Power Sources

What are the power requirements of a PostPC "appliance"?

- Extreme example – the wallet that evolves from Palm/Visor
  - Flexible
  - 10 MIPS, at 2-3% duty cycle for a month (720 hr)
  - 16-32MB non volatile memory
  - reflective color display
  - vibrator, link to pager
  - runs Java?
- This requires 5 Whr, over a very long discharge time.

Another extreme example – when will we see a battery-powered hair dryer?

Any power subsystem has three components:

Source	Reservoir/regulator	Consumer
AC	battery	characteristics: WHr
Fuel	fuel cell	size and shape
Sun/wind	supercapacitors	discharge time
Humans		burstiness (rate)

Key Battery Characteristics

Cost!

Lead-acid (car) batteries are still cheapest

$50 = 40-80 AHr = 500-1000 WHr = $0.10/WHr

they can be made small, but not very light

tradeoffs in rechargeables:

AA Alkaline (1.5 V, 2.4 AHr) costs < $1.

AA NiMH (1.5 V, 1.7 AHr) costs about $3, and needs a $25 charger. So you spend $37 for 4 batteries and charger. Would you have used up 37 alkalines in the life of the product? For cameras, YES.

How do batteries work, what determines their energy density, and other characteristics?

It's all chemistry, and gets complicated.

But the slow rate of improvement (10%/yr) is because the periodic table is fixed, and chemistry is not subject to Moore's Law.

Concepts:

- Theoretical energy density
- "Practical energy density" -- this is what improves
  but it saturates for each technology, then a
  new battery system must be reduced to practice.

Evidence for 10% growth:

Comparing 1993 data with present,

Alkalines and NiMH have each doubled in capacity.

Battery characteristics depend on format, rate

Using current Duracell specs for alkaline non-rechargeable:

AA cell	2.45 AHr	0.488 in^3	460 WHr/liter
AAA cell	1.12 AHr	0.235 in^3	436 WHr/liter
D cell	14.25 AHr	3.271 in^3	400 WHr/liter
9V	.565 AHr	1.297 in^3	240 WHr/liter
NiMH AA	1.7 AHr		320 WHr/liter

Rate dependence:

Using Concorde sealed dry lead-acid batteries:

PVX-1248T (12 V, 16 kg)
80 min discharge @ 25 A (300 W) → 25 WHr/kg
100 Hr rate → 55 AHr → 660 WHr → 40 WHr/kg

Alternative Sources of Energy

Solar: The standard unit of insolation is 1 KW/m^2 . Multiply times the effective number of hours insolation per day (2-6 hr) (see chart) Photovoltaic conversion efficiency is about 10% ➔ 200-600W/m^2 delivered outdoors, in a fixed location, per day.

Indoor illumination ➔ 1-5x10^-4 as much light energy available.

➔ 10 cm^2 of photocells can generate .1 to .5 mW under office lighting. Adequate for a calculator.

Wind?

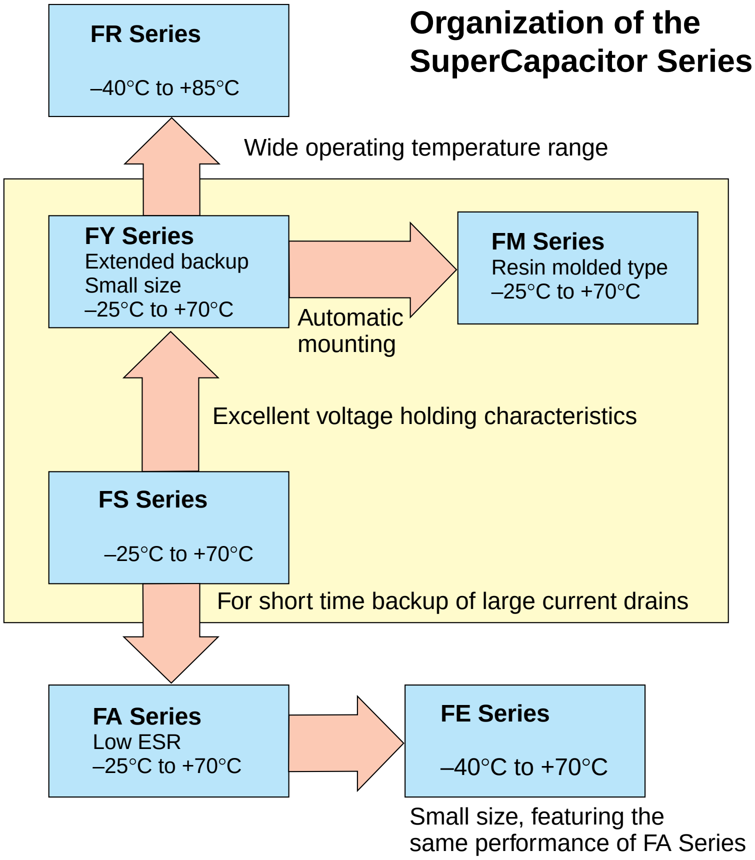
How about extracting power from the user?

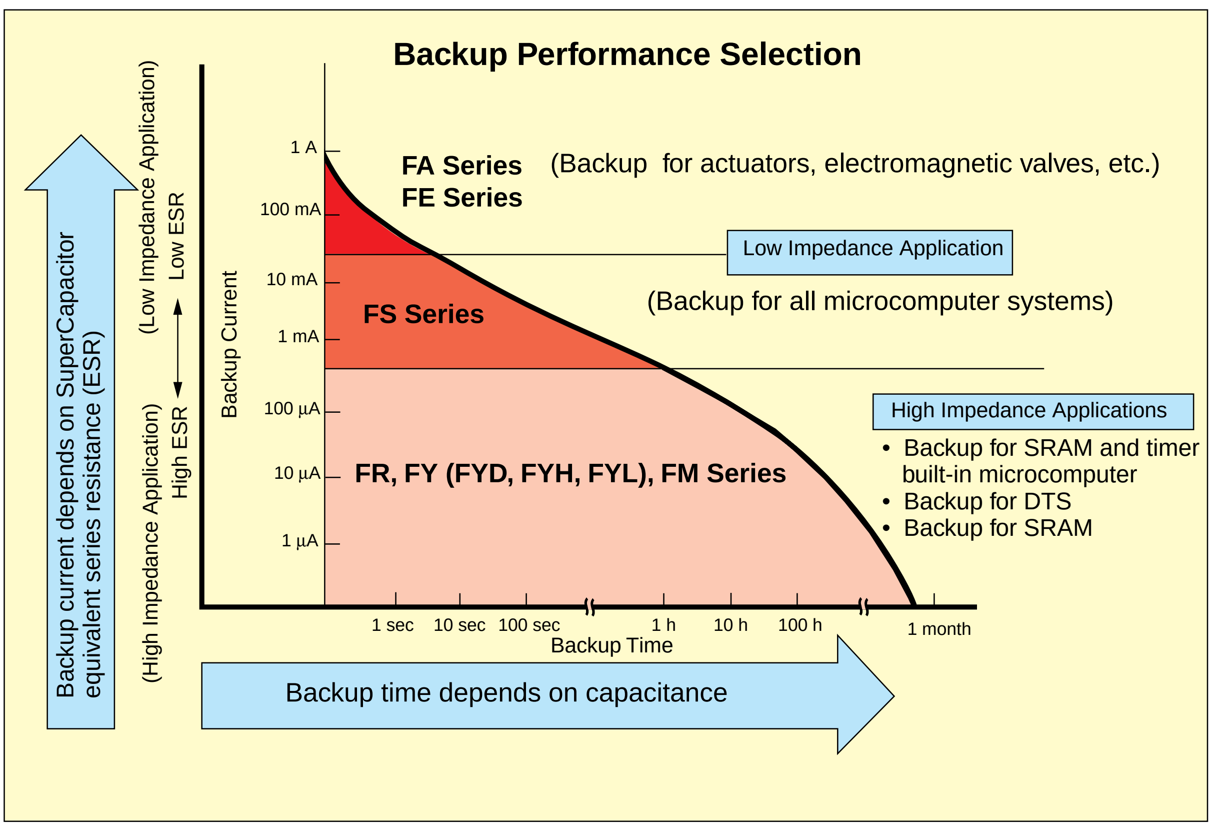
He's got it – 1 jelly donut = 400 WHr!
(Starner 1966 paper shows extraction is tough.)

Practical Limiting Capacities

	Theoretical WH/kg	Practical WH/kg	Practical WH/l
Ni/Cd	200	60	210
Ni/MH	203	100	360
Li-ion	645	215	500
Li metal/CoO_2	1070	350	700
Zn/air	1190	400	700
Alkaline	260	160	475

Organization of the SuperCapacitor Series





Operating Principles

SuperCapacitor is the most prominent capacitor concept to appear in the past decade. The large capacitance, slow rate of discharge and the small package make it useful as a non-battery reserve power source that can provide currents (1 -100 mA) and protect microcomputers from power shutdowns lasting several seconds.

It is also possible to maintain the contents of low dissipation volatile memories (i. e. CMOS) for several months. (For more detailed applications, refer to the table shown below.)

The operating principle of the SuperCapacitor is based on an electric double layer appearing at the interface between activated carbon particles and sulfuric acid solution as electrolyte. The two electrodes are separated by an ionically conducting but electrically insulating porous membrane.

Conductive rubber membranes contain the electrode and electrolyte material and rnake contact to the cell. Several cells are stacked in series to achieve the 5.5 V and 11 V rated voltages.

Since SuperCapacitors exhibit relatively high ESR, they are not recommended for ripple absorption in DC power supply applications.

In some manufacturing operations it has been polarized with the following voltage direction:

Shorter lead : positive
Longer lead (connected to case): negative

Therefore, the use of SuperCapacitor in that direction is recommended in actual usage.

Typical Applications

Functions	Backup Current	Applications	Equipment	Adequate Series
Large current supply	Up to 1A	Actuator applications (Large current in a short period)	Actuators Relays / Solenoid Starters	FA and FE Series
		Primary power supply for LED displays, toys, electric buzzers, etc.	Handheld toys Displays, Smoke detectors, Alarm devices, Emergency displays	
Medium capacity power supply	Up to 50 mA	Secondary power source for undesirable voltage drops	Vehicle radio back-up at engine start, etc.	FS Series 3.5V • 6.5V Series (FSH)
		Motor start	VCRs, video disks, record players	
Power backup for primary power outages	Less than 500µA	CMOS Microcomputers	Phones (Memory dial, Auto-answering) Electric cash registers, Electric typewriters Computer terminals Automatic measuring instruments, etc.	FY Series: FYD Type FYH Type FYL Type 3.5V • 6.5V Series (FYD) FM Series
		CMOS RAMs ICs for clocks	Digital tuning audio systems LW-MW-FM Radio, Car Radio, Stereo, etc.) Programmable consumer electronic products (VCRs, Microwave ovens, Games, etc.)	
		• CMOS RAMs • High operating temperature (85˚ C)	Measuring instruments, Automatic controls, Communications, Automotive	FR Series
Other possible applications: Programmable Thermostats, Copiers, Vending Machines, Automatic Electricity Counters, Traffic Signals, Taxi Meters, Fuel Management Systems, Process Monitoring or Control Systems, Satellite Communications, Portable "Battery" Operated Equipment, Fare Collection Systems, POS Terminals, Mail Sorters, Scale, Flow Metering, Electronic Slot Machines, Water Heat Controllers.				