APPLIED BATTERY SYSTEMS FOR THE RADIO AMATEUR
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PART I: Overview

1. Introduction
    a. I intentionally titled this course “Battery Systems for the Radio Amateur” because simply put, a battery only becomes really interesting after you connect it to something. The battery is just one part (a very important part, yes) of a system. In this course we do not want to discuss batteries in isolation. The goal of this course is to equip you to be a hands-on engineer of real-world battery systems, whether for yourself or for someone you’re helping: how to understand, evaluate, design, build, and use those systems for maximum effectiveness.
    b. In this course we’ll still barely scratch the surface of this very big world of battery systems. So in today’s discussion, I’ll give you a topic overview with the simple goal of equipping you to ask the right questions. If this topic is new to you, you will likely end tonight with more questions than answers. That’s okay. It’s simply not possible to make you a battery system engineer in the span of 20 minutes of lecture and 40 minutes of Q&A or however long we go tonight. I hope this is the first of many discussions we’ll have, and your questions are an integral part of that. So write those questions down between now and next time, and please share them with me via e-mail at sbottom@live.com. I want this course to be useful to you, and I’m sure you will think of things that I haven’t. In tonight’s Q&A we can work to address some of those questions, in part; given how complex this topic is, we may need to save some details for future sessions.
    c. Take some time to think about what your objectives for this course are, and write them down. Here are some examples:
        i. Operate your home station during a power outage
        ii. Recharge your handheld and cell phone on an extended backpacking trip
        iii. Or maybe you want to know how many spare handheld batteries you should take on a SAR mission
        iv. Replace the batteries in your RV
        v. Care for the battery in a vehicle that only sees seasonal use, like an ATV or snowmobile
        vi. Effectively utilize field expedient battery systems to communicate in an emergency
2. What is a battery?
    a. A battery is a physical energy storage device that converts chemical energy into electrical energy.
    b. A battery system delivers electrical energy in the form of direct current, or DC, to one or more loads using one or more batteries as the source. A battery system often includes a way to replenish those batteries from some other source of power.
    c. Just like I’m not a perfect instructor and I need your help to make this course useful, a battery is not a perfect device. It operates in the real world subject to the laws of physics and chemistry. There is no such thing as “the perfect battery” for

all situations. Hence, the need for you to be able to engineer a battery system for, or apply an existing one to, a given scenario or set of mission requirements.

   d. Primary (disposable) vs. secondary (rechargeable) cells – we'll focus on secondary cells but primary ones are fair game too.

3. Now, here is an outline for the rest of the course. I've thought a lot about this but it's far from perfect. Regardless, remember to think in terms of scenarios.
   a. Tonight: An overview or framework for designing a battery system or evaluating an existing system
   b. Practical use / techniques
   c. Maintenance / care
   d. System design (mini-series)
   e. Advanced charging systems (e.g. solar power)
   f. Advanced loads (e.g. inverters)
4. Battery systems overview, or a framework for battery system design and evaluation
   a. For me, I'd rather be your guide taking you down the river teaching you how to fish, than the fish merchant at the farmer's market just trying to sell you them. That's the context for tonight's overview – giving you a framework for thinking about battery systems.
   b. Let's go back and think about scenarios. In very simple terms, ask yourself:
      i. What do you want to power?
      ii. What do you want to do with it/them?
      iii. How long do you want to do this?
      iv. Where do you want to go with it?
      v. How are you going to get it there?
   c. Components to evaluate and understand – just think about this in terms of a block diagram. But before that, a word on safety: you should have an eye towards safety for everything we're about to discuss. I won't talk about safety as it's own separate section – we should be talking about it throughout this discussion.
      i. The load (e.g. your radio, a phone charger, etc)
      ii. The source (i.e. the battery itself)
      iii. The charging system (if so equipped)
      iv. The electricity delivery system (all the wiring, connectors, fuses, and other elements distributing electricity where it needs to go)
      v. The environment (where is the system located, do you need to be able to move it, etc)
   d. The load (e.g. your radio)
      i. What is the load (or loads)
      ii. Amperes – maximum (worst case)
      iii. Voltage requirements (including the stability thereof)
      iv. How long you want to be able to run it, and at what amperages (amp-hours)
   e. The source (your battery)
      i. Battery chemistry and type
         1. Lead-acid (flooded or VRLA/SLA? If VRLA, gel or AGM?)
         2. Lithium
         3. NiMH

4. Starter vs. marine vs. deep cycle

ii. Safety (acid, gassing, smoke, is it hot, is it in an airtight enclosure, could it tip over, etc)

iii. Voltage

1. Current state of charge
2. Stability as afforded by the battery chemistry, load, and current state of charge

iv. Current delivery capability (maximum sustained amps)

v. Capacity (Ampere-hours)

vi. Temperature range

vii. Physical size

viii. Weight, which is related to energy density (ratio of capacity to weight)

ix. Maintenance requirements (e.g. watering)

x. Age of the battery and its overall health

xi. Terminals

1. Are they suitable for the connectors / cables you have?
2. Are they corroded?

xii. Number of batteries and how they are connected

1. Series: Two 6-volt batteries connected to make 12 volts (add voltages, amp-hours remain the same)
2. Parallel: Two 12-volt batteries connected to double the amp-hours (add amp-hours, voltages remain the same)

xiii. Manufacturer reputation or country of origin

xiv. Cost (applies to other system elements too, of course)

f. The charging system

i. What is its maximum amperage?

ii. What is it limited by (available sunlight, gasoline, AC power)

iii. How is it controlled?

g. Electricity delivery system

i. Wiring and connectors

1. What gauge is the wire? Is it sufficient for the amperage you want to draw?
2. System layout (how far away from the battery is the load, e.g. in an RV) – how long do the wires need to be?
3. Are the connectors standard / interchangeable / well-installed / in good condition (not corroded, etc)

ii. Protection elements

1. Fusing and circuit breakers (primary purpose: protect your wires)
2. LVD (primary purpose: protect your battery)

iii. Conditioning elements: voltage converters, boosters and stabilizers

h. The environment

i. Where is the system located, or where will it be used?

ii. Will you need to move it? What level of portability is needed? How is it packaged?

iii. What level of vibration / shock resistance / water resistance is needed?