ECSE 323 - Lab 5 Report

Breakout Game

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Contents

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Design Features of Breakout Game

1. When the ball hits the border walls (top, right or left), the ball is reflected back successfully
2. When the ball hits the paddle, the ball is reflected back successfully
3. Two buttons on the ALTERA D1 board is used to control the movement of the paddle.
4. A life is successfully decremented when the ball goes beyond the paddle.
5. A grid of 5x12 blocks are generated at the start of the game
6. When the ball hits the block, the block is successfully broken
7. When the ball hits a block, the ball is successfully reflected back
8. When we lose a life, the ball and the paddle is reset to the center.
9. The game stops when all lives are lost
10. A line of text at the bottom successfully shows the score, lives and level.

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Detailed Description of the circuit

Circuit name: g47_lab4 (this is modified VGA Test Pattern Circuit from lab 3)
Input(s): clock (1 bit), rst (1 bit), level (3 bit), life (3 bit) , paddle_left_button (1 bit), paddle_right_button (1 bit), reset_ball (1 bit).
Output(s): R, G, B (4 bit), HSYNC, VSYNC
Components: g47_VGA (lab 3), g47_Text_Address_Genenrator, g47_Text_generator, fontRom (given by professor), g47_VGA_Overlay

The aim of the circuit is have a moving ball, reflective border walls, a reflective paddle, and blocks of 5 rows and 12 columns. The blocks are also reflective. When the ball touches a block, the block is broken and reflected back. The clock being used is a 50 MHz clock.

Like in previous lab, there are two counters that are being used to generate the score (please see lab 4 report for further information), as points are gained for being alive. The ball itself is a collection of 8x8 pixels, we will refer to this as the ball row and ball column. The row and column of the ball is being continuously updated via two lpm_counters, this causes the movement of the ball. 8 cases (given in the lab questions) are used to reflect the ball from the walls, blocks or paddle at multiples of 45 degree angle.

Each block is a collection of rectangular pixels of dimension 32x64. The blocks are generated row by row, where each row is 32 pixels in length. Blocks of row 0 and 4 are colored green, row 1 colored red, row 2 colored blue and row 3 colored navy blue. Initially all the pixels of a block have a binary value of 1. When the ball hits the block the value of all the pixels in the block is switched to 0, signifying that the block has been broken.

The walls are of width 16 units long. Hence the first 16 rows (from vga_row) are set to yellow to signify the top border and the first and last 16 columns (from vga_col) are set to yellow to signify the side borders. The paddle is made by setting the R, G, B values to the paddle color using the paddle position value. Also the value of current life is decremented when the ball goes out of bounds

The components of ball’s motion is reversed when the ball’s coordinates are same as the co-ordinates of one of the surfaces of wall, paddle or blocks. This way the reflection of the ball is achieved.

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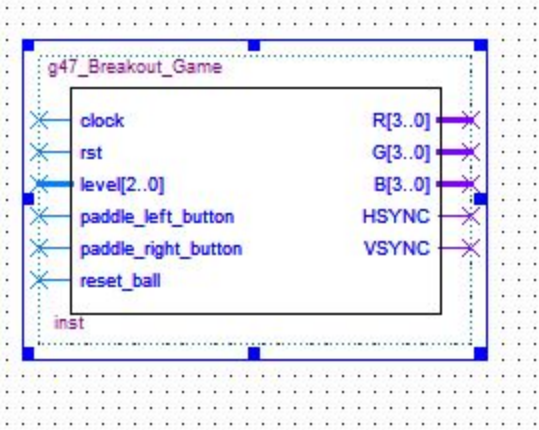


Fig 1 pinout diagram

Note: the image for the block diagram was too large hence we put it in a seperate jpeg file along with the report please refer to Rtl.jpeg.

Testing

All testing was done by seeing if the expected outcome was received on the monitor with the respective ball behaviour. The pictures from the test are given below.

Fig.2 Starting the game

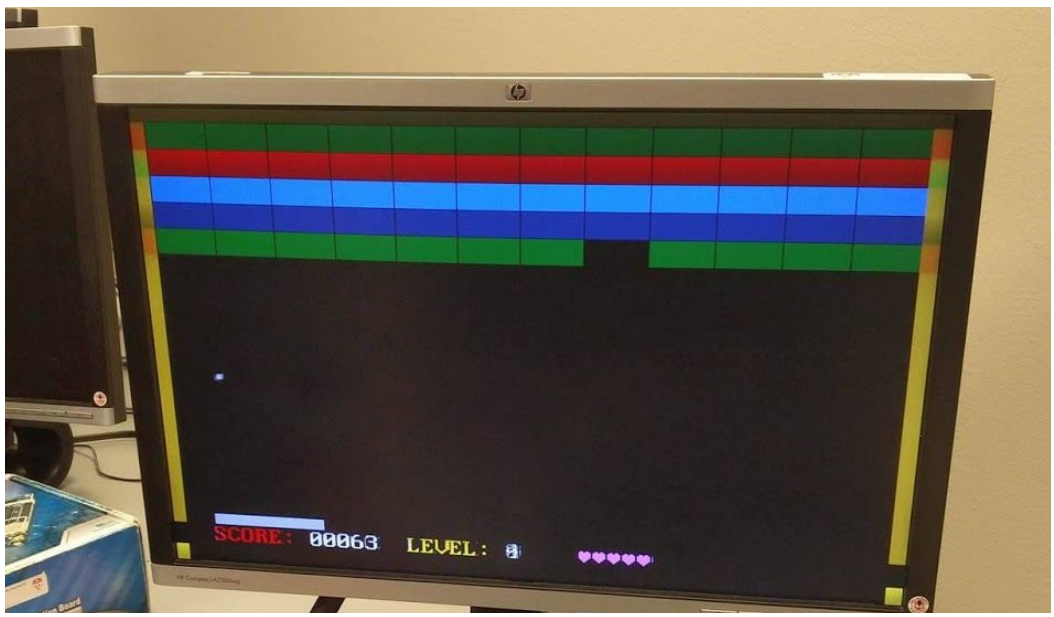


Fig.3 Breaking a block

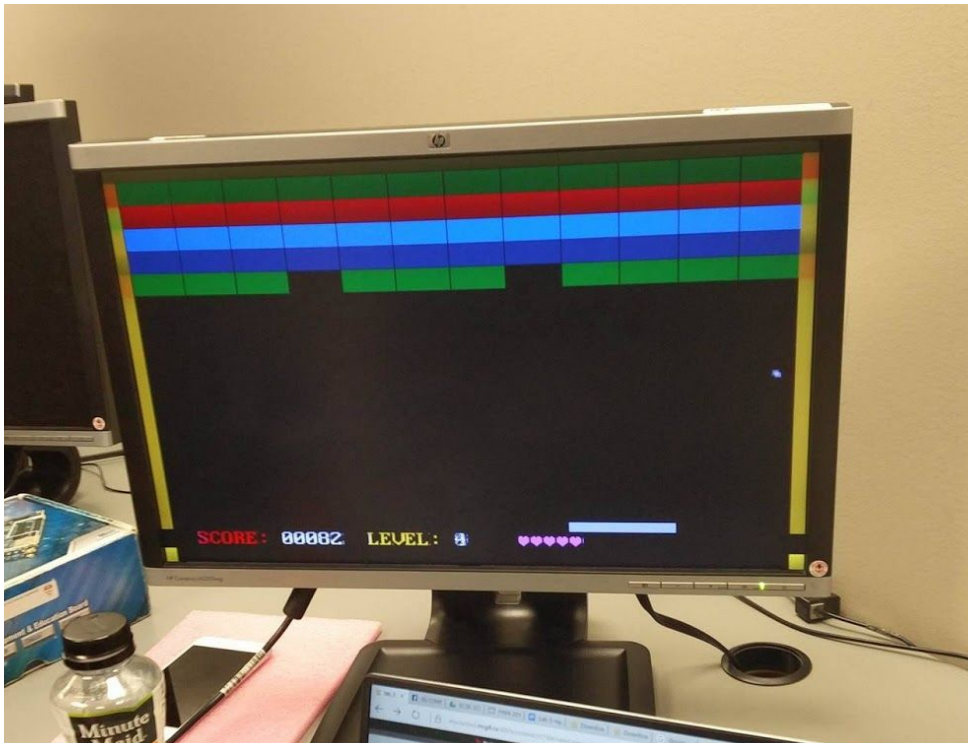


Fig.4 Reflecting off the right wall

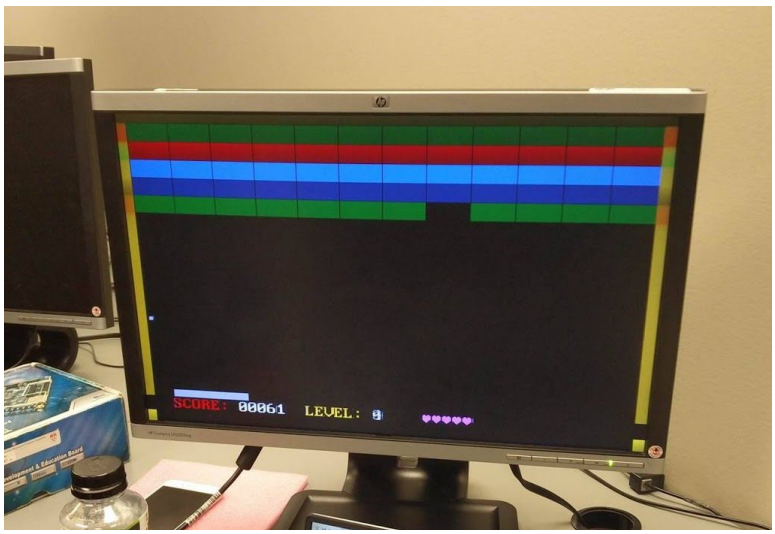


Fig. 5 Reflecting off the left wall

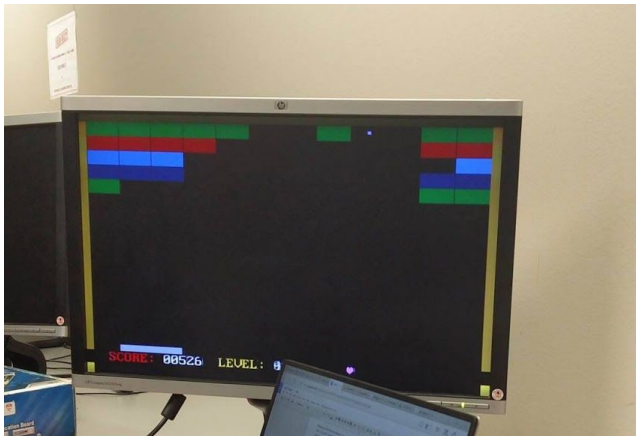


Fig. 6 Reflecting of the top wall

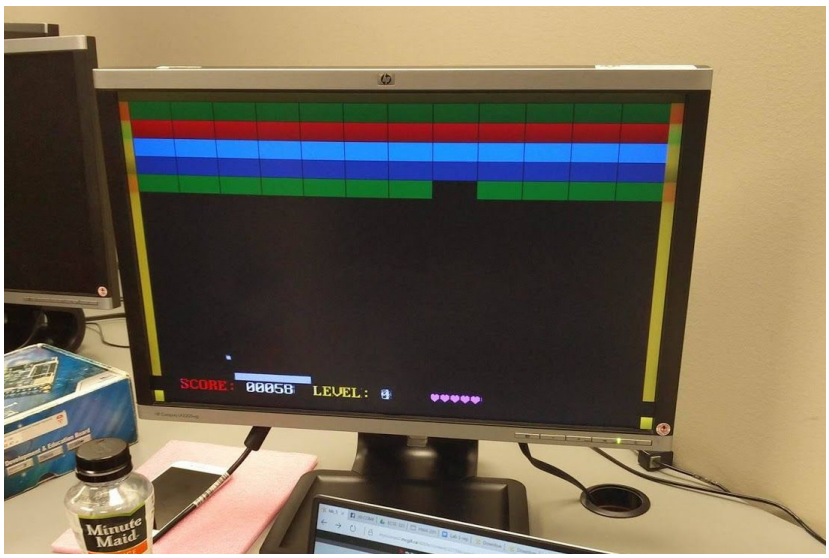


Fig.7 Reflecting of the paddle

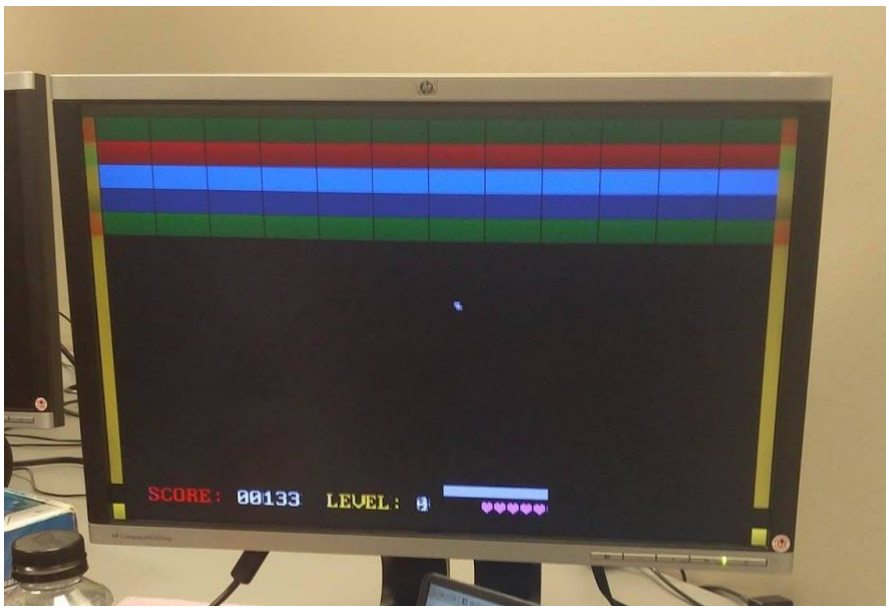


Fig.8 Before losing a life

Fig.9 After losing a life, the no of hearts decreases

User Interface

The user interface is simply the two buttons used to move the paddle as show in the picture below.

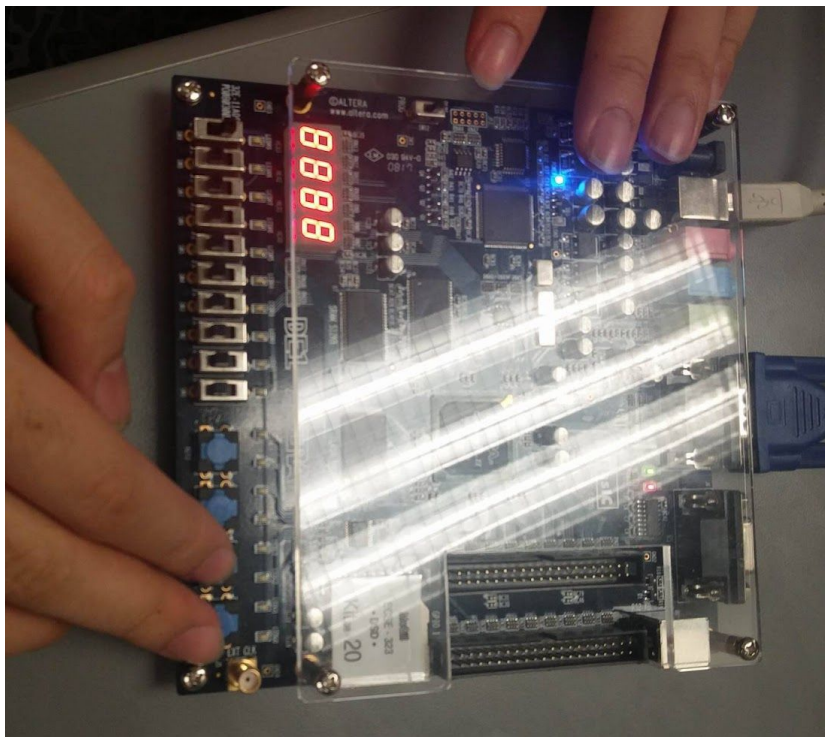


Fig.10 the two buttons used to control the paddle.

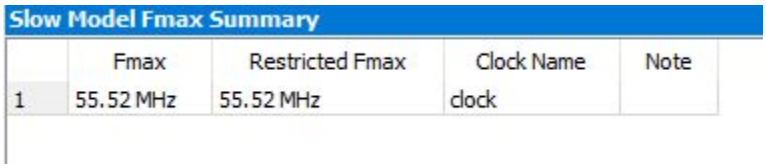
Summary of the FPGA resource utilization:

Flow Summary	
Flow Status	Successful - Mon Dec 05 20:58:56 2016
Quartus II 64-Bit Version	13.0.1 Build 232 06/12/2013 SP 1 SJ Full Version
Revision Name	g47_lab5
Top-level Entity Name	g47_Breakout_Game
Family	Cyclone II
Device	EP2C20F484C7
Timing Models	Final
Total logic elements	1,605 / 18,752 (9 %)
Total combinational functions	1,592 / 18,752 (8 %)
Dedicated logic registers	233 / 18,752 (1 %)
Total registers	233
Total pins	22 / 315 (7 %)
Total virtual pins	0
Total memory bits	16,384 / 239,616 (7 %)
Embedded Multiplier 9-bit elements	0 / 52 (0 %)
Total PLLs	0 / 4 (0 %)

Fig.11 Flow summary

Summary of the timing performance:

Fmax value is greater than 50 MHz (which is our clock speed). Slack for the fast model hold summary is positive but it is negative for the slow model setup, this caused some timing problems.



Slow Model Fmax Summary

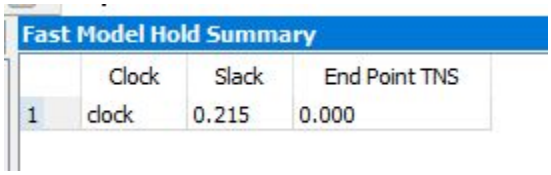
	Fmax	Restricted Fmax	Clock Name	Note
1	55.52 MHz	55.52 MHz	clock	

Fig.12 slow model Fmax

Slow Model Setup Summary

	Clock	Slack	End Point TNS
1	clock	-17.011	-2128.323

Fig.13 slow model setup



Fast Model Hold Summary

	Clock	Slack	End Point TNS
1	clock	0.215	0.000

Fig.14 fast model hold

Conclusion

Shortcomings and improvement

In conclusion, while each of the components work perfectly on their own, due to a lack of time certain features were not fully implemented or requires improvement. Those features are listed below:

1. The score does not increase when a block is broken. For now you only get points for staying alive
2. The game does not completely reset when all lives are lost, instead the game stops
3. Initially the ball starts off at the top left corner instead of the centre but this can fixed by using the rst input button once the game starts.
4. The level structure of the game can be improved upon.

We also faced some timing constraints that can seen above (Fig 13). Since we encountered negative slack, it can be seen on the output monitor in two instances. They are listed below:

1. The colors kind of mix where the blocks and border meet.
2. The current level value is pixelated.

Future enhancements made to the system should first address the above problems.

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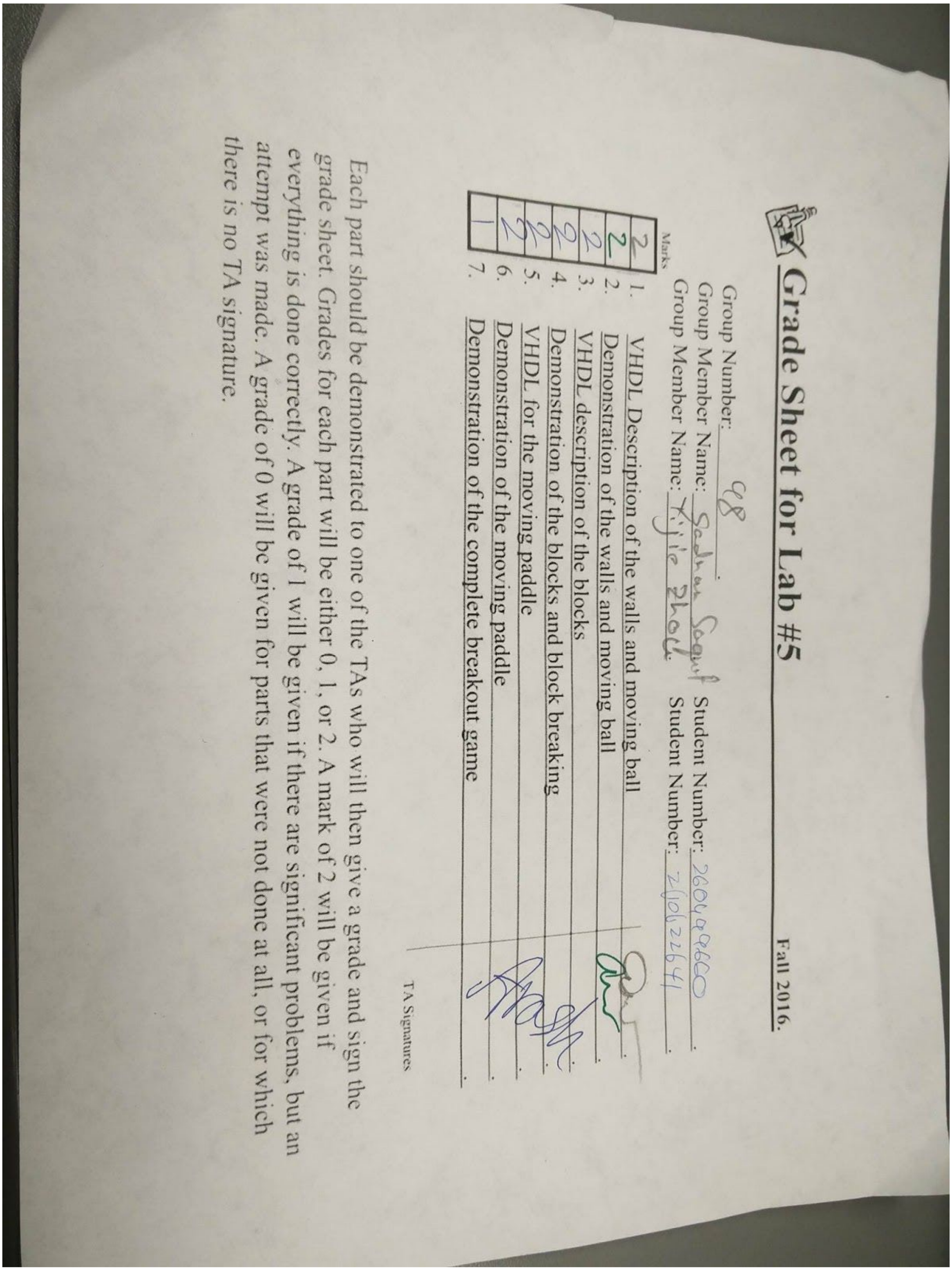

Grade Sheet for Lab #5

Fall 2016.

Group Number: 48

Group Member Name: Sadnan Saquif Student Number: 260499660

Group Member Name: Yijie Zhou Student Number: 260622641

Marks			TA Signatures
2	1.	VHDL Description of the walls and moving ball	
2	2.	Demonstration of the walls and moving ball	
2	3.	VHDL description of the blocks	
2	4.	Demonstration of the blocks and block breaking	
2	5.	VHDL for the moving paddle	
2	6.	Demonstration of the moving paddle	
1	7.	Demonstration of the complete breakout game	

Each part should be demonstrated to one of the TAs who will then give a grade and sign the grade sheet. Grades for each part will be either 0, 1, or 2. A mark of 2 will be given if everything is done correctly. A grade of 1 will be given if there are significant problems, but an attempt was made. A grade of 0 will be given for parts that were not done at all, or for which there is no TA signature.