11207: Mid-Range RF Module

Meeting Purpose:

1. Overview of the project
2. Confirm Customer Needs and Engineering Specifications
3. Review Concepts
4. Propose a design approach and confirm its functionality
5. Generate further ideas

Materials Reviewed:

1. Project Description
2. Customer Needs
3. Customer Specifications
4. Functional Decomposition
5. Risk Assessment
6. Project Plan
7. System Block Diagram
8. Concept Development and Proposed Design

Meeting Date: October 8, 2010

Meeting Location: 78-2150

Meeting Time: 12:30 – 2:00pm

Meeting Timeline	
Start Time	**Topic of Review**
12:30	Introduction
12:40	Customer Needs
12:50	Engineering Specifications
1:05	Functional Decomposition
1:15	Risk Assessment
1:25	Project Plan
1:35	System Block Diagram
1:45	Concept Development and Proposed Design

Team Members:

Ryan Toukatly (EE) – Project Manager

Peter Franz (EE) – Interface Manager

Trey Minarcin (EE)

Erwan Suteau (EE)

PROJECT MISSION STATEMENT

The mission of this project is to design and build a mid-range RF module that will be implemented into a wireless open-source/open-architecture command and control system (WOCCS). Within the WOCCS project family, this module will be responsible for transmitting and receiving analog data of the system over a mid range, which will be determined by the customer's likely application(s) and design team for efficient and effective technologies. The mid-range RF module will provide and receive an analog (RF) signal such as voltage, across a co-axial cable or antenna fitting to and from the digital baseband sub-module forming an RF modem. This rf module or modem will be housed in a mechanical packaging device built by the Wireless Components Housing Package (WCHP) team, and as a unit, will act as a modem for the Systems and Controls project track.

Project Information:

Project Name: *Mid-Range RF Module* Project Number: P11207 Project Track: *Systems and Controls* Project Family: *WOCCS* Parent Roadmap: *R10003* Planning Term: *2009-3* Start Term: *2010-1* End Term: *2010-2*	Faculty: Industry Guide: *Philip Bryan* Project Customer: *Dr. Edward Hensel* Project Sponsor: *Harris Corporation* Project Budget: *$5000/academic quarter** **SHARED BY ALL PROJECTS IN WOCCS FAMILY*

Customer Needs:

Customer Need #	Importance	Description
CN1	**9**	Realtime Transmission of Telemetry Data
CN2	**9**	Communication over Medium Distance
CN3	**9**	Able to Send/Receive Data from/to the other RF board
CN4	**9**	Multiple Communication Channels
CN5	**9**	Coexistence with other RF signals
CN6	**9**	Meets Communication Regulations
CN7	**3**	Low Power Consumption (board)
CN8	**1**	Compact Size
CN9	**1**	Light-weight
CN10	**3**	Easy to Use
CN11	**9**	Interchangeable with RF Boards
CN12	**3**	Long-lasting
CN13	**9**	Meets Environmental Regulations
CN14	**3**	Low Cost

Importance: 9 = High; 3 = Moderate; 1 = Low

Engineering Specifications:

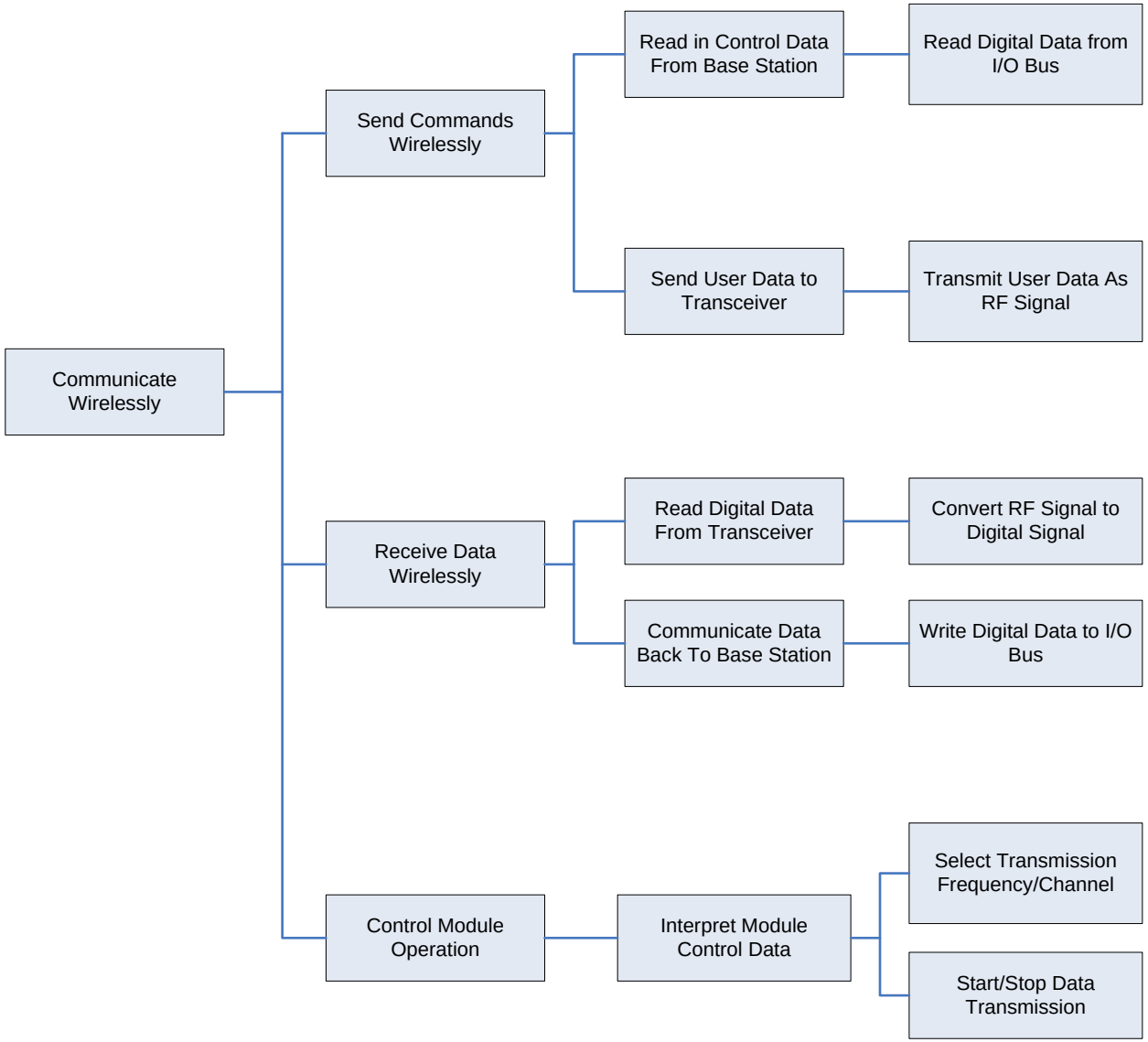
Engr. Spec #	Importance	Source	Specification Description	Unit	Min	Max	Comment/Status
			Wireless Transmission				
1	9	CN1	Data Rate of the Wireless Transmission	kbps	56		
2	9	CN2	Line of Sight Range	meters	200		
3	9	CN6	Use of industrial, scientific and medical (ISM) Radio Band	Boolean	Yes		
4	9	CN4	Number of Frequency Channels	Count	15		Allow multiple wireless systems to work at the same time
5	9	CN3	Number of Communicating Points	Count	2	2	Point to Point configuration between RF modules
6	3	CN5	Adjacent Channel Rejection	dB	20		Avoid Interference from adjacent channels
7	9	CN5	Use of a Protocol with techniques to allow coexistence	Boolean	Yes		Depends on the protocol - Possible techniques DSSS, FDMA, etc
			Low Power Consumption				
8	9	CN7	Printed Circuit Board Power	W		5	
			Dimension and Weight Requirements of the PCB				
9	9	CN8	Length	cm		9	
10	9	CN8	Width	cm		7	
11	3	CN8	Height	cm		3	
12	3	CN9	Weight	grams		300	
			Safety				
13	3	CN6	Specific Absorption Rate	W/kg		1.6	FCC Regulation in the USA
14	3	CN6	Protocols are compliant with FCC and IEEE standards	Boolean	Yes		
15	1	CN13	RoHS Compliant Parts	Boolean	Yes		
16	3	CN13	Withstandable Temperature	°C	-20	70	
17	1	CN13	Withstandable Relative Humidity	%		95	
18	3	CN12	Mean time between failures	Device Hours		3.00E+03	4 hours a day for 2 years
			Connection to other modules				
19	3	CN10	A few number of PCB Connectors	Count		3	
			Cost				
20	1	CN14	The device should not exceed allowable budget limit	$		100	

Importance: 9 = High; 3 = Moderate; 1 = Low

			Engineering Specifications																				
Number	Customer Need	Importance	Data Rate	LOS Range	ISM Band	Number of Frequency Channels	Number of Communication Points	Adjacent Channel Rejection	Coexistence Techniques	PCB Power	PCB Length	PCB Width	PCB Height	PCB Weight	Specific Absoption Rate	Compliant with FCC and IEEE	RoHS Compliant Parts	Withstandable Temperature	Withstandable Relative Humidity	Mean time between failures	Number of PCB Connectors	Allowable budget limit
CN1	Realtime Transmission of Telemetry Data	9	9																				
CN2	Communication over Medium Distance	9		9																			
CN3	Able to Send/Receive Data from/to the other RF board	9					9																
CN4	Multiple Communication Channels	9				9																	
CN5	Coexistence with other RF signals	9			3			9	6														
CN6	Meets Communication Regulations	9			3										6	9							
CN7	Low Power Consumption (board)	3								9													
CN8	Compact Size	1									9	9	9	1									
CN9	Light-weight	1									1	1	1	9									
CN10	Easy to Use	3																			9		
CN11	Interchangeable with RF Boards	9									3	3	3								3		
CN12	Long-lasting	3																3	3	9			
CN13	Meets Environmental Regulations	9															9						
CN14	Low Cost	3																				9	
	Specification Metric		>56 kbps	>200m	Yes	>= 15	2	>= 20dB	Yes	< 5 W	< 9 cm	< 7 cm	< 3 cm	< 300 g	<1.6W/kg	Yes	Yes	[-20, 70]°C	95%	3.00E3 device hours	<= 3	<= $100	
	Raw Score		81	81	54	81	81	81	54	27	37	37	37	10	54	81	81	9	9	27	54	27	
	Relative Weight		0.08	0.08	0.05	0.08	0.08	0.08	0.05	0.03	0.04	0.04	0.04	0.01	0.05	0.08	0.08	0.01	0.01	0.03	0.05	0.03	

Importance: 9 = High; 3 = Moderate; 1 = Low

Mid-Range RF Module
Functional Decomposition



Risk Table

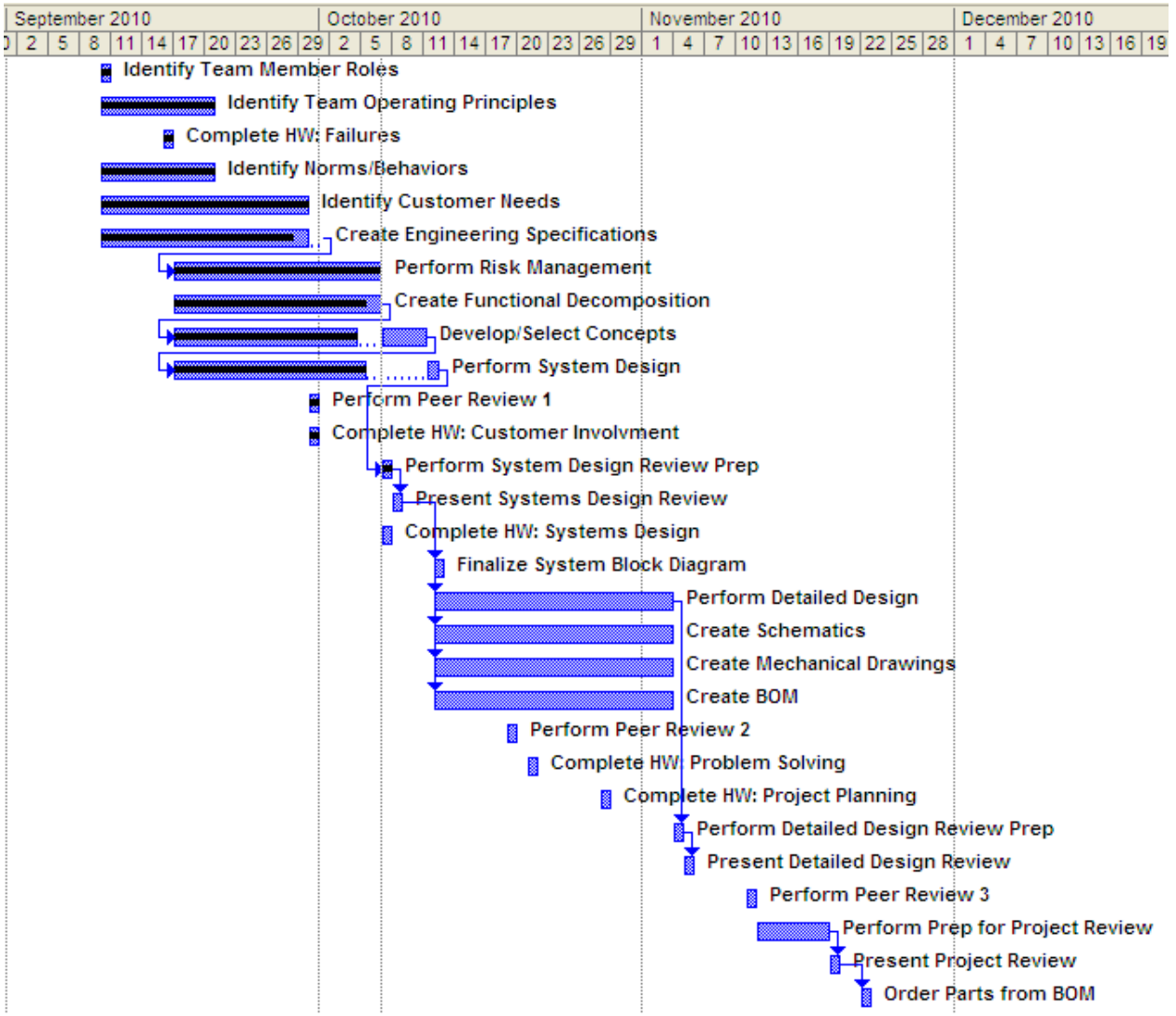
ID	Risk	Effects	Likelihood	Severity	Importance	Mitigation	Added
1	Data Transfer Rate Too Slow	Commands or data are missed or delayed, control glitches occur	**2**	**3**	**6**	Choose a protocol that operates at an acceptably high frequency	9/21/2010
2	Static Power Consumption Too High	Decreased battery and component life, increased temperature	**1**	**2**	**2**	Use efficient components, minimize circuitry, reduce power rails	9/21/2010
3	Board Doesn't Fit In Enclosure	Each board must be modified by hand, or remade	**2**	**3**	**6**	Strong communication with enclosure team, decide on definite board dimensions	9/21/2010
4	Board Connectors Misaligned	Each board must be modified by hand, or remade	**2**	**3**	**6**	Communicate with all other teams to agree on exact connector locations	9/21/2010
5	Board Is Too Heavy	End product is less mobile, more strain on user	**1**	**1**	**1**	Optimize/minimize circuitry, use compact parts, do not add unneccessary features	9/21/2010
6	Transmission Range Is Too Short	Transferred data is invalid (high BER), or signal is lost completely at mid-range	**3**	**3**	**9**	Transmit maximum allowable power, design for a longer range	9/21/2010
7	Board Fails To Meet Communication Regulations	User/producer could be fined if caught, not allowed to use board	**1**	**3**	**3**	Use only allowed frequencies, limit transmission power as specified	9/21/2010
8	Electromagnetic Interference between components	components are not functional or data is corrupted	**2**	**3**	**6**	Choose components that meet specs relating to EM noise	9/23/2010
9	Interference from outside sources	data is corrupted by outside noise	**2**	**2**	**4**	Make the module frequency selectable	9/23/2010
10	Team Member Absent	team has less contribution	**1**	**2**	**2**	Drink your fluids	9/30/2010
11	Team Runs Out of Time	Project unfinished	**2**	**3**	**6**	Keep Plan updated	10/6/2010
12	Late Arrival of Parts	Schedule is delayed	**2**	**2**	**4**	Communication with vendor	10/6/2010

13	Electronic Parts Generate Too Much Heat	Parts overheat and module is not reliable	1	3	3	Use low power components	10/6/2010
14	Requirements Change During Project	Project may need to be redesigned	1	3	3	Verify Requirements are feasable	10/6/2010
15	Module Not Functional After Assembly	May need redesign	3	3	9	Verify design through simulations and opinions of faculty	10/6/2010
16	Teammates do not Perform Assigned Work	Team will need to perform work	2	2	4	Ask for help from group when needed	10/6/2010
17	Teammates are not Prepared	Team schedule will be delayed	2	2	4	Assign tasks that are likely to be completed	10/6/2010
18	Miscommunication among Teammates	Confusion among objectives and lead to poor design	3	2	6	Ask detailed questions when there is confusion	10/6/2010
19	Miscommunication among Interface Groups	Confusion among objectives and lead to poor design	3	2	6	Ask detailed questions when there is confusion	10/6/2010
20	Arguments between Teammates	Hurt team morale and lead to unproductive work on design	1	3	3	Discussions must occur with minimal tension	10/6/2010
21	Battery Power is consumed too Quickly	Usage time will be lower than expected	1	3	3	Use low power components	10/6/2010
22	Components do not Fit on Board	Module not able to be assembled	2	3	6	Verify space on board through PCB layout	10/6/2010
23	Customer not Satisfied with Module	Project does not fit customer's needs	2	3	6	Communication with customer to ensure requirements are met	10/6/2010
24	Module Cost is Too High	Module not affordable	1	2	2	Use low cost components	10/6/2010
25	Errors in Electronic Schematic	Board will not function correctly (wrong connections)	1	3	3	Extensive schematic review, simulate as much as possible	10/7/2010
26	Errors in PCB Artwork	Board will not function correctly (wrong connections)	2	3	6	Extensive PCB layout review	10/7/2010
27	Parts Lost in Shipment	Cannot complete prototypes without all parts	1	3	3	Purchase insurance, give detailed shipping information	10/7/2010
28	Module cannot withstand Environmental Conditions	Module will fail in harsh environments	1	3	3	Use durable components	10/6/2010

Project Plan

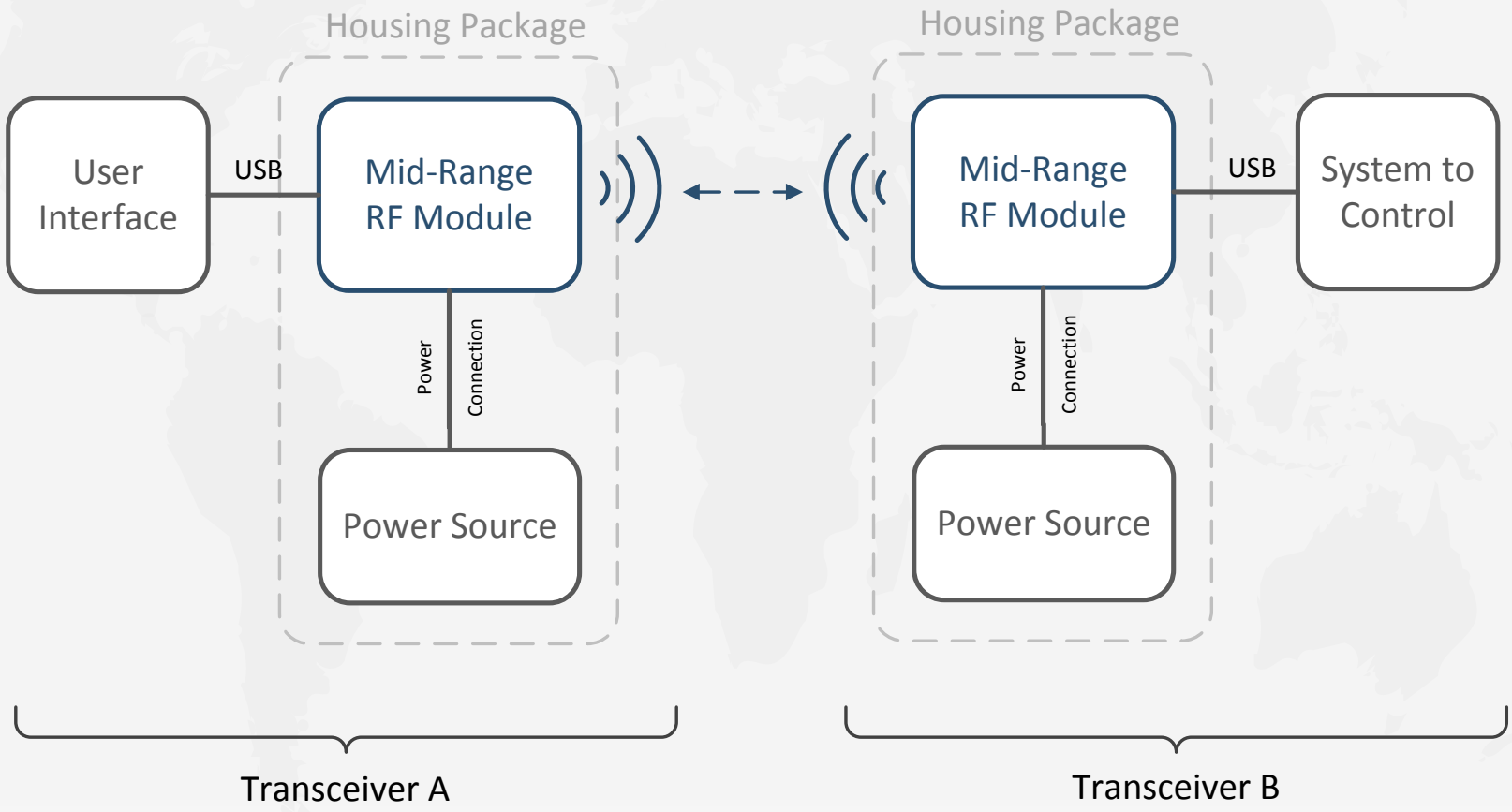
Number	Task	Length	Start Date	End Date	Dependency	% Complete
1	Identify Team Member Roles	1 day	9/10/2010	9/10/2010		100%
2	Identify Team Operating Principles	7 days	9/10/2010	9/20/2010		100%
3	Complete HW: Failures	1 day	9/16/2010	9/16/2010		100%
4	Identify Norms/Behaviors	7 days	9/10/2010	9/20/2010		100%
5	Identify Customer Needs	14 days	9/10/2010	9/29/2010		100%
6	Create Engineering Specifications	14 days	9/10/2010	10/1/2010		90%
7	Perform Risk Management	14 days	9/17/2010	10/6/2010	6	100%
8	Create Functional Decomposition	14 days	9/17/2010	10/6/2010		90%
9	Develop/Select Concepts	14 days	9/17/2010	10/6/2010	8	85%
10	Perform System Design	14 days	9/17/2010	10/6/2010	9	90%
11	Perform Peer Review 1	1 day	9/30/2010	9/30/2010		100%
12	Complete HW: Customer Involvment	1 day	9/30/2010	9/30/2010		100%
13	Perform System Design Review Prep	1 day	10/7/2010	10/7/2010	10	100%
14	Present Systems Design Review	1 day	10/8/2010	10/8/2010	13	0%
15	Complete HW: Systems Design	1 day	10/7/2010	10/7/2010		0%
16	Finalize System Block Diagram	1 day	10/12/2010	10/12/2010	14	0%
17	Perform Detailed Design	17 days	10/12/2010	11/3/2010	14	0%
18	Create Schematics	17 days	10/12/2010	11/3/2010	14	0%
19	Create Mechanical Drawings	17 days	10/12/2010	11/3/2010	14	0%
20	Create BOM	17 days	10/12/2010	11/3/2010	14	0%
21	Perform Peer Review 2	1 day	10/19/2010	10/19/2010		0%
22	Complete HW: Problem Solving	1 day	10/21/2010	10/21/2010		0%
23	Complete HW: Project Planning	1 day	10/28/2010	10/28/2010		0%
24	Perform Detailed Design Review Prep	1 day	11/4/2010	11/4/2010	17	0%
25	Present Detailed Design Review	1 day	11/5/2010	11/5/2010	24	0%
26	Perform Peer Review 3	1 day	11/11/2010	11/11/2010		0%
27	Perform Prep for Project Review	5 days	11/12/2010	11/18/2010		0%
28	Present Project Review	1 day	11/19/2010	11/19/2010	27	0%
29	Order Parts from BOM	1 day	11/22/2010	11/22/2010	28	0%

Gantt Chart


September 2010
October 2010
November 2010
December 2010
0 2 5 8 11 14 17 20 23 26 29 2 5 8 11 14 17 20 23 26 29 1 4 7 10 13 16 19 22 25 28 1 4 7 10 13 16 19
Identify Team Member Roles
Identify Team Operating Principles
Complete HW: Failures
Identify Norms/Behaviors
Identify Customer Needs
Create Engineering Specifications
Perform Risk Management
Create Functional Decomposition
Develop/Select Concepts
Perform System Design
Perform Peer Review 1
Complete HW: Customer Involvment
Perform System Design Review Prep
Present Systems Design Review
Complete HW: Systems Design
Finalize System Block Diagram
Perform Detailed Design
Create Schematics
Create Mechanical Drawings
Create BOM
Perform Peer Review 2
Complete HW: Problem Solving
Complete HW: Project Planning
Perform Detailed Design Review Prep
Present Detailed Design Review
Perform Peer Review 3
Perform Prep for Project Review
Present Project Review
Order Parts from BOM

MSD Team 11207 – High Level System Block Diagram

Thursday, October 07, 2010



Team 11207 – Initial Concept Generation

	Choices				
Function	**A**	**B**	**C**	**D**	**Advantage**
Transmission Type	RF Antenna	Infrared	Optical	Smoke Signals	Speed and distance wirelessly
User Data Protocol	USB	RS232	Firewire	Custom	USB - existing solutions and speed
RF Protocol	ZigBee	SimpliciTI	Bluetooth	Proprietary Protocol	Simple, point to point, high data rate
Visual Feedback	Status LEDs	Error Codes	JTAG	IMAX HD Widescreen Display	LEDs - simple to implement, easy to interpret
Physical Structure	PCB	Breadboard	Deadbug	-	Reliable, Durable

Concept Selection - Transmission Type

		A		B		C		D	
		RF Antenna		**Infrared**		**Optical (Light Patterns)**		**Smoke Signals**	
Selection Criteria	Weight	Rating	Notes	Rating	Notes	Rating	Notes	Rating	Notes
Range (approximate)	5	1	hundreds of meters	-1	meters	0	tens of meters	0	tens of meters
Cost	3	0	moderate	1	cheap	0	relatively cheap	-1	need to create and sense smoke
Reliability	4	1	signals can travel through obstacles	-1	must be in line of sight	-1	must be in line of sight	-1	must be in line of sight
Compactness	3	0	uses moderate board space	1	uses minimal board space (LEDs)	-1	need fairly large lights for distance	-1	need a mechanism to create smoke
Development Complexity	4	0	moderately complex	1	fairly easy to implement	-1	difficult to implement	-1	very little existing technology
	Sum +	2		3		0		0	
	Sum 0	3		0		2		1	
	Sum -	0		2		3		4	
	Total Score	2		1		-3		-4	
	Wtd Score	9		1		-11		-14	

Weight (Importance):	1	Low
	2	
	3	Moderate
	4	
	5	High

Concept Selection - User Data Protocol

		A		B		C		D	
		USB		**RS-232**		**FireWire**		**Custom Protocol**	
Selection Criteria	Weight	Rating	Notes	Rating	Notes	Rating	Notes	Rating	Notes
Data Rate	5	1	480 Mbps (Ver 2.0)	-1	20 kbps	1	400 Mbps	1	As fast as processor outputs
Ease of Development	3	0	USB converter chips exist	1	Relatively simple protocol	-1	Complex prorgamming required	-1	Must design pin protocol
User Friendliness	4	1	Standard, common cable	0	Standard but outdated	1	Relatively standard	-1	No standard, custom pinout
Physical Compactness	3	1	Miniature connectors available	-1	Large parallel connectors	0	Medium sized serial connectors	0	Medium parallel connectors
Future Compatability	2	1	USB is an active standard protocol	-1	A declining protocol	1	A developing protocol	-1	Requires maintenance and improvements
	Total +1	4		1		3		1	
	Total 0	1		1		1		1	
	Total -1	0		3		1		3	
	Raw Score	4		-2		2		-2	
	Wtd Score	14		-7		8		-4	

Weight (Importance):	1	Low
	2	
	3	Moderate
	4	
	5	High

Concept Selection - RF Protocol

		A		B		C	
		ZigBee		**SimplicTI**		**Bluetooth**	
Selection Criteria	Weight	Rating	Notes	Rating	Notes	Rating	Notes
Nominal Frequency	1	0	2.4 GHz	1	2.4 GHz or 433 MHz	0	2.4 GHz
Interference Concerns	3	0	Unlicensed ISM Band	0	Unlicensed ISM Band	0	Unlicensed ISM Band
Max Data Rate	5	1	250 kbps	1	500 kbps	1	3 Mbps (Ver 2)
Max Transmission Range	5	0	100m	1	300 m	-1	10 m
Number of Channels	2	-1	16	0	20	1	79
Max Output Power	4	0	1 mW	0	1 dBm	1	100 mW (Class 1)
Ease of Development	4	0	Designed for mesh network	1	Designed for point-to-point	-1	Small-range networks
Cost	3	-1	Medium-cost	0	Low-cost	0	Low-cost
	Sum +	1		4		3	
	Sum 0	5		4		3	
	Sum -	2		0		2	
	Total Score	-1		4		1	
	Wtd Score	0		15		2	

Weight (Importance):	1	Low
	2	
	3	Moderate
	4	
	5	High

Concept Selection - Visual Feedback

		A		B		C		D	
		Status LEDs		**Stored Error Codes**		**JTAG Feedback**		**IMAX HD Widescreen Display**	
Selection Criteria	Weight	Rating	Notes	Rating	Notes	Rating	Notes	Rating	Notes
Easy to Understand (User)	5	1	simple text labels	-1	require external code reader	-1	user needs JTAG hardware/software	1	large, clear indicators
Cost	3	1	very cheap	0	need storage (Flash, etc)	0	reader components required	-1	very expensive
Reliability	5	1	durable, long-lasting	0	reliable non-volatile memory	1	as reliable as processor	-1	complex and easy to damage
Compactness	3	1	minimal size	0	extra components required	0	requires JTAG connector	-1	very large
Development Complexity	3	1	easy to implement	-1	custom codes, external reader needed	-1	JTAG interface programming	-1	video output required
	Sum +	5		0		1		1	
	Sum 0	0		3		2		0	
	Sum -	0		2		2		4	
	Total Score	5		-2		-1		-3	
	Wtd Score	19		-8		-3		-9	

Weight (Importance):	1	Low
	2	
	3	Moderate
	4	
	5	High

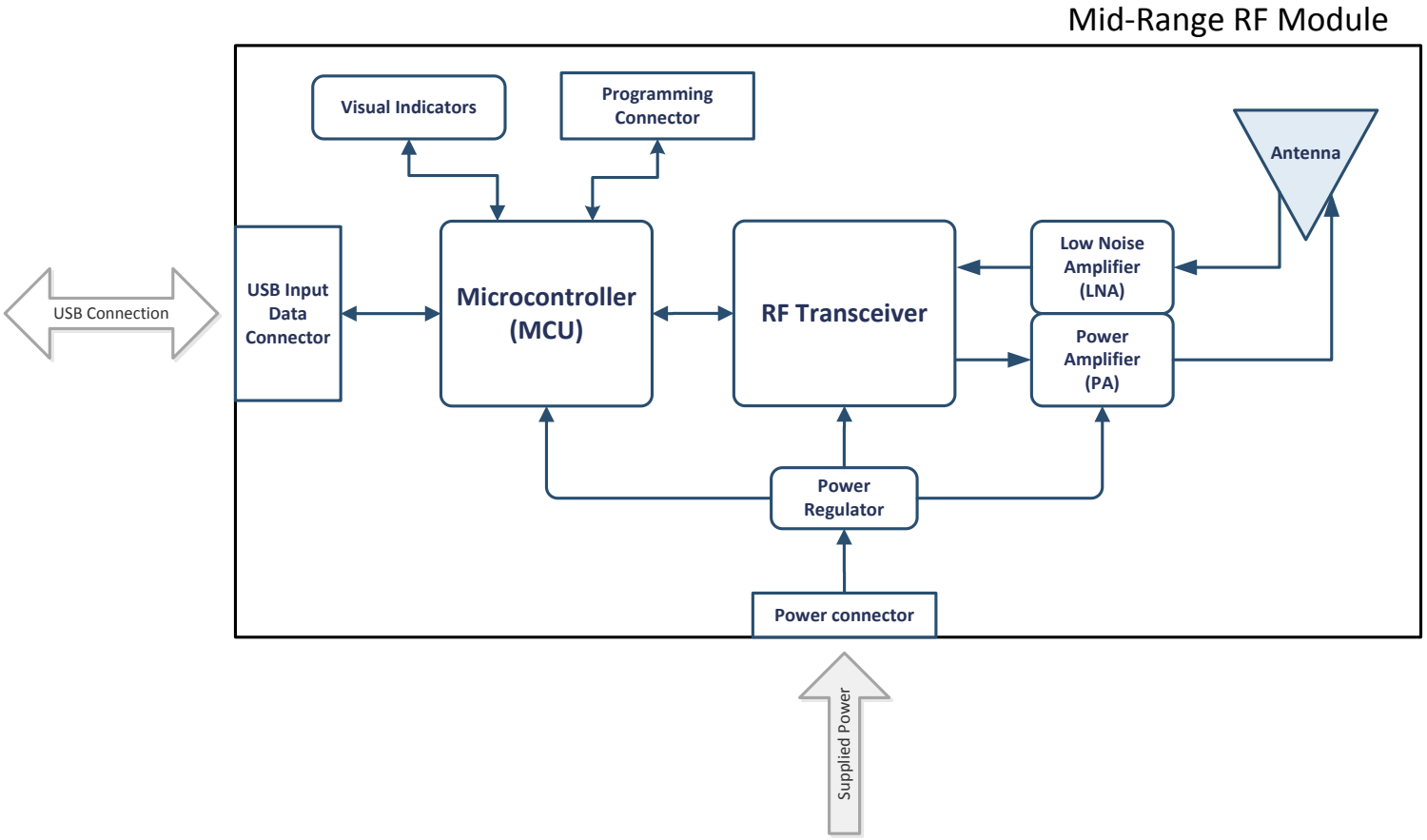
Concept Selection - Physical Structure

		A		B		C	
		Printed Circuit Board		**Breadboard**		**Deadbug**	
Selection Criteria	Weight	Rating	Notes	Rating	Notes	Rating	Notes
Cost	3	-1	higher cost to make	1	Cheap	1	no cost
Reliability	5	1	withstands movement	0	parts may come loose	-1	solder connections not reliable
Compactness	5	1	very compact	0	not as compact as PCB	-1	parts scattered
Layout Efficiency	3	1	board is organized	0	board can be unorganized, but is not complex	-1	floating parts, inefficent use of space
RF Reliability	4	1	board can be designed for RF	0	stray capacitances lead to RF interference	-1	loose wires create unreliable RF signals
	Sum +	4		1		1	
	Sum 0	0		4		0	
	Sum -	1		0		4	
	Total Score	3		1		-3	
	Wtd Score	14		3		-14	

Weight (Importance):	1	Low
	2	
	3	Moderate
	4	
	5	High

MSD Team 11207 – Module Block Diagram

Thursday, October 07, 2010



Further Actions

- Research Antenna types and respective ranges
  - PCB, Whip, Wire, microstrip
- Research Microcontrollers
  - compatibility with transceivers, data protocols
- Research Reception Distance at Different Frequencies
  - 2.4GHz, sub-1GHz, etc.
- After Selection:
  - Schematics, PCB layouts (MSD I)
  - Purchase Parts (MSD II)
  - Assembly (MSD II)
  - Test (MSD II)
  - Documentation (MSD I-II)