TAJA RACING

T. Nguyen, A. Esparza, J. Christman, A. Whitaker

Product Evaluation Report

2011

Contents

INTRODUCTION

Introducing the XiSport from the TAJA Racing development group, a portable training device for your bike that not only works indoors, but also outdoors. With a simple press of a button, it can provide the user with various workouts based on what he or she wants. Along with the workouts it has many other functions that tend to the basic needs of health enthusiasts as well as the racing extremists.

PRODUCT

The XiSport uses state of the art algorithm and data structures, developed by the TAJA RACING group, to create a user-friendly, portable training device unlike any other device in the industry and all at a low cost. With the Xi, the user is in control. They pick the workout they want, they can work at their own pace, and if they don't like the kind of workout they have, they have the option of creating their own. It is a simple installation. The user-friendly interface on the screen makes it easy for the user to interact with the device. The Xi comes with industry standard functions such as speed, distance, cadence, and time. Some of the outstanding functions of the Xi is its acceleration and gearing functionality. This is the sought after function that racing cyclist would like to, but doesn't exist in any other devices.

FEATURES & BENEFITS

The XiSport measures speed, cadence, and distance in real time, while providing the user accurate instantaneous data. Other devices usually average the data, so when the data is presented on the screen, it is not displayed in real time. There is also the newly wanted acceleration function for the hardcore cyclists. This function calculates the instantaneous acceleration that can be graphed over time. The graph allows the cyclist to determine their acceleration performance. It is a great tool for those who wish to improve their explosivness. All of the workout information is presented on the 160 X 104 pixel LCD graphical display. Using the graphical display allows the rider to quickly comprehend the data without being distracted from reading textual information. Moreover, the screen displays a progress bar for the rider to view at a glance their progression in the workout.

During the workout, the data is continuously written to a SD card. From there, the SD card can be inserted into a computer to transfer the workout data. A post-ride analysis program will then decipher the raw data and generate graphs for each workout. From the graph, the rider can determine their workout performance.

The Xi can select many types of customizable workouts from the configuration screen. These workouts range from a wide variety of choices, such as sprints and endurance training. On the CD, there are example workouts which the user may tailor to their specific needs. Microsoft Excel is required in order to create these custom workouts.

HOW IT WORKS

The XiSport calculates the speed and cadence of the bike using a mathematical equation created by the TAJA Racing Development group in which the main focus of the equation relies upon the wheel size of the bike. By inputting the wheel size in the configuration screen, the data is then transferred into the main part of the program in which it finds the speed and cadence of the bike once the bike is pedaled. There are magnets placed on the spoke of the wheel (for measuring speed) as well as on the crank (for measuring cadence). If the bike is not pedaled, the sensor for cadence will not be triggered since it does not pass the magnet, and no value will show on the screen. However, if the bike is still moving the speed will still be calculated since it is based on the magnet on the spoke (which the sensor will always be tripped when the wheel is spinning).

The calculation of distance is based on the wheel size of the bike. It takes the circumference of the wheel times the number of revolutions the wheel has spun, thus producing accurate and almost instantaneous distance updates. Instantaneous acceleration uses the difference in velocities within a certain time interval to produce its results. The timer is created using an external interrupt in which it counts the falling edge of the cycle to create each second

Once a workout is started, information during that workout, (speed. cadence, and distance) is transferred to main module via wireless and then stored onto the SD card via wireless. Once the workout is finished, the recording will stop. Data on the SD can then be transferred to the computer via mini-USB. From the included CD, users can copy the included excel files over to their computer. One of the files included will be the post ride analysis file which will use the data that is in the SD card to create graphs for the workouts. These graphs will help the user see at which point during the ride they went the fastest/slowest or when they pedaled

the most etc. By utilizing this information, the user can greatly improve his performance. Also within those files is a blank workout template. Users can use this template to create their own workouts. All the users have to do is open the file and input the values for their desired workouts. No other work necessary.

USABILITY TESTING

On December 2nd, 2011, the XiSport Cycling Training Device had its first field test by other cyclists and one cyclist/engineer and was conducted in the WSU Heskett Center, on the indoor track. After a brief talk about the device and what we were testing, we were ready to begin. The test consisted of two parts: the first part of it, we had the riders do a preprogrammed workout that we created. It started out at 15mph, then climbed to 17, 18, capping at 20mph, all before ending back down at 15mph. The length of the workouts segments were 0.5 miles with 0.2 miles as a cool down. The feedback from them, on that first run was that they didn't look down at the screen too much. Now this was partly due to the indoor track with small straightaways and upcoming turns. When they did have time to look at it, they were trying to stay close to the speed workout values and not much at everything else. After getting feedback on their first run and some thoughts that they had, they were eager to test it again. This time it would be done with a workout that they made up.

The second part of the test: the workout would start out at 20mph, increasing to 21, 22, maxing at 24mph, before cooling down at 15mph. The focus for this run was to match the speed values, since cadence is more of a preference of the rider than a standard for all. The distances were the same as the last test; 0.5 miles for each segment of the workout with a 0.2 mile cool down. Since they knew a little bit more about the position of the data on the display, we wanted for them to look down a little bit more to absorb the data on this run. After getting to know more what the device was displaying and how it was displaying it, they really enjoyed it.

Some of the pros that we heard about the device and got in the questionnaire: They loved data was displayed using the bars and the values; it gave it more meaning than just reading a number. The idea of building their own workouts to suit their needs was something they got excited about and something they would use to supplement their training. Another plus was letting the rider know what

gear they were in, instead of looking back at the cassette every time they wanted to know.

There was also some feedback on how we could make improvements that the riders thought it should have. Having it being more customizable was the thing we heard a lot of. Example, if they wanted the screen to have only speed, cadence, and gearing, that they could do that. Another suggestion was to add an audio tone when the workout was changing. The riders and Joe as well, had problems knowing when the workout was switching from one segment to another. The only way to know was to periodically look at the screen more than you would normally. Changing the way the values were being displayed on the bar was another thing that they wanted to be customized. Some wanted the bottom of the bar to be 0 and have the bar fill up to the target level while others wanted to keep it how it was now, have the bar increase/decrease from the target level more the farther you were away from the workout target.

Overall, the feedback from the riders was positive and once again confirmed how special our device really is.

USER MANUAL

CONFIGURATION

Upon turning the Xi device on, the splash screen will be displayed with the TAJA logo. After that the configuration screen will appear. From here, the user can input the tire size of their bike. If no value is input, the default shall be used. From here, the user can also change chain rings and which workout file they want to use. Pressing the menu change button will switch the screen to training mode.

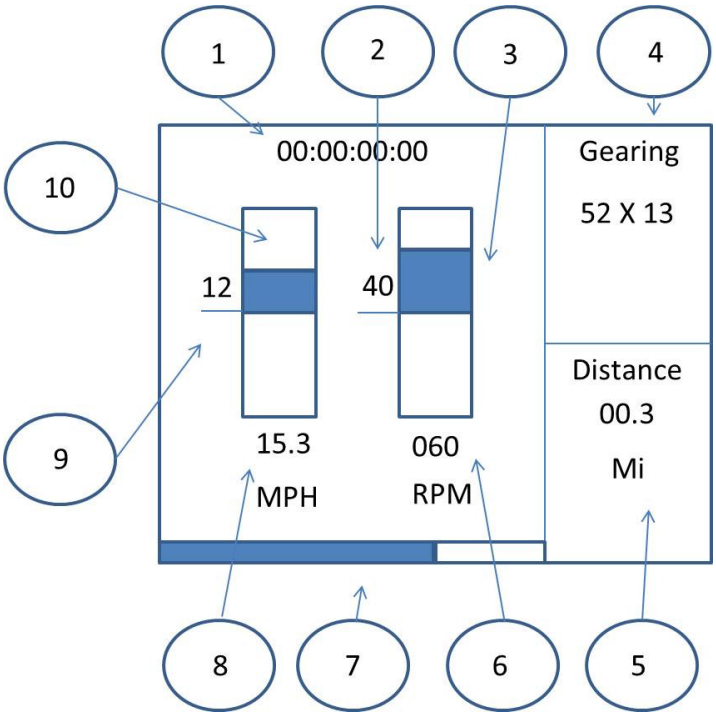
1) Shows the wheel size (changeable).

2) Shows the chain ring (changeable).

3) Shows the sprocket (changeable).

4) Shows the current workout file used (changeable).

TRAINING SCREEN



1) Shows the timer. This starts once the workout starts. It will pause when the workout is paused.

2) Shows cadence goal the user has to reach

3) Shows the current cadence progress of the user. If the user is surpassing the goal by a lot, it will go above the middle line. If the user is stabilizing at the goal it will stay at the center. Finally if the goal is not met, it shall go below.

4) Shows the current gear of the user.

5) Shows the distance the user has travel in the course of the workout. Note this is not the overall distance traveled.

6) The current cadence of the user in revolutions per minute (RPM).

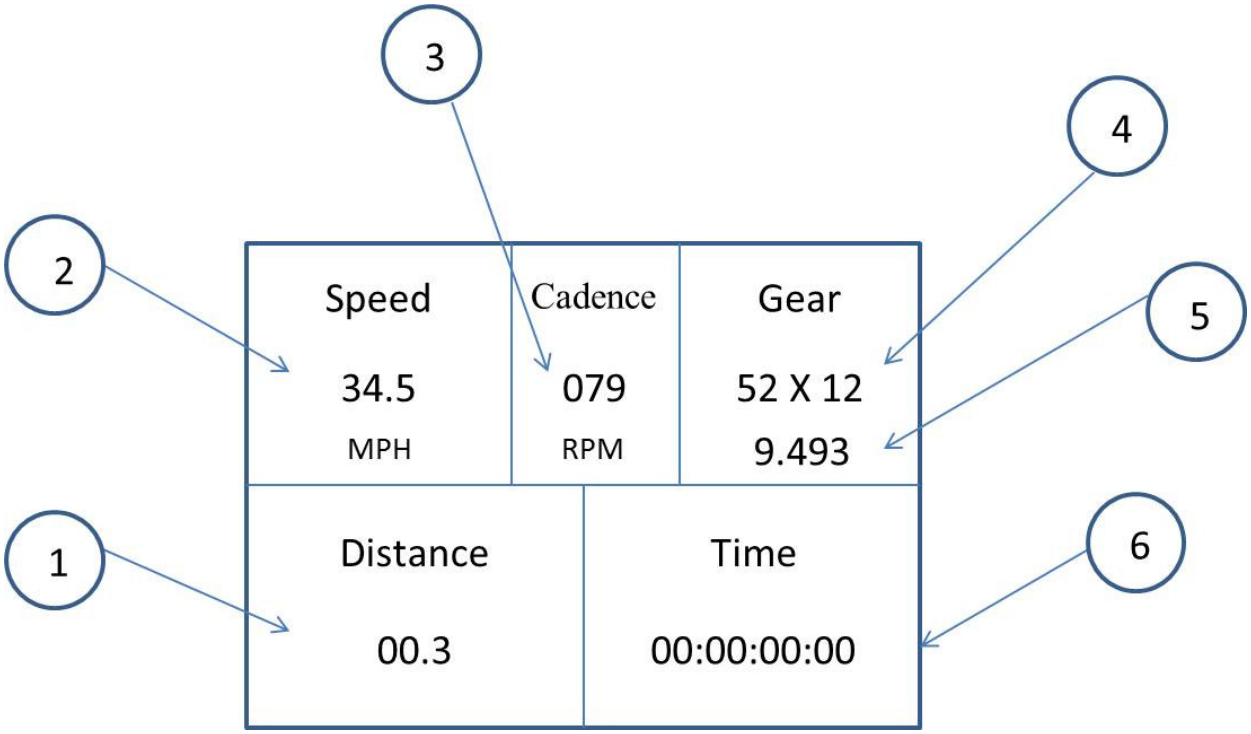
7) This shows the current progress of the workout. The workout is done once it reaches the end of the bar

8) The current speed in mile per hour (MPH).

9) Shows speed goal user has to reach

10) Shows the current speed progress of the user. If the user is surpassing the goal by a lot, it will go above the middle line. If the user is stabilizing at the goal it will stay at the center. Finally if the goal is not met, it shall go below..

NON- TRAINING SCREEN



1) The overall distance the user has traveled.
2) The current speed of the user. The units can be changed via configuration screen.
3) The current cadence of the user. The units can be changed via configuration screen.
4) The current gear of the bike.
5) The gearing ratio value. This determines the change in the next gear.
6) The stopwatch timer.

MARKETING

There are more than 200,000 people that bike daily in New York City. [i] That number is steadily growing as gas becomes more and more expensive. People search for an alternate route for transportation. This change has caused a huge growth in the cycling industry, along with it, the desire for a healthier lifestyle. For those who don't have time to go workout or just simple does not like working out in the gym, cycling is the best form of exercise and travel. The destination a person needs to reach and how he or she gets there is the difference in getting a good workout or just simply bicycling. By using the Xi developed by TAJA Racing, a person can get the best out of cycling to his workplace.

Cycling is already the major form of transportation in many regions and so there are many bikes out there already. The industry is huge with Doreal Industries, Inc. leading the way. They are a $2 billion company that has facilities in over 17 countries.[ii] There are many other companies as well both private and public that are rapidly expanding their territory.

Figure one shows the amount bikes produce between the years 1990 - 2000

Bicycle Production of Selected Countries, 1990-2000											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	Million Units										
China	31.9	36.8	40.3	41.0	42.0	41.0	38.0	30.0	23.1	42.7	52.2
France	1.5	1.2	1.0	1.0	1.3	1.3	1.3	1.3	1.6	1.8	1.9
Germany	3.9	4.9	4.6	4.1	3.5	3.2	2.9	2.8	3.2	3.2	3.2
India	8.4	8.8	9.0	9.9	10.5	11.5	11.3	11.0	10.5	11.0	11.0
Indonesia	2.0	2.0	2.2	2.5	2.8	3.0	2.3	3.0	2.8	2.6	N/A
Italy	3.5	3.6	4.1	5.2	5.8	5.3	4.0	4.0	3.0	3.3	3.2
Japan	8.0	7.5	7.3	6.9	6.7	6.6	6.1	6.0	5.9	5.6	4.7
Korea	1.5	1.5	1.3	1.1	1.2	N/A	0.9	0.8	0.6	0.6	N/A
Malaysia	0.3	0.4	0.6	0.7	0.8	0.8	0.5	0.8	0.7	0.8	N/A
Taiwan	6.8	7.7	7.5	7.9	9.2	9.7	7.4	11.9	10.1	8.3	7.5
Thailand	0.7	0.8	1.0	1.0	1.1	1.8	1.5	1.8	1.6	1.5	N/A
United Kingdom	1.3	1.2	1.2	1.1	1.2	1.2	1.2	1.3	1.2	1.3	1.2
United States	5.6	7.6	8.9	7.7	7.3	8.8	8.0	6.0	2.5	1.7	1.1
N/A indicates not available.											

Source: Bicycle Retailer & Industry News Directory, from Cycle Press, European Bicycle Manufacturers Association, Japan Bicycle Promotion Institute, Bike Europe, and Bicycle Retailer & Industry News.

MATERIALS

Control Unit Composite Assembly							
Item	**Ref. Des.**	**Qty**	**Description**	**Mfg**	**Mfg Part#**	**Source**	**Price (ea)**
1	U03	1	LCD Display	Electronic Assembly	EA DOGXL160W-7	mouser	$35.98
2	J01	2	CONN, Socket, 25-Pin Boardmount Straight	3M	929974-01-25	digikey	$2.39
	J02					-	
3	P01	1	Conn, Header, 10 Pin Single	Samtec	TSW-110-05-T-S	digikey	$0.63
4	P02	1	Conn, Header, 4 Pin Right Angle	Molex	70553-0003	digikey	$1.45
5	P03	1	Conn, Header, 10 Pin Dual	Samtec	MTMM-110-04-S-S-200	samtec	$2.68
6	U01	2	IC, Regulator +3.3V	Texas Instruments	TLV2217-33KCSE3	digikey	$1.10
	U02						
7	C01	2	Cap, Tant 33 UF 16V	Kemet	T356H336K016AT	digikey	$2.80
	C02						
8	C03	2	Cap, Tant 2.2 UF 25V	Vishay/ Sprague	173D225X9025VWE3	digikey	$1.57
	C04						
9	C05	1	Cap, Tant 0.1 UF 35V	Vishay/Sprague	173D104X9035UWE3	digikey	$1.22
10	R03	3	Res, 39.0 Ohm 1/4 Watt	Stackpole Electronics	CF14JT39R0	digikey	$0.10
	R04						

	R05						
11	R01	2	Res, 1.5k Ohm 1/4 Watt	Stackpole Electronics	CF14JT1K50	digikey	$0.10
	R02						
12	R06	1	Res, 1.0M Ohm 1/4 Watt	Stackpole Electronics	CF14JT1M00	digikey	$0.10
13	S01	4	Switch, SPST	Radio Shack	275-003	radioshack	$3.99
	S02						
	S03						
	S04						
Control Unit Interface PCB Assembly							
Item	**Ref. Des.**	**Qty**	**Description**	**Mfg**	**Mfg Part#**	**Source**	**Price (ea)**
14	U03	1	LCD Display	Electronic Assembly	EA DOGXL160W-7	mouser	$35.98
15	J01	2	CONN, Socket, 25-Pin Boardmount Straight	3M	929974-01-25	digikey	$2.39
	J02					-	
16	P01	1	Conn, Header, 10 Pin Single	Samtec	TSW-110-05-T-S	digikey	$0.63
17	P02	1	Conn, Header, 4 Pin Right Angle	Molex	70553-0003	digikey	$1.45
18	P03	1	Conn, Header, 10 Pin Dual	Samtec	MTMM-110-04-S-S-200	samtec	$2.68
19	U01	2	IC, Regulator +3.3V	Texas Instruments	TLV2217-33KCSE3	digikey	$1.10
	U02						
20	C01	2	Cap, Tant 33 UF 16V	Kemet	T356H336K016AT	digikey	$2.80
	C02						

21	C03	2	Cap, Tant 2.2 UF 25V	Vishay/ Sprague	173D225X9025VWE3	digikey	$1.57
	C04						
22	C05	1	Cap, Tant 0.1 UF 35V	Vishay/ Sprague	173D104X9035UWE3	digikey	$1.22
23	R03	3	Res, 39.0 Ohm 1/4 Watt	Stackpole Electronics	CF14JT39R0	digikey	$0.10
	R04						
	R05						
24	R01	2	Res, 1.5k Ohm 1/4 Watt	Stackpole Electronics	CF14JT1K50	digikey	$0.10
	R02						
25	R06	1	Res, 1.0M Ohm 1/4 Watt	Stackpole Electronics	CF14JT1M00	digikey	$0.10
26	S01	4	Switch, SPST	Radio Shack	275-003	radioshack	$3.99
	S02						
	S03						
	S04						
Sensor Unit Composite Assembly							
Item	**Ref. Des.**	**Qty**	**Description**	**Mfg**	**Mfg Part#**	**Source**	**Price (ea)**
27	A01	1	PCB Assy, Sensor Unit I/O	TAJA Racing	N/A	N/A	N/A
28	A02	1	PCB Assy, PSoC 5 FirstTouch Starter Kit	Cypress	CY8CKIT-014	digikey	$48.88
29	A03	1	PCB Assy, WirelessUSB	Cypress	CYWM6935	digikey	$14.30
30	*01	1	Enclosure, Sensor Unit Upper	TAJA Racing	N/A	N/A	N/A
31	*02	1	Enclosure, Sensor Unit Lower	TAJA Racing	N/A	N/A	N/A
32	*03	1	Batt, 9V Lithium	Energizer	LA522	digikey	$10.00

33	S01	1	Switch, Submini Slide	Radio Shack	275-406	radioshack	$3.19

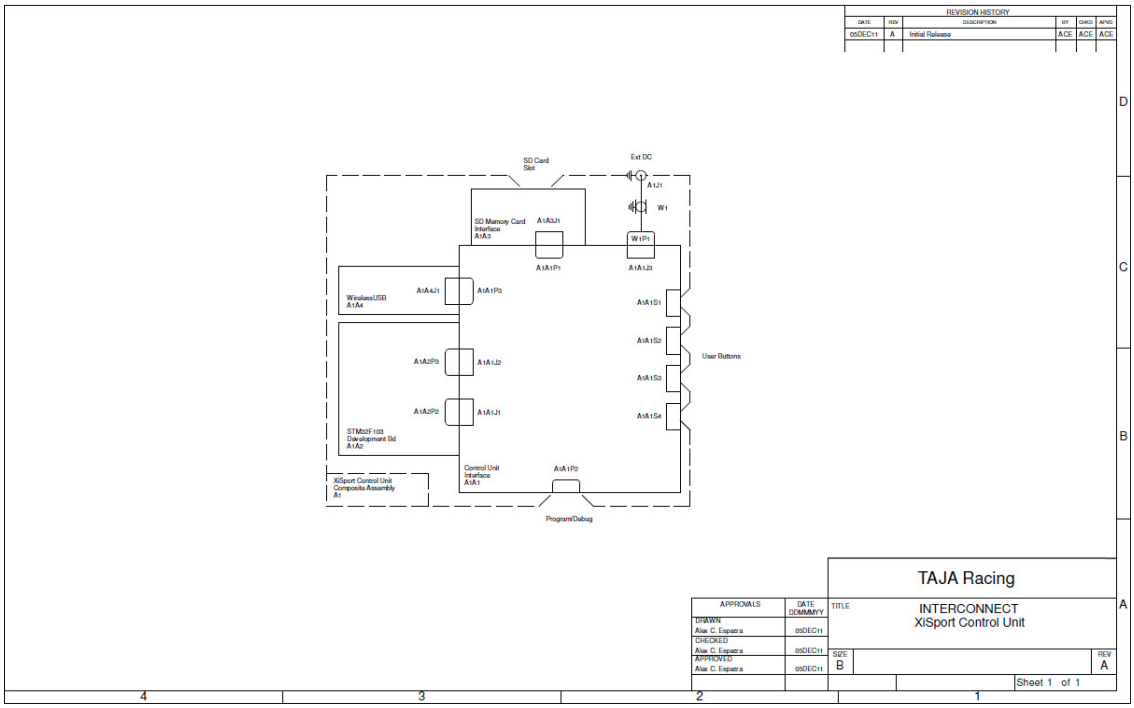
INDUSTRY STANDARDS/ LIABILITY

This product, the XiSport, was made by TAJA Racing Development (RD) has no afflilation with WSU or any other source. This product was made solely using TAJA RD's own resources. All materials were bought by TAJA RD and all code or creations was created by TAJA RD. The only exception is the enclosures which was produced by an affiliate of TAJA RD. However, the drawing of the enclosures was made by TAJA RD. The individual piece of a material were each created by thire respective manufacturs.

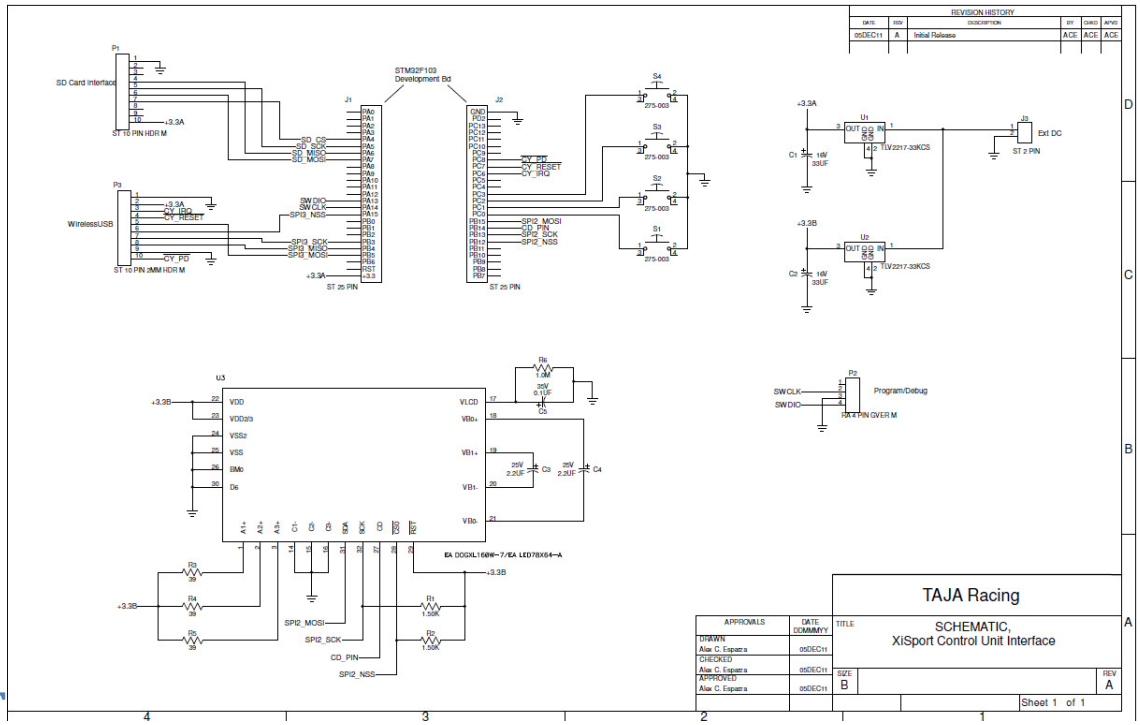
Though there are many similar devices out there, none is the same as the one produced by TAJA RD. Other device may have some of the Xi's functions but not all. The acceleration function, is only available in higher priced training devices. Even then, the acceleration function of other is not the same instantaneous acclertaion that the TAJA RD has developed. The Xi also comes with a function that deteremines what gear the user is in.The Xi also comes with progress bar and progress meter to help the user throughout the workout.

SCHEMATICS/DIAGRAMS/PICTURES

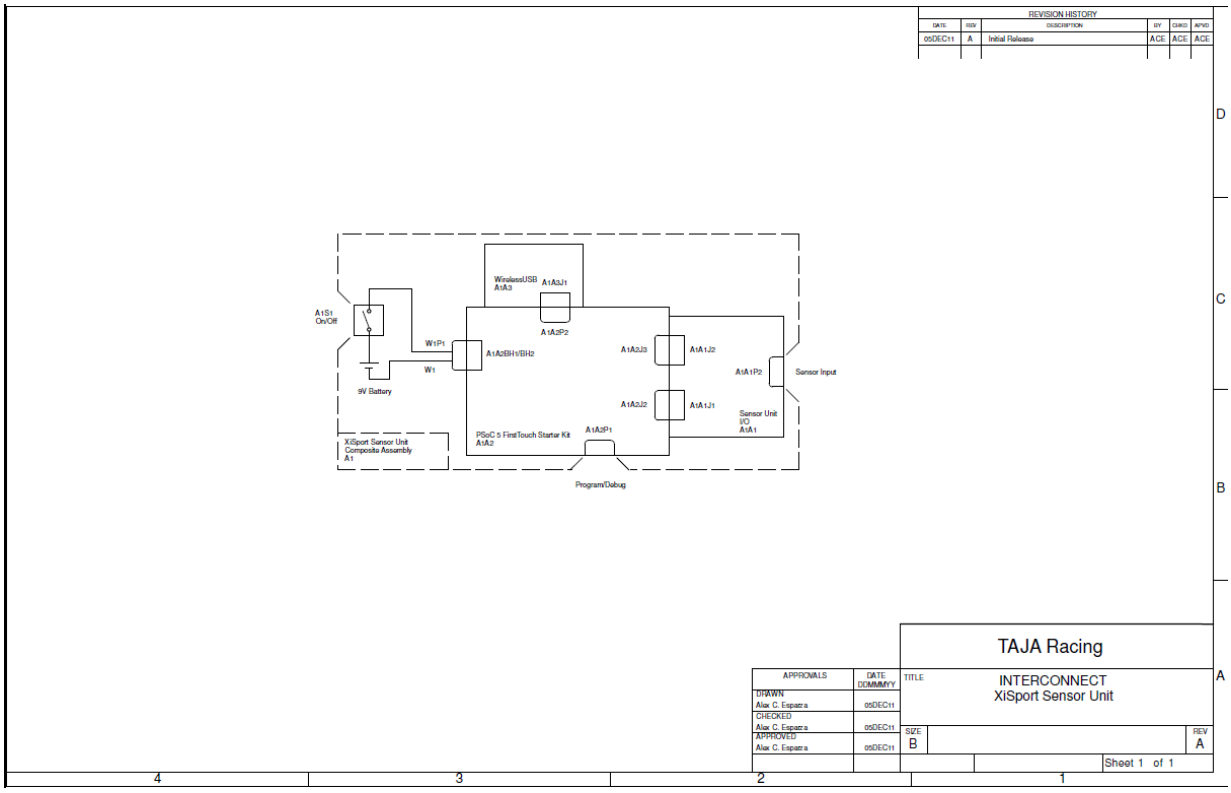
INTERCONNECT DIAGRAM FOR CONTROL UNIT



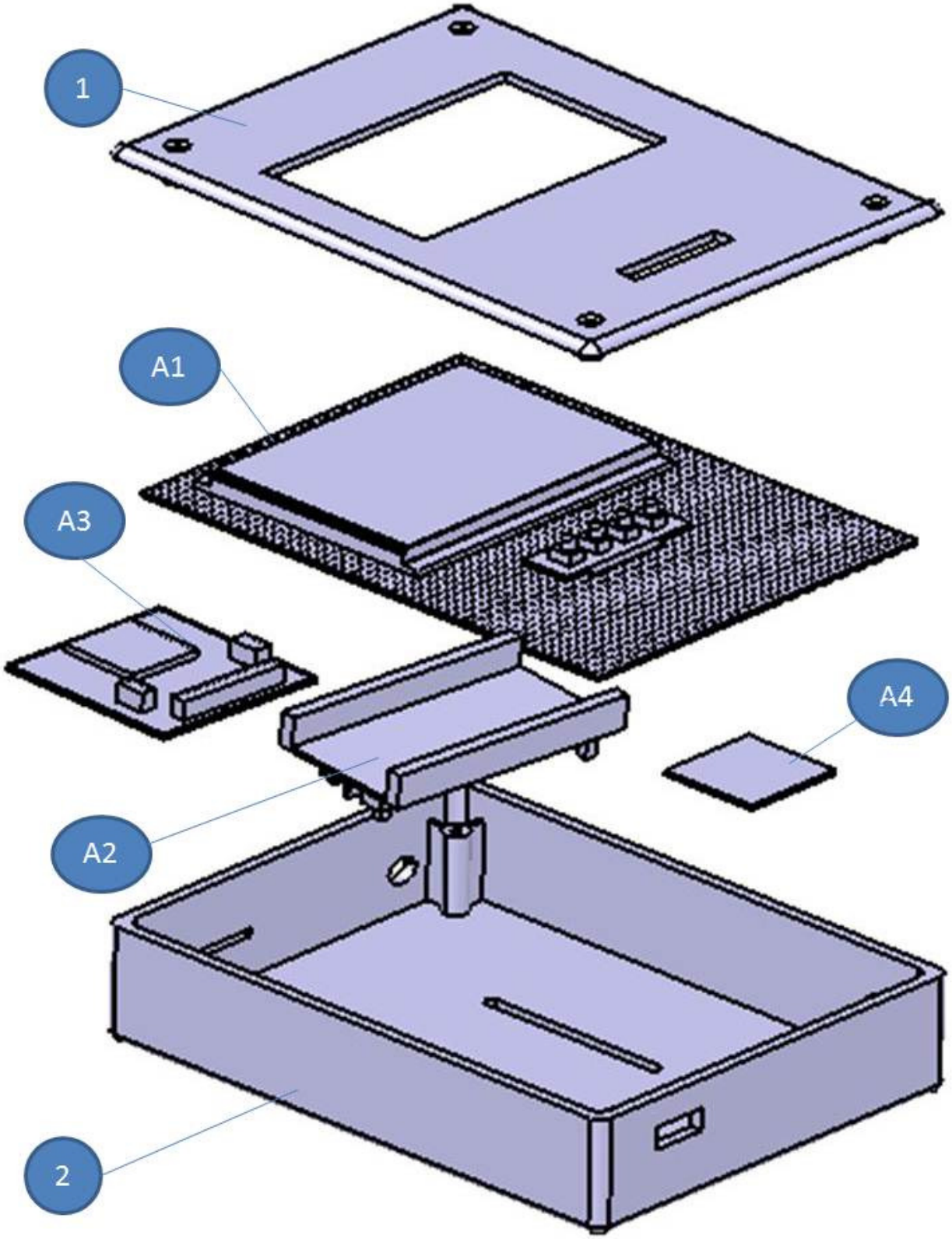
SCHEMATIC FOR CONTROL UNIT



INTERCONNECT DIAGRAM FOR SENSOR UNIT



MECHANICAL ASSEMBLY DRAWING


1
A1
A3
A4
A2
2

Below are the CATIA drawings for the wireless enclosure

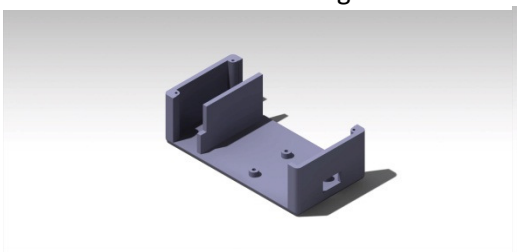


Figure 1 - Bottom of wireless enclosure

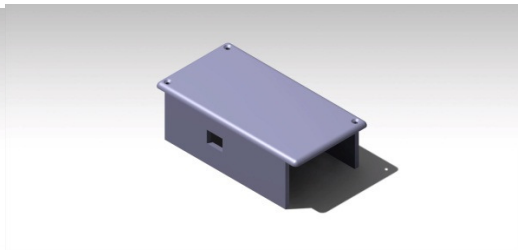


Figure 2 – Top of wireless enclosure

Figure 3 – Assembled wireless enclosure

Below is a picture of the wireless device with the enclosure

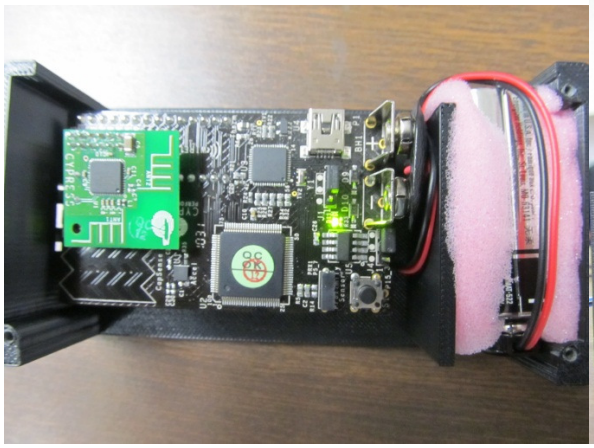


Figure 4 – Top View

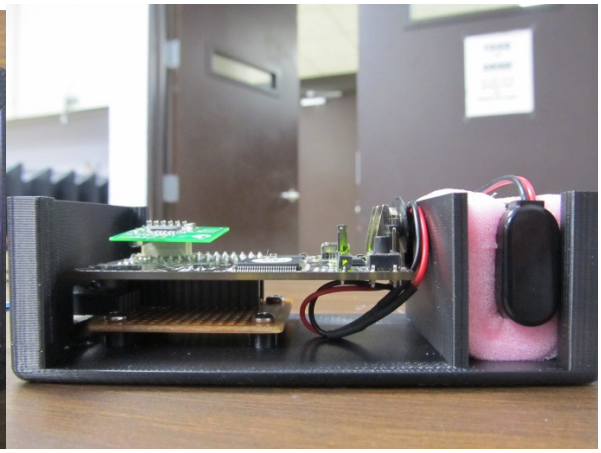


Figure 5 – Side

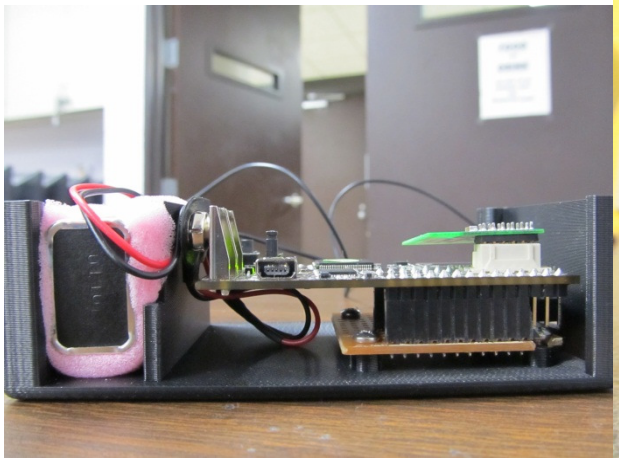


Figure 6 – Opposite side view

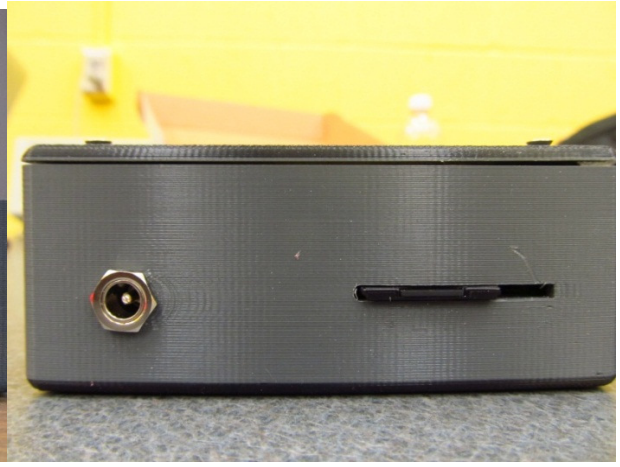


Figure 7 – Control Unit side view

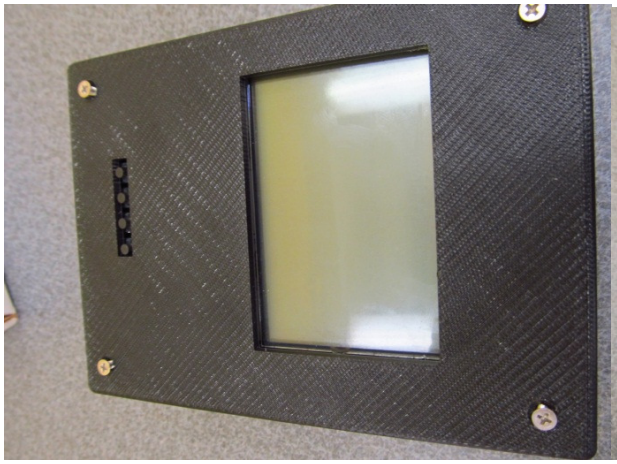


Figure 8 – Assembled Control Unit

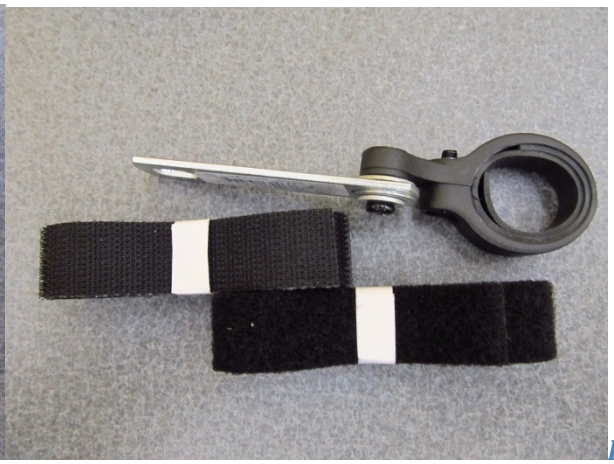


Figure 9 – Assembled Control Unit

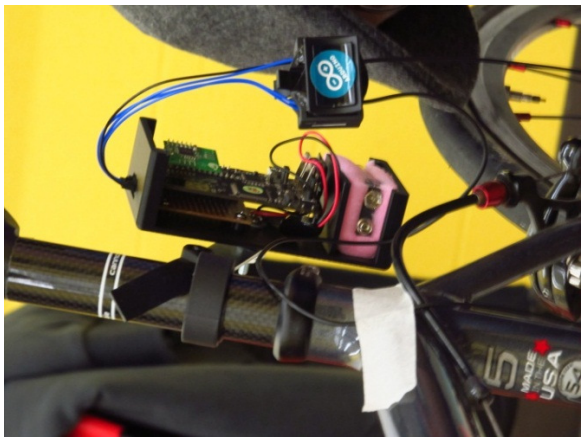


Figure 10 – Installed Sensor Unit on the bike

HISTORY

Cycling has always been a passion for Joe Christman, and so, from the start, he knew what he wanted to do for his senior design project. He wanted everyone to enjoy the benefits the cycling as well as help those who has already been cycling. Thus his idea of creating the XiSport came into play. Although not a cyclist themselves, three other classmates, Thuan Nguyen, A.J. Whitaker, and Alex Esparza, shared Joe's vision, and the TAJA Racing development group was created.

With the time limit of a year, this group has amazed people month after month with their new development. Just within the first month, the Xi's Prototype I was created using the Arduino[iii]. After three months, Prototype II was created. Prototype II used a more complex microcontroller (STM32F100x[iv]) than Prototype I, mainly because of the peripheral, power, and its unseen capabilities. Four months later, an even more powerful microcontroller (STM32F103xRb[v]) was used for Prototype III.

This group has won 5th place in a state-wide business plan competition with just their Prototype II design. They continue to lead other groups and set an example for the following students to come.

REVISIONS

vPrototype .Hardware .Software	Date	Software /Hardware	Comments
v1.0.0	1/28/2011	Hardware	Prototype I created Micro-controller: Ardiuno Function: Speed, Distance, Cadence Screen: Two Line display
v1.0.1	2/4/2011	Software	Function: Timer was add
v2.0.0	5/6/2011	Hardware	Prototype II created Micro-controller: STM32F100x Screen: 160x104 pixel graphical display w/ backlight
v2.0.1	7/8/2011	Software	Function: acceleration added
v3.0.0	9/2/2011	Hardware	Prototype III created Micro-controller: STM32F103xRb Screen: 160x104 pixel graphical display w/ backlight Started analysis of the SD card The creation of the external interrupt
v3.1.0	9/12/2011	Hardware	Started drawing of configuration and training screen
v3.2.0	9/30/2011	Hardware	Configuration, training, non-training screen completed
v3.3.0	10/3/2011	Hardware	Added wireless communication device (Cypress)
v3.4.0	10/5/2011	Hardware	Logging data into SD card
v3.4.1	10/10/2011	Software	Gearing ratio function added

v3.5.1	10/14/2011	Hardware	Wireless communication working between Cypress and STM32 Tested the range and integerity of wireless
v3.5.2	10/21/2011	Software	Gearing Fixed
v3.6.2	10/24/2011	Hardware	Button to toggle through screens
v4.1.1	11/1/2011	Hardware	Prototype IV created On a bread board, the display is connected to one side, the SD card reader, wireless and microtroller is connected to the other side, thus forming a small compact device (smaller than prototype III)
v4.1.2	11/8/2011	Software	Range of wireless tested. CATIA drawing of enclosure also made
v4.1.2	11/13/2011	Software	The progress bar for speed/cadence is both functional New gearing code is working
v4.2.2	11/17/2011	Hardware	Wireless enclosure made
v4.2.3	11/17/2011	Software	Reading/Writing to SD card successful
v4.3.4	11/21/2011	soft/hardware	Reading workouts and logging information on SD card successfully Enclosure for the entire circuit made

REFERENCES

[ii] http://www.bikesbelong.org/resources/stats-and-research/statistics/

[ii] http://seekingalpha.com/article/133109-high-growth-and-big-margins-in-the-61-billion-bicycle-industry

[iii] http://www.arduino.cc/
[iv] http://www.st.com/internet/mcu/class/1734.jsp

[v] http://www.st.com/internet/mcu/class/1734.jsp