APPLICATION NOTE

# Operating a 2638A Hydra Series III Data Acquisition System/Digital Multimeter under battery power

## Freedom from the ac power outlet

Many data logging tasks take place on or near equipment that has ac power outlets available nearby so the availability of ac line power is not an issue for many applications. But what do you do when you need to collect data from a location far away from a convenient ac outlet, or simply want the freedom of a mobile test cart to move throughout your facility? This application note offers advice for selecting a portable ac power supply for your Hydra Series III data logger.

## System overview

A basic system consists of a 12 volt battery of sufficient amp-hour capacity to power a 12 volt to 120 volt or 220 volt ac dc-to-ac inverter and the Hydra 2638A. The battery and inverter are generic off-the-shelf items that can be purchased at many retail and industrial outlets. Put this simple combination of battery, inverter and Hydra Series III on a roll-around cart or in a vehicle to power the Hydra from hours to days of recording.

While the selection of the battery and inverter to use in your system may not be critical to the overall operation of the Hydra, there are some areas to consider in selecting components that meet your needs.

## Power inverter considerations

Commercially available dc-to-ac power inverters you might consider can be separated into two very basic types of dc-to-ac conversion design. The basic selections for this application are either "pure" sine wave, also referred to as modified sine wave and the modified square wave or simply square wave output types.

A potential advantage to the pure sine wave output type is a typically lower total harmonic distortion (THD) specification compared to the square wave type converter. Many have regulated output voltage specifications of ± 3 % to 5 % under full load and frequency specifications within a few Hertz of standard 50 Hertz or 60 Hertz line frequencies. These specifications give some assurance that the voltage and frequency presented to the Hydra will be within the Hydra's power specifications. Pure sine wave inverters are also more capable of driving small inductive loads such as hand drills and small motors should you need that capability.

Modified square wave converters we reviewed offered no voltage regulation specification and often do not specify output frequency or THD. A potential disadvantage of square wave inverters with high THD could be radiated noise in a frequency region where a measurement instrument may be more susceptible to interference. The very act of generating a square wave ensures there will be rich harmonic content and potentially radiated noise. This may be an area where concern for measurement integrity is warranted. You should take the time to verify for your particular installation.

The frequency of the inverter should be close to the standard line frequency for your area, either 60 Hertz or 50 Hertz. This will maintain correct a/d clocking on the 2638A which is important to overall performance to specifications.

Selecting an inverter with an automatic low voltage shutdown feature (typically at 10.5 volts dc) allows you to potentially save a battery from going into a deep discharge state and also gives notice of the need to switch to a fully charged battery to continue recording. Alternately, you could use an open channel on the Hydra to monitor battery voltage using a Hi-Hi alarm setting to give you advance notice of the need to parallel a back-up battery to continue recording.

While the empirical test described here used a 300 watt square wave inverter, which performed admirably, you may want to explore other choices such as a pure sine wave inverter. The Hydra Series II has a 36 watt power consumption so smaller rated inverters could be used in this application but were not tested during this review.

One last mention in the selection of an inverter is the quiescent or static current draw. A quick review of specifications for both pure sine wave and modified sine wave inverters showed ranges from 0.2 to 1.1 amps. This higher range could significantly reduce the time available from any given battery when connected to a Hydra and placed under full load.

## Battery considerations

In deciding what battery to use, the amp-hour capacity specification is at the top of the list. Whether your hourly usage is expected to be 4 hours, 8 hours, or 24 hours, your battery needs to have the basic amp-hour capacity to allow system operation over the intended operating time. Other considerations might be battery weight, battery composition (lead acid, Li on, NiMH, etc.) and overall dimensions. Time to recharge can vary with different battery construction, so these features as well as a compatible charger should also be reviewed based on your application needs.

## Estimating required battery capacity

As a general comment, different battery types respond differently to higher or lower discharge rates and discharge cycles. Marine deep cycle batteries, for example, are designed to be discharged to a low level (approximately 9.5 volts) repeatedly and still recover upon charging. Other types of batteries such as ones designed as “starting” batteries typically do not respond well to repeated deep discharges much below 10.5 volts for multiple cycles.

Most lead acid batteries, with the exception of automotive batteries, are most often specified in an amp-hour (AH) rating, which is basically defined as the draw of one amp over a 20-hour time that will bring the battery to a 10.5 V level. So a 20 AH rated battery should supply one amp for 20 hours or 2 amps for 10 hours, 5 amps for 4 hours or 20 amps for 1 hour before reaching 10.5 volts. This is a common industry standard.

So for example, the chosen inverter together with the Hydra drew 1.65 amps from the battery while the 2638A was scanning with its display on. If you needed to scan for 13 hours with this system, you would need a 21.45 AH battery (1.65A * 13 hours). A close commercially available standard AH capacity up from this value is 24 AH. In a perfect world, a 24 AH battery would offer 14.55 hours of operations for this system.

There are formulas for estimating battery performance based on battery age, temperature and battery composition. One equation, Peukert’s Law, describes the change in effective AH capacity with higher or lower current loads. However, for this application most users will only need a basic linear calculation of system hours of operation and the current draw to determine the AH rating of the battery needed.

**Lead acid battery hours of operation based on a 1.65 amp draw***

| **Battery amp-hour rating** | 14 AH | 24 AH | 36AH | 48AH |
|---|---|---|---|---|
| **Load 1.65 amps (Inverter and Hydra)** | 7.1 hours | 13.6 hours | 22.2 hours | 31.4 hours |

*The estimates in this table utilize Perkert’s Law for sealed lead acid batteries and a K=1.2

## Peukert's Law

Peukert's Law was developed in 1897 to describe the non-linear effect of the change in actual AH capacity of a lead acid battery based on different rates of discharge applied. The formula below solves for discharge time with a known discharge rate and AH battery capacity. The Peukert's constant in part accounts for battery age by an increase in value.

**Peukert's Law** $$T = H\left(\frac{C}{IH}\right)^k$$

**H = rated test discharge time in hours (Typically rated at 20 Hours for most applications)**

**C = rated battery capacity in amp-hours**

**I = actual discharge current in amps**

**K = Peukert constant**

**T = actual time to discharge the battery in hours**

| Battery construction type | Peukert's constant |
|---|---|
| **Lead acid** | 1.1 to 1.3 |
| **AGM (absorbed glass mat)** | 1.05 to 1.15 |
| **Gel cell** | 1.1 to 1.25 |
| **Flooded (SLA)** | 1.2 to 1.6 |

## Empirical system evaluation

Looking for a worst case test scenario for, we selected a square wave inverter with a 300 watt continuous operating specification and 400 W peak start-up operation. The data sheet for the square wave inverter did not specify output voltage regulation, line frequency, wave shape type or THD. When tested with a Fluke 41 power analyzer, the measurements indicated that the output voltage was 116 volts ac, line frequency of 57.6 Hertz and a THD of 40 % in a no load condition.

For this test we selected an available 12 volt 14 AH sealed lead acid battery. Our next step was to measure the actual current draw from the system. Our measurements showed that the inverter we selected drew 0.2 amps in the quiescent state. Powering up the Hydra without scanning with display on drew a total of 1.6 amps. Scanning with the Hydra display on drew 1.65 amps and 1.5 amps scanning with display off. Peak current draw from the battery under full combined load of the inverter and the Hydra was 1.65 amps.

A quick check of measurement accuracy was needed to insure no EMI was being picked up by the Hydra measurement circuits. To do this we set the a/d sample rate to "fast" (0.2 PLC), which would be a worst case for noise rejection. We then connected a 4-foot long unshielded K thermocouple to a measurement channel and placed the thermocouple probe in an ice bath at 0.1 °C. We also connected an unshielded 4-foot wire pair to a measurement channel set for two wire resistance and terminated the leads with a 1 mega Ohm resistor. After verifying the temperature of the thermocouple and resistor value with a 8846A digital multimeter, we started scanning and recording measurements. The results on both channels were identical within a few counts of that measured on the 8846A. It appeared the Hydra was able to reject EMI that was most probably being radiated from the inverter.

Once we determined normal operation under this inverter set up, the test was terminated, trusting the total duration of the battery life to Peukert's Law.

## Conclusion

We can make a reasonable recommendation to those needing portable power for their Hydra 2638A Series III that an inexpensive dc-to-ac inverter and appropriately selected battery can provide hours or days of freedom from the extension cord.

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Printed in U.S.A. 3/2016 6006623a-en