MIT Subcommittee on Battery Terminology

Review of Meeting with TRW on Battery Parameters and Discussion of Terms.

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Scope - General

- The following ideas are being proposed for battery modeling and simulati and better understanding of a battery used in a <u>dynamic</u> application.
- Parameters that define a battery's electrical performance (Deliverable Energy, Charge Acceptance and State of Health).
- Parameters that define the Aging and Condition effects on a battery's performance.
- The terms are initially being developed for the Lead Acid battery.
- The terminology is presently being discussed in an MIT subcommittee to gain general acceptance and to recommend methods of measurement or testing to determine a value for the characteristic.

What Are We Trying to Measure ?

- State of Charge (SOC), a measure relative to capacity under nominal conditions, only reflects the number of amp-hours removed from a battery.
- SOC does not characterize a battery for dynamic application.
- Our goal is to determine the <u>Deliverable Energy</u> , <u>Charge Acceptance</u> and <u>State-of-Health</u> of a battery at any time in its use.
- To do this we need to develop broader standards for describing battery performance and life, that allow for comprehensive modeling and simulatio

Goals

Agree on terminology

Develop test methods for each attribute and table of values

Show simple model approach to Deliverable Energy

Develop word “two”, (charge acceptance and life(and show the same as abo

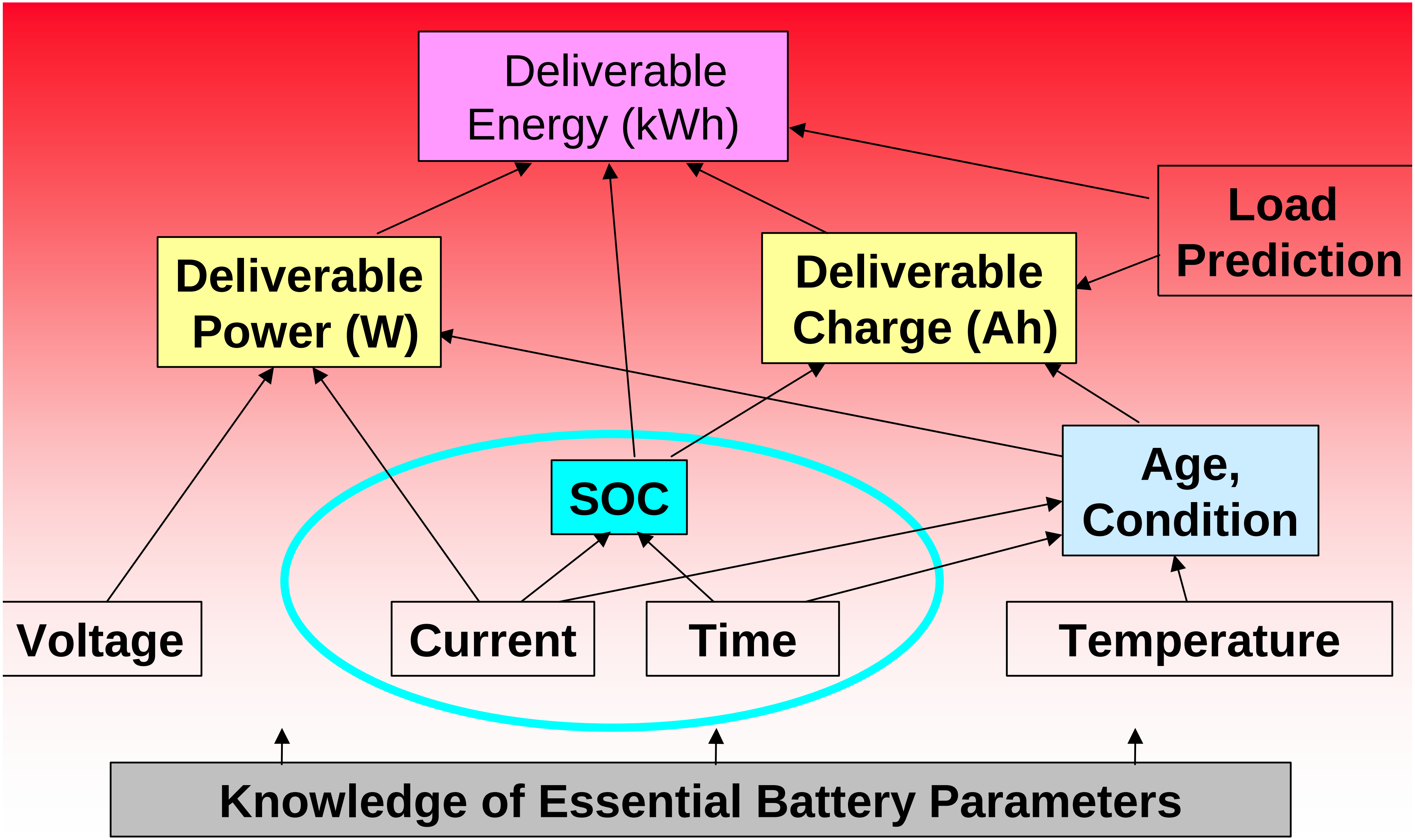
Test product to show how “life” and “condition” affects Deliverable Energy

Help with Saber and Advisor models to define transfer functions with related attributes

Agree that time temperature, voltage and current are the only variables that affect the attributes.

Parameters do not give design information (I.e. Plate weights, densities)

Battery Condition Monitoring 2



Essential Parameters for Discharge Performance I

(1) **Nominal Capacity** — This is the battery's ability to deliver charge at the 20 hour rate. It also sets a data point for *Peukert's Curve.*

(2) **Peukert's Slope** — This describes the battery's ability to deliver charge at different rates.

(3) **Charged Voltage** — The open circuit voltage of a battery at equilibrium when fully charged and at rest with no loads.

(4) **OCV/SOC Slope** — This is the slope of the curve that shows the OCV to the State-of-Charge.

Note: All the above characteristics require a special test procedure to attain the proper result. See following pages.

Essential Parameters for Discharge Performance II

(5) **Internal Resistance** — Measured in milli-ohms, it is the total ohmic resistance of a battery which is charged and conditioned.

(6) **Ionic/Electronic Ratio** — This term gives the ratio of the ionic resistive component to the electronic resistive component in a battery. This allows for modeling the temperature dependence of the resistive components.

(7) **Kinetics** — This is the voltage drop due to the reaction to form lead sulfate. It is this nonlinear voltage drop plus the temperature corrected internal resistance, which will give the voltage drop of the battery under load.

(8) **Thermal Time Constant** — The ability to dissipate heat. The heat capacity divided by heat transfer coefficient.

Note: All the above characteristics require a special test procedure to attain the proper result. See following pages.

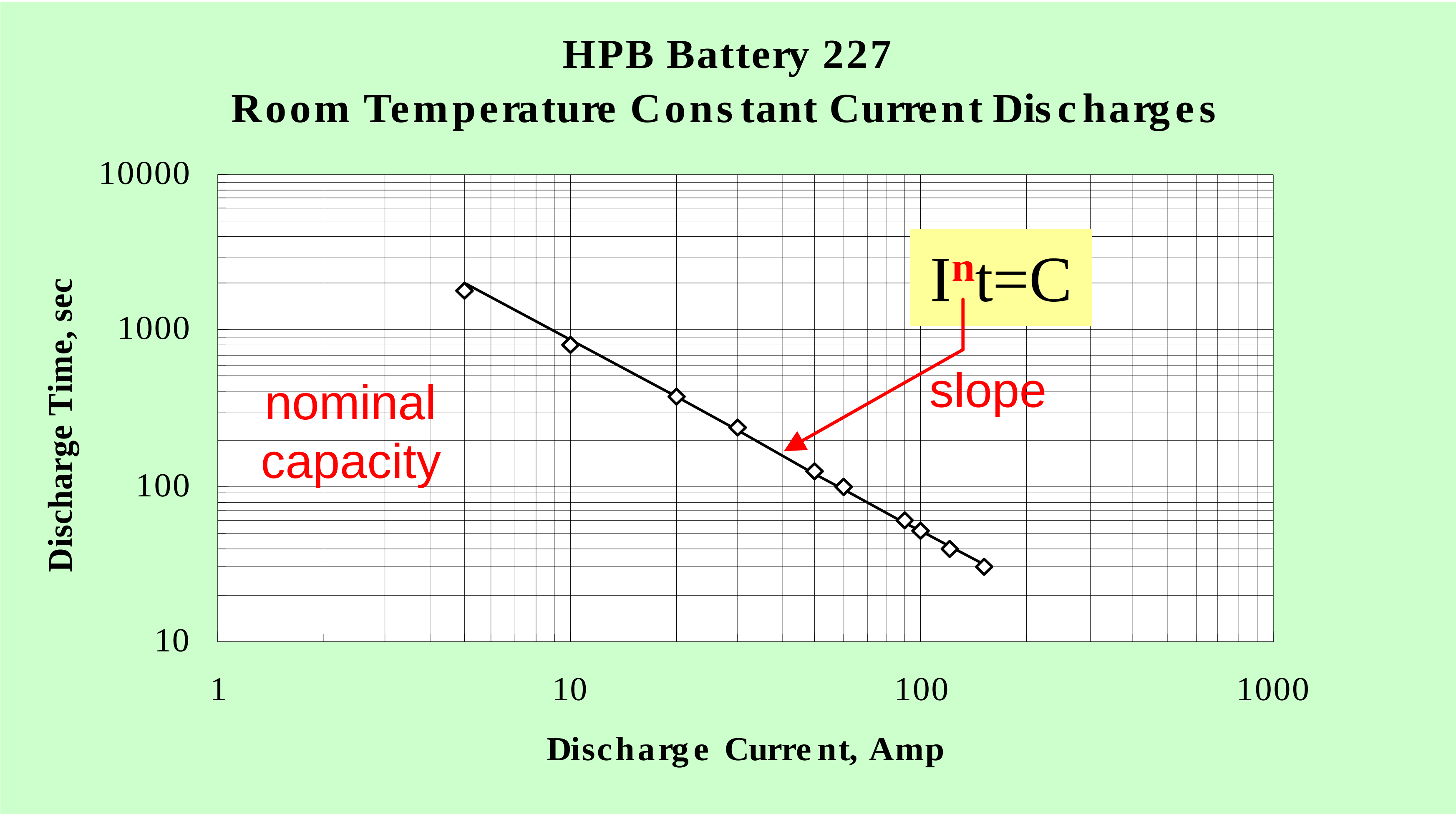
"Word I" - *one possible implementation*

The first of the two words that describe the battery´s properties which allow for modeling would have the letters A-Z and 1-0 in each digit.

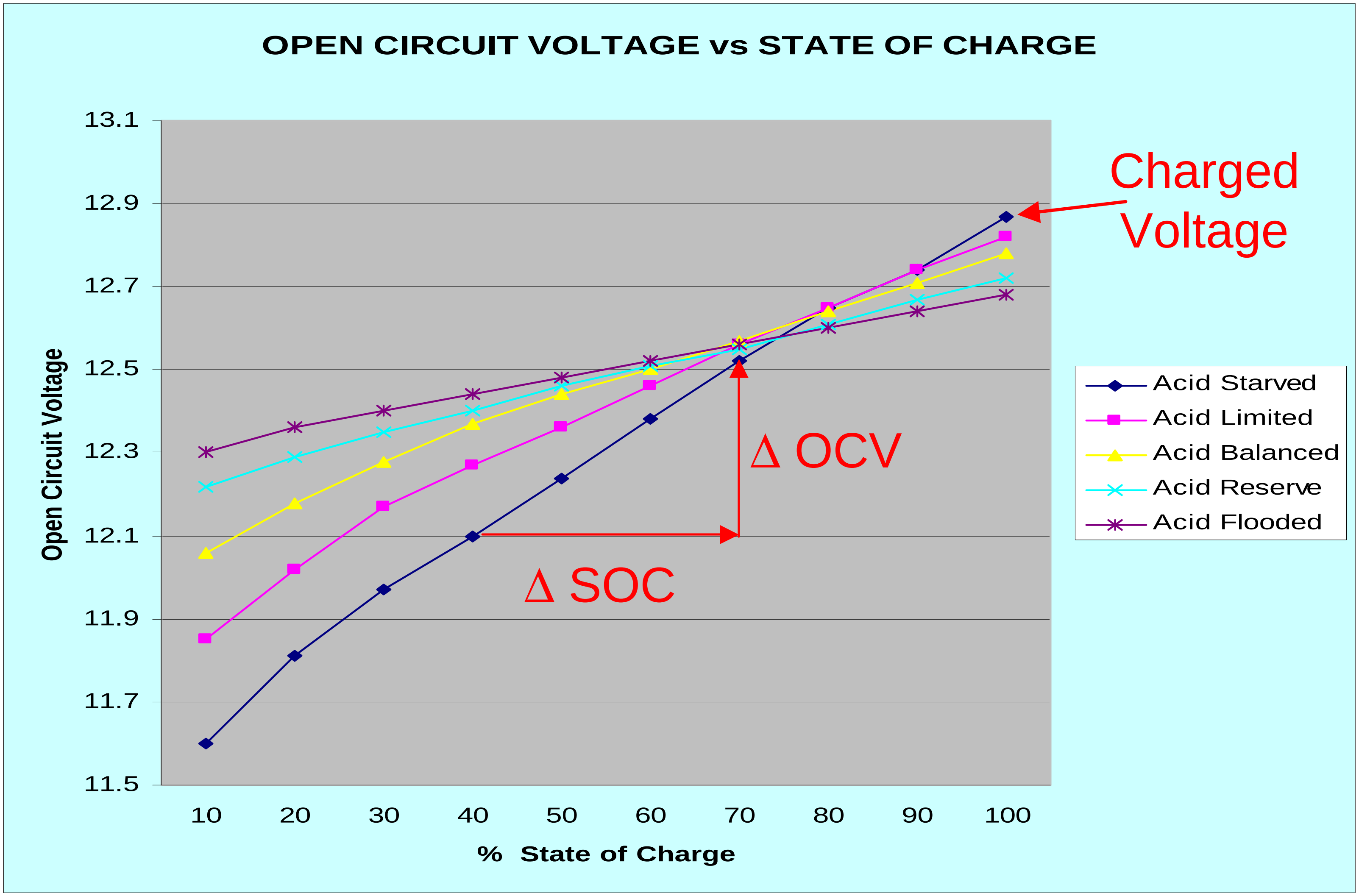
The word could look like the following, **PTGXNR24** where:

P =	Nominal capacity	(45 Ah)
T =	Peukert's Slope	(1.28)
G =	Charged Voltage	(12.85 V)
X =	OCV/%SCO	(.015 V/%SOC)
N =	Internal Resistance	(6.5 mΩ)
R =	Ratio of Ionic/Conductor	(.35)
2 =	Kinetics	(.80)
4 =	Time for °C of Temp. drop	(1.5 min)

(1,2) Peukert's Curve - *Example*

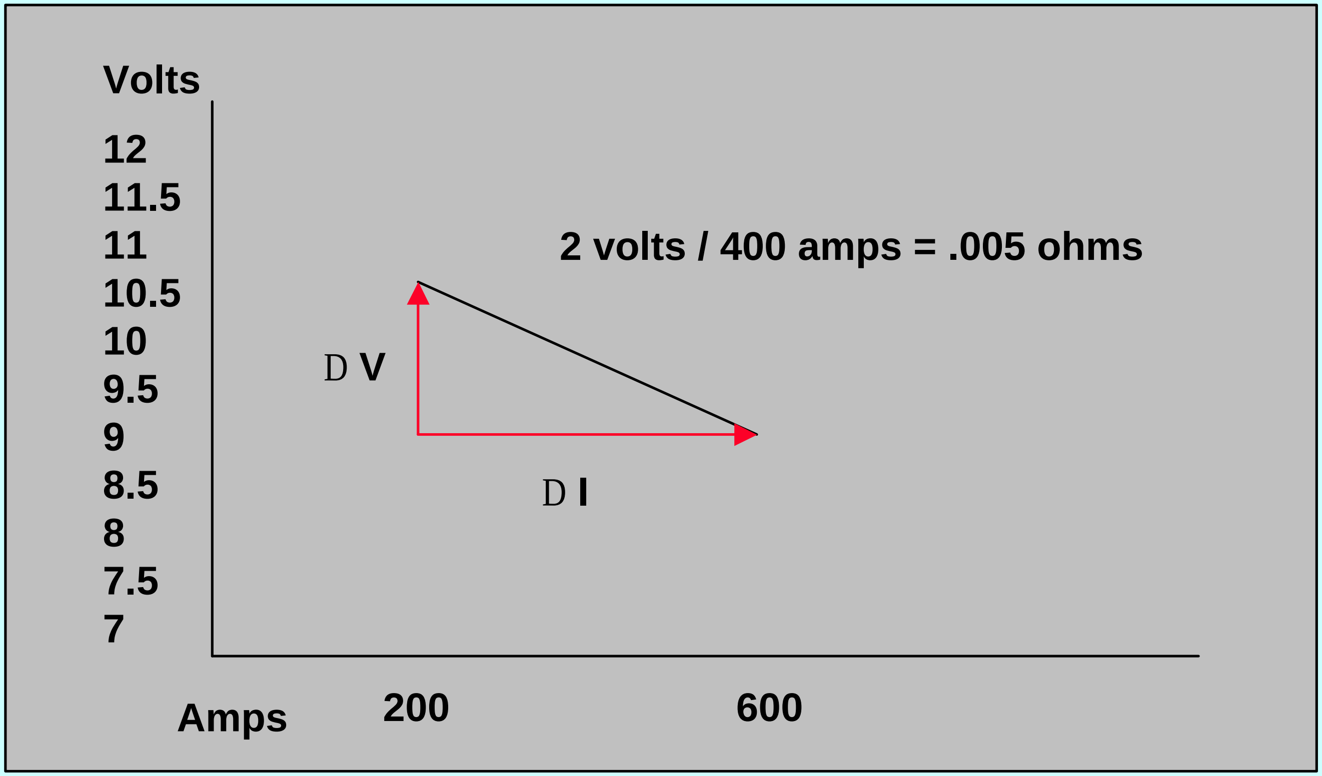


(3,4) SOC vs. OCV - *Example*



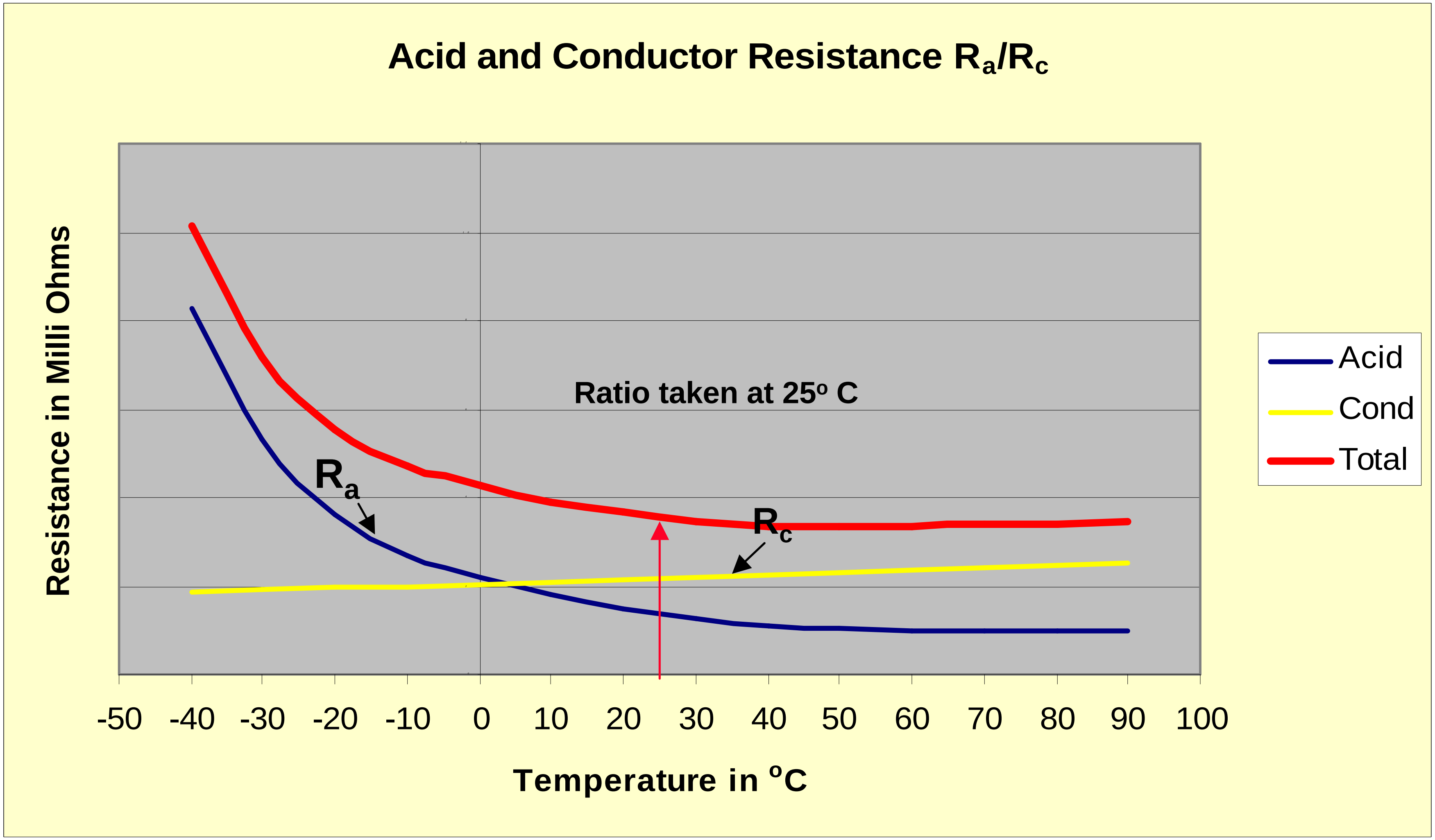
(5) Total Resistance Measurement - *Example*

Resistance R = D V / D I at high current levels

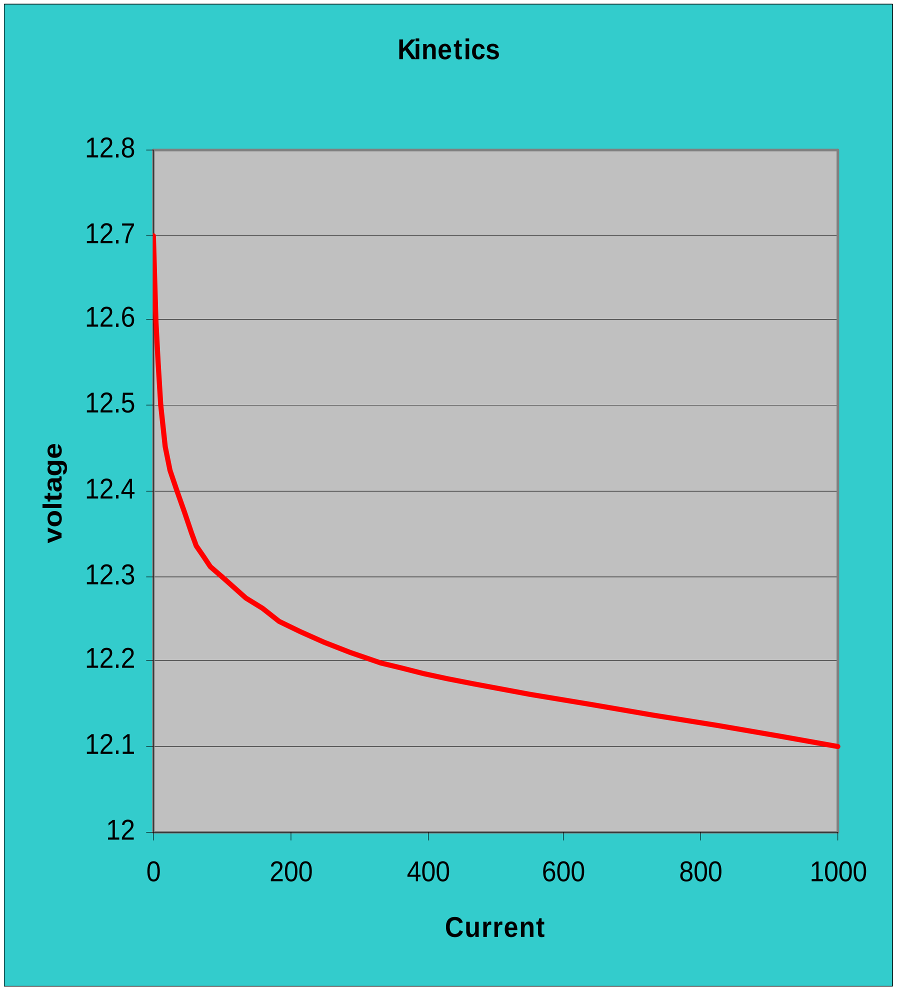


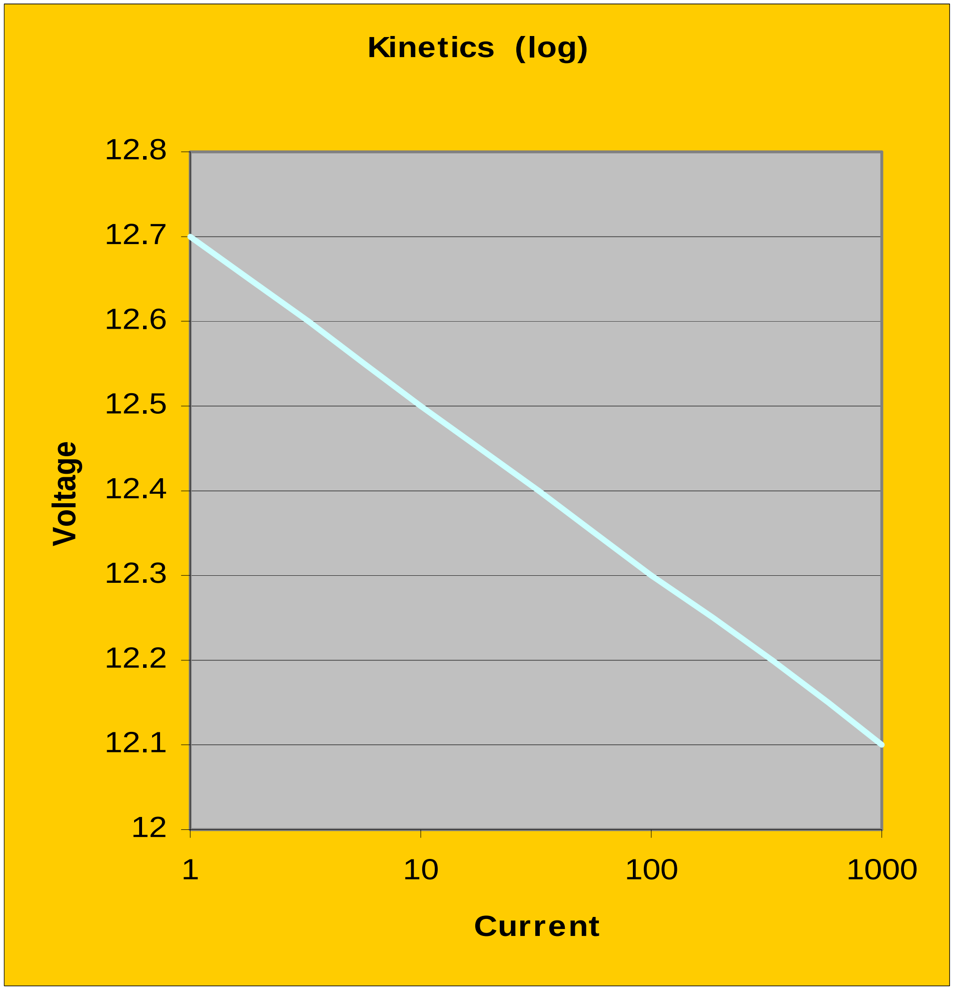
Example - Typical 50 Ahr 12 V Battery

(6) Ionic/Electronic Resistance Ratio - *Example*

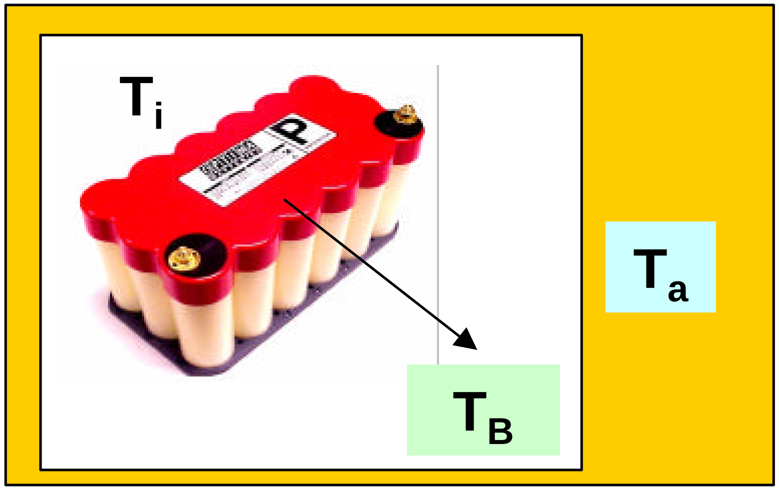


(7) Kinetics - *Example*





(8) Thermal Time Constant - *Example*



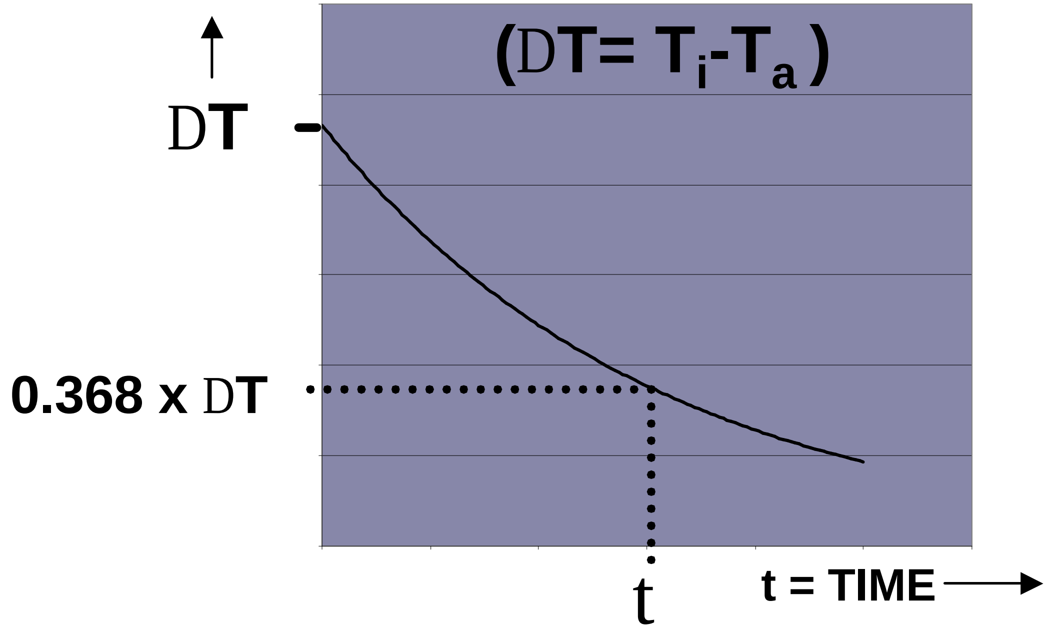
T_B = average mass temperature

T_i = initial average mass temperature

T_a = ambient temperature

t = Time Constant

BATTERY TEMPERATURE DECAY



If:

T_i= 60°C, T_a = 25°C

Then:

t = t @ T_B= 0.368 x DT

t = t @ T_B= 37.9°C

Conclusion

- The parameters developed reduce design time by supporting improvements in such tools as the Saber and Advisor Models
- This also enables simple real-time processing (model-based diagnosis) in vehicles to determine the ability of a battery to Deliver Energy over its life.
- With the added functionality of these characteristics we will develop new insight to system performance.
- The information content of the 8 essential discharge parameters is equivalent to less than 40 bit ("Word-1").