

# Universal DC Power Adapter & Charger

Configurable for conversion, charging, and other applications.

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Early in the project, it was noted that the deployment needs of our embedded devices would require compatibility with a wide variety of power sources. Where stationary Motes deployed in-home could be powered using AC wall adapters, mobile and outdoor devices would require battery packs of varying capacity and possibly supplemented by solar cells.

The truth is that, as the project continues, we cannot fully predict what power sources are either available or suitable from application to application.

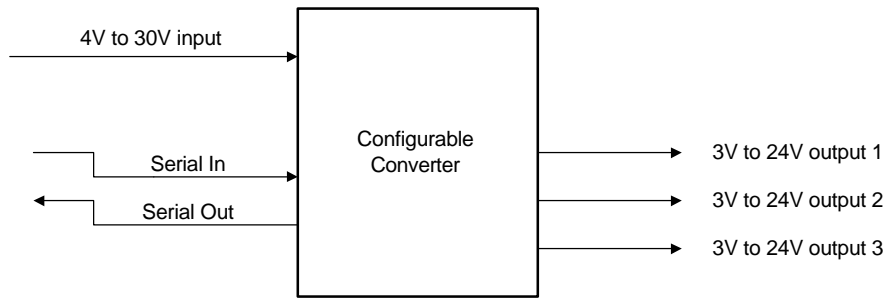
Consider the voltage requirements of our existing components:

- 3.3V Motes, GPS Receiver
- 5.0V Passive Tag RFID Reader, iPaq
- 12V TravelBag Charger Input
- 7.8V TravelBag Audio Amplifier

Thus far, we have been creating power adapters as needed for these devices on a case-by-case basis. A few examples of these are listed below.

<u>Meta Component Name</u>	<u>Conversion Required</u>
MoteModem RS-232	5 to 12V in. 3.3V out.
MoteModem USB	5V in. 3.3V out.
Travel Bag Electronics	7.8V in. 3.3V, 5V, and 7.8V out.

As we explore the concept of Rich Components as applied to such building blocks as the GPS Server, MoteModem, and RFID, we can now more easily conceptualize generic building blocks where none had been previously considered. In the context of power converters, it is clearly desirable to have a single standardized adapter we could configure through a serial port to accept a wide ranging voltage as an input and specify the output voltage for at least three separate taps.



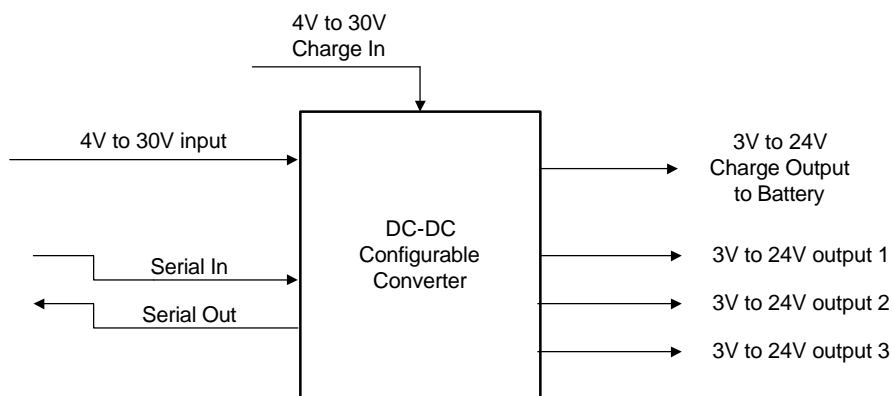
**Fig 1: The configurable voltage converter. Because the converter allows for different voltage levels on each tap, it is possible to embed the device into many complex systems using different electrical requirements.**

This converter enables our students to adapt almost any power source to the needs of present and future projects. To make the device even simpler, the input voltage is rectified to allow normal operation even when connected backwards. No electronics experience is required beyond knowing the voltage requirements of the project.

### Managing Batteries

It doesn't take long to realize that the basic ingredients that make such a programmable supply could also be applied to ease the development of rechargeable battery packs. This in mind, our DC adapter includes additional connections designed specifically for the purpose.

In addition to the the Voltage In and the configurable Voltage Out taps, the device has an output connection for the charging of battery packs, as well as connections for an independent charger power supply such as an AC adapter or solar cell. As with the input power leads, the charge leads are rectified so that input polarity is not a consideration.



**Fig 2: The configurable voltage converter with battery charger capability. Adding the charger circuit was a snap because we're mostly duplicating the electronics that comprise the output taps explained previously.**

With the charging circuit now fully embedded into our DC adapter, we have a truly universal module that can be configured for almost any power supply and battery pack we're likely to encounter.

The device can also monitor the coulombs of current flowing in and out of the battery. This allows for very accurate estimations of battery capacity, providing us with information much like a fuel gauge estimation of gas in an automobile's tank. The significance of this is that fairly accurate predictions of remaining battery life can be made. Where measuring battery voltage will tell you when the battery is reaching depletion, measuring coulombs can tell you how long it will be before depletion. It is then possible to make mission-critical decisions based on battery life.

## **The Serial Interface**

By default, the TTL serial port has been programmed to operate at 9600 baud, N81. This connection is meant for embedding the unit into a larger system, as you cannot connect directly to a PC using this method—a TTL to RS-232 adapter is required. If you want to connect to a PC, adapters are readily available from HVW Technologies ([www.HVWtech.com](http://www.HVWtech.com)) for only \$10.

When the device first powers-up, the following sign-on message is displayed:

```
APP: CONFIGURABLE DC-DC CONVERTER & CHARGER  
September 23 2005  
14:36:51
```

The sign-on message is the best opportunity to verify that the serial connection has been made correctly, and that the module has been programmed with the correct version of software.

## **Configuring the device**

The device can be configured using familiar AT-style command strings, similar in spirit to a Hayes smart modem. From any operating mode, the device can be put into a “command” mode by sending it the string “ATCOMMAND” (without the quotes) on the serial link, followed by a carriage return [cr] character

It is envisioned that a systems integrator will configure the device using a terminal program such as HyperTerminal. When the integrator enters the command string “ATCOMMAND” (without the quotes) followed by a carriage return, the following is displayed:

```
COMMAND MODE BEGIN  
OK
```

The integrator could now get the menu of commands available. This is accomplished by typing "ATH" followed by a carriage return. The following is displayed:

```
COMMANDS :
  ATBAUD4800 .. SETS 4800 BAUD
  ATBAUD9600 .. SETS 9600 BAUD
  ATBAUD19200 .. SETS 19200 BAUD
  ATBAUD38400 .. SETS 38400 BAUD
  ATBAUD57600 .. SETS 57600 BAUD
  ATMVOUT1=nnnnn .. SETS THE MILLIVOLTS ON TAP 1
  ATMVOUT2=nnnnn .. SETS THE MILLIVOLTS ON TAP 2
  ATMVOUT3=nnnnn .. SETS THE MILLIVOLTS ON TAP 3
  ATBATTTYPE=n .. SETS TYPE OF BATTERY CHEMISTRY
                  0=NONE 1=SEALED LEAD ACID 2= NiCD 3=NiMH 4=LiOn
  ATBATTMV=nnnnn .. SETS THE MILLIVOLT RATING OF THE BATTERY
  ATBATTMAH=nnnnn .. SETS THE MILLIAMP HOUR RATING OF THE BATTERY
  ATLEDn .. SETS LED MODE 1=ENABLED 0=DISABLE
  ATDEFAULT .. RESTORES SYSTEM DEFAULTS
  ATSHOW .. SHOW CURRENT SETTINGS
  ATSAVE .. EXIT COMMAND MODE & SAVE
  ATEXIT .. EXIT COMMAND MODE WITHOUT SAVING
  ATH OR AT? .. THIS SCREEN
OK
```

Baud rate commands are self-explanatory. The others we'll discuss here.

The setting ATLED either enables or disables the LEDs. Though it is usually most desirable to have LEDs disabled, it might be advantageous to enable them in some situations to diagnose the system.

#### ATMVOUT1 - ATMVOUT3

These commands will set the voltage output for the specified tap. Note that the desired output voltage can't be more than 8500 millivolts of the expected input voltage. The step-up regulators we use won't go any higher than this.

#### ATBATTTYPE

Different battery chemestries require different charge methods, and if the device is being used to recharge batteries, this allows the charging function to determine how best to charge and maintain the specified battery type.

#### ATBATTMAH

If the device is being used with rechargeable batteries, use this setting to specify the capacity of the battery. This allows the charging function to determine how best to regulate charging current when necessary.

#### ATBATTMV

If the device is being used with a battery, use this setting to specify the voltage rating of the battery. This allows the device a simple method to determine when the battery is drained. Also, if the device is being used with a rechargeable battery, it allows the charging function to determine how much voltage should be applied to the battery to

charge it.

Use ATSHOW to display settings. An example show is as follows:

```
SETTINGS:
BAUD=9600
ENABLE_LEDS=1
TAP 1 MV=3300
TAP 2 MV=5000
TAP 3 MV=0
BATTERY_TYPE=1 (SLA) MV=12000 MAH=5000
OK
```

Command ATEXIT is used to exit command mode without saving the settings into flash. The unit will automatically reset and the old settings will be restored.

Command ATSAVE is used to save the settings into flash and exit command mode. The unit will automatically reset and the new settings will take effect.

### **Serial Messages During Normal Operation**

Once the device has been configured and the settings saved, the device will operate in accordance with those settings.

Every few seconds, a status information page is sent from the converter at the configured baud rate, and will reflect the actual status of the unit in operation. The status page will look something like this:

```
BEGIN CONVERTER STATUS

INPUT MV=13800
TAP 1 MV=3000
TAP 2 MV=5000
TAP 3 MV=7800
BATTERY CAPACITY=89%
CHARGE MV=13800 MA=2000

END CONVERTER STATUS
```

Note that the voltage reported by the taps reflects the settings as configured. The input MV, battery capacity, charger MV and MA readings reflect true values as if a multimeter were being used to probe these areas.

## **Status Information on LEDs**

When LEDs are enabled, the device will use them to display status information described as follows:

The green LED is on when the input voltage is sufficient to power the device.  
The green LED is flashing when the battery is below 50% capacity.  
The yellow LED is on when charge voltage is sufficient to charge the battery.

## **Appendix A: Peering into the future.**

The hardware put in place for the development of this module actually has more capability than the user interface as described can take advantage of.

For example, there is no reason that we can't expand the interface to allow more direct control of charging voltage and more immediate feedback for charging current. This would make it possible to momentarily overvolt a battery to blow off corrosion and quickly drop back to a normal charging voltage. It would also allow for more direct control of the charge cycle in general.

Along those same lines, it is also possible to generate an API that allows for dynamically changing the output voltages on any tap in response to a command. This would make it possible to perform such tasks as "spiking" the voltage for a few milliseconds to get a DC motor turning, and then reducing the voltage when the motor has reached a desirable RMP. This concept can be similarly applied to solenoids or any magnetic-coil driven device.

The ultimate trump card is that this module is entirely reprogrammable, so that it can be used in ways we haven't yet considered.