Remote Station Power Analysis (2007)

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Remote Station Power Analysis

UNAVCO has developed an engineering model to assist power system design for year-round operation of instrumentation systems at high latitudes. Currently, this model incorporates power input from solar panels and power storage using sealed lead-acid (SLA) batteries. Power system development is ongoing, and this page will be updated, refined, and expanded as the analyses are improved and as more data is collected on performance of components such as wind turbines.

Solar Panels and SLA Batteries Required for Year-Round Operation at High Latitudes

As of August 2007, the bulk of UNAVCO design work has focused on the Antarctic Margin (Coastal) Station design, which will operate in high wind environments but without the extreme cold found on the Antarctic Plateau. As such, these power analysis results apply to bedrock locations and not to the interior of the Antarctic (or Greenland) ice sheets. Also they do not yet extend beyond 80 degrees latitude, an arbitrary cutoff point past which the extreme cold will quickly and severaly degrade battery peformance. Finally, analyses have centered on a nominal 5-watt load. The current UNAVCO polar GPS system, consisting of a Trimble NetRS receiver, Trimble Choke Ring antenna, and Iridium data retrieval, uses approximately 4.5 W average.

TABLE 1. Minimum SLA amp-hour capacity needed for year-round operation of a 5-watt system.

LATITUDE	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
2 Panels (170 W)	900	900	900	1100	1300	1500	1700	1900	2100	2200	2300	----	----	----	----	100*
3 Panels (255 W)	700	700	800	1000	1200	1400	1600	1800	2000	2200	2300	----	----	----	----	100*
4 Panels (340 W)	500	500	600	900	1100	1300	1500	1700	1900	2100	2300	----	----	----	----	100*

* At 90S latitude, plug in system to Amundsen-Scott South Pole station power and use one battery for backup.

Notes on Power Analysis

The power analysis relies in part on output from the PV-DesignPro-S v6.0 software package from Maui Solar Software . This program uses solar intensity and earth orbit parameters, along with local clearness index observations, to calculate solar irradiance at ground level on an inclined solar panel. Irradiance is generated on an hourly basis, modeling weather variations using randomization functions. The annual power delivered from the solar array to the battery bank is tracked from mid-summer to mid-summer, while subtracting the constant load. The battery bank size is then increased until its capacity during the winter is not depleted before enough sunlight returns to supply the load. The selected solar panel model was a BP585 85-Watt module, and the battery calculations are based on experience with the Deka 8G31 SLA battery (see the Power Systems page for information).

A total of 28 locations between 59 and 80 degrees north and south latitude were individually analyzed to generate the results presented here. The accuracy of this analysis was then validated against independent observations from existing year-round GPS installations in the Antarctic. For both Fishtail Point (78.9 S) and Cape Roberts (77.0 S), year-round operation was predicted from this analysis, including two versions of solar/battery arrays deployed at Cape Roberts. Furthermore, this analysis was also validated against performance of the UNAVCO GPS Test Facility at McMurdo Station (77.8 S) observed during winter 2006. This system was intentionally underpowered to observe power cycle behavior, and the dates of both autumn shutdown and spring startup were accurately predicted by this analysis.

Two key assumptions should be noted. First, as solar charging diminishes in the autumn, 100% of available solar panel power (minus the load) is used to charge the battery bank. This condition is maintained from the summer solstice to the winter solstice, and the battery bank is not allowed to overcharge (i.e. its nominal capacity in amp-hours is not exceeded). During the dark period the batteries are then discharged as described below. During the return of sunlight during the spring, it is conservatively assumed that the batteries will accept 30% of the available power from the solar panels.

The second key assumption involves de-rating battery discharge performance in the cold. For latitudes below 64 degrees it is assumed that the batteries deliver 100% of their nominal capacity, and for latitudes between 64 and 80 it is assumed that they deliver 70% of their nominal capacity. These two figures are derived from the fact that sealed lead-acid batteries can deliver significantly more than their nominal room-temperature capacity when discharged at very small rates. For example, 5 watt system will draw ~40 mA from each member of a 1000 amp-hour battery bank. At that discharge rate, a 100 amp-hour battery will provide approximately 140 amp-hours of capacity. To account for temperature, this 140% effective capacity is then de-rated by 30% for latitudes below 64 degrees and 50% for latitudes between 64 and 80. The overall 70% battery efficiency figure has been verified at McMurdo Station (77.8 S) during wintertime operation.