

## The Rules of Collegiate Mechatronic Football

This document sets forth rules of the game of Collegiate Mechatronic Football for the Spring 2010 game. All Rules and Guidelines are subject to change at any time at the discretion of the Commissioners and course instructors.

### A. Players and Teams

1. The game is played by two opposing Teams the Blue Team and Gold Team, each consisting of up to 11 remotely controlled mechatronic machines, referred to as Players.
2. No more than 8 Players from a Team are allowed on the playing field during a play, i.e. the game is 8-on-8. A 1-point delay of game penalty is assessed against the Team with an excess of Players on the field at the beginning of a play.
3. A Team is required maintain a minimum of 5 functioning Players on the field. Failure to do so results in a forfeiture of the game by the offending Team.
4. Humans are not allowed to touch any of the Players on the field of play, except for one individual from the Offensive Team who will be allowed to:
  - a. place the ball on the Center before an offensive play, and
  - b. place the ball in the kicking tee before a kicking play.This individual is not allowed to touch any other Player on the field and can touch the Center/Kicker only to place the ball. Positioning the Center/Kicker is not allowed. A violation results in an interference penalty of 20 ft. This person does not have to be off the field within the 25-second clock, but must make a sincere effort to do so.
5. Locomotion of Players must be DC powered, with a 24v maximum circuit voltage. Other stored energy sources can be used to power Player accessories, but any non-DC power source must be approved and inspected by the Commissioners or their representatives prior to use during competition. Any lead acid batteries must be sealed.
6. Players must have a kill-switch mounted externally to their top surface. When activated, the switch should disconnect the main power to the system. Additional details are provided in the Technical Appendix.
7. No Player can weigh more than 25 pounds. An exception is the Kicker as detailed in subsequent rules.
8. A coin toss before the game determines initial possession. Each Team will designate one individual as the Captain. The Captain will be present for the coin toss.
9. Each Team will designate one individual as the Coach. The Coach will act as the sole representative of the Team in all communications with the Referees.
10. Teams may substitute Players between plays and during time outs.
11. Trainers can remove a damaged Player from the field between plays, but once touched by a human, that Player cannot participate in the next play unless the team calls a time out.
12. All Players will be positioned on the field by remote control using the controllers provided by the Commissioners. Teams may modify their remote controllers as they see fit; however, they cannot interfere with the signals broadcast from the opposing Team *if* the opposing Team has not modified their controllers. Additional details are provided in the Technical Appendix.

13. Players must incorporate a microprocessor in some significant fashion. Additional details provided in the Technical Appendix. Embedded intelligence and autonomous actions by Players are strongly encouraged.
14. The Commissioners will provide each Team with 11 sensors that will be used to indicate if an upsetting event (knockdown, fall down, or tackle) has occurred. The sensor is a digital accelerometer. The code that determines whether an upsetting event has occurred, based on the accelerometer's output, will be provided to each Team. Additional details are provided in the Technical Appendix.
15. The Commissioners will provide each Team with a single multi-color, high-intensity LED light that is used to indicate Player status. During normal play, each Player on the field for a given team will display a designated color for identification and status. Additional details are provided in the Technical Appendix.
16. The Team will design and fabricate/purchase a diffusion lens to fit on the LED light holder. The light holders and diffusion lens must be mounted so as to avoid damage to the holder and lens as a result of impacts between Players and to make them visible from any direction. Additional details are provided in the Technical Appendix.
17. When the sensor detects an upsetting event, it will signal the lighting system to turn RED for 2 seconds and provide a signal to the Player's microprocessor to remove power from the Player's drive system for 2 seconds. The sensor must be rigidly mounted in a horizontal orientation to a horizontal interior surface of each Player's base plate in a manner that enables a trainer to manually activate the reset button on the sensor within 10 seconds and a cable to be attached to reload the sensor software within 1 minute. Details of the mounting requirements are in the Technical Appendix.
18. A Player cannot take the field if it:
  - a. is judged by the referee to have a malfunctioning upset-event sensor, or
  - b. does not provide the 2 second immobilization upon occurrence of an upset-event.
19. A Player in possession of the ball is tackled when the upset-event sensor is activated.
20. At their discretion, the Referees may verify that any Player has a functioning upset-event sensor at any dead ball. If a ball carrier goes out of bounds or into the endzone and the Referees determine immediately afterward that the upset-event sensor is not functioning properly, a 15-foot penalty and loss of down will be assessed. For non ball carriers, the penalty will be just the 15-foot penalty without loss of down.
21. A Player's base plate must be solid and made of HDPE not thinner than ½ inch. A reasonable number of clearance holes for component mounts, component clearance, fasteners and wires are allowed. The outside of the base plate must be completely ringed with a bumper (specifications in the Technical Appendix) that can be directly contacted from any horizontal direction by another Player's bumper-covered base plate. This requires that no fixed/permanent part of a Player may protrude beyond a vertical prism projected up and down from the base plate's bumper. For example, any fasteners mounting the bumper to the perimeter of the base plate will need to be countersunk. Nonconforming Players, except the kicker, cannot take the field.
22. Stiff-arming is not allowed. Violation of this rule results in stoppage of play, loss of down and 15 feet. Stiff-arming is defined as the deployment of any material beyond the perimeter of the base plate that impedes the ability of a opponent to contact a Player's base plate and thus block or tackle a Player. If an appendage is deployed by a Player who is carrying the ball, upon simple contact by an opponent with the deployed appendage, the referee will call a touch-tackle and the play will be dead and the penalty enforced.

23. The centerline of a Player's base plate must be located  $3.0 \pm 1$  inches above the playing surface and remain in that position at all times. This distance can be measured at any point during play by a referee, and if the Player is out of tolerance, the Player is no longer eligible to play.
24. There are no restrictions on the shape of a base plate or Player, but all Players, except the Quarterback, must fit within a 16 inch square, 24 inch tall box at the beginning of any play. Only the Quarterback may reach out from beyond this footprint before a play, and only to take the ball from the Center.
25. Tires must be mounted on rigid, solid, wheels. Plastic is an acceptable material. Foam tires are allowed, but they can be no thicker than 1/2 inch and no softer than 30 Shore. Pneumatic tires are not allowed. Suspensions and shock absorbing systems are not permitted.
26. Players must be readily identifiable from the sidelines as a member of their Team and have visible numbers.
27. Players can have no more than 2 extensible arms consisting only of rotational joints. Each arm may extend no more than 18 inches in any direction from the center of the joint at which it connects to the player. Arms may have cross sectional dimensions no greater than 3 inches, except for the terminus of the arm, considered to be its final 4 inches, which may have a cross sectional dimension no greater than 5 inches. Cross sectional dimensions of arms containing any flexible materials like fabric or netting are measured with the materials fully stretched.
28. Each Team will develop a kicking Player/tee/system with which kicking is accomplished by striking the ball with a solid object. Stored mechanical energy may be used to power the device that kicks the ball. Requirements for the punting and place-kicking system (kickoff, field goal and point-after touchdown) are identical, and the same hardware can be used for either type of play. The kicking tee, upon which the ball can be manually placed, can elevate the lowest portion of the ball no more than 3 inches above the playing surface. The kicking tee may be an integral part of the kicking Player/system.
29. The kicking tee/system can be an attachment to another Player and, if it is, the 25lb weight limitation is waived for the composite device and that Player is then designated as a Kicker. A kicker can only advance the ball if it fully complies with all other Player requirements.
30. For any kicking play, the kicker must be positioned on the field by remote control, and once positioned, the ball can be placed on the kicking tee by the designated person designated in Rule A.5 as long as the person does not alter the kicker's position.
31. When a Team elects to either punt or kick a field goal, it must verbally notify the referee and opponent which action it is taking prior to the placement of the ball on the kicker/tee.

#### **B. The Playing Field, Player and Ball Positioning**

1. The game will be played in Stepan Center on a field 94 feet long and 50 feet wide, as shown in Figure 1. (Note that the roof of Stepan Center leaks and that all field dimensions are expressed in feet assuming a nominal tolerance of  $\pm 1$  ft.) End zones extend 15 feet past the goal lines. From end to end, the playing field is divided laterally into three equal sections 31.3 ft in length.
2. At the beginning of each half, after a Touchdown, and after a Field Goal, the Defending Team kicks off to the Receiving Team from the one-third field mark of their own territory. The clock is started and play is initiated when the Kicker contacts the ball.

3. A kick is caught by the first Player touching the kicked ball. If that Player can take possession of the ball, before being tackled by an opponent, the Player may advance the ball.
4. Prior to the ball passing the middle third of the field on the kick-off, only the Receiving Team may catch the kicked ball. After passing the middle third of the field, either Team can catch the kicked ball.
5. If a ball is kicked out of bounds, the Receiving Team has the option to: (1) take possession of the ball from the point on the field where the out of bounds occurred, or (2) take possession of the ball at the one-third field mark of their territory. If a ball is kicked into or past the End Zone, the Receiving Team takes possession of the ball at the one-third field mark of their territory.
6. A first down is realized when a one-third span (31.3 feet) of the field is covered within 4 plays.
7. The Referee initiates a kicking play of any kind by blowing a whistle. The Kicker cannot kick the ball earlier than 2 seconds after the initiation of the play. The penalty is a replay of the down and a loss of 15 feet.
8. The Team receiving the Punt will take possession at the point where one of its Players touches the punted ball. If that Player can take possession of the ball, before being tackled by an opponent, the ball may be advanced.
9. If a ball is punted out of bounds, the Receiving Team takes possession at the point of the field where the out of bounds occurred. If the ball comes to rest in the End Zone, or if the ball is punted out of the End Zone, the Receiving Team takes possession of the ball at the one-third field mark of their territory. The Receiving Team has the option of picking the ball up in the End Zone and advancing the ball.
10. A Player is considered out of bounds when any portion of its footprint crosses the inside of a sideline.
11. Each Team will have a sideline area on one-half of the field. See Figure 1. The direction of play will remain the same for the entire game, with Team's sideline area being on their offensive side of the line of scrimmage. Humans controlling the Players and engineers providing service to Players are restricted to this area except as noted in Rules B-22 and B-23.
12. Offensive Player controllers can enter the playing field between plays to facilitate positioning their Players on the line of scrimmage prior to the snap of the ball. A specially marked referee will stand on the stage-side hash mark, 15 feet from the line of scrimmage on the offensive side of the line of scrimmage. The offensive team human controllers who are on the field cannot move any closer to the line of scrimmage than the imaginary line indicated by this referee – the Controller Boundary. Doing so is a 1-point off-sides penalty.
13. Once the offensive Players are positioned, all but two of the offensive Player controllers must return to their sideline prior to the snap of the ball. Two offensive Player controllers may remain on the field during the play but must remain behind the Controller Boundary and between the hash marks for the entire play. If the Player with the ball or the ball itself approaches their location, they must make an obvious effort to retreat or leave the playing surface.
14. Defensive Player controllers are restricted to their designated sideline areas at all times.
15. No members of either Team are allowed on the Stage.
16. After each play, the Referee spots the forward progress of the ball with a pointed toe touching the ground. This is called a "toe-spot", and it marks the new line of scrimmage. If yardage was gained in the previous

play, the ball will be toe-spotted at the point of maximum forward progress of the ball. If yardage was lost, the ball will be toe-spotted at the point where the ball was located when the Player was tackled.

17. The Offensive Center will line up with its leading edge on the line of scrimmage as indicated by the Referee's toe-spot.
18. The ball will be toe-spotted on the hashmarks closest to the side of the field where the play ended. The hashmarks divide the field equally in the lateral direction. See Figure 2.
19. If a ball carrier loses control of the ball and the ball touches the ground, the ball is considered fumbled. The Team that first touches a fumbled ball gains possession. If the Player who touches the fumbled ball can take possession of the ball before being tackled by the opposition, that Player may advance the ball. If the Quarterback should drop the ball or cause the ball to fall to the ground from the Center, it is considered a fumble.

### **C. Game Timing**

1. The game consists of two 15-minute halves and a 10-minute halftime. Modified running time is used.
2. The Offense has 25 seconds, indicated by the play clock, from the time when the Referee toe-spots the ball to initiate a play. Failure to do so results in a 1 point delay of game penalty. The play clock is restarted.
3. Game clock stoppage occurs:
  - a. when the ball carrier steps out of bounds, or
  - b. after a play during which a penalty is called, or
  - c. when there is an incomplete pass,and the game clock restarts when the referee toe-spots the ball.
4. Game clock stoppage occurs when:
  - a. there is a change in ball possession, or
  - b. a dead-ball penalty is called, or
  - c. a Field Goal, Touchdown or Safety is achieved, or
  - d. a time out is calledand the game clock restarts with the beginning of the next play.
5. Referees may call an official time out at any time, for any purpose, and for any length of time. An example is to allow whatever time is necessary for trainers to remove an injured Player from the field.
6. Other than for kick-offs, punts and kicked PATs, a play is initiated the moment the Quarterback separates the ball from the Center.
7. Each Team is allowed 2 time outs per half. A time out can only be designated by the Team Coach by forming a T with his/her hands. Each time out is of 1 minute duration maximum. The 25-second play clock is started after the 1 minute time out has expired. If a Team calls a time out after all time outs have been used, that Team will be charged with a 1-pt delay of game penalty.
8. The game can end in a draw. No overtimes will be played.

### **D. Scoring Rules**

1. A Touchdown is worth 6 points.

2. A kicked Point After Touchdown (PAT) is spotted at the one-third field mark and is worth 2 points.
3. A PAT may also be run in, or passed in, and is then worth 1 point. If passed in, the completed pass has its own value as well. See pass scoring below.
4. A Field Goal is worth 5 points.
5. Forward passes can only be thrown from behind the line of scrimmage.
6. A completed forward pass of 5-15 feet beyond the line of scrimmage is worth 7 points. This is a *short pass*. If a *short pass* is intercepted, 2 points and possession of the ball are awarded to the defense.
7. A completed forward pass of more than 15 feet beyond the line of scrimmage is worth 12 points. This is a *long pass*. If a *long pass* is intercepted, 3 points and possession of the ball are awarded to the defense.
8. A completed forward pass of greater than 5 feet but to a Player that is not at least 5 feet beyond the line of scrimmage is worth 3 points. This is a *screen pass*. If a *screen pass* is intercepted, 1 point and the possession of the ball are awarded to the defense. Forward passes less than 5 feet can be completed/intercepted, but result in no score.
9. A ball downed in an Offensive Team's End Zone results in a Safety, with 2 points being awarded to the Defensive Team. The team charged with the Safety punts the ball from the one-third field mark of their territory. All rules regarding punting apply.

#### **E. Offense**

1. The game is played using the miniature souvenir football provided by the Commissioners. The ball may not be modified in any way and must be pressurized to a pressure within the range stated on the ball. Each Team will be given two game balls on game day. Each Offense may elect to use their own ball for their possessions. Referees may confirm that the ball is unaltered and properly inflated at any dead ball. Violations will result in a 15-foot penalty and loss of down.
2. A play initiated before the end of a half can extend beyond the half.
3. Only 1 Player in the backfield can be in motion at the snap of the ball, and that Player must be running parallel to, or away from, the line of scrimmage. More than 1 Player in the backfield can initially shift; however, all backfield Players must be set for 1 second before the Player goes in motion. Violation results in a 5-foot backfield in motion penalty from the original line of scrimmage.
4. All Players, including the linemen, are eligible to run down field and catch passes. Receivers can all line up on one side. There does not have to be a balanced wide receiver set.
5. The Quarterback must take the ball from the Center. The Center cannot transfer the ball to the Quarterback in any way.
6. The ball cannot be advanced while "contained" in a net, bag, or anything of the like. Any Player advancing the ball, except one preparing to pass the ball, must "hold" it in a manner that exposes 60% of the ball's surface area. From a reasonable perspective, a Referee on the field must be able to see 60% of the ball AND easily touch the same 60% of the ball with his/her fingers without touching the player. A play will be whistled dead at the location where a Player first violates this rule. A passing Player may only violate this rule to throw a pass. No rushing yardage can be gained by a passing Player who is "containing" rather than

“holding” the ball. The passing player must place the ball in a “held” configuration before advancing it by rushing.

7. A Pass is considered as caught or intercepted by a Player when that Player contacts the ball before the ball touches the ground. If that Player can take possession of the ball, before being tackled by an opponent, the Player can advance the ball.
8. A passed ball that touches the ground before touching a Player is an incomplete pass.
9. Reverse laterals, pitches, or passes are allowed. If a reverse lateral, reverse pitch, or reverse pass is incomplete, the ball is considered fumbled.
10. A Field Goal or kicked PAT is scored when the kicked ball crosses the goal line between the hashmarks before touching the ground.
11. If a Field Goal attempt outside the Defending Team's one-third field mark is missed, the Defending Team takes possession of the ball at the point of the Field Goal attempt. If a Field Goal attempt inside the Defending Team's one-third field mark is missed, the Defending Team takes possession of the ball at its one third field mark.

#### **F. Defense**

1. Full rush is allowed on every down.
2. “Bump and Run” on an offensive Player is allowed within 5 feet of the line of scrimmage. Beyond the 5 feet, there should be no *significant* (upsetting) contact between an offensive Player who is a potential pass receiver and a Defender. The Player guilty of initiating the contact will be charged with Offensive or Defensive pass interference.
3. A Player is considered tackled if it is in contact with other players and unable to move the ball in any direction within a 2 second period. This is known as “down due to lack of forward progress”.

#### **G. Offensive and Defensive Penalties**

1. Offended Teams may decline penalties. All distance penalties will be assessed as half the distance to the goal line in cases where that distance is less than the prescribed penalty.
2. There is a 4-inch neutral zone on either side of the line of scrimmage. The only Player allowed in the neutral zone before a play is initiated is the Offensive Center. A Lineman is offside when it breaks the neutral zone prior to the snap, even if no contact is made with the opponent. The penalty is a 1-point deduction from the offending team and a replay of the down.
3. When a Player makes contact with another Player in a manner that is not deemed by the Referees and Commissioners to be an attempt to knock the ball loose from the ball carrier, tackle the ball carrier, or block any other player, the offending player is guilty of a 30-foot “roughing” penalty. In the event of such a penalty, if the offended Player is damaged, it becomes the discretion of the Referees to either disable an equivalent Player on the offending Team or require the offending Team to forfeit the game. Players with deployable arms are responsible not to damage other players with those arms.
4. After releasing the ball, there may be no significant contact between the Defense and the passing Player as result of the motion of the defensive Player. The penalty is 30 feet for roughing the passer. If the passer is then damaged, the offending Team forfeits the Game.

5. The Offense and Defense are both required to have at least 4 Players on the line of scrimmage at the time of the snap. The 4 Players can be anywhere on the field laterally, as long as they are within 1 foot of the line of scrimmage. If either Team fails to have 4 Players on the line at the start of the play, a 1-point deduction delay of game penalty results.
6. Defensive pass interference will result in an automatic first down and 10-foot penalty marked from the spot of the foul. Offensive pass interference will result in a loss of down and 15-foot penalty marked from the original line of scrimmage.
7. Taunting or verbal abuse by humans will not be tolerated. First offense results in a warning to the individual. A second offense results in a 20-foot penalty for unsportsmanlike conduct. A third offense by the individual results in immediate ejection from the game.

Figures:

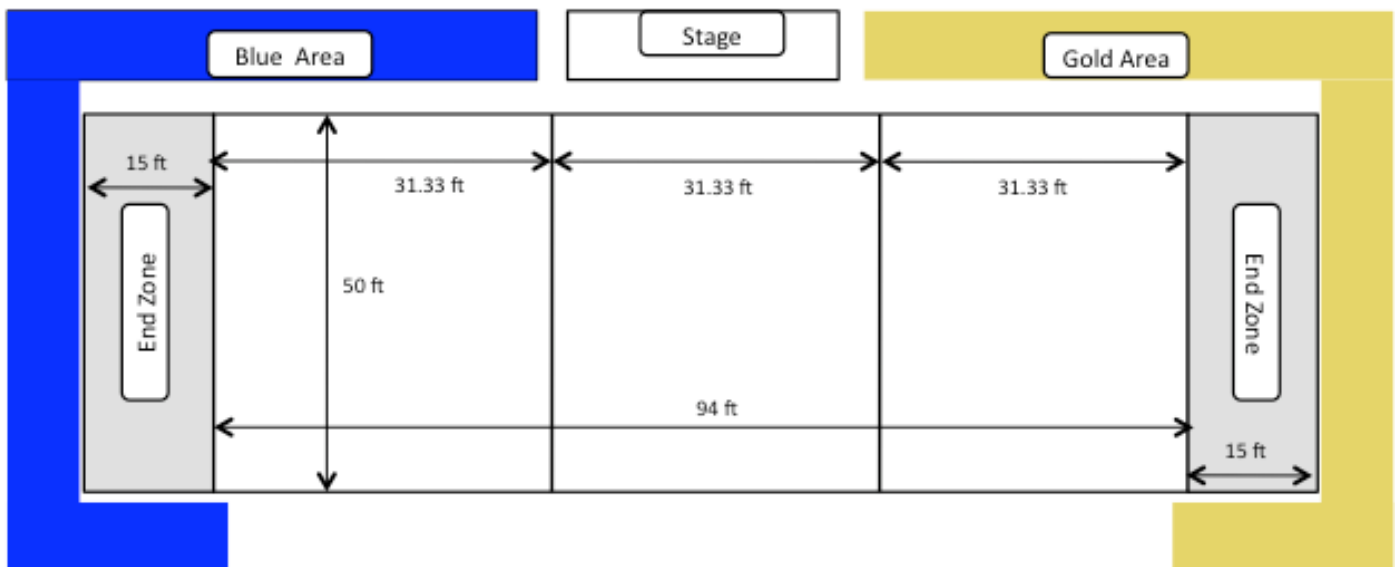


Figure 1: Playing Field Dimensions



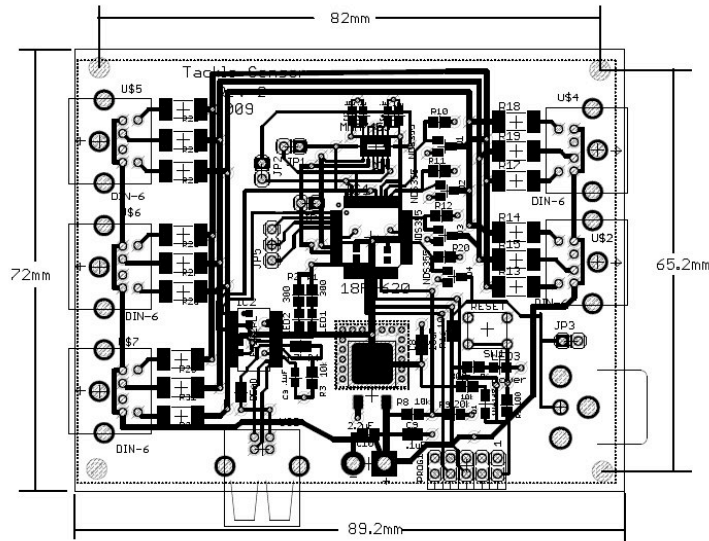
Figure 2: Hashmark Locations

## Technical Appendix:

The following items are AME40463 provided equipment for this project. The equipment will be provided but its proper installation and operation are the responsibility of the design groups. Mr. Brownell in the ISALL Lab will be a primary resource for electronics support.

### 1. Upset-Event (Knockdown – Fall down – Tackle) Sensor:

- The sensor is mounted on a printed circuit board and the circuit board must be rigidly attached to the Player's base plate in a horizontal fashion. The circuit board has ¼ inch standoff spacers attached, one at each corner, along with 4-40 nuts. The teams will have to supply 4-40 bolts to secure the circuit board to the base plate. No additional spacers may be used. The dimensions of the circuit board, along with the locations of the mounting holes are shown below.



### 2. LED status indicator holder and light:

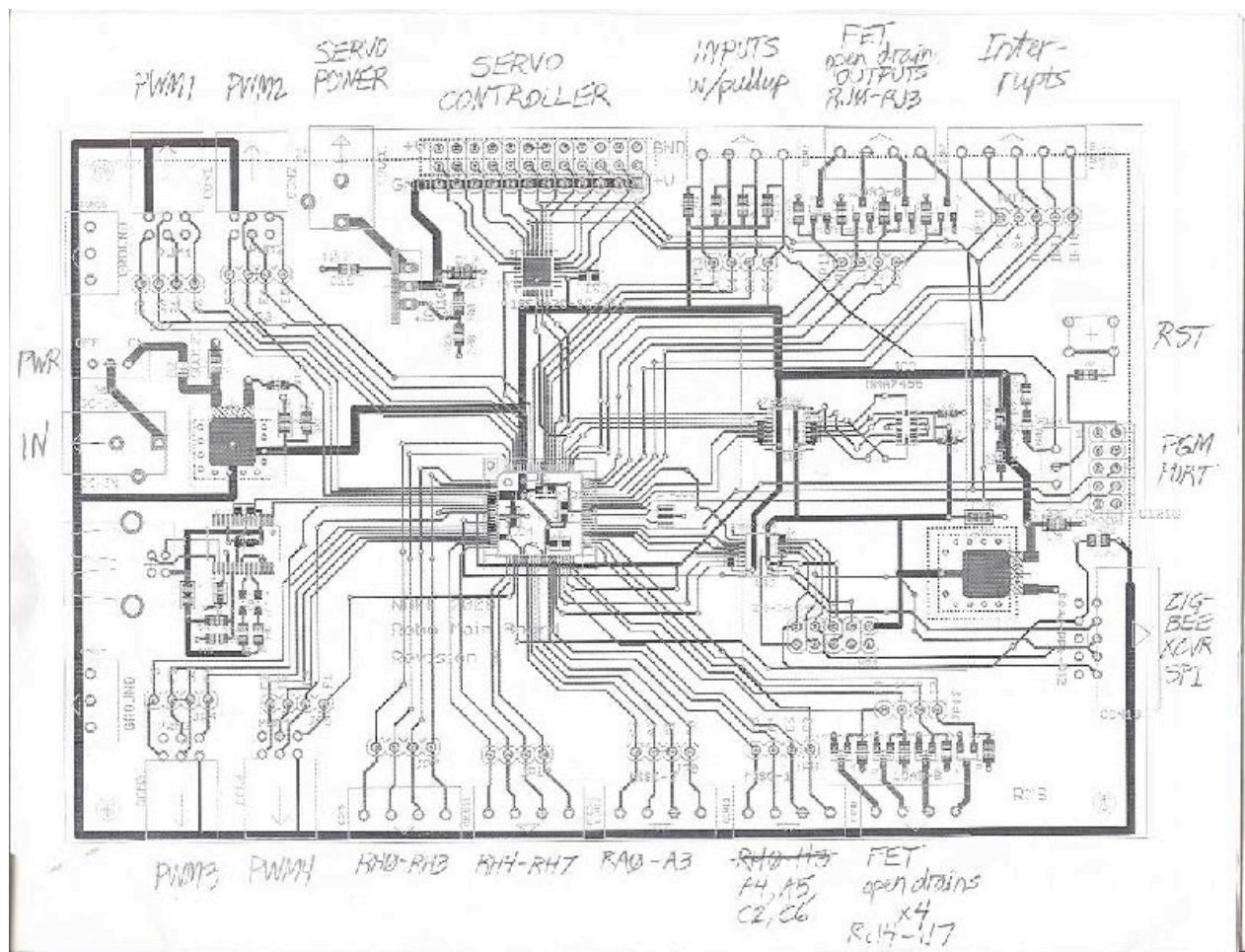
- The LED light holder must be mounted on top of the Player and be clearly visible from any viewpoint. Each light holder weighs 0.15 lb and generates 1.5W of heat. The weight of the light holder is to be included in the weight of the Player. For dimensions refer to the website, [www.tycoelectronics.com/catalog/bin/TE.Connect?C=1&M=BYPN&TCPN=2008675-1&RQPN=2008675-1](http://www.tycoelectronics.com/catalog/bin/TE.Connect?C=1&M=BYPN&TCPN=2008675-1&RQPN=2008675-1), which includes CAD models and product specifications.

### 3. Microprocessor:

- The microprocessor used in the transmitter is PIC18F4620 and in the receiver is PIC18F8722. Additional information and technical specifications can be found at <http://www.microchip.com/>.

### 4. Controller – Transmitter / Receiver:

- Code will be supplied, and the teams will need to change the numbers to match for each robot as well as the output channel designation. The layout for the controller is shown below.



Board: ZigBee Addresses for Robots and Remotes

Function:

Provide ZigBee address information for the transceivers in the remotes and the robots.

Description:

The transceivers used in the remotes and robots are Atmel part ATRF231. They are 802.15.4 compliant transceivers. (There is a difference between 802.15.4 and ZigBee, but here we will use ZigBee generically.)

ZigBee has 16 different channels, numbered 11 to 26. Each device is also assigned an address (we are using 16 bit addresses) and a PAN (Personal Area Network), also 16 bits.

Each team will have a PAN. The Gold team will use DDDD<sub>H</sub>, and the Blue team will use BBBB<sub>H</sub>.

The ZigBee transceivers are set up to do address recognition and filtering. With this enabled, the transceiver will only interrupt the processor when a packet arrives with the correct PAN and correct destination address.

Each robot will be assigned an address. This is a 16 bit address, and the upper byte will be the robot number. The lower byte will be 0.

Each remote will also be assigned an address. The upper byte will be the robot number the remote is controlling. The lower byte will be 1.

The channel number, the PAN, and Addresses are stored in the EEPROM that is integral to the microcontrollers on the boards. Upon reset, the software reads these values and sets the appropriate registers in the transceiver.

The EEPROM can be programmed when the microcontroller is programmed as follows:

```
//          chan  panl  panh    0-rob 1 = rem    rob#  
  
#pragma DATA _EEPROM, 0x0C, 0xDD, 0xDD,      1,      3
```

The above will set the channel to 0C<sub>H</sub>, the PAN to DDDD<sub>H</sub>, and the address to 0301<sub>H</sub>. Thus, this would be the remote that is communicating with robot board 3 on the Gold team.

The appropriate use of channels is a design challenge to be reconciled by the teams for each individual Player.

Details:

#### 1. Memory Map

This table gives the order of the information in the EEPROM memory.

Memory Location	Information	Format
0x00	Channel Number	11 <sub>D</sub> to 26 <sub>D</sub>
0x01	PAN (low order byte)	0x00 to 0xFF
0x02	PAN (high order byte)	0x00 to 0xFF
0x03	16 Bit address (low order byte)	0x00 to 0xFF
0x04	16 Bit address (high order byte)	0x00 to 0xFF

The following pieces of equipment are required team-provided items:

#### 1. Kill switch:

- a. It is recommended that you use a lever type battery cut-off switch made for automotive applications. The kill-switch must be readily identifiable and colored red. A good example can be found at <http://www.pegasusautoracing.com/productdetails.asp?ReclD=4913>.
- b. The switch cannot have a removable key, such as in the kill-switch found at <http://www.pegasusautoracing.com/productdetails.asp?RecID=1465>

2. Base-plate bumper material:

- This will consist of Extreme-Temperature Silicon Rubber in the shape of an “L”. The nominal wall thickness is 1/8 inch, and the nominal outside width and height are ¾ inch. The material can easily conform to different shapes. Each team will be required to purchase enough material for all of their Players. It can be purchased through McMaster-Carr using part number 3482K5. Additional information can be found at <http://www.mcmaster.com/#3482k5/=5fi7ck>.

3. LED Light Diffuser:

- A diffuser must be attached to each LED holder so the light can be seen from all sides of the Player. It is up to each team to design and fabricate/purchase a diffuser for each of their Players.