Eta Electronics

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Contents

1 System Description

This is a description of the components involved in the vision system and how they interact.

1.1 Schematic

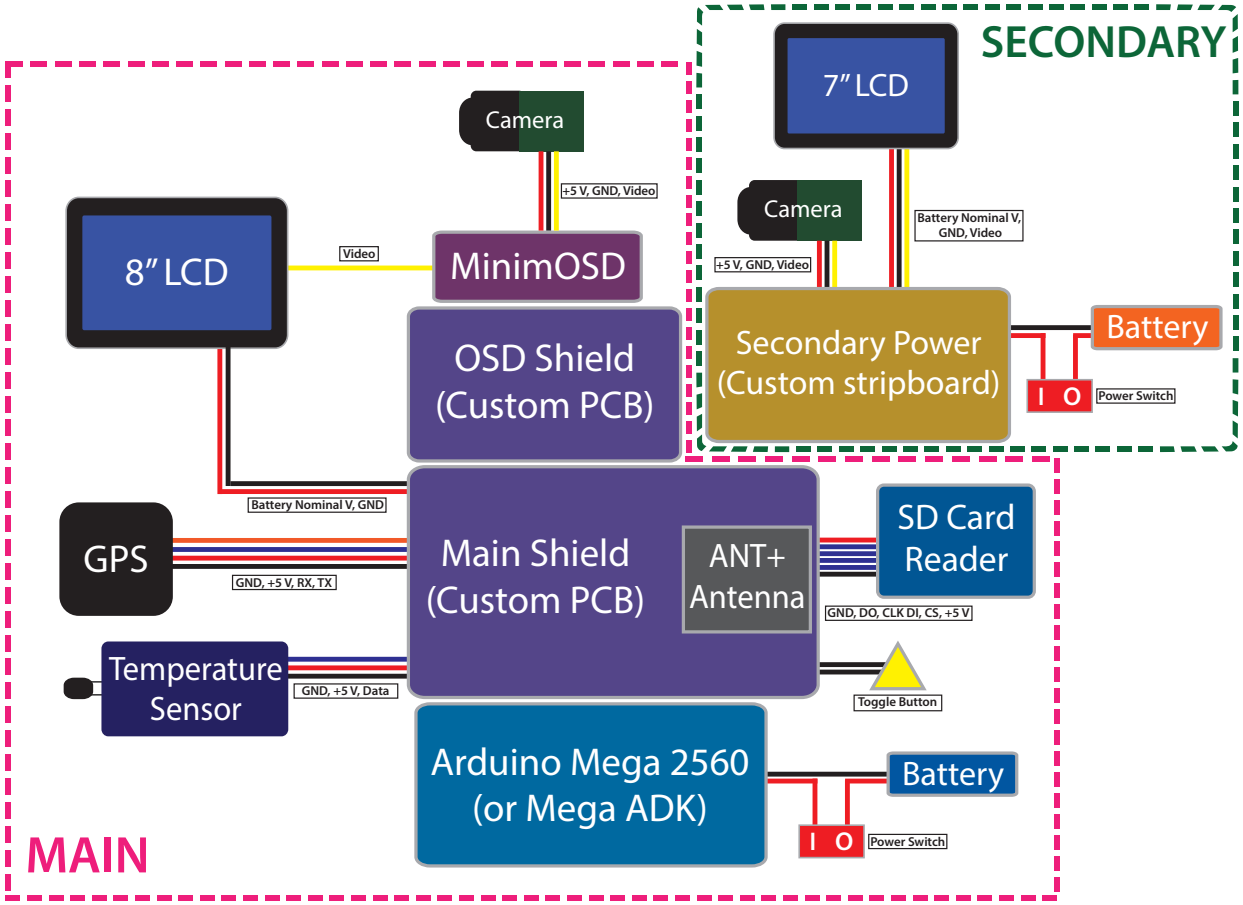


Figure 1: A block diagram of all the electronics in Eta.

1.2 Component Breakdown

1.2.1 Main

Arduino Mega

The main Arduino is either an Arduino Mega 2560 or an Arduino Mega ADK. The latter is more expensive and has several extra development features for Android. It also comes with a more efficient voltage regulator than the Mega 2560. However, the Mega 2560's voltage regulator was manually replaced and therefore both Arduino's on hand perform extremely similarly. Currently the Mega ADK is used in Eta and the Mega 2560 with the modified voltage regulator is used in Bluenose.

Main Shield
This is the custom printed circuit board (PCB) ordered by Oleksiy from OSH Park (`https://oshpark.com`). The main Arduino (Mega 2560 or Mega ADK), is pressed onto the shield from the bottom and held by many pins. It has several surface mounted sockets for various cables such as the main LCD video cable, main LCD power cable, and GPS. The ANT+ transceiver antenna is also mounted on the board. The EAGLE schematic is located in the Github repository (See File Management), and a screenshot has also been included in the appendix (See Main Shield). Note that some parts of the board have been used differently since there is only one on-screen display unit (OSD), and not two as originally intended when the boards were made. The changes reduce the external wiring and take advantage of as many of the surface mounted sockets as possible.

OSD Shield
This is the custom PCB for the OSD board. As mentioned earlier, there is room for two MinimOSD boards, however only one is being used. Parts of the unnecessary PCB were adapted for use in the secondary system, as is clear with the BNC and Mini-XLR connectors being epoxied on the board.

MinimOSD
The on-screen display board is responsible for taking data from the main Arduino through a serial connection and appropriately modifying the analog video feed from the camera. The board contains a microcontroller that must be programmed in the Arduino environment as described in Uploading Code to the OSD. MinimOSD boards are available from 3D Robotics (`http://3drobotics.com`). It is continuously updated and there is good chance that a bridge of solder must be added on the bottom for analog video (for newly purchased ones). In the summer of 2014, a cheap replica of the official 3DR MinimOSD board from Amazon was used for several weeks until it mysteriously stopped working. It is recommended to handle this part with care and use the official 3DR board for important applications.

GPS
The GPS unit is also from 3D Robotics and contains a uBlox module. It is a slightly newer version than the one found in Bluenose. For general configuration and debugging there is a program called U-Center, created by uBlox.

ANT+ Antenna
The ANT transceiver is mounted on the main shield. It receives messages from ANT+ compatible devices such as the SRM cranks, the Garmin heart rate monitor, and the power pedals. It was ordered from digikey and the documentation can be found in the Github repository. From past experience, it had proven to be sensitive and may require a restart if physical contact is made on the pins.

Camera
The cameras both have a wide angle lens, and are purchased from Misumi Electronics (`http://www.misumi.com.tw`). The exact part number is: MO-B5609-3D-N. They have the same camera body as the ones in Bluenose (MO-B5609-6F-N), but have a different lens.

LCD
Both the 8" and 7" screens are from New Generation Hobbies (`https://www.nghobbies.com/cart/`). They are intended for FPV use and have performed well on both Bluenose and Eta.

SD Card Reader
The SD card reader is mounted to the side of the electronics box and connected to the main shield by a header with 6 pins. The original, surface mounted mini-SD card slot was never able to initialize the card correctly.

Temperature Sensor
The temperature sensor is from RobotShop. It has a physical sliding switch for analog versus digital. It should be kept in analog to get reasonable readings.

1.2.2 Secondary

Power Board
The secondary system board powers the back-up LCD off the nominal battery voltage, and also runs a voltage regulator for the 5 volts that the camera requires. The board also contains the required resistors for measuring the battery voltage for the main system.

2 General Operation

2.1 Checklist

1. Check connections **inside** electronics box:
   (a) Both dean's connectors properly attached to the correct battery, and wires meticulously placed free from obstruction. Batteries should fit with little play, but not under any serious pressure. (See Batteries)
   (b) Confirm SD card wiring is properly connected.
   (c) Confirm that the loose row of headers is seated correctly into the board.
   (d) Organize temperature senor wiring and place the unit in between the batteries and main boards.
2. Seat lid in correct orientation and wrap the velcro strap tightly around the box.
3. Check connections **outside** electronics box:
   (a) The LCD power cable marked *MAIN* should be plugged into the main power socket. The unmarked LCD power cable should be plugged into the secondary power socket. (**Note:** Ensure the threaded head is correctly tightened.)
   (b) The main LCD video cable is Mini-XLR (3 pins) and should be connected in the appropriate socket. The secondary LCD video cable is BNC and has only one place to plug into.
   (c) The GPS cable is Mini-XLR (4 pins) and there is only one place to plug into.
   (d) The two camera cables are both Mini-XLR (3 pins) and can be interchanged depending on which camera (lower or upper), is desired as the main screen. At the other ends of these cables is another interchangeable connection with the cameras in the faired spine. (**Note:** Generally the shorter cable was used as the main video cable, and matching the green masking tape at the other end of the cable ensures the upper camera with a better field of view is on the main screen.)
4. Check SD card is correctly inserted into the electronics box.
5. Line up the wires and use the velcro strap attached to the frame to mount the box.
6. Turn on the two rocker switches on the box. They will light up when powered.
7. Turn on the two LCD screens.
8. If calibration routine is programmed, the SRM must be turned on. Pedal for a few cycles and then stop. When the cranks are stationary, the SRM will continuously broadcast the calibration message. The main board should receive the data after several seconds and should display the relevant messages on the screen (*Waiting*, then

Receiving, then *Value:* with the corresponding slope offset. The default is 507 Hz) **Note:** Sometimes it takes much longer to receive the message, maybe 30-60 seconds. At Battle Mountain 2014, interference from radios was able to prevent any calibration at all.

*** Currently the calibration routine must be executed before the main program can run. That is, even data like speed will not be displayed on the screen until the calibration has been performed. A bypass to calibration should be implemented in software.

2.2 Batteries

2.2.1 Inventory

A list of the batteries on hand:

1. **Blue LiPo (1800 mAh):** Best used to power the main board and main screen (8"). This battery powers the Arduino, OSD, GPS, one camera, and main screen. The dean battery connector should be marked with white masking tape.

2. **Orange LiFe (1500 mAh):** Best used to power the secondary camera and screen (7"). This battery only powers the lower, smaller screen and one camera, if connected to the dean battery connector marked with green masking tape.

3. **Black LiPo (1300 mAh):** Used as a backup. It is the lowest capacity, so should not last as long as the batteries above.

4. **2nd Orange LiFe (1500 mAh):** Marked as "BAD" and had not been able to hold a charge. It hasn't been used with the vision system since poor performance was noticed.

All batteries are 3 cells. (Denoted as *3S* on the charger)

2.2.2 Charging

The battery charger has four buttons for navigating a somewhat inefficient UI. They can either be pressed momentarily or held for a couple seconds for different functions. The button labels should be relatively clear and a bit of trial and error is likely the best way to learn the interface flow. The user manual has been appended to this document for reference if required. (See Battery Charger Manual) If there is a problem with a battery, the voltage can be measured and compared to the data recorded at Battle Mountain 2014. (See Sample Voltage Data)

Things to Note:

- LiPo batteries will be permanently damaged if drained too low. It is important to monitor voltage and it is recommended to stop using a LiPo when its voltage is roughly 3.7 V per cell. For these 3 cell batteries that would mean a cutoff voltage of 11.1 V,

assuming the cells are close to balanced. The data in Sample Voltage Data shows that this was relatively easy to follow at Battle Mountain.

- LiFe batteries are known to be more resilient after being drained too low. However based on the quality of the orange LiFe batteries and the fact that one was damaged, it would be best to follow the same rule as mentioned above. At a cell voltage of 3.3 V, the orange LiFe's should not be drained below 9.9 V.

- The cell voltage setting on the charger must be 3.7 V for LiPo and 3.3 for LiFe. This must be changed in the settings of the charger each time.

- A conservative and safe charge current in Amps is the capacity/1000. For example, the blue LiPo could be charged at 1.8 A and the orange LiFe could be charged at 1.5 A.

- The number in the bottom right corner while charging is the capacity restored in mAh. It is a good indication of how much the battery was drained and if it is still holding a charge well.

- The batteries have a 4 pin connector that should be plugged into the charger to give individual cell readings, therefore allowing for balancing.

- The *BALANCE* option on the charger is preferred when charging to maintain battery health. If *CHARGE* is used, it is advised to balance the cells every 8-10 charge cycles.

2.2.3 Sample Voltage Data

Wednesday Morning Practice Session, ∼2 hours

Battery	Before Charge (V)	Capacity Added	After Charge (V)
Blue LiPo:	11.17 V	1200 mAh	12.57 V
Orange LiFe:	9.89 V	875 mAh	10.68 V

Wednesday Evening Session, 1 run

Battery	Before Charge (V)	Capacity Added	After Charge (V)
Blue LiPo:	12.25 V	191 mAh	12.59 V
Orange LiFe:	10.00 V	137 mAh	10.56 V

Thursday Evening Session, 1 run

Battery	Before Charge (V)	Capacity Added	After Charge (V)
Blue LiPo:	12.26 V	190 mAh	12.58 V
Orange LiFe:	9.99 V	145 mAh	10.49 V

Friday Morning Session, 1 run

Battery	Before Charge (V)	Capacity Added	After Charge (V)
Blue LiPo:	12.34 V	130 mAh	12.57 V
Orange LiFe:	10.00 V	106 mAh	10.66 V

Friday Evening Session, 1.5 runs

Battery	Before Charge (V)	Capacity Added	After Charge (V)
Blue LiPo:	11.91 V	388 mAh	12.57 V
Orange LiFe:	10.00 V	289 mAh	10.54 V

Saturday Morning Session, 1 run

Battery	Before Charge (V)	Capacity Added	After Charge (V)
Blue LiPo:	12.24 V	202 mAh	12.57 V
Orange LiFe:	10.00 V	211 mAh	10.59 V

3 Advanced Operation

This section addresses customizing and changing the current design as well as more obscure testing and features of the system. Much of this section is taken from the documentation that Justin Li worked on during the summer.

3.1 File Management

All the code and revision history can be found in this repository: `https://github.com/ASelwa/EtaVisionSystem` It also includes the required Arduino library files, documentation, datasheets, EAGLE schematics, and any log files from Battle Mountain 2014.

3.2 Main Board

This section covers the main Arduino board that handles all the data logging, ANT+ transmissions, simulations, and OSD updates. Note that the OSD data is sent over a serial line to another microcontroller on the OSD board, which handles the visual arrangement and display of that information separately.

3.2.1 Code Description

HPV_ArduinoMega contains files defining the system's logic. The Arduino streams data from peripheral devices, calculates values of interest, and sends the data to the OSD. Currently, the peripherals supported are:

- ANT+ receiver configured for power pedals, SRM cranks, and heart meter
- uBLOX GPS
- Battery meter
- Temperature sensor
- SD card reader

HPV_ArduinoMega.ino
This is the central processing centre of the system. The setup initializes all the peripherals and pins and calls the calibration function to calibrate the pedals. The main loop receives data from the peripherals, calculates values of interest, and sends these values to the OSD chip via its serial link. In general, data is sent whenever a new message is received from the GPS or the ANT+ receiver. This file also takes care of most of the logging activity, writing values every two seconds to the SD card. Every time the GPS sends data, or every one second if the GPS is not available, the program will check if the profile toggle button has been pushed. If so, the program will load the next profile. Notes:

- Most of the variables to display are sent to the OSD when there is a GPS update. Since the GPS may not always be available, there are two lengthy cases containing nearly identical code. One block will execute whenever the GPS updates with a new message while the other block will take over if the Arduino loses its GPS connection. Remember to copy any code you add into both blocks (if applicable).
- The update frequency of logs can be set by changing PERIOD in ANT_interface.h
- Anything related to the START variable seems to have been deprecated.

Ant_interface.cpp
This file contains functions for communication with the antenna. No changes should be necessary to the current code.

BatteryCheck.ino
This file contains functions to measure the temperature and battery voltage.

GPS_Func.ino
This file contains logic related to the calculations done with GPS coordinates.

SD_Func
This file contains functions to perform basic write and read operations.

TargetSpeed_Func
The functions in this file carry out a variety of tasks not necessarily related to calculating the target speed. The main function is toggle(), which takes care of loading new profiles and switching between real-time and simulation modes. There are also functions to calculate target speed and target power.

3.2.2 Uploading Code to Main Board

The code for Eta's vision system is divided into two main directories: HPV_ArduinoMega and HPV_OSD. A wealth of standard and custom libraries also support the system's functioning. With the exception of ArduCam_Max7456 and GPS_UBLOX, there should be no need to modify any of these libraries.

In the Arduino environment, under preferences, the *Sketchbook location* can be set to the *Arduino* folder located in the the Github repository (See Figure 2). This will ensure the correct libraries are available. Note the environment will likely require a restart for the changes to apply. An alternative method is to copy the libraries from the repository into the default Arduino folder but this might be less desirable from an organizational standpoint.

Once the libraries are correctly located, the code should be able to compile and upload to the Arduino. To open the project, open the file called *HPV_ArduinoMega.ino* in the Arduino environment, and all the associated files will be accessible in the tab interface. In the

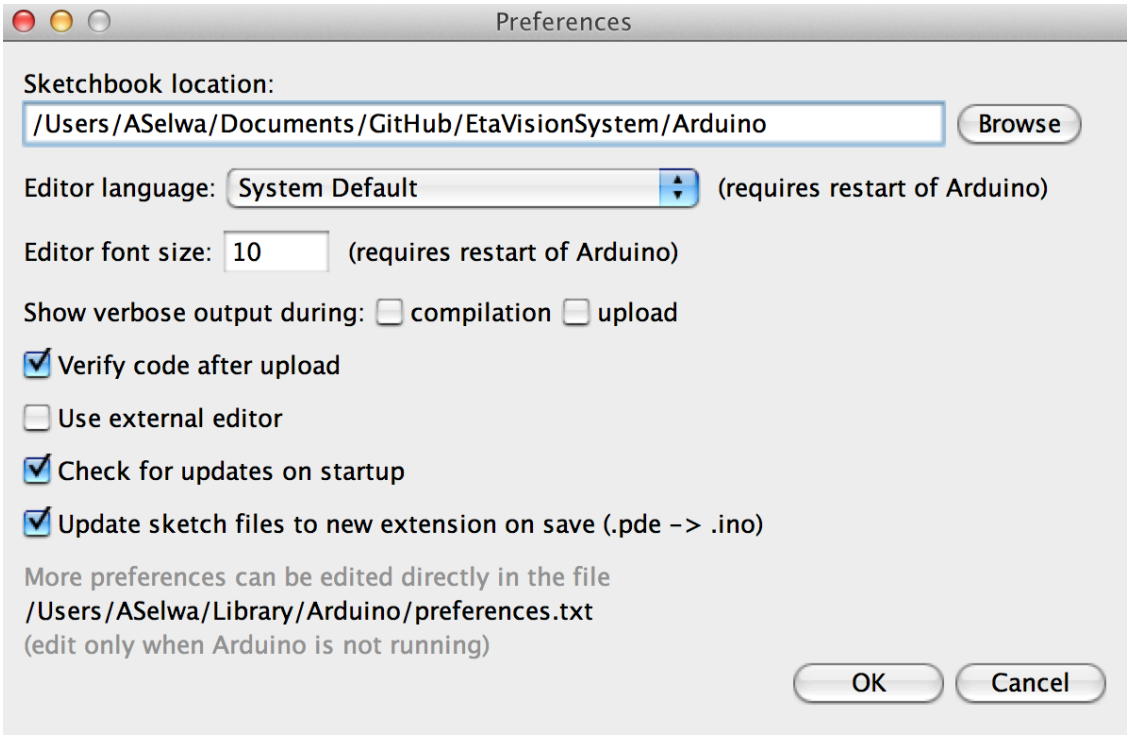


Figure 2: An example of what the Arduino preferences window might look like.

Arduino environment, the board should be set as:

Arduino Mega 2560 or Mega ADK (See Figure 3)

3.3 Uploading Code to the OSD

The uploading process is very similar to the main board. The **HPV_OSD** project should be opened in the Arduino environment and uploaded to the OSD board. The board itself must be connected to the computer using the FTDI-USB programming adapter (See Figure 4). Make sure to use the correct orientation of the six pin header with the pins on the OSD board. The labels do not match perfectly but there should be an obvious orientation (I.e. make sure that the ground and power pins line up.) In addition, be sure to set the board in the Arduino environment as:

Arduino Pro or Pro Mini (5V, 16 MHz) w/ ATMega328 (See Figure 5)

Note: Do not use the OSD configuration GUI. It seems to be incompatible with the way Eta's OSD is currently set up and it does not support custom panels.

Adding a Display

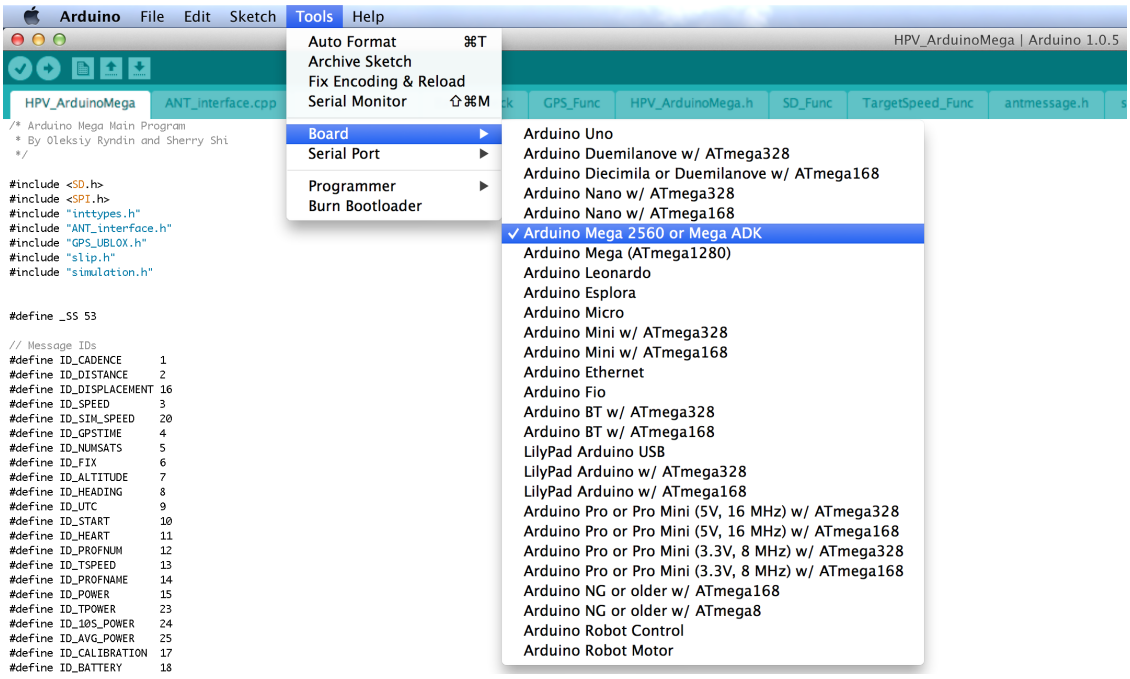


Figure 3: A screenshot of which board to use when programming the main board (On OS X 10.9.5).

To add a variable to display onto the screen:

1. Define an ID at the beginning of OSD_SLIP.h and in HPV_ArduinoMega.ino
2. Perform calculations in the main loop of HPV_ArduinoMega.ino
3. Send the value in the main loop via `SlipPacketSend()`
4. Add an extern variable declaration in OSD_SLIP.cpp
5. Add the regular variable declaration in HPV_OSD.ino
6. Add a case to OSD_SLIP.cpp to extract the value from the buffer and assign it to the variable from steps 4 and 5.
7. Add a panel function to OSD_panels_HPV.ino
8. Call the function in `writePanels()` (also located in OSD_panels_HPV.ino)

Parameters of Interest
Baud rate: TELEMETRY_SPEED found in ArduCAM_OSD.ino
Start-up speed: BOOTTIME found in ArduCAM_OSD.ino

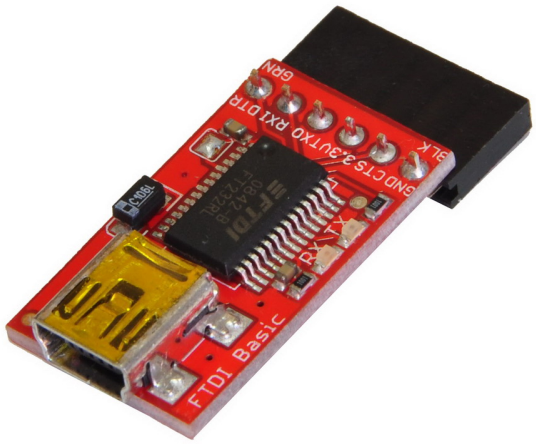


Figure 4: The FTDI programming board for the OSD board.

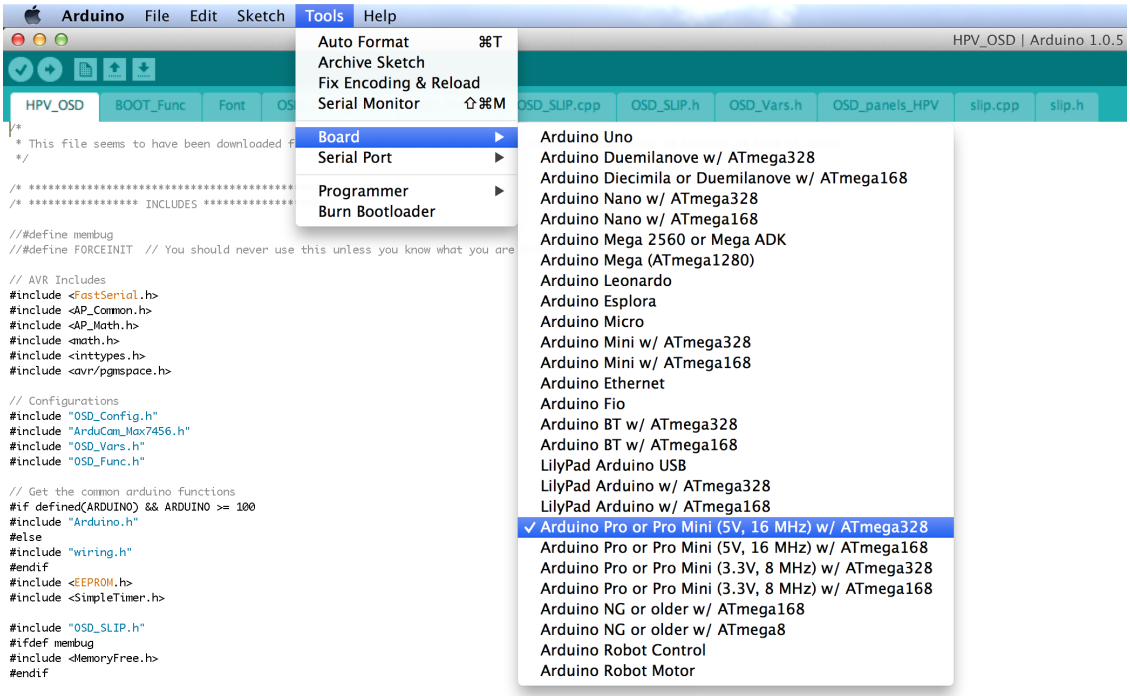


Figure 5: A screenshot of which board to program the OSD. (On OS X 10.9.5)

3.4 Speed and Power Profiles

Speed Profile
Create a new file on the SD card called *PF##* where the pound signs are the next unused profile number. (**Note:** Numbering must begin at 01 and all subsequent profile numbers must be consecutive. The program will stop looking for profiles if it cannot find a profile with the next consecutive number.) The first argument is the profile name. The name should be a maximum length of 10 characters and cannot contain spaces. A profile name longer than the limit will be truncated when it is displayed. The next six arguments are the coefficients for the polynomial approximation in order of highest power (degree 6) to lowest (constant term). Each argument must be separated by a space.

Power Profile
The target power profile currently uses a simple linear equation to find the target value. The starting and ending targets are defined as preprocessor variables POWER_START and POWER_PRE_SPRINT. To change the method of calculation, modify functions `calcPower()` and `calcDisplacePower()` in TargetSpeed_Func.ino.

Finish Line Coordinates
Edit the file on the SD card called *FinCoord.txt*. The first argument is the latitude (in degrees), the second is the longitude (in degrees), and the third is the altitude (in metres). Each argument must be separated by a space. (Tab will not work.)

*** Confirm that this is actually implemented, and that the coordinates are not just hard coded in the HPV_ArduinoMega project.

4 Debugging and Development

4.1 Further Expansion

There are several areas of concern that should be addressed:

- When the yellow toggle button is in one state, the code consistently jumps into simulation mode after calibrating, and pressing it again has no impact. This did not occur when the button was in the opposite state and went unnoticed until the final run at Battle Mountain 2014.
  Proposed process: First test the button hardware with a multimeter and then proceed to tracing in the code where and how the `toggle()` function is used. Pay particular attention to the difference between high and low states of the button, which seemed to "fix' the bug. (Assuming the hardware was functioning as expected.)

- Brainstorm and implement a way of bypassing the calibrating of the SRM that can be performed once the system is turned on. (The current method of uploading different code is not very convenient.)

- Investigate ANT+ reception in the presence of radios and other disturbances. Perhaps incorporate a timeout if the program is stuck on *Waiting* in these circumstances.

Simulation
By adapting the PowerCalc.m script to take the raw power data from the *SLG* log files and to include the additional power from elevation, the simulated velocities predicted onboard the Arduino in realtime can be compared to the simulated velocities in MATLAB. It seems the two simulations are very similar except for near the traps where the onboard simulation consistently starts slowing down early. First thing to check is what happens to the simulation on the Arduino when the displacement crosses zero. Perhaps it is happening a bit too early (based on the user-defined coordinates of the finish, see Finish Line Coordinates) and something changes in the simulation.

*** Will be adding several figures and uploading modified MATLAB files after going through more of the BM logs.

4.2 Known Issues

Arduino peripherals (e.g. GPS) stop working after uploading new code
Cases
Uploading the code using Justin's laptop running Arduino 1.5.5 (older, no longer supported), the code works as expected. When identical code is uploaded using Steven's laptop running Arduino 1.0.5 (newest version of the 1.0 series), the GPS will not initialize.

Analysis
Compiling on different versions of the IDE (or possibly on different computers) may break

the code. In the given case, it seems to be related to the pre-processor variables that detect what Arduino board the GPS is running on (see `GPS_UBLOX_Class::Init in GPS_UBLOX.cpp`). More testing is required to determine the cause of this. We suspect this problem can be fixed by removing the pre-processor variables, forcing the code to assume an ATMega board.

Serial Buffer Overflow - Solved

Cases

The ANT+ serial will occasionally receive corrupted messages that can be up to 255 bytes long. This is highly dangerous, as the ANT+ buffer is only large enough to support messages up to 64 bytes. (In theory, no messages should be above 9 bytes in length.) Additional bytes will write into adjacent memory, overwriting any variables that may be stored there. This behaviour is completely undefined.

Analysis and Solution

It seems as though these large, "cancerous" messages are actually composed of a few 9-byte messages repeated many times. The code relies on a sync byte (0xA4 or 0xA5, although in practice it always seems to be 0xA4 and the code ignores 0xA5 for extra security) to identify the beginning of a message. The program is usually fine at synchronizing with the ANT+ serial, but sometimes it misinterprets a 0xA4 that is part of a message payload to be the sync byte of a new message. It will then assume that the following byte is the message length, causing this error. A check has been put into place in `receiveANT()` of ANT_interface.cpp to discard the message as soon as the message length byte is greater than 9. This means an overflow should never occur with `antBuffer`.

SD card contains strange files

Cases

The SD card is susceptible to corruption. Our testing has shown the following cases:

- A file with the name " . " that Windows Explorer thinks takes up around 4GB of drive space. Pulling up the Properties window, however, shows that it is an empty (0B) file.
- A "ghost" file that takes up no space and cannot be deleted (deleting is successful, but refreshing the directory will cause the file to reappear).

Analysis

This problem likely stems from the fact that the SD card can be removed at any time, including during a write operation. There is a library function to initialize the SD card, but no function to disconnect safely from the SD.

Simulation - Solved?

Cases

The `simulate()` function risks dividing by 0, which may cause undefined behaviour. On the Arduino, variables will become infinity or NaN (not a number). On the OSD, they may display as garbage values. As soon as velocity and/or distance become either of these values, they will not recover.

Analysis and Solution
Steps have already been taken to prevent floating point calculations from ruining the program. Guards are present in many `simulate()` calculations to attempt to handle unreasonable values, and `simulate()` includes a final check that will abort the current iteration without updating any of the values if any variables become infinite or undefined. Recent testing and logging have not revealed any problems with infinite or undefined variables; however, they have also not revealed any cases in which undefined variables were actually caught and handled gracefully. Therefore, it is not known if the current security measures are effective.

Shorting - Solved
Cases
When standoffs were still installed on the box and the Arduino was powered without properly locking it in place, the board heated rapidly, becoming hot enough to burn the epoxy.

Analysis and Solution
We speculate that one of the standoffs came into contact with the Vin pin on the bottom of the Arduino and shorted it by conducting across the carbon fibre board. Never run the circuit while the Arduino is sittng on a conductive surface. The nature of the problem could have been avoided by always fixturing the board with the appropriate hardware or by replacing the metal standoffs with foam or another insulating material. The board now rests on vibration damping foam and the inside of the box is now taped to prevent this from happening in the future.

OSD shows rapidly flashing garbage numbers in place of meaningful ones - Solved
Cases
Whenever a value is rapidly written to the OSD (no explicit time delay between writes), the value flickers to random numbers.

Analysis and solution
The reason for this is unknown, but the problem can be solved by ensuring an adequate delay between write operations.

4.3 Troubleshooting

No calibration data is received (Display will read *Waiting*)
This is likely a problem with the antenna. If certain antenna pins short, the antenna will

not work until the short is removed and the antenna is reinitialized.

1. Unplug and plug the antenna. Ensure nothing is shorting the pins. Restart the program.

2. Replace the antenna with the backup

3. Measure the three baud rate selection pins while the Arduino is powered on and ensure their logic levels math the ones specified for the baud rate used in the program (See Antenna Datasheet***)

4. Comment out the call to `calibrate()` in HPV_ArduinoMega's `setup()`. Run the program using the Serial Monitor. If there are no ANT+ messages received after the ANT+ setup has complete, the problem is likely with the antenna.

At this point, if the problem persists, switch to a back-up system and try again later.

Power, cadence, distance and heart rate displays freeze
These are all dependent on the antenna. See above.
The power meter will automatically shut off after a specified period of no activity (around 2 minutes). After this time, the program will stop calculating new values.

GPS not available

1. Check that the device is getting power (Red LED should be lit)

2. Restart the system.

3. Try the old GPS. If it works, the new one is likely damaged or misconfigured.

4. Start U-Center and plug the GPS into the computer. Ensure the correct messages are being sent, the baud rate is configured correctly, and the message rate is reasonable. (Refer to the GPS configuration section). If U-Center can't communicate with the GPS, it may be damaged. Use the backup GPS.

OSD text flickers on screen

1. Ensure the OSD wire connections are stable and nothing is touching the OSD chip.

2. Ensure any calls to `OSD.clear()` are controlled appropriately. (Do not attempt to call the function without a time delay.)

3. Ensure the display and OSD chip are both set on NTSC mode (See OSD section)

A Value jumps to an extremely large number
This is most likely caused by a division by zero (And not some hidden modification of variable values or overwriting memory where it shouldn't be overwritten). Check any calculations related to the variable and ensure that undefined operations cannot occur.

4.4 Miscellaneous Notes

Forward Declarations
Arduino automatically generates forward declarations for functions. It is therefore never necessary to do so for most functions. Exceptions include functions with function pointers as parameters, default arguments, and functions declared in a namespace or class. Manual declarations will be necessary.

Multi-file Programs
Arduino (.pde and .ino) files do not work like regular .c or .cpp files. The Arduino compiler concatenates all Arduino files in the same folder into one compilation unit. (C and C++ files are treated as separate compilation units.) The concatenation begins with the main file (which shares the folder name), followed by the other Arduino files in alphabetical order (not verified, widely accepted). Therefore, for Arduino files in the same folder:

1. Include statements are only necessary in the main file.
2. The `static` keyword will not restrict variable scope to only the local Arduino file.
3. Global variables in one file do not have to be decalred as `extern` in another to be used
4. Regular variable scope rules still apply. A global variable declared in *B.ino* cannot be referenced in *A.ino* because A will be concatenated before B.

SD Card
Arduino cannot log files with names longer than 8 characters (FAT 8.3 standard).
Arduino capitalizes all letters in file names when creating a file.

5 Appendix

5.1 EAGLE Schematics

5.1.1 Main Shield

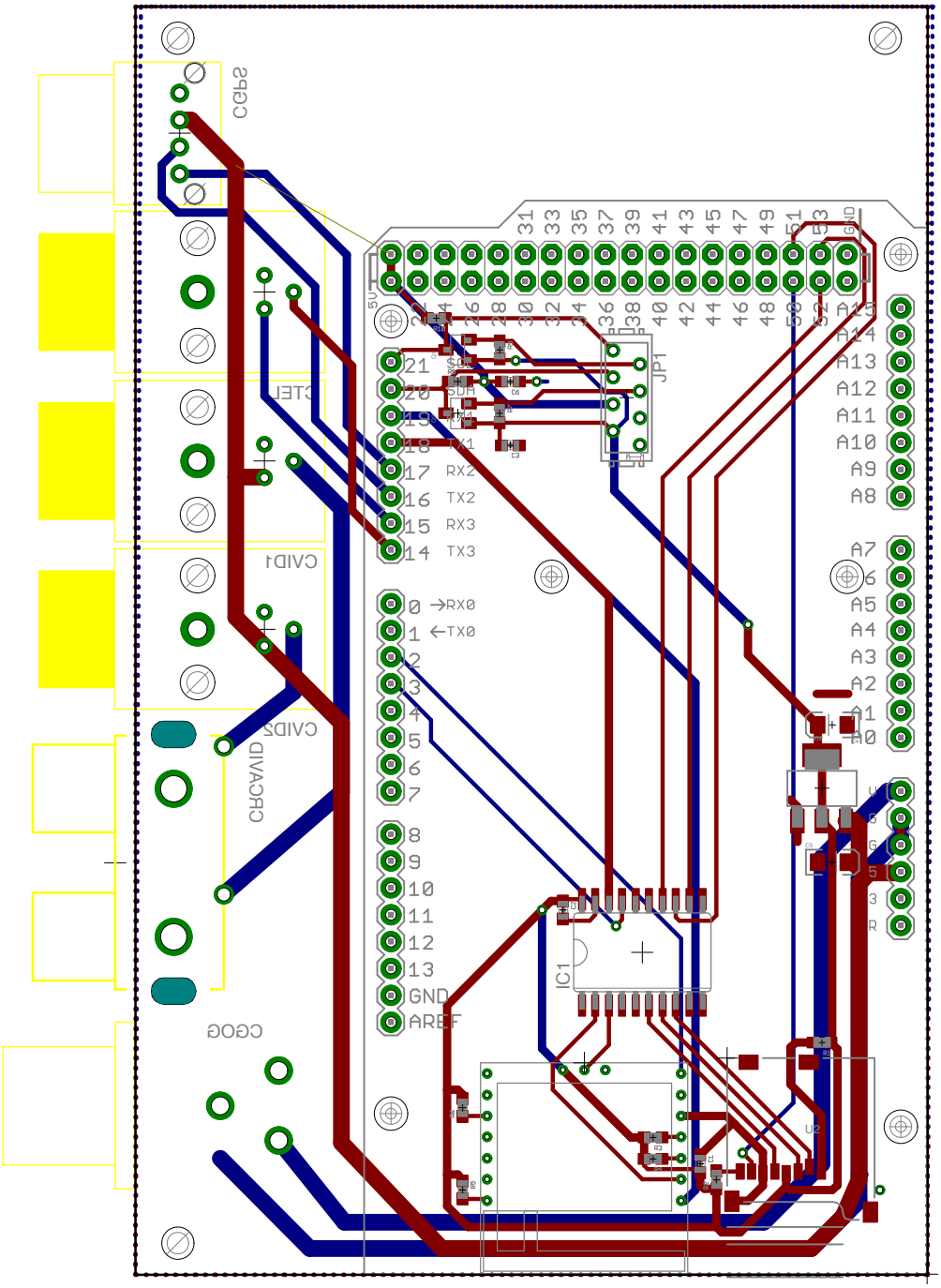


Figure 6: A diagram of the main printed circuit board.

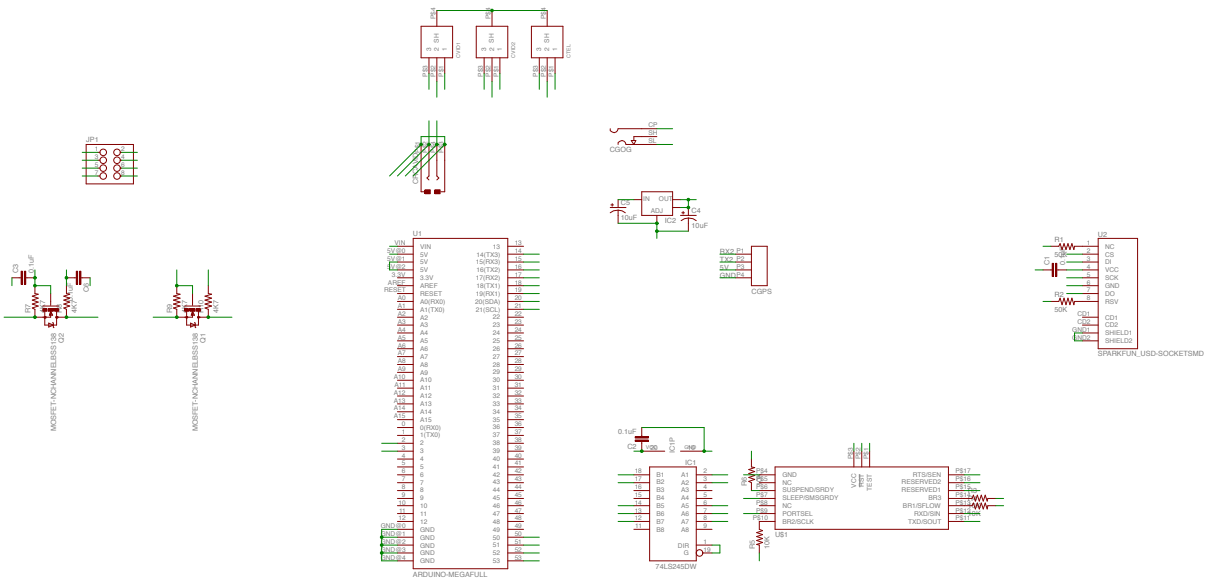


Figure 7: A schematic of the main printed circuit board.

5.1.2 OSD Shield

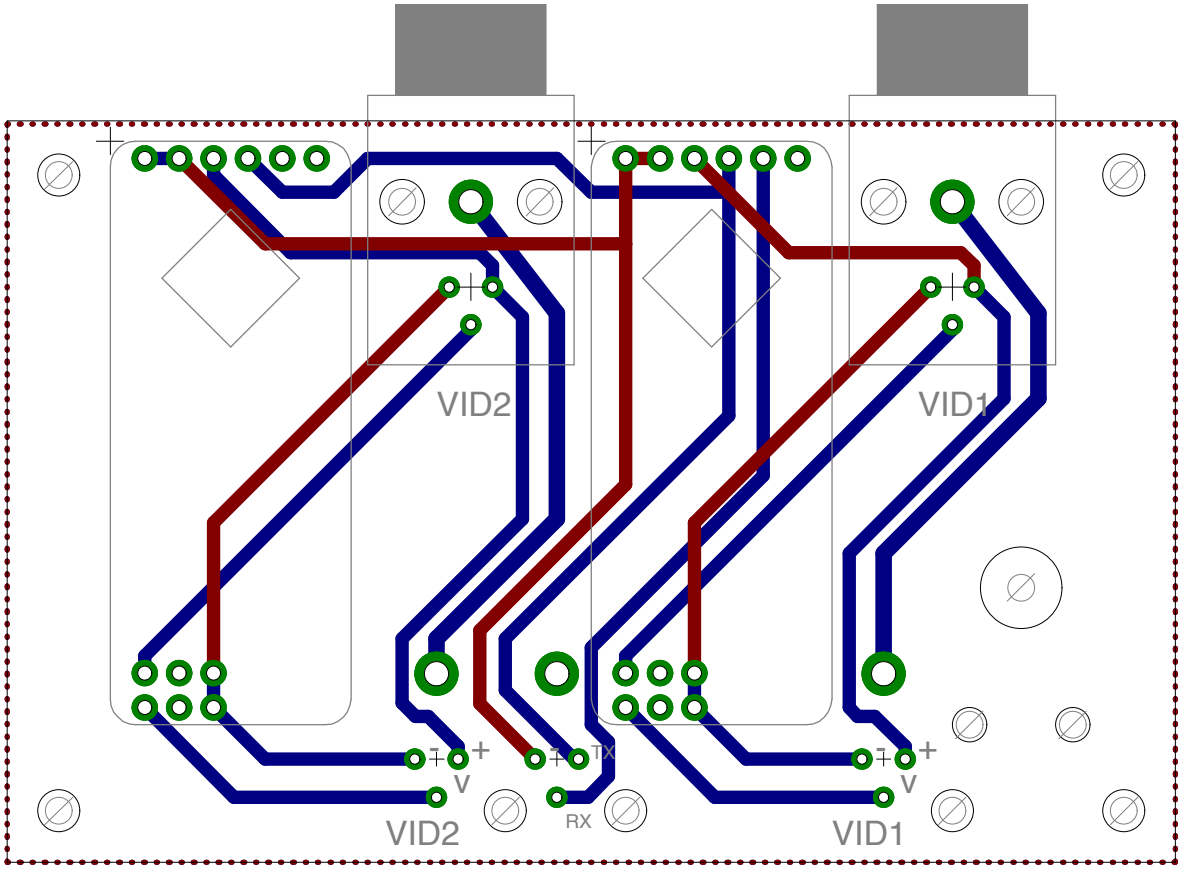


Figure 8: A diagram of the OSD printed circuit board.

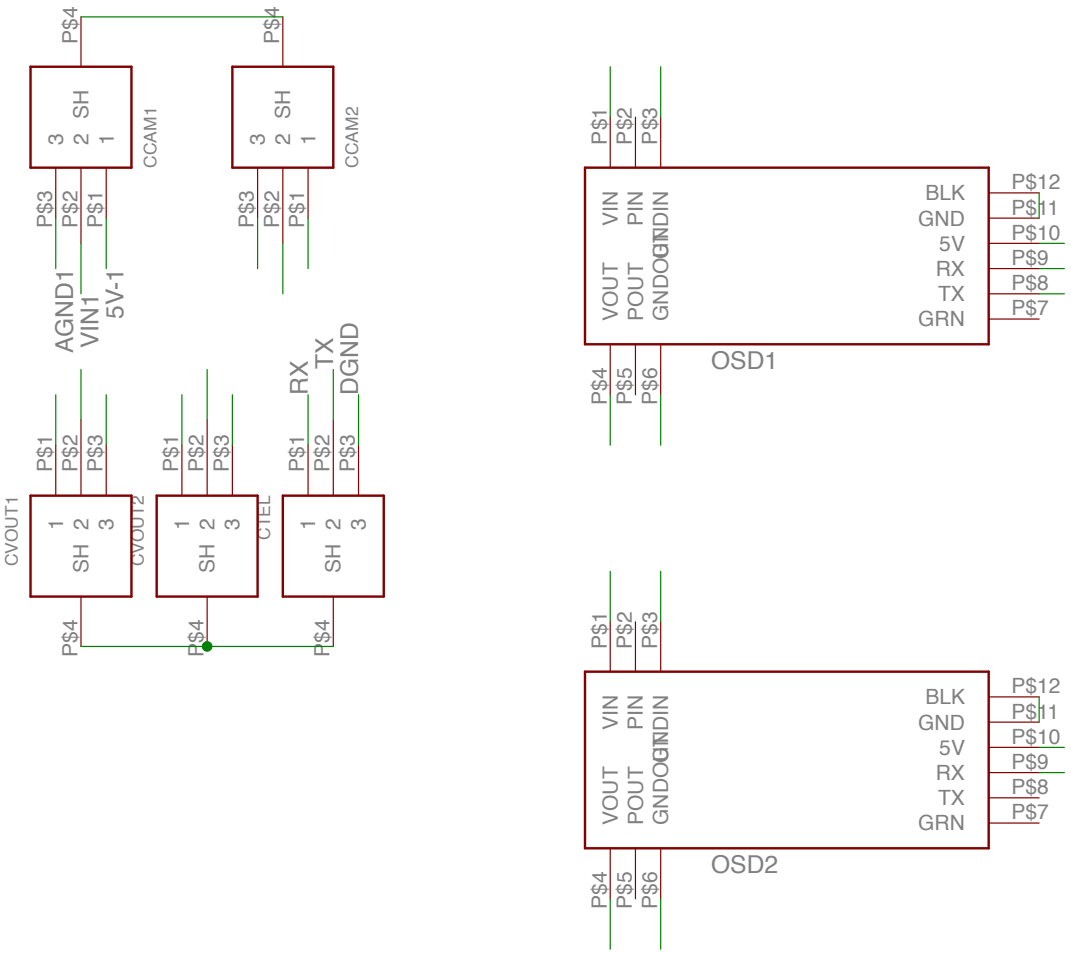


Figure 9: A schematic of the OSD printed circuit board.

5.2 Battery Charger Manual

See next page.

AC/DC

AC/DC INPUT, PROFESSIONAL
BALANCE CHARGER/DISCHARGER

multi charger X1 AC PLUS

INSTRUCTION MANUAL

Li-Po	Li-Fe	Li-ION	Ni-CD	Ni-MH	PB
1-6 cell	1-6 cell	1-6 cell	1-15 cell	1-15 cell	2-20 V

Table of Contents

Introduction

Congratulations on your choice of the Hitec X1 charger from Hitec RCD USA. The Hitec X1 is a high-performance, microprocessor controlled charger/discharger with battery management capabilities that are suitable for use with most popular battery types. The X1 also features integrated balancing for six-cell, Lithium-Polymer (LiPo), Lithium-Ferrite (LiFe) and Lithium-Ion (Li-Ion) batteries.

Please read this entire operating manual before using the X1 Charger. If you are unsure of its proper operation after reading the manual, please seek advice from an experienced hobbyist or someone familiar with proper battery charging procedures.

Warning

THE CHARGING AND DISCHARGING OF RC HOBBY BATTERIES CAN BE DANGEROUS. FAILURE TO FOLLOW THESE EXPLICIT WARNINGS CAN RESULT IN PROPERTY DAMAGE AND/OR LOSS OF LIFE.

⚠ NEVER LEAVE YOUR CHARGER UNATTENDED WHILE IN OPERATION.

⚠ NEVER CHARGE ON OR AROUND COMBUSTIBLE MATERIALS.

⚠ NEVER CHARGE A DAMAGED BATTERY PACK.

⚠ LOW COST, NO-NAME BATTERY PACKS POSE THE MOST DANGER. WE RECOMMEND YOU ONLY USE BATTERY PACKS THAT ARE SOLD AND WARRANTIED BY A REPUTABLE COMPANY.

⚠ IT IS HIGHLY RECOMMENDED THAT YOU UTILIZE A SAFETY DEVICE SUCH AS A STEEL CASE OR LIPO SACK™ WHILE CHARGING LITHIUM CHEMISTRY BATTERIES.

⚠ IT IS HIGHLY RECOMMENDED THAT YOU KEEP AN OPERABLE "CLASS A" FIRE EXTINGUISHER IN THE CHARGING AREA.

FAILURE TO FOLLOW THESE WARNINGS CAN BE CONSIDERED NEGLIGENCE BY THE OPERATOR AND MAY NEGATE ANY CLAIMS FOR DAMAGES INCURRED.

Hitec RCD USA will not be held responsible for any damages or injuries that may occur by persons who fail to follow these warnings or who fail to properly follow the instructions in this manual.

Warnings and Safety Notes


Warning


Tip


Note


Caution

Warning: Be sure to read this section for your own safety.

Caution: Be sure to read this section to prevent accidents and damage to your charger.

Tip: This section will help you maximize the performance of your charger.

Note: This section will provide more detailed explanations.

These warnings and safety notes are of the utmost importance. You must follow these instructions for maximum safety. Failure to do so can damage the charger and the battery; and in the worst cases, may cause a fire.


Warning

NEVER LEAVE THE CHARGER UNATTENDED WHEN IT IS CONNECTED TO ITS POWER SOURCE. IF ANY MALFUNCTION IS FOUND, TERMINATE THE PROCESS AT ONCE AND REFER TO THE OPERATION MANUAL.

⚠ The allowable DC input voltage is 11-18V DC.

⚠ The allowable AC input voltage is 100-240V AC.

⚠ Keep the charger away from dust, damp, rain, heat, direct sunlight and excessive vibration.

⚠ If the charger is dropped or suffers any type of impact, it should be inspected by an authorized service station before using it again.

⚠ This charger and the battery should be put on a heat-resistant, non-flammable and non-conductive surface.

⚠ Never place a charger on a car seat, carpet or similar surface. Keep all flammable volatile materials away from the operating area.

⚠ Make sure you know the specifications of the battery to be charged or discharged to ensure it meets the requirements of this charger. If the program is set up incorrectly, the battery and charger can be damaged.

⚠ Fire or explosion can occur due to overcharging.

⚠ To avoid a short circuit between the charge lead, always connect the charge cable to the charger first, then connect the battery. Reverse the sequence when disconnecting.

Warnings and Safety Notes

⚠ Never attempt to charge or discharge the following types of batteries:

- A battery fitted with an integral charge circuit or a protection circuit
- A battery pack which consists of different types of cells (including different manufacturer's cells)
- A battery that is already fully charged or just slightly discharged and non-rechargeable batteries (these pose an explosion hazard)
- A faulty or damaged battery
- Batteries installed in a device or which are electrically linked to other components
- Batteries that are not expressly stated by the manufacturer to be suitable for the currents the charger delivers during the charge process

PLEASE BEAR IN MIND THE FOLLOWING POINTS BEFORE YOU COMMENCE CHARGING:

- Did you select the appropriate program suitable for the type of battery you are charging?
- Did you set up the adequate current for charging or discharging?
- Have you checked the battery voltage? Lithium battery packs can be wired in parallel and in series, i.e. a 2-cell pack can be 3.7V (in parallel) or 7.4V (in series).
- Have you checked that all connections are firm and secure?
- Make sure there are no intermittent contacts at any point in the circuit.

Warnings and Safety Notes

Standard Battery Parameters

	LiPo	LiIon	LiFe	NiCd	NiMH	Pb
Nominal Voltage	3.7V/cell	3.6V/cell	3.3V/cell	1.2V/cell	1.2V/cell	2.0V/cell
Max. Charge Voltage	4.2V/cell	4.1V/cell	3.6V/cell	1.5V/cell	1.5V/cell	2.46V/cell
Storage Voltage	3.8V/cell	3.7V/cell	3.3V/cell	n/a	n/a	n/a
Min. Discharge Voltage	3.0-3.3V/cell	2.9-3.2V/cell	2.6-2.9V/cell	0.1-1.1V/cell	0.1-1.1V/cell	1.8V/cell

Warning

WHEN ADJUSTING YOUR X1 CHARGING PARAMETERS, BE SURE YOU SELECT THE PROPER BATTERY TYPE AND CELL VOLTAGE FOR THE TYPE OF CELL YOU ARE CHARGING. CHARGING BATTERIES WITH THE WRONG SETTINGS MAY CAUSE THE CELLS TO BURST, CATCH FIRE OR EXPLODE.

Charging

Before charging your batteries, it is critical that you determine the maximum allowable charge rate for your batteries. The X1 is capable of charging at high rates that may not be suitable or safe for your particular batteries. For example, Lithium cells are typically safe to charge at 1C, or the total mAh÷1000. A 1200mAh battery would have a 1C charge rate of 1.2 amps. A 4200mAh battery would have a 1C charge rate of 4.2 amps. Some manufacturers are offering Lithium cells that can be charged at greater than 1C but this should ALWAYS be verified before charging a Lithium battery at rates higher than 1C. Voltage is just as critical as the charging amperage rate and this is determined by the number of cells in series, or "S". For example, a 3S LiPo is rated at 11.1 volts ("S" multiplied by a single LiPo cell with a nominal voltage of 3.7 volts DC. 3 cells x 3.7 volts each equals 11.1 volts DC).

Connect the battery's main leads to the charger output: red is positive and black is negative. Keep in mind that the gauge or thickness of your charging leads from the X1 to your battery must be of an acceptable current rating to handle the applied charge current. For maximum safety and charging effectiveness, always match or exceed the main battery lead rating when assembling or selecting your charging leads. If you charge a battery at a high current rate (amperage) with a charging lead not rated for the chosen amperage, the wire could get hot, catch fire, short out and/or potentially destroy your battery and the charger. When in doubt, always use a higher gauge wire (lower AWG number). It is common to see charging leads constructed of 14AWG, 16AWG or 18AWG wire.

Warnings and Safety Notes

Always refer to recommendations from your battery manufacturer for your specific battery type and size before initiating a charge or discharge process.

Do not attempt to disassemble or modify Lithium or Lead-Acid battery packs.

Discharging

The X1 discharging functions are for two specific purposes:

- Refreshing the capacity of a Nickel-based battery that has lost capacity over time (NiMH or NiCd).
- Reducing the voltage of a Lithium battery for safe storage.

Warning

LITHIUM CHEMISTRY BATTERY PACKS SHOULD ONLY BE DISCHARGED TO THEIR MINIMUM SAFE VOLTAGE, NO LOWER. DEEP DISCHARGING A LITHIUM CELL WILL DO PERMANENT DAMAGE. REFER TO THE STANDARD BATTERY PARAMETERS TABLE ON PAGE 6 OF THIS MANUAL FOR MINIMUM DISCHARGE VOLTAGES.

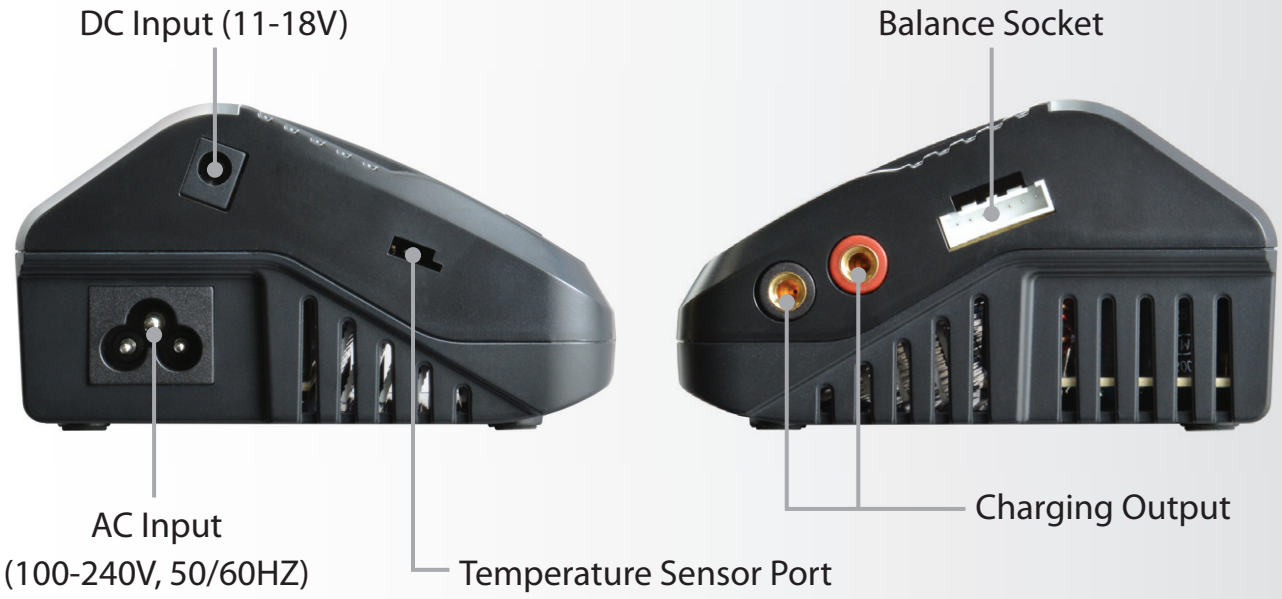
LiPo Charge/Discharge Cycling

Lithium batteries are known to reach full capacity after a break-in period of about 10 charge/discharge cycles. We do not recommend you use the X1 charger to do this, normal use and recharging will achieve the same results. If you wish to perform a Lithium break-in on the bench with the X1, discharging to minimum acceptable voltages and performing a balance charge at 1C maximum rate is recommended. If you choose to break in your Lithium batteries under normal use, charging at only 1C for the first ten cycles will help ensure full performance and service life from your Lithium cells.

Charger Layout

1. Hitec X1 AC Plus Charger
2. AC Power Cord
3. DC Power Cord
4. 18AWG Wire Charging Cable
5. Balancing Board Cable
6. Universal Balancing Board

Charger Layout



Specifications

AC Input	100 - 240 Volts
DC Input	11-18 Volts
Charge Circuit Power	50 Watts
Charge Current Range	0.1 - 1.0 Amps
Discharge Current Range	5 Watts
Discharge Current Power	0.1-1.0 Amps
Current Drain for Balancing LiPo	300mA per cell
NiCd/NiMH Battery Cell Count	1-15 Cells
LiPo/LiFe/Lilon Cell Count	1-6 Cells
Pb Battery Voltage	2-20V
Net Weight	15 oz.

Features

Optimized Operating Software
The X1 "auto" feature sets the charge and discharge current for you automatically, preventing overcharging which can damage your battery. In the event of an error, the X1 instantly disconnects the circuit and sounds an alarm. This feature can be set by the user and controlled through the two-way link for maximum safety.

Internal Independent Lithium Battery Balancer
The X1 features a built-in cell voltage balancer so you don't need to fuss with external balancers while charging.

Balancing Individual Cells During Discharging
The X1 also monitors and balances each cell in the pack individually while discharging. If the voltage of any single cell is abnormal, the X1 will display an error message and the process will end automatically.

Adaptable to various types of lithium batteries
The X1 will charge and discharge a variety of Lithium batteries, such as Li-ion, LiPo and the new LiFe series of batteries.

Fast and Storage Mode of Lithium Batteries
The X1 features two styles of charging. "Fast" charge reduces the charge duration while "Store" controls the final voltage of your battery, to optimize your packs for long term storage and maximum lifespan.

Maximum Safety
Our delta-peak voltage detection program ends the charge cycle whenever a battery's voltage exceeds the set threshold.

Automatic Charging Current Limit
Charging current can be set by the user when charging NiCd or NiMH batteries. The 'AUTO' charging mode, however, is recommended when charging NiMH batteries with low impedance and capacity.

Capacity and Temperature Limits
The charge process will terminate if either the charging capacity or battery temperature exceeds the limit set by the user. The temperature function requires an optional temperature probe, which is not included with the X1.

Features

Processing Time Limit
Protect your battery by setting a maximum time limit for charging and discharging.

Input Power Monitoring
The X1's input voltage is monitored to protect the battery from becoming damaged. The process ends automatically if it drops below the limit.

Data Store/Load
A maximum of five setting profiles can be stored for your convenience. The X1 will store the data pertaining to a program's settings and you can call up data at anytime.

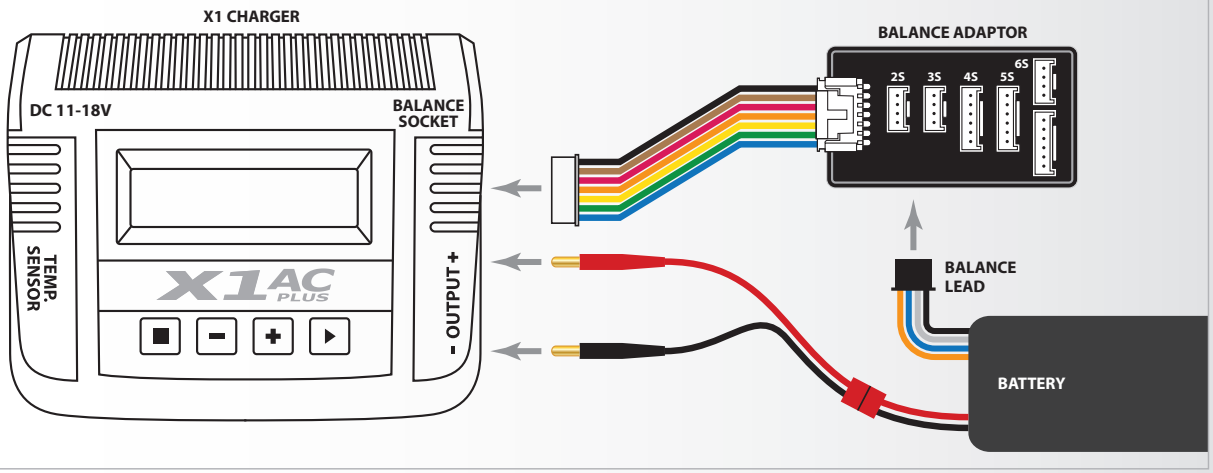
Cyclic Charging/Discharging
A battery can be cycled 1 to 5 times consecutively. This process is good for refreshing and balancing your battery.

Charger/Battery Connections

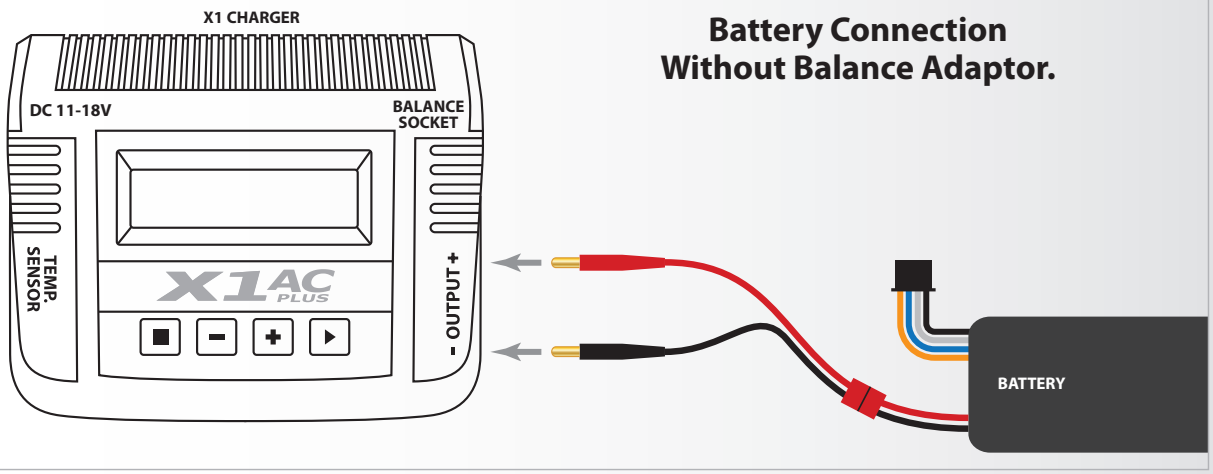
Warning

TO AVOID SHORT CIRCUITS, ALWAYS CONNECT THE CHARGE LEADS TO THE CHARGER FIRST, AND THEN TO THE BATTERY. REVERSE THE SEQUENCE WHEN DISCONNECTING THE PACK.

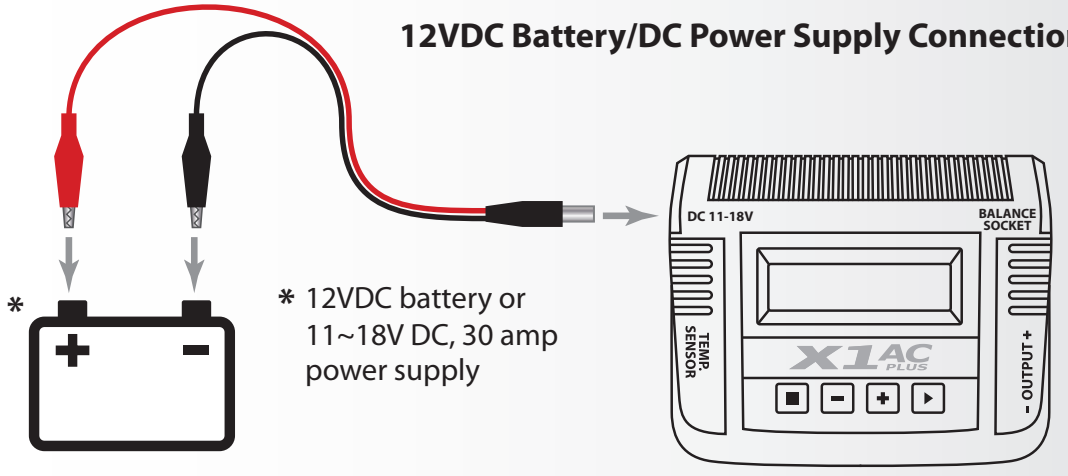
Battery Connection With Balance Adaptor.



Battery Connection Without Balance Adaptor.



12VDC Battery/DC Power Supply Connection.



Lithium

This program is only suitable for charging/discharging Lithium (LiPo/LiIon/LiFe) batteries.

Charge Modes

The X1 offers the following lithium charge modes: Charge, Balance Charge, Fast Charge, Storage and Discharge.

Warning **BEFORE SELECTING A CHARGE MODE, IT IS CRITICAL THAT YOU SELECT THE CORRECT TYPE OF LITHIUM BATTERY TO BE CHARGED. FAILURE TO DO SO CAN RESULT IN DAMAGE TO THE BATTERY AND POSSIBLE EXPLOSION.**

Selecting a Lithium Battery Type

From the "USER SET PROGRAM->" screen, press the ► button once to advance to the "V.Type" screen. The default setting is "LiPo 3.7V".

Press the ► button once and the voltage value will begin flashing. Use the ✚ or ━ buttons to choose from the following options: "LiPo 3.7V", "LiIo 3.6V" or "LiFe 3.3V". Once you have selected the correct battery type, press the ► button to save your settings.

Lithium Charge Mode

Warning **BEFORE YOU BEGIN CHARGING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES 4-7.**

Note **IN THE CHARGE MODE, LITHIUM BATTERIES CAN BE CHARGED WITHOUT THE USE OF A BALANCE ADAPTOR. A BALANCE ADAPTER CAN BE USED, BUT IT IS NOT REQUIRED. BALANCE CHARGE MODE IS RECOMMENDED FOR ANY BATTERY WITH A BALANCE LEAD.**

See page 12 for the appropriate charging connections setup for this operation.

First, select the correct battery type by following the instructions above. Once you have set the correct battery type, press the ■ button once to return to the "USER SET PROGRAM->" screen. Press the ■ button to enter the "PROGRAM SELECT" screen. On this screen you should see the type of battery you have selected.

Lithium Charge Mode (cont.)

Press the ► button once to enter the "CHARGE" screen. Press the ► button again and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the amp rate.

Press the ► button again and the voltage value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. The voltage and cell count should match the values listed on the battery label.

Choosing "AUTO" for the voltage/cell count setting will allow the X1 to automatically determine these settings. If you choose the "AUTO" setting be sure to confirm that the correct cell count is displayed once charging begins.

You are now ready to begin charging. Press and hold the ► button until you see "BATTERY CHECK WAIT..." followed by the "CONFIRM/CANCEL" screen.

This screen displays the number of cells you set up as "R" and the number of cells detected by the processor as "S". If both numbers are identical, you may press and hold the ► button to confirm and begin charging. If these numbers do not match, press the ■ button to return to the previous screen to carefully check the number of cells of the battery pack before proceeding.

Once charging has commenced, the charger will display the following real-time information: Battery type/cell count, charging current, battery voltage, charging time and charged capactiy.

Caution

DURING CHARGING, THE BATTERY SHOULD BE PLACED INSIDE A FIREPROOF/RETARDANT BAG AND ON A FIRE PROOF SURFACE, AWAY FROM OTHER COMBUSTIBLE OBJECTS.

If you are using a balance adapter, during charging you may press the ✚ button to view the voltage of each individual cell.

Once the battery is fully charged the screen will read "FULL" and the charger will emit a chiming sound. Press the ■ button to stop charging. You may press the ■ button at any time during the charging process to stop charging.

Lithium Balance Charge Mode

This function is for balancing the voltage of individual Lithium-polymer battery cells while charging. In order to use the Balance Mode, the battery must have a balance lead. Charging in this mode is different from the normal modes because the built-in processor monitors the voltage of each individual cell and controls the input current fed into each cell in order to equalize the voltage. Use of a balance adaptor with any battery that has a balance lead will improve the performance and lifespan of your battery.

Warning **BEFORE YOU BEGIN CHARGING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES 4-7.**

See page 12 for the appropriate charging connections setup for this operation.

First, select the correct battery type by following the instructions on page 13. Once you have set the correct battery type, press the ■ button once to return to the "USER SET PROGRAM->" screen. Press the ■ button again to enter the

"PROGRAM SELECT" screen. On this screen you should see the type of battery you have selected.

Press the ► button once to enter the "CHARGE" screen. Now use the ✚ or ━ buttons to change the charge mode to "BALANCE". Press the ► button again and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the amp rate.

Press the ► button again and the voltage value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. The voltage and cell count should match the values listed on the battery label.

You are now ready to begin charging. Press and hold the ► button until you see "BATTERY CHECK WAIT..." followed by the "CONFIRM/CANCEL" screen.

This screen displays the number of cells you set up as "R" and the number of cells detected by the processor as "S". If both numbers are identical, you may press the ► button to confirm and begin charging. If these numbers do not match, press the ■ button to return to the previous screen to carefully check the number of cells of the battery pack before proceeding.

Lithium Balance Charge Mode (cont.)

Once charging has commenced, the charger will display the following real-time information: Battery type/cell count, charging current, battery voltage, charging time and charged capactiy.

Caution

DURING CHARGING, THE BATTERY SHOULD BE PLACED INSIDE A FIRE PROOF/RETARDANT BAG AND ON A FIRE PROOF SURFACE, AWAY FROM OTHER COMBUSTIBLE OBJECTS.

During charging you may press the ✚ button to view the voltage of each individual cell.

Once the battery is fully charged the screen will read "FULL" and the charger will emit a chiming sound. Press the ■ button to stop charging. You may press the ■ button at any time during the charging process to stop charging.

Lithium Fast Charge Mode

Charging in Fast Charge Mode allows for a shorter charge time and will result in a slightly reduced charging capacity. To achieve maximum charge capacity, we recommend you use the Lithium Balance Charge Mode. If a fast charge is necessary, select the fast charge mode and follow the same charging instructions as for the Lithium Charge Mode or Lithium Balance Charge Mode.

Warning

BEFORE YOU BEGIN CHARGING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES 4-7.

Note

IN THE FAST CHARGE MODE, LITHIUM BATTERIES CAN BE CHARGED WITHOUT THE USE OF A BALANCE ADAPTOR. A BALANCE ADAPTOR CAN BE USED, BUT IT IS NOT REQUIRED. BALANCE CHARGE MODE IS RECOMMENDED FOR ANY BATTERY WITH A BALANCE LEAD.

See page 12 for the appropriate charging connections setup for this operation.

Lithium Fast Charge Mode (cont.)

First, select the correct battery type by following the instructions on page 13. Once you have set the correct battery type, press the ■ button once to return to the "USER SET PROGRAM->" screen. Press the ■ button again to enter the

"PROGRAM SELECT" screen. On this screen you should see the type of battery you have selected.

Press the ► button once to enter the "CHARGE" screen. Now use the ✚ or ━ buttons to change the charge mode to FAST CHG. Press the ► button again and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the amp rate.

Press the ► button again and the voltage value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. The voltage and cell count should match the values listed on the battery label.

You are now ready to begin charging. Press and hold the ► button until you see "BATTERY CHECK WAIT..." followed by the "CONFIRM/CANCEL" screen.

This screen displays the number of cells you set up as "R" and the number of cells detected by the processor as "S". If both numbers are identical, you may press and hold the ► button to confirm and begin charging. If these numbers do not match, press the ■ button to return to the previous screen to carefully check the number of cells of the battery pack before proceeding.

Once charging has commenced, the charger will display the following real-time information: Battery type/cell count, charging current, battery voltage, charging time and charged capactiy.

Caution

DURING CHARGING, THE BATTERY SHOULD BE PLACED INSIDE A FIRE PROOF/RETARDANT BAG AND ON A FIRE PROOF SURFACE, AWAY FROM OTHER COMBUSTIBLE OBJECTS.

If you are using a balance adapter, you may press the ✚ button to view the voltage of each individual cell.

Once the battery is fully charged the screen will read "FULL" and the charger will emit a chiming sound. Press the ■ button to stop charging. You may press the ■ button at any time during the charging process to stop charging.

Lithium Storage Mode

This function is for charging/discharging batteries that will not be used immediately. The program is designed for charging/discharging batteries up-to or down-to safe storage levels. The program will automatically begin to discharge if the current state of the battery exceeds the voltage level for storage.

Warning **BEFORE YOU BEGIN CHARGING/DISCHARGING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES XX-XX.**

Note **IN STORAGE MODE, LITHIUM BATTERIES CAN BE CHARGED WITH OR WITHOUT THE USE OF A BALANCE ADAPTOR. USE OF A BALANCE ADAPTOR IS RECOMMENCED WHENEVER POSSIBLE.**

See page 12 for the appropriate charging connections setup for this operation.

First, select the correct battery type by following the instructions on page 13. Once you have set the correct battery type, press the ■ button once to return to the "USER SET PROGRAM->" screen. Press the ■ button again to enter the

"PROGRAM SELECT" screen. On this screen you should see the type of battery you have selected.

Press the ► button once to enter the "CHARGE" screen. Now use the ✚ or ━ buttons to change from "CHARGE" mode to "STORAGE". Press the ► button again and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the amp rate.

Press the ► button again and the voltage value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. The voltage and cell count should match the values listed on the battery label.

Press and hold the ► button and charging will begin.

Once charging has commenced, the charger will display the following real-time information: Battery type/cell count, charging current, battery voltage, charging time and charged capactiy.

Lithium Storage Mode (cont.)

Caution

DURING CHARGING/DISCHARGING, THE BATTERY SHOULD BE PLACED INSIDE A FIRE PROOF/RETARDANT BAG AND ON A FIRE PROOF SURFACE, AWAY FROM OTHER COMBUSTIBLE OBJECTS.

If you are using a balance adapter, you may press the ✚ button to view the voltage of each individual cell.

Once the battery is fully charged the screen will read "FULL" and the charger will emit a chiming sound. Press the ■ button to stop charging. You may press the ■ button at any time during the charging process to stop charging.

Lithium Discharge Mode

If you plan to discharge your battery to reach safe storage levels we strongly recommend that you use Storage Mode. In very few instances should discharging become necessary with LiPo batteries. One such instance may include preparing a battery for disposal, in which case the battery should not be completely discharged. Be sure to follow the discharging instructions provided by the battery manufacturer. **Over-discharging a battery can severly damage the battery and may cause a fire or explosion.**

Warning

DISCHARGING LITHIUM CHEMISTRY BATTERIES CAN CAUSE PERMANENT DAMAGE TO THE BATTERY AND IT IS NOT RECOMMENDED FOR ANYTHING OTHER THAN THE DISPOSAL OF THE BATTERY. IF YOU CHOOSE TO DISCHARGE YOUR LITHIUM BATTERIES, MAKE SURE TO PAY CLOSE ATTENTION TO THE MINIMUM VOLTAGE SETTING. IF YOU WANT TO STORE YOUR BATTERY FOR A LONG PERIOD OF TIME YOU SHOULD UTILIZE THE STORAGE MODE CHARGE PROGRAM AS THIS IS THE SAFEST METHOD OF STORING YOUR LITHIUM CHEMISTRY BATTERIES.

Note

IN DISCHARGE MODE, LITHIUM BATTERIES CAN BE DISCHARGED WITH OR WITHOUT THE USE OF A BALANCE ADAPTOR. THE USE OF A BALANCE ADAPTOR IS RECOMMENDED FOR DISCHARGING ANY BATTERY THAT HAS A BALANCE LEAD.

Lithium Discharge Mode (cont.)

See page 12 for the appropriate charging connections setup for this operation.

First, select the correct battery type by following the instructions on page 13. Once you have set the correct battery type, press the ■ button once to return to the "USER SET PROGRAM->" screen. Press the ■ button again to enter the

"PROGRAM SELECT" screen. On this screen you should see the type of battery you have selected.

Press the ► button once to enter the "CHARGE" screen. Now use the ✚ or ━ buttons to change from "CHARGE" mode to "DISCHARGE". Press the ► button again and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the amp rate.

Press the ► button again and the voltage value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. The voltage and cell count should match the values listed on the battery label.

Press and hold the ► button and discharging will begin.

Once discharging has commenced, the charger will display the following real-time information: Battery type/cell count, discharging current, battery voltage, discharging time and discharged capactiy.

Caution

DURING CHARGING/DISCHARGING, THE BATTERY SHOULD BE PLACED INSIDE A FIRE PROOF/RETARDANT BAG AND ON A FIRE PROOF SURFACE, AWAY FROM OTHER COMBUSTIBLE OBJECTS.

If you are using a balance adapter, you may press the ✚ button to view the voltage of each individual cell.

Once discharging is complete, the X1 charger will emit a chiming sound. Press the ■ button at any time to stop discharging.

NiCd/NiMH

This program is only suitable for charging/discharging NiCD/NiMH batteries.

Charge Modes

The X1 offers the following NiCd/NiMH charge modes: Charge, Discharge and Cycle.

Warning **BEFORE SELECTING A CHARGE MODE, IT IS CRITICAL THAT YOU SELECT THE CORRECT TYPE OF BATTERY TO BE CHARGED. FAILURE TO DO SO CAN RESULT IN DAMAGE TO THE BATTERY.**

Selecting the Battery Type

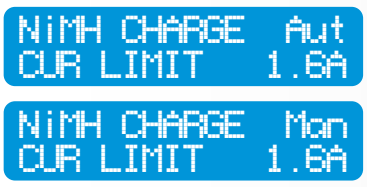
After you power on the X1, press the ■ button repeatedly until you reach the appropriate progam for the battery type you wish to charge. For this example we have chosen the "NiMH BATT" program. Now press the ► button to enter the desired program.

NiCD/NiMH Charge Mode

Warning **BEFORE YOU BEGIN CHARGING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES XX-XX.**

After selecting the correct battery type, if the screen does not read "CHARGE", use the ✚ or ━ buttons to change it to the "CHARGE" mode.

Press the ► button and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the amp rate.



The charge rate can be set to "Aut" (automatic) or "Man" (manual). If you choose" Man", the charge rate will remain the same throughout the entire charge cycle. If you choose "Aut", the X1 will determine the appropriate charge rate. In the "Aut" function you should set the upper limit of the charge current to avoid damage by an excessive charge rate. To choose between the "Aut and Man" function, press and hold the ✚ and ━ buttons simultaneously while the amp rate is flashing. Release both buttons once the screen displays the desired setting.

NiCd/NiMH Charge Mode (cont.)

Press and hold the ▶ button to begin charging.

Once charging has commenced, the charger will display the following real-time information: Battery type, charging current, battery voltage, charging time and charged capactiy.

Once the battery is fully charged the screen will read "FULL" and the charger will emit a chiming sound. Press the ■ button to stop charging. You may press the ■ button at any time during the charging process to stop charging.

NiCd/NiMH Discharge Mode

Warning

BEFORE YOU BEGIN DISCHARGING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES 4-7.

After selecting the correct battery type (see pg 21), use the ✚ or ━ buttons to select to the "DISCHARGE" mode.

Press the ▶ button and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the amp rate.

Press the ▶ button again and the voltage cutoff will begin to flash. Use the ✚ or ━ buttons to adjust the value to the desired rate. Follow the instructions provided with your battery when setting the voltage cutoff. The X1 will stop discharging when the battery has reached the preset voltage cutoff.

Press and hold the ▶ button to begin discharging. Once discharging has commenced, the charger will display the following real-time information: Battery type, discharging current, battery voltage, discharging time and discharged capactiy.

When discharging is complete the X1 will chime.

NiCd/NiMH Cycle Mode

The X1 makes cycling of NiCd/NiMH batteries easy. The process of discharging and recharging (cycling) can be achieved automatically with one simple step and will improve the performance of NiCd/NiMH batteries. We strongly recommend cycling any battery that has been discharged and then stored for a preiod of time. This will increase battery life and improve performance.

Warning

BEFORE YOU BEGIN CYCLING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES 4-7.

For cycling, the X1 uses the charge/discharge amperage and voltage settings entered in charge mode (see pages 21-22).

After selecting the correct battery type (see pg. 21), use the ✚ or ━ buttons to select to the "CYCLE" mode.

The Cycle Mode gives you two cycling options: "DCHG>CHG" or "CHG>DCHG". The "DCHG>CHG" option will first discharged the battery and then charge the battery. The "CHG>DCHG" option will first charge the battery and then discharge the battery. If this screen does not currently show the cycling option you desire, press the ► button once and this setting will begin flashing. Use the ✚ or ━ buttons to change this setting.

Pressing the ► button again will cause the # of cycles option to begin flashing. Use the ✚ or ━ buttons to change this to the number of cycles you want the X1 to run. The X1 can cycle the battery a maximum of 5 times consecutively.

Press and hold the ► button and cycling will begin.

Once cycling has commenced, the charger will display the following real-time information: Battery type, charging/discharging current, battery voltage, charging time and charged capactiy. You will also see "D>C" or "C>D". This will indicate which cycling order you have chozen. Either "D" or "C" will be flashing. This flashing indicates which part of the cycle is currently being executed.

Once the cycling process is complete, the X1 will display the charge/discharge capacity for each cycle. Using the ✚ or ━ buttons, you can scroll through this data for each cycle.

Pb (Lead-Acid)

This program is only suitable for charging Pb (lead-acid) batteries with nominal voltages of 2 to 20V. A Pb (lead-acid) battery is significantly different from NiCd/NiMH batteries. Pb batteries can only deliver current lower in comparison to their capacity. The same restriction applies to the charging process. Consequently, the optimum charge current can only be 1/10 of the capacity. A Pb battery cannot be used for fast charging, so please follow the instructions provided by the battery manufacturer.

Pb Charge Modes

The X1 offers the following NiCD/NiMH charge modes: Charge and Discharge.

Warning **BEFORE SELECTING A CHARGE MODE, IT IS CRITICAL THAT YOU SELECT THE CORRECT TYPE OF BATTERY TO BE CHARGED. FAILURE TO DO SO CAN RESULT IN DAMAGE TO THE BATTERY.**

Selecting the Battery Type

After you power on the X1, press the ■ button repeatedly until you reach the "Pb BATT" progam. Now press the ► button to enter the program.

Pb Charge Mode

Warning **BEFORE YOU BEGIN CHARGING YOUR BATTERY, MAKE SURE YOU HAVE READ AND UNDERSTAND ALL OF THE WARNINGS AND SEFETY INFORMATION CONTAINED ON PAGES 4-7.**

After selecting the correct battery type, if the screen does not read "CHARGE", use the ✚ or ━ buttons to change it to the "CHARGE" mode.

Press the ► button and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. The amp rate should be set to 1/10 of capacity. The example shows the appropriate amp rate setting for a 7Ah battery. Follow the instructions provided with your battery when setting the amp rate.

Press the ► button again and the voltage rate value will begin flashing. Use the ✚ or ━ buttons to set the voltage and number of cells.

Pb Charge Mode (cont.)

Press and hold the ▶ button and charging will begin.

Once charging has commenced, the charger will display the following real-time information: Battery type, charging current, battery voltage, charging time and charged capactiy.

When charging is complete the X1 will chime.

Pb Disharge Mode

After selecting the correct battery type (see pg. 24), if the screen does not read "DISCHARGE", use the ✚ or ━ buttons to change it to the "DISCHARGE" mode.

Press the ▶ button and the amp rate value will begin flashing. Use the ✚ or ━ buttons to adjust the value to the desired rate. The amp rate should be set to 1/10 of capacity. The example shows the appropriate amp rate setting for a 7Ah battery. Follow the instructions provided with your battery when setting the amp rate.

Press the ▶ button again and the voltage rate value will begin flashing. Use the ✚ or ━ buttons to set the voltage and number of cells.

Press and hold the ▶ button and discharging will begin.

Once discharging has commenced, the charger will display the following real-time information: Battery type, discharging current, battery voltage, discharging time and discharged capactiy.

When discharging is complete the X1 will chime.

Save/Load Data Programs

The Save Data and Load Data programs make it easy to store and load charge and discharge profiles for up to 5 batteries. Data can be saved for each battery type and each charge mode available with the X1. This allows you to call back data for each battery when charging or discharging without having to set up the program over again. You can also edit settings for each saved battery.

Save Data Program

Press the ■ button repeatedly until you reach the "SAVE DATA" program. Press the ► button to enter the program. When you enter the program, the profile number will be flashing. Use the ✚ or ━ buttons to choose which profile (1-5) you wish to edit.

Press the ► button again and the battery type will begin flashing. Use the ✚ or ━ buttons to choose a battery type.

Press the ► button again and the voltage rate value will begin flashing. Use the ✚ or ━ buttons to set the voltage rate. This should match the voltage listed on the battery label.

Press the ► button again and the battery capacity will begin flashing. Use the ✚ or ━ buttons to set the battery capacity. This should match the battery capacity listed on the battery label.

Press and hold the ► button and you will be taken to the "CHARGE" screen. Use the ✚ or ━ buttons to choose from the available charge modes.

Press and hold the ► button and the amp rate value will begin flashing. Use the ✚ or ━ buttons to set the amp rate.

* If this profile is for a NiMH/NiCD battery, simply press and hold the ► button and the profile will be saved. If this profile is for a LiPo battery continue to the next step. See the end of this section for instructions regarding the Manual and Automatic Modes available with charging NiMH/NiCD batteries.

Save Data Program (cont.)

Press the ► button again and the voltage rate value will begin flashing. Use the ✚ or ━ buttons to set the voltage rate and cell count. The cell count will change automatically as you change the voltage. The voltage and cell count should match the battery label.

Press and hold the ► button and this profile will be saved.

Load Data Program

Press the ■ button repeatedly until you reach the "LOAD DATA" program. Press the ► button to enter the program. When you enter the program, the profile number will be flashing. Use the ✚ or ━ buttons to choose which profile (1-5) you wish to load.

Press and hold the ► button and the profile will be loaded.

Overview

Press the ■ button repeatedly until you reach the "USER SET PROGRAM->" screen.

Battery Type
Press the ▶ button once to advance to the "V.Type" screen. This screen will allow you to choose the type of lithium battery you wish to charge. Instructions for setting the battery type can be found on pg. 13.

Each time you press the ✚ button you will advance to the next setting. Pressing the ━ button will take you back to the previous selection.

Battery Check Timer
Press the ✚ button once to advance to the "CHK Time" screen. This screen will allow you to delay the voltage error message in the case of a highly discharged battery.

NiMH Sensitivity
Press the ✚ button once to advance to the "NiMH Sensitvity" screen. This screen will allow you to adjust the cutoff voltage of the automatic charge termination of NiMH batteries.

NiCd Sensitivity
Press the ✚ button once to advance to the "NiCD Sensitvity" screen. This screen will allow you to adjust the cutoff voltage of the automatic charge termination of NiCD batteries.

USB Temperatre Cut-off
Press the ✚ button once to advance to the "Temp Cut-off" screen. This screen will allow you set the battery temperature at which the charging process will be terminated. This feature requires an optional temperature probe that is not supplied with the X1.

Waste Time
Press the ✚ button once to advance to the "Waste Time" screen. This screen will allow you set the time delay between charge>discharge cycles, allowing time for the battery to cool.

Overview (cont.)

Safety Timer
Press the ✚ button once to advance to the "Safety Timer" screen. This screen will allow you to set the maximum charge time in order to prevent accidental overcharging.

Capacity Cut-off
Press the ✚ button once to advance to the "Capacity Cut-off" screen. This screen will allow you to set the maximum charge capacity in order to prevent accidental overcharging.

Key Beep & Buzzer
Press the ✚ button once to advance to the "Key Beep Buzzer" screen. This screen will allow you to control the sound options on the X1.

Input Power Cut-off
Press the ✚ button once to advance to the "Input Power Cut-off" screen. This screen will allow you to set the minimum input voltage cut-off in order to protect the input source.

Battery Check Timer

The X1 recognizes the cell count of the Lithium battery automatically at the beginning of the charge or discharge process to avoid an erroneous setting by the user. In the case of a highly discharged battery, the X1 may initially misread the cell count. By setting the Battery Check Timer, the user can delay the voltage error message, allowing the X1 enough time to determine the correct cell count. Normally, 10 minutes is enough time to perceive the cell count correctly. For a battery of larger capacity, you may extend the time term. However, if you set it too long for a battery of smaller capacity, the charge or discharge process can be finished within the time term with an erroneous cell count. This can cause a fatal result. If the processor recognizes the cell count incorrectly at the beginning of the charge or discharge process, you may extend the time. Otherwise, you should use the default value.

See pg. 28 for instructions on accessing the "CHK Time" screen.

Battery Check Timer (cont.)

Press the ▶ button once to and the timer value will begin flashing. Use the ✚ or ━ buttons to change the timer value. The timer can be set between 5 and 60 min. We strongly recommend that the timer be set to 10 minutes or less.

Press ▶ to set the Battery Check Timer.

NiMH Sensitivity

NiMH Sensitivity shows the cutoff voltage for the automatic charge termination of a NiMH battery. The effective setting ranges from 5 to 20mV per cell. If the trigger voltage is set higher, there is a danger of overcharging the battery; if it is set lower, there is a possibility of premature termination. Please refer to the technical specifications of the battery (NiMH default: 7mV).

See pg. 28 for instructions on accessing the "NiMH Sensitvity" screen.

Press the ▶ button once and the voltage value will begin flashing. Use the ✚ or ━ buttons to change the voltage value. The voltage can be set between 5mV and 20mV.

Press ▶ to set the voltage.

NiMH Sensitivity

NiCd Sensitivity shows the cutoff voltage for the automatic charge termination of a NiCd battery. The effective setting ranges from 5 to 20mV per cell. If the trigger voltage is set higher, there is a danger of overcharging the battery; if it is set lower, there is a possibility of premature termination. Please refer to the technical specifications of the battery (NiCd default: 12mV).

See pg. 28 for instructions on accessing the "NiCd Sensitvity" screen.

Press the ▶ button once and the voltage value will begin flashing. Use the ✚ or ━ buttons to change the voltage value. The voltage can be set between 5mV and 20mV.

Press ▶ to set the voltage.

USB Temperatre Cut-off

The Temperature Cut-off is turned on or off with the use of the optional temperature probe by contacting the surface of the battery. If it is on, set the maximum temperature that the charger should allow the battery to reach during charging. Once the battery reaches this temperature, the process will be terminated to prevent damage to the battery.

See pg. 28 for instructions on accessing the "Temp Cut-off" screen.

Press the ► button once and "Temp Cut-off" will begin flashing. Use the ✚ or ━ buttons to toggle between Temp Cut-off and USB Enable.

While "Temp Cut-off" is flashing, the ► button again and the temperature value will begin flashing. Use the ✚ or ━ buttons to change the temperature value. This value can be set between 20ºC and 80ºC.

Press ► to set the Temperature Cut-off.

Waste Time

During the charge>discharge or discharge>charge cycle, batteries increase in temperature. The Waste Time program allows the user to specify the time delay between cycles, allowing time for the battery to cool.

See pg. 28 for instructions on accessing the "Waste Time" screen.

Press the ► button once and the timer value will begin flashing. Use the ✚ or ━ buttons to adjust the timer value. The timer can be set to 0 to 60 minutes.

Press ► to set the Waste Timer.

Safety Timer

When the charge process starts, the integrated safety timer starts to run simultaneously. If an error occurs or the termination circuit cannot detect whether the battery is fully charged or not, the X1 is programmed to prevent overcharging and will terminate the charging process.

Safety Timer Calculation
When charging NiCd or NiMH batteries, divide the capacity by the current, then divide the result by 11.9. Set this number of minutes as the setting for the safety timer setting. If the charger stops at this time threshold, about 140% of the capacity will have been fed into the battery.

See pg. 28 for instructions on accessing the "Safety Timer" screen.

Press the ► button once and "ON" will begin flashing. Use the ✚ or ━ buttons to turn the timer off. We strongly recommend that you leave the Safety Timer on.

Press ► to set the Safety Timer.

Capacity Cut-off

This program provides a maximum capacity protection function. If the Delta-peak voltage can not be detected or the Safety Timer times out, the charge process will stop automatically when the battery reaches the user-set maximum charge capacity in order to prevent accidental overcharging.

See pg. 28 for instructions on accessing the "NiCd Sensitvity" screen.

Press the ► button once and "ON" will begin flashing. Use the ✚ or ━ buttons to turn the Safety Timer off. Press the ► button again and the mAH value will begin flashing. Use the ✚ or ━ buttons to change the mAHvalue. This can be set between 10mAH and 50,000mAH.

Press ► to save these settings.

Key Beep & Buzzer

A beep sounds to confirm the user's operation every time a button is pressed. The buzzer or melody sounds at various times during an operation to confirm a different mode change. These functions can be switched on or off.

See pg. 28 for instructions on accessing the "Key Beep" and "Buzzer" screen.

Press the ► button once and (Key Beep) "ON" will begin flashing. Use the ✚ or ━ buttons to turn "Keep Beep" off. Press the ► button once and (Buzzer) "ON" will begin flashing. Use the ✚ or ━ buttons to turn "Buzzer" off.

Input Power Cut-off

This function monitors the voltage of the input source used to power the charger. If the voltage drops below the user setting, the program will end forcibly to protect the input source.

See pg. 28 for instructions on accessing the "Input Power Cut-off" screen.

Press the ► button once and the voltage value will begin flashing. Use the ✚ or ━ buttons to change the voltage.

Press ► to set the voltage.

Warnings and Error Messages

REVERSE POLARITY

Reverse Polarity
The battery/charger connections (red/black) are reversed.

CONNECTION BREAK

Connection Break
The battery connection has been diconnected.

SHORT ERR

Short Circuit
There is a short circuit in one of the leads or plugs. If no short is found in one of the leads or plugs you may have a faulty battery, which should not be charged any further.

INPUT VOL ERR

Input Voltage Error
The input voltage is incorrect. The X1 is can draw power from a 100 to 240AC outlet or from an 11-18V DC power source.

VOL SELECT ERR

Input Selection Error
The voltage of the battery pack has been selected incorrectly.

BREAK DOWN

Break Down
The charger has malfunctioned. Contact Customer Service at 858.748.1767 or at service@hitecrcd.com.

BATTERY CHECK
LOW VOLTAGE

Battery Check - Low Voltage
The charging voltage is lower than what was input.

BATTERY CHECK
HIGH VOLTAGE

Battery Check - High Voltage
The charging voltage is higher than what was input.

BATTERY VOLTAGE
CELL LOW VOL

Battery Voltage - Low Cell Voltage
Voltage of one cell in the battery pack is too low. Check the voltage of each cell.

BATTERY VOLTAGE
CELL HIGH VOL

Battery Voltage - Low Cell Voltage
The voltage of one cell in the battery pack is too high. Check the voltage of each cell.

BATTERY VOL ERR
CELL CONNECT

Battery Voltage - Cell Connection Error
No balance adaptor is detected while charging in balance mode.

Warnings and Error Messages (cont.)

TEMP OVER ERROR

Over Temperature Error
The internal temperature of the charger is too high. Allow the charger to cool down.

CONTROL FAILURE

Control Failure
The charger has malfunctioned. Contact Customer Service at 858.748.1767 or at service@hitecrcd.com.

Warranty and Service

LIABILITY EXCLUSION

This charger is designed and approved exclusively for use with the types of batteries stated in this Instruction Manual. Hitec RCD, USA accepts no liability of any kind if the charger is used for any purpose other than that stated. We are unable to ensure that you follow the instructions supplied with the charger, and we have no control over the methods you employ for using, operating and maintaining the device. For this reason, we are obliged to deny all liability for loss, damage or costs which are incurred due to any misuse or operation of our products. Unless otherwise prescribed by law, our obligation to pay compensation, regardless of the legal argument employed, is limited to the invoice value of Hitec RCD, USA products which were immediately and directly involved in the event in which the damage occurred.

ONE YEAR LIMITED WARRANTY

For a period of one year from the date of purchase, HITEC RCD USA, INC. shall REPAIR OR REPLACE, at our option, defective equipment covered by this warranty. Otherwise, the purchaser and/or consumer is responsible for any charges for the repair or replacement of the charger. This warranty does not cover cosmetic damages and damages due to acts of God, accident, misuse, abuse, negligence, improper installation, or damages caused by alterations by unauthorized persons or entities. This warranty only applies to the original purchaser of this product and for products purchased and used in the United States of America, Canada and Mexico. Plastic cases are not covered by this warranty.

Warranty and Service (cont.)

THIS WARRANTY IS IN LIEU OF ANY AND ALL OTHER WARRANTIES, WHETHER FOR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND WHETHER EXPRESS OR IMPLIED. REPAIR OR REPLACEMENT AS PROVIDED UNDER THIS WARRANTY IS THE EXCLUSIVE REMEDY. HITEC RCD, INC. SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR BREACH OF ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THIS PRODUCT, EXCEPT TO THE EXTENT PROHIBITED BY APPLICABLE LAW. ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ON THIS PRODUCT IS LIMITED TO THE DURATION OF THIS WARRANTY, REPAIR AND SERVICE.

SERVICE AND REPAIR INFORMATION

To have your Hitec charger serviced:

1. Visit the Hitec website at **www.hitecrcd.com** and download the service request form (under Support section).
2. Fill out the service request form completely and include a copy of your original receipt showing the purchase date.
3. Package your product in its original packaging or use a suspension-type packaging (foam peanuts or crumpled newspaper). Hitec RCD shall not be responsible for goods damaged in transit.
4. Ship prepaid (COD or postage-due returns will not be accepted) via a traceable common courier (UPS, insured parcel post, FedEx, etc.) to:

Hitec RCD USA, Inc., Customer Service Center, 12115 Paine St., Poway CA 92064

www.hitecrcd.com

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