DC Power Fundamentals

- **Volt - A unit of electrical pressure hence a potential for the flow of energy.**

  You measure voltage by probing any two points where you expect a potential to exist. The system does not have to be turned ON to produce useful voltage readings.

- **Amp - A unit of electron flow. 1 Ampere of current is equal to one Coulomb of electrons (6.24×10^{18}) per second of flow.**

  Current is a rate that must be measured by getting in series with the circuit of interest . . . The system must be active (ON) for a current measurement to be useful . . .

- **Ohm - A unit of resistance. The measure of an INABILITY to carry a loss-free flow of electrons - often described electrical friction.**

  Resistance is measured by causing a KNOWN current to flow through the resistance and then measuring the resulting voltage drop.

- **Watt = a unit of electrical power defined as 1 Ampere of current flowing under the pressure of 1 Volt.**

You CAN acquire an instrument that directly measures Watts but the common technique is to measure applied voltage and current consumption. Then multiply the two readings to get Watts of power being consumed. Watts is a rate.

- **Joule = a measure of ENERGY defined as one Watt of Power being transferred for one Second, ie. Watt-Second.**

    Joules is a product of Watts multiplied by the time over which that power is being delivered. Joules can be an integrated total of a highly variable load. For example: If you consume 3W for 9S, 1.5W for 6S and 10W for 3S, the energy total is 27J + 9J + 30J = 66 Joules.

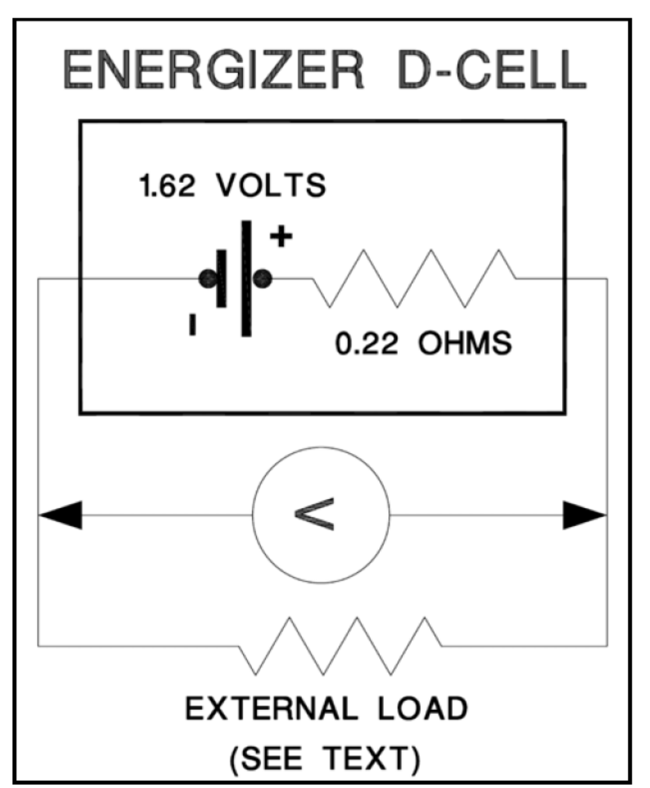


Figure 2-2. D-Cell Experiment

Assuming an external load resistor of 1 Ohm, Ohm's Law allows us describe the following characteristics about this example:

Amps = Volts/Ohms

(2) 1.62 volts impressed across 1.22 ohms will produce a current flow of 1.62/1.22 or 1.33 amps.

Another relationship of these concepts states that the power dissipated in the circuit resistance:

Watts = Volts x Amps

1.62 Volts x 1.33 Amps = 2.15 Watts

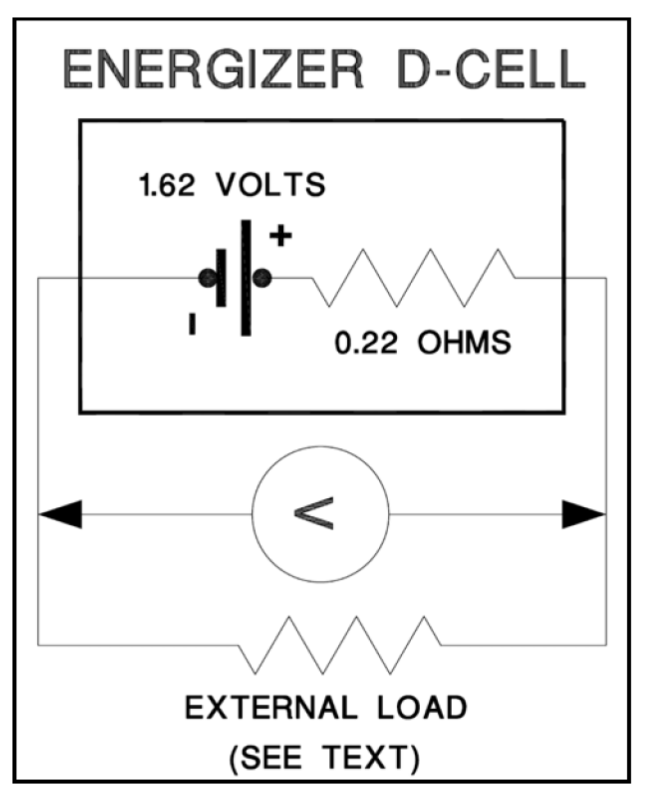


Figure 2-2. D-Cell Experiment

Part of the power is dissipated in the D-cell's internal resistance:

Volts = Amp x Ohms

1.33A x 0.22 Ohms = 0.29V

0.29V x 1.33A = 0.39 Watts.

Hence only 1.76 Watts of the total power is available for use outside the cell and voltage at the cell's terminals under load is:

Volts = Amps x Ohms

1.33A x 1.00 Ohms = 1.33V

Ohm's Law in algebraic terms:

(1) VOLTS (FORCE) = AMPS (FLOW) X OHMS (RESISTANCE)

(2) $OHMS = \frac{VOLTS}{AMPS}$

(3) $AMPS = \frac{VOLTS}{OHMS}$

Figure 1-1 Ohm's Law - Three Variations on a Theme

Rules for calculating power:

(1) WATTS = AMPS x VOLTS

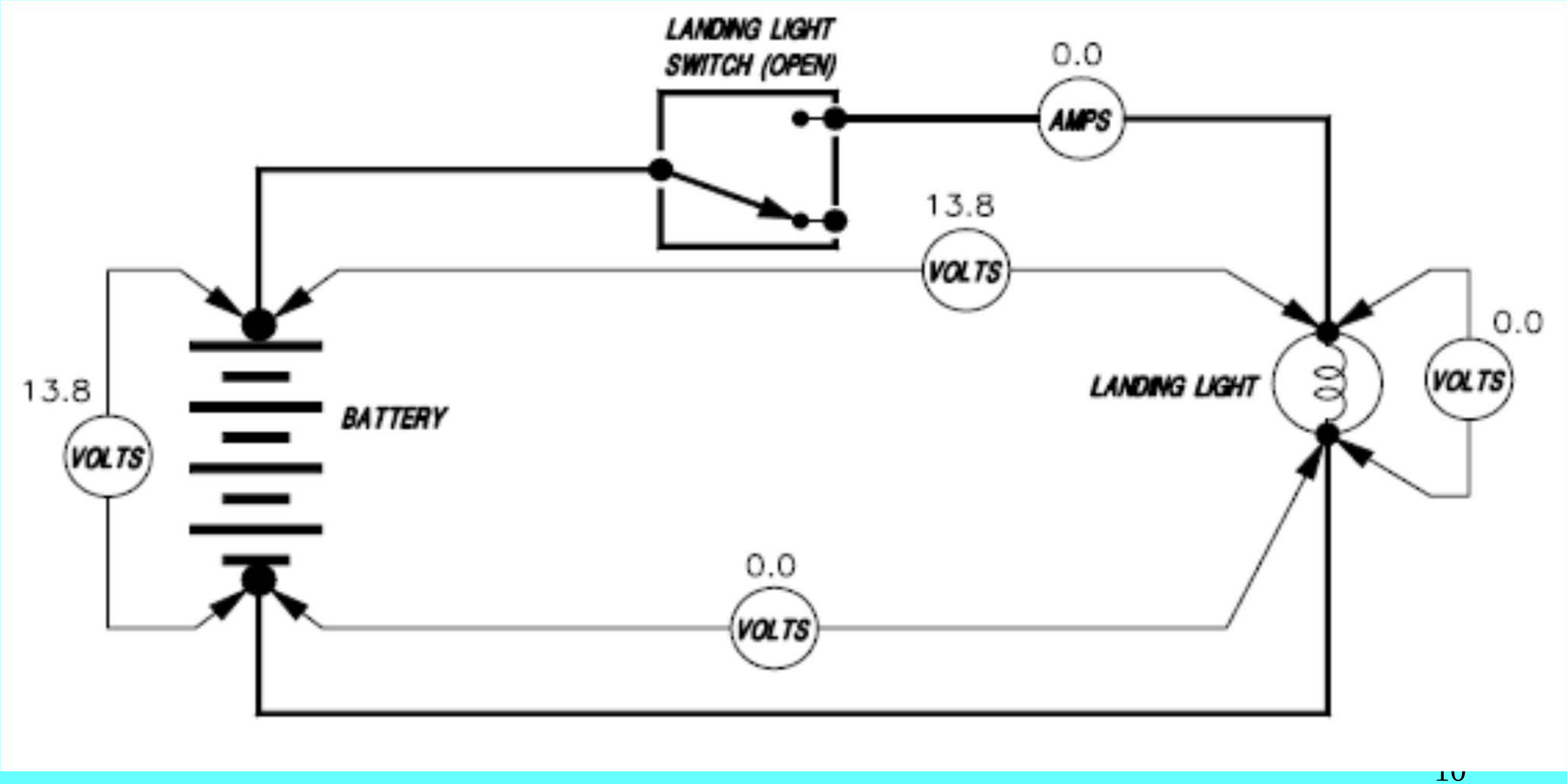
(2) $WATTS = \frac{VOLTS^2}{OHMS}$

(3) $WATTS = AMPS^2 \times OHMS$

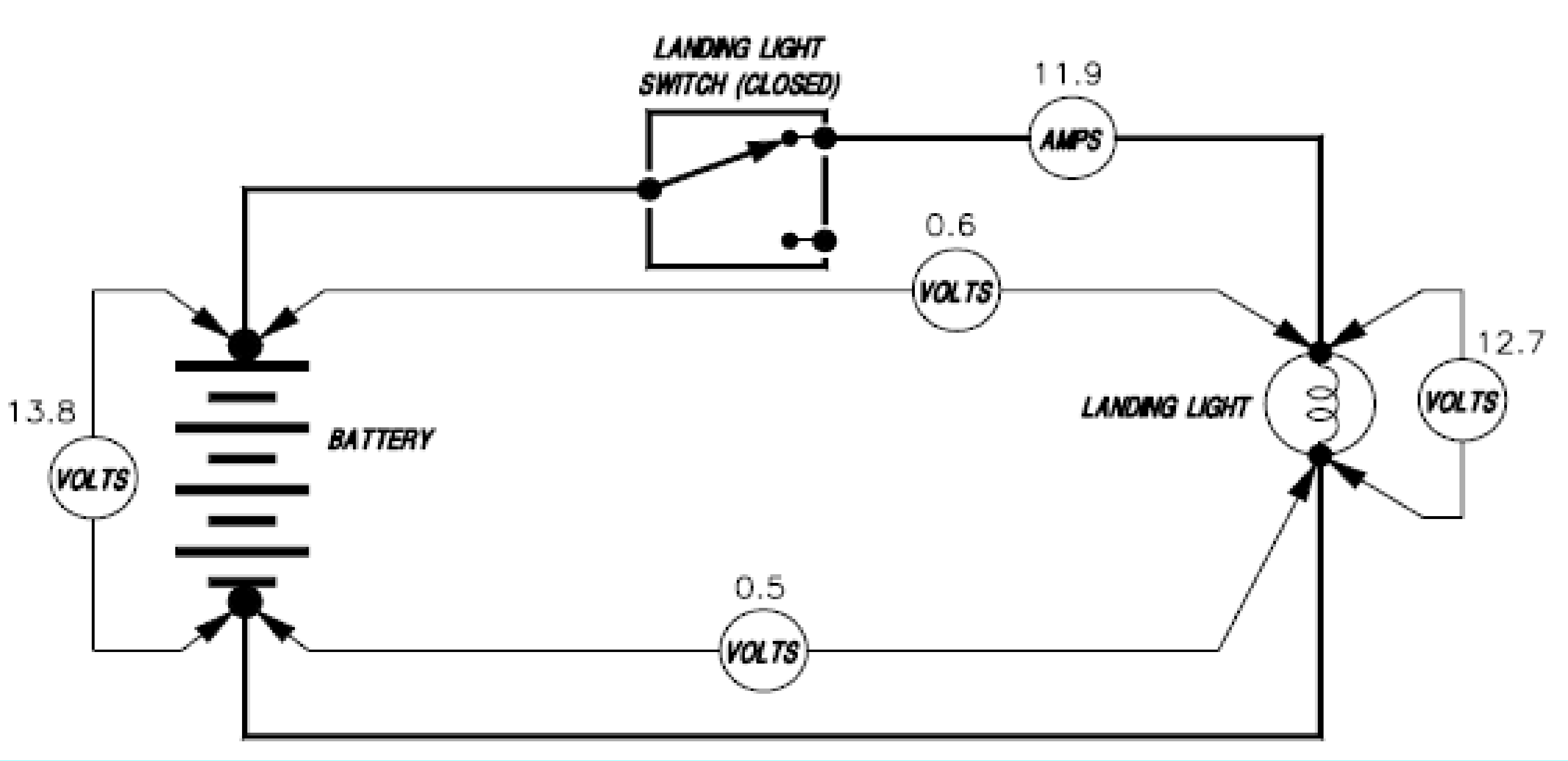
Figure 1-2. Three Formula for Calculating Watts

Voltage Drop and Current Flow in Open and Closed Circuits

Switch is open no current flows



Note that an ammeter goes in SERIES with the load to be measured. It deduces electrons/second of current flow past it's location in the circuit.



Resistance of EVERYTHING produces observable effects on performance during HIGH CURRENT operations.

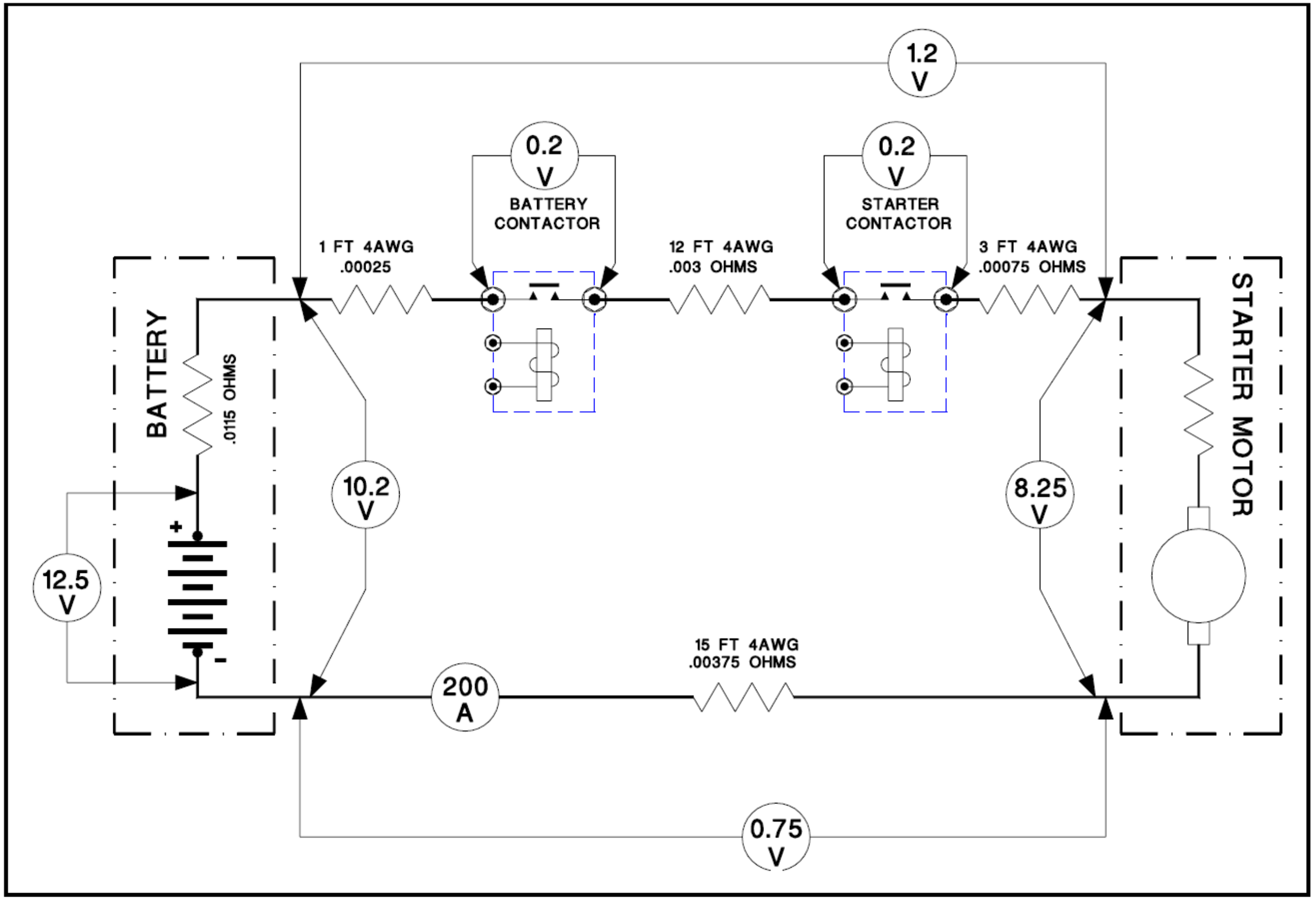


Figure 2-3. Cranking Circuit Analysis.

In a nutshell . . .

- **First decision for crafting your project's electrical system is to decide what operating voltage best meets your design goals.**
    - **Every system has an *energy* requirement that is quantifiable in terms of *Voltage* and current (*Amps*) over time (*Watt-Seconds*). Energy considerations drive selection of batteries, alternators and cooling.**
    - **Every system has a consumption requirement (*Amps*) that drives sizing of wire and circuit protection.**

In a nutshell . . .

- **It's useful to achieve a comfortable working knowledge of how voltage, current and resistance define normal operations for any system on your airplane –** ***Analysis of measurements is the key to diagnosing and repairing an misbehaving system*****.**

In a nutshell . . .

"When you can measure what you are speaking about and express it in numbers, you know something about it."

-Lord William Thomson Kelvin (1824-1907) -

- **You DO own a multimeter? The least expensive instruments you can buy are on the order of $3 each!**
- **They are more accurate than instruments of choice only 25 years ago.**

Questions?

- You've come a long way baby . . .
- I purchased this Simpson 260 about 1963 for about $60. This instrument would cost $360 in 2007 dollars.

- **Analysis of measurements is the key to designing a new or diagnosing and repairing an old system.**