale starting at zero (on the left), with indications of increasing amperes toward the right. Because this ammeter shows alternator/generator output only, it can also be referred to as a Load Meter. It indicates what load is being required from the alternator/generator.



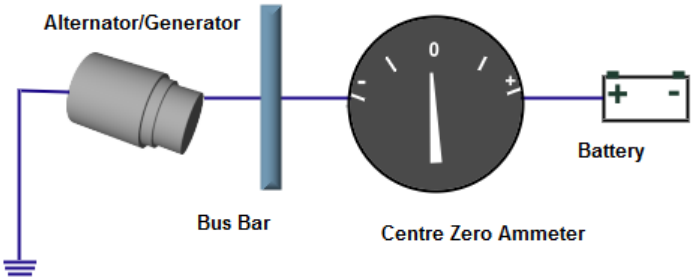
If the engine is running and the alternator is off, the ammeter will show zero. If the engine is running and the alternator switch is on, then the ammeter will show the alternator output.

After starting the battery will have depleted some of its charge, therefore the ammeter will initially show a relatively high charge rate

Once the battery is charged, the ammeter should show just above zero if all other circuits are off, as these circuits are switched on the ammeter reading will increase.

8.2.7 Centre-Zero Ammeter

The centre-zero ammeter measures the flow of current either into or out of the battery. Current flowing into the battery is charge, and the needle will indicate right of centre (toward the +). Current flowing out of the battery is discharge, and the ammeter needle will indicate left of the centre 0, (toward the -). When there is no charge or discharge of the battery, the needle will indicate 0 (centre).



With the battery switch on and the engine not running, the needle will indicate discharge (the battery is supplying power to any powered circuits).

With the engine running and the alternator/generator providing adequate current, there will be a flow of charge to the battery (until it is fully charged), and the needle will indicate a charge, right of the centre.

If the electrical circuits are absorbing more current than the alternator is capable of producing, the battery will provide current to assist with the demands, and the needle will indicate discharge (left of the centre point).

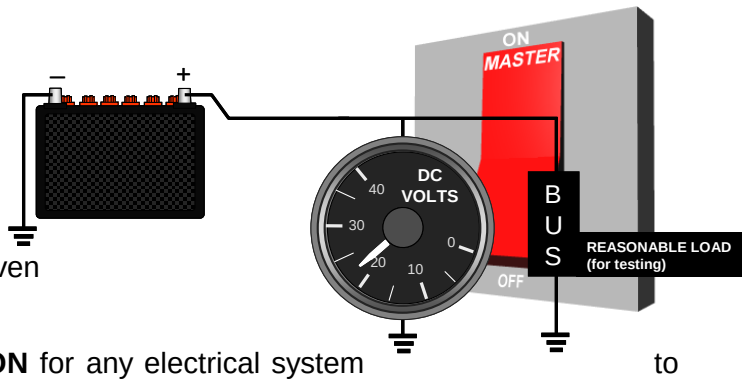
8.2.8 Voltmeter

Some aircraft also employ a voltmeter to measure the electro motive force available to deliver the current. 1 volt is required to force 1 ampere of current to flow through a 1 ohm resistor. When the engine is not running, a voltmeter will indicate the voltage of the battery, i.e. a 12 volt battery will show 12 volt on the voltmeter.

The generator/alternator voltage output is usually slightly higher than the battery voltage. For example a 12v-battery system would be fed by a generator/alternator system of approximately 13.8 - 14v. This voltage difference keeps the battery charged. This voltage will then be displayed by the voltmeter. For a 24V battery, 28V will usually be displayed on the voltmeter while the engine is running.

8.2.9 Master Switch

The master switch controls all the aircrafts electrical systems, except the ignition system (receives power from the engine driven magneto).



The master switch must be **ON** for any electrical system to receive power. If the aircraft has an electrical clock it will draw a small of amount of power at all times.

The master switch must also be on even if the engine is running for the battery to be charged. Once the engine has been shut down, the master switch must be switched off to prevent the battery from discharging via the services connected to it.

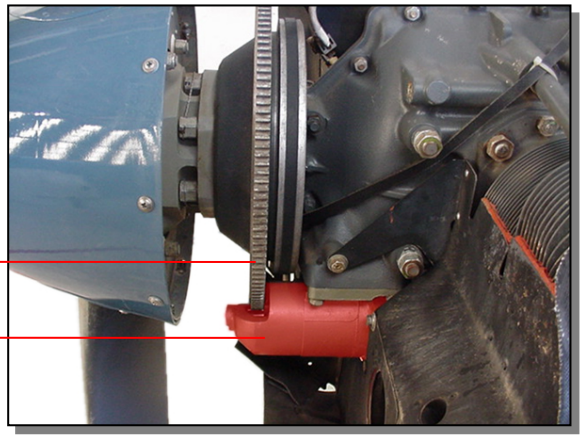
If the aircraft is fitted with an alternator the master switch will consist of two "halves":

- One which connects the battery to the bus bar
- The other connects the alternator field to the bus bar, providing the alternator with battery power for the excitation of the field.

Both switches must be on for normal operation of the electrical circuit. Although the switches can be switched on separately, only the alternator switch can be switched off separately. If the battery switch is switched off, the alternator switch is automatically switched off as well. This prevents the possibility of unregulated Alternator current being supplied to the aircraft systems.

8.2.10 Starter Motor

Modern aircraft use a DC starter motor to start the engine. The starter motor power comes from the aircraft battery and is controlled by either a push button type switch or by turning the combined magneto/starter switch key to the "start" position.

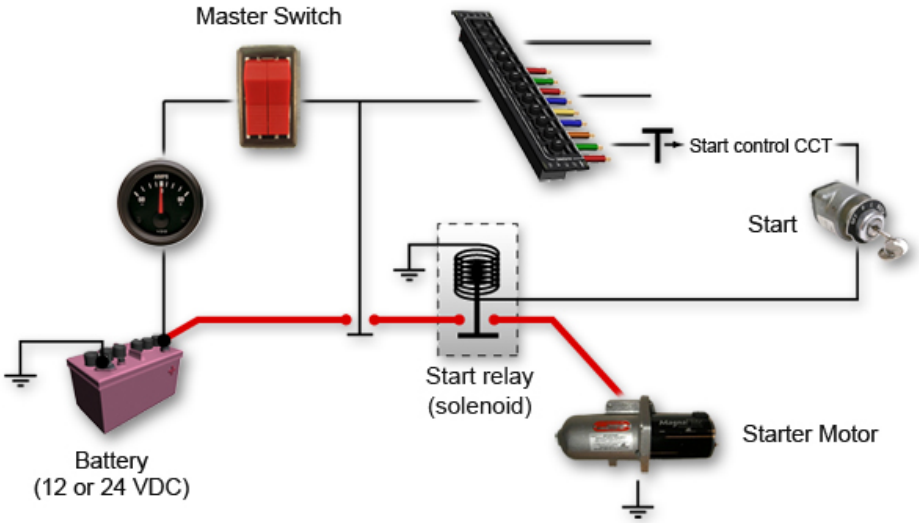


Starting an engine causes high current to flow between the battery and starter motor, heavy duty wiring is therefore needed. For safety reasons a solenoid relay is installed in the start circuit, which is operated by the ignition switch. This avoids the use of heavy duty wiring through the cockpit.

Moving the ignition switch to "***Start***", causes a small current to energise the solenoid, creating an electromagnetic field which moves an iron core (heavy duty switch), closing the heavy duty circuit.

The engine cannot be started unless the master switch is on. The high starting current is not seen on the ammeter because it takes a direct path from the battery through thick, low-resistance wires via the starter solenoid to the starter motor.

Typical general aviation aircraft Starter Circuit



8.2.11 Fuses and circuit breakers

Fuses and circuit breakers are provided to protect electrical equipment from current overload. Each will be marked to display the correct current rating.

If there is current overload or short circuit, a fuse wire will melt, or a circuit breaker will 'trip' (pop out), and break the circuit, preventing the flow of current. This action may prevent fires and damage to expensive equipment. If a circuit breaker "trips", and there is no obvious sign of distress (smell burning electrics, smoke etc.) it is normal practice to reset the circuit breaker after a cooling period, normally 90 seconds or 2 minutes. If it "trips" again, however, an electrical malfunction should be assumed and the circuit breaker should not be reset.

Glass tubular fuse

When a blown fuse has been detected it should be replaced with a fuse having the correct amperage. It is bad practice to replace a fuse of low amperage with one of greater amperage, i.e. replace a 5 ampere fuse with a 15 ampere fuse. Such action allows more current to flow through the circuit and reduces the protection function.

Fuses should not be replaced more than once and spare fuses of the appropriate type and rating should be kept in the cockpit.

8.2.12 Overload switches

The overload switch is simply a"trip switch", which automatically switches off when an electrical overload is detected. The pilot resets the switch (to on), after a short waiting period (which allows the circuit to cool).

8.2.13 External Power

External power is often used whilst an aircraft is on the ground. It is usually applied for the following reasons:

To conserve the aircraft battery

Substitution for a flat battery

Assistance in engine starting

Aircraft maintenance and servicing.

The external power source is often called a Ground Power Unit (GPU) and can be either mobile or fixed.

During external power operations the aircraft battery is bypassed by means of a switch either inside the cockpit or externally at the external power receptacle. After start and external disconnection the aircraft battery is introduced back into the electrical system.

Always consult the pilots operating handbook (POH) for the correct procedures in using external power.

8.3 Abnormal Electrical System Operation

8.3.1 Circuit Breaker 'Trips"

- Turn OFF affected equipment
- Wait about 90 seconds/2 minutes to cool off
- If no sign of fire or smoke, reset the circuit breaker
- Don't reset circuit breaker if it trips for a second time.

It is not recommended that a 'Tripped" Circuit Breaker, associated with the Aircraft Fuel system, is reset as there could be the risk of fire if an electrical malfunction has occurred.

8.3.2 Ammeter indicates insufficient current from the alternator or alternator failure

- Switch off all non essential equipment
- Land as soon as possible.

Note: If the alternator produces insufficient current, or no current at all, the battery is not being charged. The battery now supplies all of the required current to the various electrical equipment, until it runs flat.

8.3.3 Ammeter indicates excessive rate of charge

- Switch off the alternator as excessive charge rate could cause the battery to overheat and cause damage.
- Land as soon as possible.

Note: Overcharging by the alternator is usually caused by a faulty voltage regulator. If fitted, an over-voltage sensor would automatically disconnect the alternator Causing a red warning light to illuminate inside the cockpit.