ME218b Smart Product Design

ME 218b Winter 2013 Project: Joustball
Jockeys On Unmanned Steeds Throwing Balls At Lords and Ladies

Project Preview on March 2, 2014 6-10PM in SPDL **Grading Session** on March 4, 2014 6-10PM
Project Presentations on March 5, 2014 in the Peterson Atrium starting at 7:00 PM

Goals:

The goal of this project is to provide you with an opportunity to apply your knowledge to solve an open-ended problem. The task is to design and build a machine that can play a challenging and fun-to-watch game against an opponent machine.

Purpose:

The underlying purpose of this project is to give you some experience in integrating all that you have learned. The avenue through which you will gain this experience is the design and implementation of an autonomous mobile robot that can compete in a game of skill and strategy against a machine constructed by another team from the class.

The Game:

The game is patterned loosely on an absurd mashup of Jousting and Nerf Battle. The object of the game is to unhorse your opponent by knocking them off their steed with a lance. You may also score points by hitting your opponent with thrown foam balls or throwing the same kind of foam ball into your opponents goal. Information about the state of the round will be made available to your robot.

Specifications

The Joust-Field:

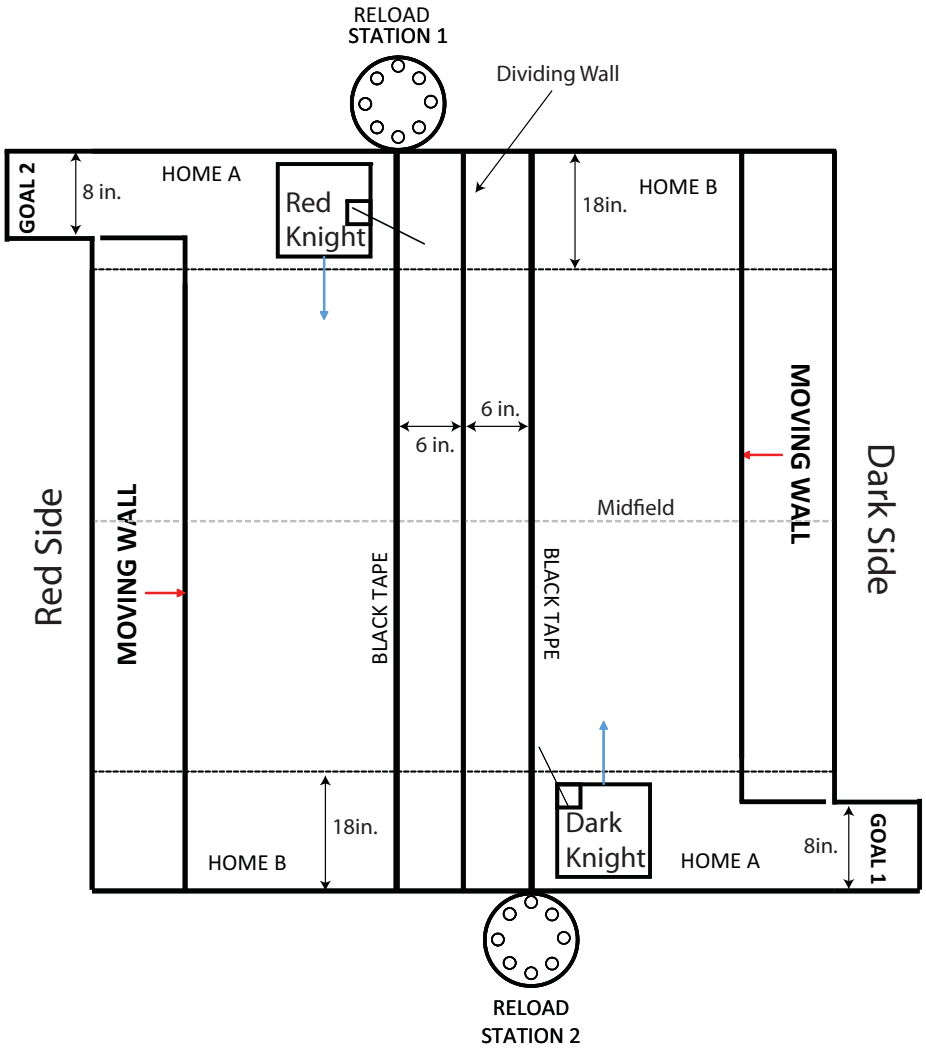
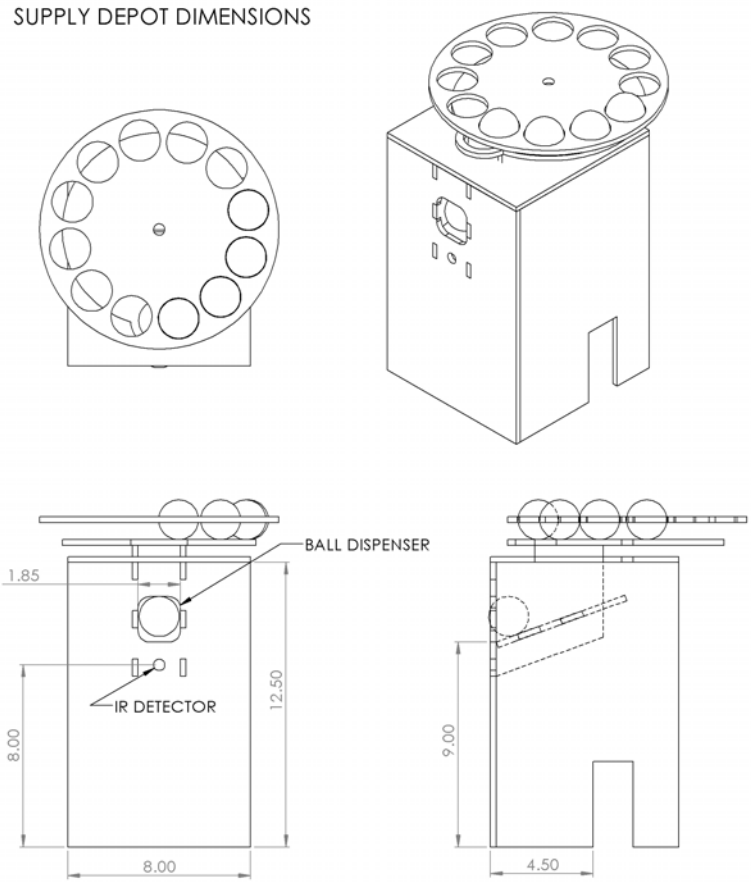


Fig. 1 The Playing Field

- ☐ The playing field is an 8'x8' area with exterior walls 3.5" tall and a center dividing wall, 5.5" tall.
- ☐ The center dividing wall will be mounted so that there is a 2" gap between the lower edge of the wall and the playing field below the wall.
- ☐ The Red Knight will start on the Red side. The Dark Knight will start on the Dark side.
- ☐ Each side will have a re-supply depot located with its center aligned with the guideline at the back wall of the Home A region for each side (as shown).
- ☐ Each side will have its own goal with an observation stage for the Lords and Ladies located above the goal opening. The width of the goal opening will be 8" with a height of 12"
- ☐ Each side will have a set of 1" black tape lines, as shown in Fig. 1. Beneath the black tape will be a wire carrying a 100mA current modulated by a sine wave at 20kHz.

The Re-Supply Depots:



- ☐ The re-supply depot will deliver a single ball each time its IR detector receives a series of 10 pulses with a 10ms (±0.1ms) on time and a 30ms (± 0.1ms) off time. While delivering these pulses the Knight must also illuminate a visible LED that is clearly visible to any observer.
- ☐ The time from request to physical delivery of the a ball may be as much as 3 sec. During this time, the 'bot may not request another ball.
- ☐ The IR detector at the re-supply depot will be mounted at a height of 8" off the playing surface.

The Joust Status Reporter:

- ☐ The Joust Status Reporter (JSR) will provide information to the Knight about the progress of the joust. This will include an indication of which round of the Joust is currently active (see Game Play).
- ☐ The JSR will communicate with your robot over a 4-wire SPI bus.
- ☐ The JSR will be recognized by and communicate wirelessly with the field infrastructure, so it must be mounted on the top-most level of your robot with no fixed structure above or surrounding it.
- ☐ A complete description of the Joust Status Reporter, from both an electrical and protocol standpoint, is included in a separate document that accompanies this project description.

The Knights:

- ☐ Your robot Knight must be a stand-alone entity, capable of meeting all specifications described in this document. Battery power is required. Your robot must execute from code on either (or both of) the ‘C32 and ‘E128.
- ☐ Robots will be numbered 1-19 corresponding to your team number.
- ☐ Robots must be autonomous and un-tethered.
- ☐ The only parts of the robot that may ever touch the playing field surface are wheels, ball transfers, or slippery supports used to balance the robot.
- ☐ When the Knight's lance is deployed, the longest distance between any 2 points on the Knight (including the deployed Lance), projected onto the horizontal plane, must not exceed a 24 inches.
- ☐ The JSR must be mounted so that the top surface of the JSR is horizontal and 12” off the playing field.
- ☐ The Knight must provide a flat surface at 12" off the playing field to carry the Knight's head.
- ☐ The Knight's head, provided by the SPDL staff, will be 4" in diameter, 6" tall, and carry an IR emitting beacon modulated at 1250Hz. Power source TBD
- ☐ If your robot shoots the foam balls, then the foam balls must exit your robot with a horizontal or above-horizontal trajectory, land no more than 6 feet from the robot and reach a peak height of no more than 3’ above the floor of the playing field. Foam balls may also be rolled across the surface of the field.
- ☐ Each robot will carry an easily accessible switch. The purpose of the switch will be to cut power to the ‘bot in case of a software or hardware malfunction.
- ☐ Each robot may carry a maximum of 5 balls at any time. Each robot will start a round loaded with up to 5 balls, as desired by your team.
- ☐ No part of your Knight, other than the lance and the head, may extend above the surface on which the JSR is mounted.
- ☐ Each Robot must be constructed as part of ME218b. It may not be based on a commercial or otherwise pre-existing platform.
- ☐ Any exterior corners on the robot must have a radius of at least 1/4".
- ☐ You are limited to an expenditure of **$200.00/ team** for all materials and parts used in the construction of your project. Materials from the lab kit or the Cabinet Of Freedom do not count against the limit, all other items count at their Fair Market Value.
- ☐ Each ‘bot must provide a clearly visible indicator when it thinks that the game is in progress. This indicator should be activated when the ‘bot determines that a Match has started and be de-activated when the game status indicates the end of the Match.
- ☐ The portion of the Lance that extends across the center wall must be made up of only the foam tube supplied by the SPDL. No stiffening of this material is allowed.

- [ ] The supplied motors must be used to drive anything that transfers force to the ground.

Game Play:

- [ ] The Match is a head-to-head contest between Knights as they attempt to score points by striking their opponent with a lance-blow, unhorsing their opponent, striking their opponent with foam balls and shooting foam balls into the opposing goal.
- [ ] Each Match will consist of three rounds in which the two Knights move between the regions labeled Home A and Home B in Fig. 1
- [ ] At the beginning of a Match, each Knight will be placed by a team member in the region called out as Home A on their side in Fig. 1.
- [ ] The Match will begin when a query to the JSR indicates that the game state has changed from "waiting for start' to "Pas d'Armes".
- [ ] When a round begins each Knight has a maximum of 30 seconds to move from their current position to the next destination attempting to score points as they move. The destination for round 1 is Home B, for round 2 it is Home A and for round 3 it is Home B.
- [ ] A round ends (and will be indicated by the JSR by a transition to Recess) when the first Knight completely enters its destination Home region or 30 seconds pass. This begins a brief recess period (no less than 10 seconds) during which the outer walls will be moved inwards.
- [ ] During recess no more points may be scored until the JSR indicates that the next round has begun however, moving and reloading are permitted.
- [ ] During the recess intervals between rounds, the outer walls of the playing field will be moved inwards toward the central wall creating a progressively narrow region in which the Knights may operate. The playing region will begin as 48" wide. As the outer walls are moved inwards (15" between each round), they will push any Knight whose position would be outside the new playing field width.
- [ ] A Knight may only reload at the end of round two and then only if the entire body of the Knight has passed the midfield line since the beginning of the match.
- [ ] The lance may only be deployed for a period of no more than 3 seconds at a time and must be retracted for a period of at least 1 second. A lance is retracted when the projected area onto the playing field of the lance is within the projected perimeter of the Knight.
- [ ] A Match ends at the end of the third round or when a Knight is unhorsed.
- [ ] In case of a tie at the end of a Match, a maximum 30 second sudden death round will determine the winner. If there is no change in score at the end of sudden death, both Knights are removed from the competition.
- [ ] If the score does not change throughout a Match, then both Knights are removed from the competition.

Scoring:

- [ ] Crossing into Home region first: **1 point**.
- [ ] Scoring a ball into the opposing team's goal: **2 Points**.
- [ ] Hitting your opponent with a foam ball: **2 Points.**
- [ ] Hitting your opponent with a lance blow: **10 Points.**
- [ ] Unhorsing your opponent: **25 points and the Match ends** (does not count as an additional lance blow).

Rules:

- [ ] No solder-less breadboards (proto-boards) are permitted in the final project.

- ☐ The only things allowed to cross or be propelled across the center wall are the SPDL supplied lance tip and foam balls.
- ☐ Each Robot must start and remain in one piece during the round. Any locomotion of the robot should cause all parts of the robots to move.
- ☐ Your Robot may not **IN ANY WAY** alter the condition (e.g. mar the walls or the floor) of the playing field or the foam balls.
- ☐ Intentional jamming of your opponent's senses is prohibited.

Safety:

- ☐ The Robots should be safe, both to the user and the spectators. The teaching staff reserves the right to disqualify any Robot considered unsafe. This also applies during testing, so keep the 'bot velocity and shooting velocity low enough so as not to cause problems.
- ☐ Robots must be stable in the presence of a 30MPH wind.
- ☐ No part of the machine may become ballistic. The foam balls are not part of your machine, but the Lance is.
- ☐ All liquids, gels and aerosols must be in three-ounce or smaller containers. All liquids, gels and aerosols must be placed in a single, quart-size, zip-top, clear plastic bag. Each 'bot can use only one, quart-size, zip-top, clear plastic bag.
- ☐ Robots may alter the Space-Time continuum only during the public presentations.

Check-Points

Design Review:

During the day on **02/11/14** we will conduct design reviews. A few teams at a time will meet with the teaching staff to present their ideas and get feedback on their proposals. Each group should prepare a **few** sheets of paper showing your idea(s). The focus should be on the overall design and how you are tackling what you think are the critical subsystems. These should be scanned into a no-frills PowerPoint file for projection. You will have 10 minutes to walk us through your ideas. The members of the other teams, the teaching staff, and coaches will be on hand to hear about your ideas and provide feedback and advice.

First Check-Point:

On **02/14/14**, you will turn in a set of Protel schematics, textual descriptions and software design documentation (including refined state chart) that describes the state of the design *at that point in time*. The designs need not be tested at this point, but must include designs to address all of the major subsystems. It must be turned in as soft copy. Only one team member needs to submit your checkpoint.

Second Check-Point:

On **02/19/14**, you must demonstrate your motorized platform moving under autonomous software control. Your platform must be able to drive forward and reverse (or turn and drive in the opposite direction) under software control.

Third Check-Point:

On **02/22/14**, you must demonstrate the integration of the JSR with your mobile platform and your robot's ability to communicate with the JSR to exercise all of the JSR's capabilities.

Fourth Check-Point:

On **02/26/14**, you must demonstrate your robot's ability to sense and locate the IR beacon on the goal and be able to shoot at the goal.

Project Preview:

At the Project Preview on **03/02/14**, each Robot must demonstrate (in an integrated form) 1) the ability to move under software control and 2) the ability to communicate with the JSR and 3) the ability to request a ball from the re-supply depot.

Grading Session:

During the **Grading Session on 03/04/14** each Robot will be required to demonstrate the ability to 1) correctly respond to the JSR; 2) Move within 30 sec. from a position in the Home A region to a position in the Home B region. 3) score by shooting a ball into the goal, 4) navigate to the re-supply depot, request and accept a ball from the re-supply depot; 5) locate and shoot at a static opponent; 6) deploy a lance and lance a static opponent. If your 'bot fails at its first attempt to demonstrate its ability, it must then demonstrate the ability two times in succession at its next attempt. These increases continue after repeated failed attempts to a maximum of 4 required successive demonstrations. This evaluation will take place a static opponent. Evaluation for grading purposes will occur only during these sessions. At the time of the grading session, you must submit a copy of the .S19 file that you run during the grading session to your Reports folder for archiving.

Public Presentation:

Will take place on **03/05/14** starting at 7pm in the Peterson Atrium.

Report:

Draft due on **03/10/14** at 4:00pm. Final version with revisions due by 5:00pm on **03/14/14**.

Evaluation

Performance Testing Procedures:

One or more of the team members will operate the Robots during the performance evaluation. A competition among the class's Robots will take place after the performance evaluation.

Performance Evaluation:

Performance evaluation will take place twice during the project duration, at the Project Preview and at the Grading Session. Everyone will participate at this level.

The Competition:

On the night of the public presentations, a tournament will be held. **Performance during the tournament has no impact on your grade**.

Grading Criteria:

- ☐ **Concept (10%)** This will be based on the technical merit of the design and coding for the machine. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware, software and use of physical principles in the solution.
- ☐ **Implementation (15%)** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will not presume to judge true aesthetics, but will concentrate on craftsmanship and finished appearance.
- ☐ **Check-Point Performance (10%) Based on demonstrating the required functionality at the checkpoints.**
- ☐ **Preliminary Performance (10%)** Based on the results of the performance testing during the **Project Preview.**
- ☐ **Performance (20%)** Based on the results of the performance testing during the **Grading Session**.
- ☐ **Coaches Evaluation (5%)** Evaluation by your coach: did you make use of their input before the design review and during the course of the project.

- [ ] **Report (20%)** This will be based on an evaluation of the written report. It will be judged on clarity of explanations, completeness and appropriateness of the documentation. The report should be in the form of a web site and must include schematics, pseudo-code, header & code listings, dimensioned sketches/drawings showing relative scale, a complete Bill-of-Materials (BOM) for the project as well as a 1 page description of function and a "Gems of Wisdom for future generations of 218ers" page. The web-site must be submitted as a single **Zip** file (The zipping software (7-zip) is installed on all the workstations in the lab). The only file types in your final report should be HTML (including style sheets if you choose), JPEG or other viewable image files and PDF files. Schematics should be PDF files, **not** bitmaps (PNG, JPEG, GIF, etc.). A bitmap place-holder with a link to a PDF is the best solution to readability. Do not include .doc, .docx, .xls, .xlsx or other files that require opening a separate application outside of the browser. **Do not embed video files** directly into your site. If you want to include video, link to a You-Tube or other video sharing site. It is critical that your report be in the Reports folder on time so that the peer reviewing team will have an adequate opportunity to review it before class the following day. Final versions of the reports, incorporating the review comments are due (also in the form of a single zip file) by 5:00pm on 03/14/14. The front page of your project description must be in a file called `index.html` at the root folder of the web site. Test your zip-file by unzipping it into an empty folder. Once un-zipped, you should be able to view the entire site starting from the `index.html` file. Make sure to test all of your links before submitting. If we can't simply unzip it and read it on our machines, then we can't grade it.

- [ ] **Report Review (10%)** These points will be awarded based on the thoroughness of your review of your partner team's report. Read the explanations, do they make sense? Review the circuits, do they look like they should work?

- [ ] **Housekeeping** Based on the timely return of SPDL components, cleanliness of group workstations as well as the overall cleanliness of the lab. No grades will be recorded for teams who have not returned the items borrowed from the SPDL, including but not limited to E128 & C32 boards, power supplies, tools....

Team Organization

While it may be tempting (as more efficient) to organize your teams around specialists who handle, for example, communications, sensing, motion, etc. I believe that in the long run this will be a mistake. I have heard from many 218 alumni who did this and reported that they were sad that they had because they didn't get, for example, communications experience. I would like to encourage you to remember that, first and foremost, the purpose of the project is to enhance your learning of the material. An organization that deeply involves all of the team members in the details of the design, implementation and debugging of all subsystems will not only provide a better learning experience, it will also prevent you from getting hung up during the integration and testing phase because the "expert" on that subsystem is not available.

ME218b Smart Product Design

Joust Status Reporter for ME 218b Project 2014

Rev 1 02/05/2014

Purpose:

The primary purpose of the Joust Status Reporter (JSR) is to act as a gateway to the field infrastructure to allow your robot to request information about the state of the jousting match. Data on the status of the match will be updated on the JSR from the field infrastructure at 10Hz.

Interface Connection

Connector:

The connector of the JSR is a 6-pin keyed Molex connector.

Pinout:

Pin	Name/Function
1	+5V (@ 100mA) / Power to the JSR (V_{dd})
2	SDI / Serial Data Into the JSR
3	SDO / Serial Data Out of the JSR
4	SCK / Serial Clock
5	SS / active low select line for the JSR
6	GND / Ground reference for the JSR

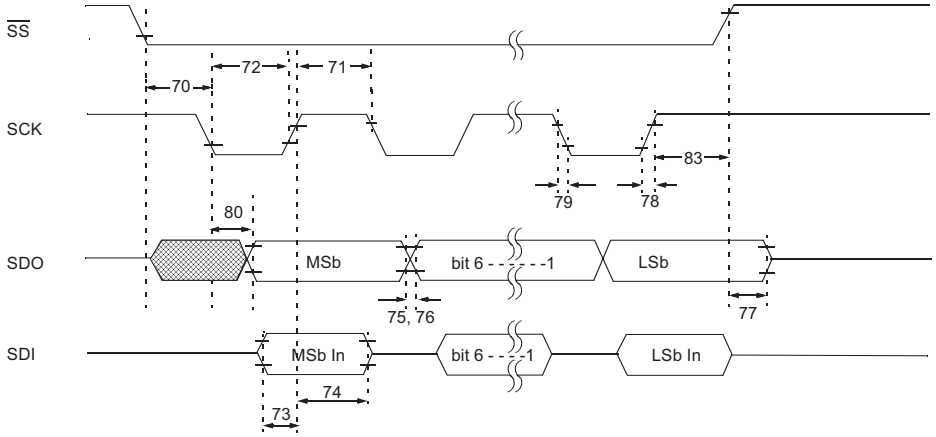
Electrical Specifications

Parameter	Min.	Max	Units
V_{iH}	V_{dd}*0.65		V
V_{oH}	V_{dd}-0.4		V
V_{iL}		V_{dd}*0.35	V
V_{oL}		0.4	V
$I_{iH,}$ I_{iL}		±1	µA
I_{oH}	-20		µA
I_{OL}	20		µA
All Specifications at V_{dd} = 5V			

Byte Transfer Specification

The Joust Status Reporter uses a synchronous serial signaling method to transfer data into and out of the JSR. The signaling method is compatible with SPI communications, with the JSR operating as a slave device on an SPI network. The $\overline{SS}$ line must be lowered (asserted) to begin a 4-byte (32 bit) transfer and raised at the completion of the 4-byte transfer. The $\overline{SS}$ line must remain de-asserted for a minimum of 2ms between transfers. The SDO line represents the serial data out of the JSR, while the SDI line represents serial data into the JSR.

The relationships between the four lines involved in the transfer of a byte are shown in the figure & table below:



Param No.	Symbol	Characteristic		Min	Typ	Max	Units	Conditions
70*	TssL2scH, TssL2scL	$\overline{SS}\downarrow$ to SCK$\downarrow$ or SCK$\uparrow$ input		TCY[a]	—	—	ns	
71*	TscH	SCK input high time (Slave mode)		TCY + 20	—	—	ns	
72*	TscL	SCK input low time (Slave mode)		TCY + 20	—	—	ns	
73*	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge		100	—	—	ns	
74*	TscH2diL, TscL2diL	Hold time of SDI data input to SCK edge		100	—	—	ns	
75*	TdoR	SDO data output rise time	3.0-5.5V	—	10	25	ns	
			2.0-5.5V	—	25	50	ns	
76*	TdoF	SDO data output fall time		—	10	25	ns	
77*	TssH2doZ	$\overline{SS}\uparrow$ to SDO output high-impedance		10	—	50	ns	
78*	TscR	SCK output rise time (Master mode)	3.0-5.5V	—	10	25	ns	
			2.0-5.5V	—	25	50	ns	
79*	TscF	SCK output fall time (Master mode)		—	10	25	ns	
80*	TscH2doV, TscL2doV	SDO data output valid after SCK edge	3.0-5.5V	—	—	50	ns	
			2.0-5.5V	—	—	145	ns	
83*	TscH2ssH, TscL2ssH	$\overline{SS}\uparrow$ after SCK edge		1.5TCY + 40	—	—	ns	

* These parameters are characterized but not tested. [a]Tcy = 33μS

Byte Level Protocol Specification

Common Byte Format:

Exchanges between the Joust Status Reporter (JSR) and your robot take place with four successive bytes being exchanged. The first byte from the robot to the JSR is the actual command. The value returned from the JSR during this transfer will be 0x00, but has no meaning. The values sent to the JSR as the second through fourth bytes of the sequence should always be 0x00. The meanings of the values returned by the second through fourth byte transfers will be the results from the command byte.

Robot to Joust Status Reporter Bytes:

The meaningful values for the command bytes from the robot to the Joust Status Reporter are shown in the following table:

Command	Meaning
0x3F	Return the status of the game.
0xC3	Return current score in the match.

Joust Status Reporter to Robot Bytes:

The values and meanings of the response bytes returned by the Joust Status Reporter are shown in the following table:

Command	Response Bytes	Description of meaning
0x3F	0xFF, 0x00, SS	SS = match status: Bits 0-2: 0x00 = waiting for start; 0x01 = Pas d'Armes (match underway), 0x03 = Recess (break for walls to move), 0x04 = entering sudden death; 0x05 = end of match; Bit 7: Your Knight's head status: set = unhorsed; Bit 6: Reload status set = allowed to re-load.
0xC3	0xFF, RR,DD	Score in the match: RR = score for Red Knight, DD = Score for Dark Knight

Query the Status of the Game:

To query the game status, send a byte of 0x3F to the JSR followed by 3 bytes of 0x00. The JSR will process the query and during the three 0x00 bytes of the exchange will return 0xFF, followed by 0x00 followed by the game status byte.

Query the Score:

To query the match score, send a byte of 0xC3 to the JSR followed by 3 bytes of 0x00. The JSR will process the query and during the three 0x00 bytes of the exchange will return 0xFF, followed by the Red Knight's score followed by the Dark Knight's score.

Power on and reset behavior:

Initially, after power on or a reset, the Joust Status Reporter will return 0xFF from any query until such time as the Forward Artillery Controller is internally initialized.

Command Timing:

The interval between two successive transfers from robot to Joust Status Reporter should be at least 2ms. The $\overline{SS}$ line must remain high for a minimum of 2ms between successive transfers.

Invalid Command Bytes:

If the Joust Status Reporter receives a command byte not listed in the table, it will respond to the invalid command byte by queuing a series of 0xFF bytes to be returned to the robot.

Sample Byte Sequence:

'Bot to JSR	0x3F	0x00	0x00	0x00	0x3F	0x00	0x00	0x00	0xC3	0x00	0x00	0x00
JSR to 'Bot	0x00	0xFF	0x00	0x00	0x00	0xFF	0x00	0x41	0x00	0xFF	0x0A	0x0B

In this sequence, the 'bot queries the game state(0x3F), which will return 0xFF, then 0x00 followed by 0x00 if the match has not started yet. The next query (0x3F) shows the result from a status request during active play when your 'bot is allowed to re-load. . The next query (0xC3) demonstrates requesting the score. The returned result indicates a score of Red = 10, Dark = 11.

Physical Specifications

Dimensions:

The Joust Status Reporter dimensions are 2" x 3" x 1".