Relation between power and capacity

Collection of facts and mathematics in www

as answer to thread http://www.edaboard.com/thread215514.html

From Wikipedia, the free encyclopedia : **Farad**

Definition

A farad is the charge in coulombs which a capacitor will accept for the potential across it to change 1 volt.

A coulomb is 1 ampere second.

Example: A capacitor with capacitance of 47 mF (47 millifarads, more often expressed as 47 000 µF) will increase by 1 volt per second with a 47 mA input current.

or

1 Farad is SI unit of capacitance, formally defined to be the capacitance of a capacitor between the plates of which there appears a potential difference of one volt when it is charged by a quantity of electricity equal to one coulomb.

Symbol: F

A farad has the base SI representation of:

$s^4 \cdot A^2 \cdot m^{-2} \cdot kg^{-1}$

Farad can further be expressed as:

$$\mathrm{F} = \frac{\mathrm{A}\cdot\mathrm{s}}{\mathrm{V}} = \frac{\mathrm{J}}{\mathrm{V}^2} = \frac{\mathrm{W}\cdot\mathrm{s}}{\mathrm{V}^2} = \frac{\mathrm{C}}{\mathrm{V}} = \frac{\mathrm{C}^2}{\mathrm{J}} = \frac{\mathrm{C}^2}{\mathrm{N}\cdot\mathrm{m}} = \frac{\mathrm{s}^2\cdot\mathrm{C}^2}{\mathrm{m}^2\cdot\mathrm{kg}} = \frac{\mathrm{s}^4\cdot\mathrm{A}^2}{\mathrm{m}^2\cdot\mathrm{kg}} = \frac{\mathrm{s}}{\Omega}$$

A=ampere, V=volt, C=coulomb, J=joule, m=meter, N=newton, s=second, W=watt, kg=kilogram, O=ohm

For electronics, one farad is a fairly large amount of capacitance. The most commonly used submultiples in electrical and electronic usage are the microfarad, nanofarad and picofarad.

The 'farad' should not be confused with the faraday, which is the electric charge carried by one mole of singly charged ions.

From Wikipedia, the free encyclopedia : **Capacitor**

The simplest capacitor consists of two parallel conductive plates separated by a dielectric with permittivity ε (such as air). The model may also be used to make qualitative predictions for other device geometries. The plates are considered to extend uniformly over an area A and a charge density $\pm\rho = \pm Q/A$ exists on their surface. Assuming that the width of the plates is much greater than their separation d, the electric field near the centre of the device will be uniform with the magnitude $E = \rho/\varepsilon$. The voltage is defined as the line integral of the electric field between the plates

$$V = \int_0^d E \mathrm{d}z = \int_0^d \frac{\rho}{\varepsilon} \mathrm{d}z = \frac{\rho d}{\varepsilon} = \frac{Qd}{\varepsilon A}.$$

Solving this for $C = Q/V$ reveals that capacitance increases with area and decreases with separation

$$C = \frac{\varepsilon A}{d}.$$

The capacitance is therefore greatest in devices made from materials with a high permittivity, large plate area, and small distance between plates. However solving for maximum energy storage using Vd as the dielectric strength per distance

$$E = \frac{1}{2}CV^2 = \frac{1}{2}\frac{\varepsilon A}{d}(V_d d)^2 = \frac{1}{2}\varepsilon A d V_d^2$$

where

> C is the capacitance;
> A is the area of overlap of the two plates;
> ε_r is the relative static permittivity (sometimes called the dielectric constant) of the material between the plates (for a vacuum, $\varepsilon_r = 1$);
> ε_0 is the electric constant ($\varepsilon_0 \approx 8.854\times10{-}12$ F m^{-1}); and
> d is the separation between the plates.

we see that the maximum energy is a function of dielectric volume, permittivity, and dielectric strength per distance. So increasing the plate area while decreasing the separation between the plates while maintaining the same volume has no change on the amount of energy the capacitor can store. Care must be taken when increasing the plate separation so that the above assumption of the distance between plates being much smaller than the area of the plates is still valid for these equations to be accurate.

From Wikipedia, the free encyclopedia : **Capacitance**

In electromagnetism and electronics, capacitance is the ability of a body to hold an electrical charge. Capacitance is also a measure of the amount of electrical energy stored (or separated) for a given electric potential. A common form of energy storage device is a parallel-plate capacitor. In a parallel plate capacitor, capacitance is directly proportional to the surface area of the conductor plates and inversely proportional to the separation distance between the plates. If the charges on the plates are $+Q$ and $-Q$, and V gives the voltage between the plates, then the capacitance is given by

$$C = \frac{Q}{V}.$$

The SI unit of capacitance is the farad; 1 farad is 1 coulomb per volt.

The energy (measured in joules) stored in a capacitor is equal to the *work* done to charge it. Consider a capacitor of capacitance C, holding a charge $+q$ on one plate and $-q$ on the other. Moving a small element of charge $\mathrm{d}q$ from one plate to the other against the potential difference $V = q/C$ requires the work $\mathrm{d}W$:

$$\mathrm{d}W = \frac{q}{C}\,\mathrm{d}q$$

where W is the work measured in joules, q is the charge measured in coulombs and C is the capacitance, measured in farads.

The energy stored in a capacitor is found by integrating this equation. Starting with an uncharged capacitance ($q = 0$) and moving charge from one plate to the other until the plates have charge $+Q$ and $-Q$ requires the work W:

$$W_{\text{charging}} = \int_0^Q \frac{q}{C}\,\mathrm{d}q = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = W_{\text{stored}}.$$

From Wikipedia, the free encyclopedia : **Power**

In physics, power is the rate at which work is performed or energy is converted.

As a simple example, burning a kilogram of coal releases much more energy than does detonating a kilogram of TNT, but because the TNT reaction releases energy much more quickly, it delivers far more power than the coal.

If ΔW is the amount of work performed during a period of time of duration Δt, the **average power** P_{avg} over that period is given by the formula

$$P_{\text{avg}} = \frac{\Delta W}{\Delta t}.$$

It is the average amount of work done or energy converted per unit of time. The average power is often simply called "power" when the context makes it clear.

The **instantaneous power** is then the limiting value of the average power as the time interval Δt approaches zero.

$$P = \lim_{\Delta t \to 0} P_{\mathrm{avg}} = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t} = \frac{dW}{dt} \, .$$

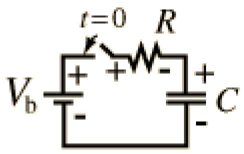
In the case of constant power *P*, the amount of work performed during a period of duration *T* is given by:

$$W = PT \, .$$

In the context of energy conversion it is more customary to use the symbol *E* rather than *W*.

Capacitor charge and discharge

From http://hyperphysics.phy-astr.gsu.edu/hbase/electric/capdis.html



$$V_b = V_R + V_C$$

$$V_b = IR + \frac{Q}{C}$$

As charging progresses,

$$V_b = IR + \frac{Q}{C}$$

current decreases and charge increases.

The transient behavior of a circuit with a battery, a resistor and a capacitor is governed by Ohm's law, the voltage law and the definition of capacitance. Development of the capacitor charging relationship requires calculus methods and involves a differential equation. For continuously varying charge the current is defined by a derivative

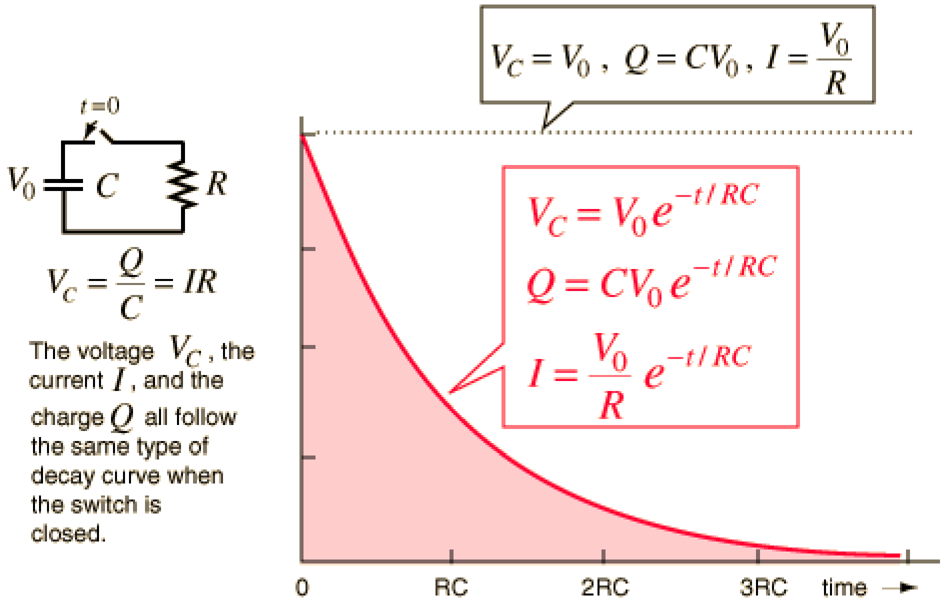
$$I = \frac{dQ}{dt} \quad \text{and} \quad V_b = R\frac{dQ}{dt} + \frac{Q}{C}$$

This kind of differential equation has a general solution of the form:

$$Q = Ae^{-pt} + B$$

and the detailed solution is formed by substitution of the general solution and forcing it to fit the boundary conditions of this problem. The result is

$$Q = CV_b\left[1 - e^{-t/RC}\right]$$



If we select R=1ohm C=1000µF and V=100V, we get momentary values (dt = 0)

time = 0	Q=100mC	I=100A	V=100V	P= 10000W
time 1µs	Q= 36.8mC	I= 36.8A	V= 36.8V	P= 1354W
time 2µs	Q= 13.5mC	I= 13.5A	V= 13.5V	P= 188.5W

SUMMARY:

With simple words

So if we examine power and capacitance together ,
we must remember , that power we get from capacitor
when dicharging , is function of dicharge time.
We can count momentary values over discharge time. (dt = 0)
Power we got is integral over disharge time.
We must tell , that it is Pavg (0 to disharge time seconds)

KAK 14.06.2011.