

Predicting Power Requirements for Battery Selection

An Application Note by Chris Gliniecki

When designing a portable device - in particular, one with mechanical parts driven by an electronic controller and power source - one is quickly posed with the question of what sort of battery to use. This application note describes a step-by-step process for taking all of a system's components, figuring out how much power they will likely use, and using this information to make an educated initial guess as to what the system will require.

This document exists for two reasons: first, because it is a required assignment for the Michigan State University Electrical Engineering Program Senior Design Course, and second, because I feel that someone may well need a little help sorting out how to power a system similar to our ATGTS in the future. It is for this second reason that I format the note in an extremely general sense, rather than going over the specific numbers of this particular project.

The methods in this note assume that all components in the system that the reader intends to design already runs from a DC source, as would be deliverable by a battery. Otherwise, a power inverter would be in order, and could be accounted for in much the same way as a buck or boost converter.

Most electromechanical devices describe how much power they are designed to use on a datasheet (or something similar) which can usually be found somewhere on the manufacturer web page. Examples of this for the AGTS can be found here. As a running example, I'll direct you to the [STC 2-way Solenoid's page](#):

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Solenoid Valve Specifications and Dimensions: 2S025-050 Series

Valve Model	2S025	2S040	2S050
Valve Type	2 Way Normally Closed (NC)		
Action	Direct Acting		
Cv (Orifice)		0.5 (5mm)	
Operating Pressure	0 to 150 PSI	0 to 100 PSI	0 to 100 PSI
Operating Temperature	NBR Seal: -20 to 80°C Viton Seal: -10 to 120°C	NBR Seal: -20 to 80°C Viton Seal: -10 to 120°C	Viton Seal: -10 to 120°C
Port Size (NPT)	1/4	3/8	1/4
Body Materials	Stainless Steel		
Seal Materials:	NBR (Options: EPDM, Viton)		Viton (Options: EPDM, NBR)
Coil Protection Insulation Class	H Class IP65		
Coil Duty	100% ED		
Coil Power	20W		14W
Electrical Connections	DIN		
Service	Air, Gas, Liquid, Vacuum Steam (with Viton Seal)		Air, Gas, Liquid, Vacuum, Steam

ALL Standard valves are supplied with CONTINUOUS DUTY COILS of the proper class of insulation for the service indicated on the valve. The coil temperature may become hot after being energized for extended periods, but it is normal. Smoke or burning odor indicates excessive coil temperature and should disconnect the power to the coil immediately.

VOLTAGES: Standard: 12-24V DC and 24-110-220-230V/50-60 Hz AC. Voltage tolerances: +10% -5% for DC, +10%-15% for AC; .

SERVICE LIFE: The service life of the solenoid valve depends on the operating conditions such as pressure, temperature, type of medium and the voltage. Normally the STC solenoid valves are reliable for more than 5 million cycles.

2S025-050 are DIRECT ACTING solenoid valves and do not require a minimum operating differential pressure. As shown below when the coil is energized (right diagram), it lifts the solenoid plunger, which normally rests on the valve seat and lifts it to open the main valve orifice. When the coil is de-energized (right diagram), the spring force the plunger return to the valve seat to close the valve orifice.

De-energized

2-Way, Direct Acting, Normally Closed

Energized

Most of these data sheets will give two values for the component that are important for our purposes: the supply voltage under which it operates (in Volts, naturally), and the power that it consumes while in operation (in Watts). If a typical rating of the device's current draw (Amps) is given, take note of this as well.

If someone has the misfortune of needing to power a component for which no data sheet can be found, then one must figure out the component's properties oneself. If the device is labeled with its designated supply voltage, one may simply turn it on and measure the current in the lab. If neither a voltage nor a current are given, deducing the device's properties can be a tricky matter... but then, it also raises the question of why one is attempting to use a completely unknown device in the first place.

The next step is to decide and calculate how long each component needs to stay in operation, both on the whole and relative to the other components.

Regardless of what is being designed, there is going to be some expectation of how long it needs to keep running. For a flashlight, this expectation translates into how long the bulb needs to stay alight while it is in use, which in turn can be used to directly calculate how much power the device uses. For applications with multiple components, such as the ATGTS, this is somewhat more complicated.

What one needs to find in this step is the amount of time a given component will actually be operating during the interval in which the device will be in use. In the case of the ATGTS, the device runs in a deterministic cycle every 4 hours for a full month, and during each cycle each component runs for a predetermined amount of time within that cycle. Similar situations may entail that the device run in continuous cycles, but only when the user has it switched on, in which case the designer will need to make a judgment call as to how long the product should run before the batteries need to be recharged or replaced. In this case, I would recommend choosing a suitable unit of time for this step such that one can more easily weigh operation time against battery cost later on.

For this running example, let's say that we simply need the solenoid valve from the previous page to open and drain water for 20 seconds once every ten minutes, and will continue this cycle for a full 8 hours each day. It depends on the application, but here let's also assume that its time of operation could be believably measured in days.

The calculation would thus go as follows:
 $(20 \text{ seconds of operation} / 10 \text{ minutes}) * (60 \text{ minutes/hour}) * (8 \text{ hours/day}) = 9600$
seconds per day = 2.67 hours per day

Repeat this calculation for each component in the system. It is good at this point to have a table of components with their voltages, currents, and operation times, like so:

Component	Voltage	Current	Time
Valve	24V	1.7A	2.67 hours/day
Exampleslot	0V	0A	0 hours/day
Timer	12V	10 mA	8 hours/day

So far we have calculated how long each component operates and how much current each component draws as it does so. We are now almost ready to go battery shopping.

All of the components of the ATGTS run at 12 volts, and can thus all use the same battery by default. However, I realize that this is not always going to be the case. If some of a system's components run on different voltages from others, then one is faced with another decision: is it better to split them up and run these components with different power supplies, or to use a voltage converter to allow these components to run off of the same battery?

Using multiple batteries entails splitting up the table and calculating how much power each battery will need to supply during the device's operation, but is otherwise fairly painless. Building in a converter will entail some more calculation, but may save space. As it is outside the scope of this note, one must seriously look into which type of converter to use in order to enact this plan: here are the Wikipedia articles on [Buck](#) and [Boost](#) converters, as a start. A converter will alter the way that a component absorbs power - staging up the voltage makes the converter draw more current than the component does normally, for instance.

For our example, let's assume that we can use a 12 volt battery for the timer and a 24 volt battery for the valve without much trouble.

Most online dealers of batteries rate the longevities of their wares in amp-hours or milliamp-hours. As such, we take the current draw and operation time for each of our components multiply them together, and add up the results for each battery group:

$$\begin{aligned} 1.7\text{Amps} * 2.67 \text{ hours per day} &= 4.539 \text{ Ah/day} \\ + (\text{other 24V components would go here}) & \\ = 4.539 \text{ Ah/day} \end{aligned}$$
$$10 \text{ mA} * 8 \text{ hours/day} = 80 \text{ mAh/day}$$

So, this system will need one 24V battery capable of providing at least 4.54 Amp-hours for each day of operation and one 12V battery that can provide 80 mAh for each day.

If the device absolutely needs to run for a certain period of time, as it does for the ATGTS, a battery should be selected that can exceed it by a wide margin. It must also have the capacity to serve your device when it is drawing peak power; to make sure of this, find the most power-intensive point in the cycle and calculate the current draw by adding up the currents for each component that is active at that time.

This concludes my little application note. If you are still in need of some help in this area, or anything remotely related to electronics or electro-mechanical systems, feel free to [contact one of us](#).