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November 1, 2002

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
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Re: ENSC 340 Project Functional Specifications of MicroTracker

Dear Dr. Rawicz:

Attached is the *Functional Specifications of MicroTracker*, which provides a list of functional requirements for our Engineering Science 340 Project.

We are presently in the design stage of our project. The MicroTracker is planned to include functions such as tracking tagged objects, notifying users of left behind items, and alarming users of emergency calls from the tags. The development of our project will be divided into two phases. The functions defined for phase 1 will be implemented in the demo prototype, while functions defined for phase 2 will be added, if time permits.

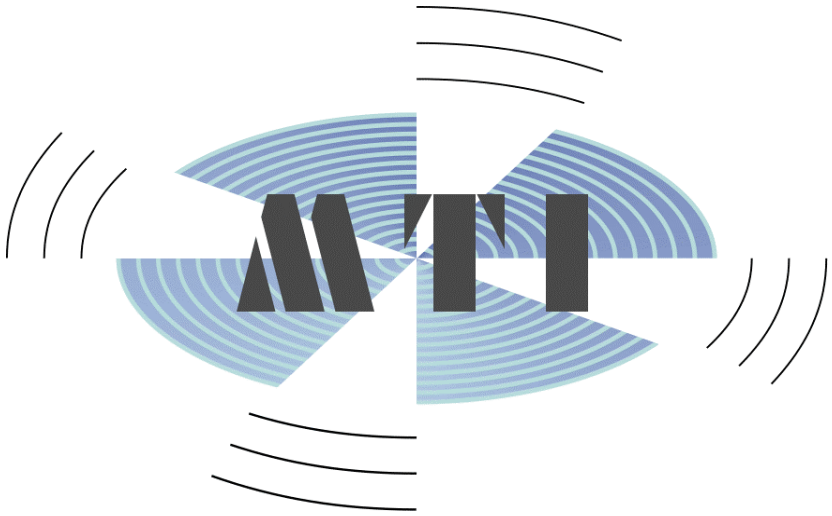
MicroTrak Inc. consists of five enthusiastic and dedicated, fourth-year engineering students: Lawrence Li, President and Chief Executive Officer; James Dykes, Chief Financial Officer; Victor Leung, Chief Operations Officer; Herman Lo, Chief Technology Officer; and Bernard Ng, Chief Hardware Engineer. If you have any questions, feel free to contact us at (604) 525-9185 or via email at 340-group@sfu.ca.

Sincerely,

Lawrence Li

Lawrence Li
President and CEO,
MicroTrak Inc.

Enclosure: *Functional Specifications of MicroTracker*



Functional Specifications of MicroTracker

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Submitted To:	**Dr. Andrew Rawicz - ENSC 340** **Steve Whitmore - ENSC 305** **School of Engineering Science** **Simon Fraser University**
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Revision:	**1.1**

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Executive Summary

In today's fast paced world, most of us suffer from information overload. As a result, we often forget where we place our belongings, such as wallets, lunch boxes, baggage, and jackets. To combat this problem, MicroTrak Inc. has come up with a simple, compact, and easy-to-use tracking device - MicroTracker. By attaching tags onto objects, users can located these objects using the tracker. Also, MicroTracker has the capability to alarm users of left behind items.

MicroTracker will be developed in two phases. Phase 1 of development includes building a tracker and two tags with the following key features:

- Compact
- Cost effective
- Maximum operating range of 400 feet
- Multiple alarm settings
- Selectable alarm activation range
- Separate range and alarm modes
- Voltage regulation
- Emergency button on tags
- Tag and tracker power status indicator
- Range indicator

In phase 2, the following features will be added to the device:

- A selective power down mode for power conservation
- A RF burst input to reactivate the system from power down mode
- Dual solar-battery powered for longer battery life
- Changeable tag mount
- Enhance the alarm mode to allow for automatic sweep of all tag frequencies associated with a tracker
- RFID compatible for supporting increased number of tags

A demo prototype will be completed by December 2002, with all phase 1 features implemented. Phase 2 features are optional to the demo prototype.

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1 Introduction

1.1 Scope

MicroTracker is a compact, handheld tracking device for locating multiple tags. This document discusses the general features, applications, functional specifications, limitations, standards, and test plan for the MicroTracker.

1.2 Acronyms

FSK	Frequency Shift Keying
LED	Light Emitted Diode
MHz	Megahertz
MTBF	Mean Time Between Failure
MTI	MicroTrak, Inc.
RF	Radio Frequency
RFID	Radio Frequency Identification
RSSI	Received Signal Strength Indicator
VSWR	Voltage Standing Wave Ratio

1.3 Referenced Documents

[1] Canadian Table of Frequency Allocations, 9 kHz to 275 GHz. Dated December, 2000. From Industry Canada's Spectrum Management and Telecommunications Policy.

[2] Connecterized ¼ wave Antennas. Linx Technologies.

[3] Data Guide: "Splatch" Planar Antennas. Linx Technologies.

[4] HP Series-II Evaluation Kit Data Guide. Linx Technologies.

[5] HP Series-II RF Reciever Module Design Guide. Linx Technologies.

[6] HP Series-II RF Transmitter Module Design Guide. Linx Technologies.

[7] Resource Document: Legal considerations for Linx products in operational areas governed by the Federal Communications Commission (FCC). Linx Technologies.

[8] Proposal for a Hand-held Tracking Device. MicroTrak Inc.

[9] RF Systems, Components, and Circuits Handbook.

1.4 Notation

The following convention is used throughout this document to denote any requirements:

[R #] A requirement for Phase 1 development

[R' #] A requirement for Phase 2 development

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2 System Overview

MicroTracker consists of a handheld tracker and multiple tags, as illustrated in Figure 1.

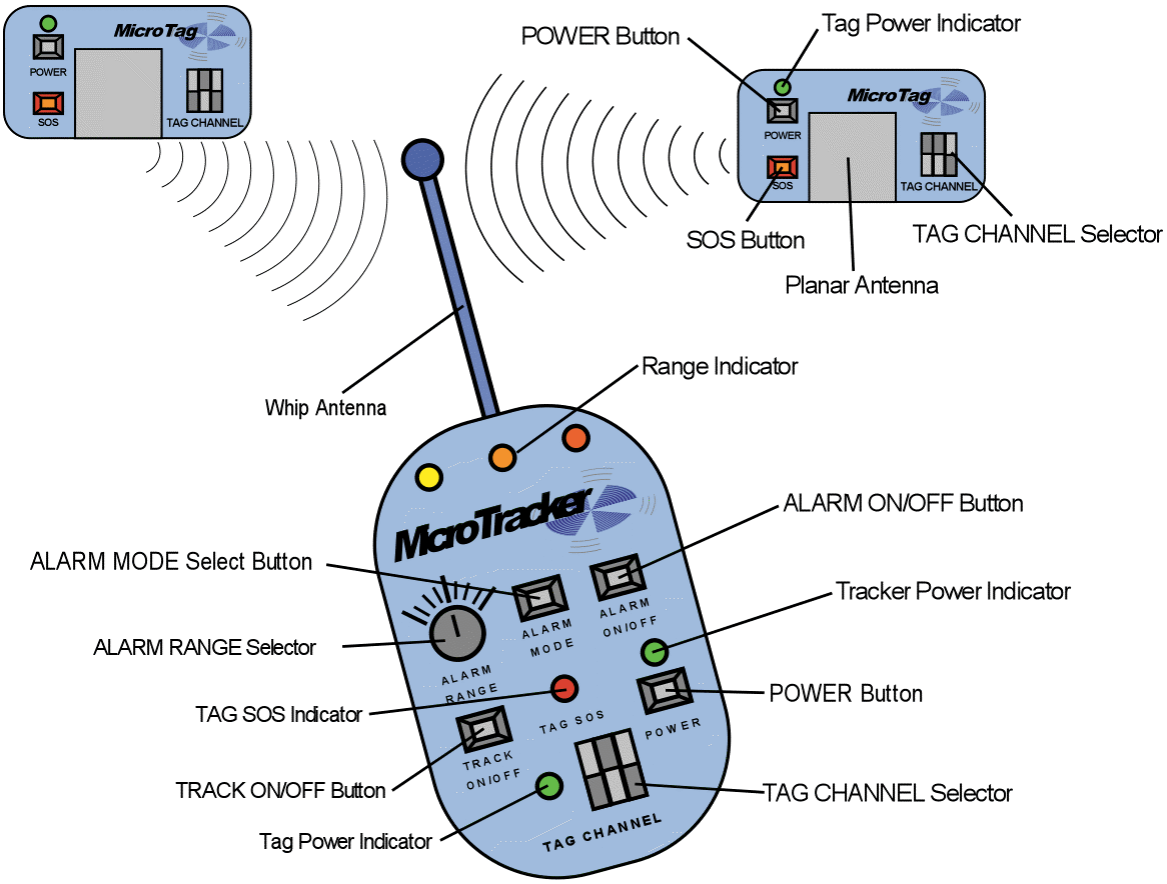

Figure 1. MicroTracker System Diagram

MicroTracker has two main functions: to track objects and to alarm users of left behind items. Each transmitter tag's carrier frequency can be configured using three binary bits to distinguish itself from the other tags. The tracker can support up to eight different carrier frequencies. The tag signals are transmitted using FSK modulation. By attaching tags to objects and setting the tracker to tracking mode, users can locate the tagged items by setting the target tag's frequency and following the signal strength indicator on the tracker. In the alarm mode, users will be notified of left behind belongings when the tracker and the tagged objects are over a certain distance apart, as specified by the user. Also, the user has the option of being notified when the tracker and the tagged object are too close together. Furthermore, each tag has an emergency button to activate the emergency LED and sound the buzzer on the tracker.

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2.1 General Features

MicroTracker consists of the following general features:

- Compact
- Cost effective
- Maximum operating range of 400 feet
- Multiple alarm settings
- Selectable alarm activation range
- Separate range and alarm modes
- Voltage regulation
- Emergency button on tags
- Tag and tracker power status indicator
- Range indicator

2.2 General Applications

MicroTracker can be used for many applications such as the following:

- Theft prevention
- Track lost objects
- Reminder for left behind items
- Child monitoring
- Animal tracking
- Search and Rescue Aid
- Surveillance (prisons, nursing homes, day-care facilities, hospitals, shops)

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3 System Requirements

MicroTracker consists of two main components: tags and a tracker, as described in Section 3.1 and 3.2, respectively. This system will be developed in two phases. Phase 1 features will be included in the demo prototype, while Phase 2 features will be added if time permits. Unless otherwise specified, the listed features will be implemented in phase 1.

3.1 Transmitter (Tag) Requirements

3.1.1 Functional Descriptions

Each tag will have the following functions in phase 1:

[R 1] Power On/Off button
[R 2] A three-switch mechanism for selecting one of eight channel frequencies for the tag
[R 3] An LED on each tag and a signal to the tracker to indicate the tag's power status
[R 4] A button on each tag for sending emergency signal to tracker
[R 5] An antenna to transmit the signals to the tracker

The tag should have the following functions in phase 2:

[R' 1] A selectable power down mode for power conservation

[R' 2] An RF burst input from tracker to force tag out of power down mode (this function requires using a transceiver to implement the tags)

[R' 3] Tag should be dual solar-battery powered for longer battery life
[R' 4] Changeable tag mount

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3.1.2 Physical Requirements

The tag must meet the physical requirements listed in Table 1.

Table 1. Tag's Physical Requirements

Requirement No.	Physical Features	Descriptions
[R 6]	Standalone Size (Length x Width x Thickness)	70mm x 50mm x 20mm
[R 7]	Mounted Size (Length x Width x Thickness)	70mm x 50mm x 40mm
[R 8]	Weight	100 grams
[R 9]	Packaging	Plastic casing. Fully Enclosed. 6 feet drop sustainable. Shock Resistant.
[R 10]	Pushbuttons	Pushable 100 thousand times.
[R 11]	LEDs	5 year lifetime.

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3.1.3 RF Requirements

To ensure proper transmission to the tracker, each tag must complies to RF contraints listed in Table 2.

Table 2. Tag's RF Requirements

Requirement No.	RF Features	Min.	Typical	Max.	Units
[R 12]	Channel Frequency Range[1]	902	-	928	MHz
[R 13]	Number of Channels	-	8	-	-
[R 14]	Channel Spacing	1.5	3	4.5	MHz
[R 15]	Overall Frequency Accuracy	-50	-	50	KHz
[R 16]	Harmonic Emissions[2]	-	-	-50	DBc
[R 17]	Output Power	-3	0	4	DBm
[R 18]	Occupied Bandwidth	-	32	-	KHz

Note 1: Signal modulated to higher frequency (carrier frequency) for easier demodulation.
Note 2: Power lost due to harmonics

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3.1.4 Electrical Requirements

The tag must meet the electrical requirements listed in Table 3.

Table 3. Tag's Electrical Requirements

Requirement No.	Electrical Features	Min.	Typical	Max.	Units
[R 19]	Operating Voltage Range	2.7	9	16.0	Vdc
[R 20]	Current Average	-	20	22	mA
[R 21]	Power Consumption	54	180	352	mW

3.1.5 Maximum Ratings

Limited by the transmitter chip's operational requirements, the tag must operate under the maximum ratings listed in Table 4.

Table 4. Tag's Maximum Ratings

Requirement No.	Category	Min.	Max.	Units
[R 22]	Supply Voltage	-0.3	18.0	Vdc
[R 23]	Operating Temperature	0	70	^{o}C
[R 24]	Storage Temperature	-45	85	^{o}C
[R 25]	Humidity	5%	80%	-

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3.1.6 Antenna Requirements

A planar antenna must be used for the tag to achieve compact size. Table 5 lists the antenna's requirements.

Table 5. Tag's Antenna Requirements

Requirement No.	Features	Values	Units
[R 26]	Physical Dimensions (length x width x thickness)	1.102 x 0.54 x 0.062	Inch
[R 27]	Electrical Length	¼ λ	-
[R 28]	Center Frequency	916	MHz
[R 29]	Useable Bandwidth	40	MHz
[R 30]	Characteristic Impedance	50	Ohm
[R 31]	VSWR	<1.7	-
[R 32]	Loss	-1	-

3.1.7 Response Time

The tag's limited response time to certain signifcant events are listed in Table 6.

Table 6. Tag's Response Time

Requirement No.	Events	Response Time	Units
[R 33]	Tag Power Off	1	milliseconds
[R 34]	Channel Change	1.2	milliseconds

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3.2 Receiver (Tracker) Features

3.2.1 Functional Descriptions

The tracker must have the following functions for Phase 1:

- **[R 35]** A Power On/Off button
- **[R 36]** A three-switch mechanism for selecting the target tag's channel
- **[R 37]** An alarm On/Off button
- **[R 38]** A buzzer for the alarm
- **[R 39]** A knob for adjusting alarm activation range
- **[R 40]** An alarm mode button for choosing the away and close modes
- **[R 41]** A set of 3 LEDs for indication of the target tag's range by signal strength
- **[R 42]** A Track On/Off button for the range indicator
- **[R 43]** An LED and a buzzer to indicate the activation of the emergency signal at the target tag
- **[R 44]** An LED to indicate the tracker's power status
- **[R 45]** An LED to indicate the target tag's power status
- **[R 46]** An antenna for receiving the tag's signal

The tracker should have the following functions for Phase 2:

- **[R' 5]** A button that sends an RF burst to activate a target tag that is in power down mode
- **[R' 6]** An LCD display with input buttons for allowing naming of tags, setting the target tag's channel, and configuring the alarm settings
- **[R' 7]** Enhance the alarm mode to allow for automatic sweep of all tag frequencies associated with a tracker

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3.2.2 Physical Requirements

The tracker must meet the physical requirements listed in Table 7.

Table 7. Tracker's Physical Requirements

Requirement No.	Physical Features	Descriptions
[R 47]	Standalone Size (Length x Width x Thickness)	100mm x 50mm x 20mm
[R 48]	Mounted Size (Length x Width x Thickness)	100mm x 50mm x 40mm
[R 49]	Weight	150 grams
[R 50]	Packaging	Plastic casing. Fully Enclosed. 6 feet drop sustainable. Shock Resistant.
[R 51]	Pushbuttons	Pushable 1 million times.
[R 52]	LEDs	10 year lifetime.

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3.2.3 RF Requirements

The tracker must be able to receive RF signals from the tag accurately. Table 8 lists the requirements the tracker must achieve for proper reception of tag signals.

Table 8. Tracker's RF Requirements

Requirement No.	RF Features	Min.	Typical	Max.	Units
[R 53]	Center Frequency	903.37	-	921.37	MHz
[R 54]	Noise Bandwidth	-	280	-	KHz
[R 55]	Data Bandwidth	300	-	50000	Bps
[R 56]	RSSI Voltage Range	0.8	-	2.5	V

3.2.4 Electrical Requirements

The tracker must meet the electrical requirements listed in Table 9.

Table 9. Tracker's Electrical Requirements

Requirement No.	Electrical Features	Min.	Typical	Max.	Units
[R 57]	Operating Voltage Range	2.7	9.0	16.0	Vdc
[R 58]	Current Average	18	20	22	mA
[R 59]	Power Range	48.6	180	352	mW

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3.2.5 Maximum Ratings and Limitations

Limited by the receiver chip's operational requirements, the tracker must work within the maximum ratings and limitations listed in Table 10.

Table 10. Tracker's Maximum Ratings and Limitations

Requirement No.	Category	Min.	Max.	Units
[R 60]	Supply Voltage	-0.3	18	Vdc
[R 61]	Operating Temperature	0	70	^{o}C
[R 62]	Storage Temperature	-45	85	^{o}C
[R 63]	Detection Range	-	400	Feet

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3.2.6 Antenna Requirements

The tracker antenna must have the requirements listed in Table 11.

Table 11. Tracker's Antenna Requirements

Requirement No.	Features	Values	Units
[R 64]	Physical Length	3.13	Inch
[R 65]	End Radius	0.57	Inch
[R 66]	Electrical Length	¼ λ	-
[R 67]	Center Frequency	916	MHz
[R 68]	Useable Bandwidth	25	MHz
[R 69]	Characteristic Impedance	51.19	Ohm
[R 70]	VSWR	<1.2	-

3.2.7 Response Time

The tracker's limited response time to certain significant events are listed in Table 12.

Table 12. Tracker's Response Time

Requirement No.	Events	Response Time	Units
[R 71]	Data Output Transition	33	Milliseconds
[R 72]	Channel Change	10	Milliseconds
[R 73]	Tracker Turn On	12	Milliseconds
[R 74]	Tracker Turn Off	1	Milliseconds

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3.2.8 Operating Requirements

The tracker must have the operating modes listed in Table 13 when powered on.

Table 13. Tracker's Operating Mode

Requirement No.	Mode	Range On/Off	Alarm On/Off	Alarm Mode
[R 75]	Range/Alarm Off	Off	Off	-
[R 76]	Alarm Away	Off	On	Away
[R 77]	Alarm Close	Off	On	Close
[R 78]	Tracking On	On	Off	-
[R 79]	Range On/Alarm Away	On	On	Away
[R 80]	Range On/Alarm Close	On	On	Close

3.3 Reliability

[R 81] Due to the simplicity of the circuitry, the tracker and tags should have an MTBF of 100,000 hours.

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4 Limitations

The MicroTracker system has the following limitations:

- Limited tag powered lifetime since tag is continuously active for normal operation (improved by dual solar-battery power and power down mode option in phase 2)
- Limited maximum range of 400 feet limited by power, carrier frequency (918 MHz), antenna quality, and environmental factors
- Tag or tracker cannot be fully enclosed by conductors or high density materials such as concrete, since RF signals cannot penetrate through these materials
- The RF signals from the tags can be intefered by other signals at similar frequencies, such as signals from radio stations, UHF television channels, radiosonde, navigation aids, surveillance radar, and radio altimeters
- The size of the tag and length of tracker antenna are restricted due to the number of components and the carrier frequency used, respectively
- Limited range indicator accuracy due to resolution of signal strength indication and multipath error
- Requires user to memorized the channel associated with each tag (can be solved in phase 2 where user can assign names to each tag)
- Restricted number of tag channels which limits the number of tags (can be solved in phase 2 where digital RFID is used to identity tags with anti-collision algorithm)

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5 Standards Compliance

[R 82] The MicroTracker must comply to the Federal Communications Commission (FCC) regulations. The required regulatory measures regarding equipment authorization and RF devices are described in Part 2 and Part 15 of the CFR 47 document, which is included in referenced document [5].

[R' 8] Upon the completion of our project, the MicroTracker product may be tested in the nearest FCC approved test facility (Washington) for ensuring the product's compliance to FCC standards.

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6 Test Plans

All testcases in this section are denoted by [T #].

6.1 Tag Testing Procedures

Table 14 lists the procedures for testing the tags.

Table 14. Tag Testing Procedures

Test Case	Requirement Tested	Function	Procedure
[T 1]	**[R 1]**	POWER On/Off Switch	1. Ensure battery is connected. 2. Turn the power switch to ON position. 3. Probe the power plane for power supply voltage and check if power LED is on.
[T 2]	**[R 2]**	TAG CHANNEL Selection Switch	1. Switch all tag channel bits to 1. 2. Probe tag channel lines for power supply voltage at each of channel line.
[T 3]	**[R 4]**	Emergency Button	1. Push the emergency button. 2. Probe emergency signal line for power supply voltage.
[T 4]	**[R 3]**	PWD LED indicator	1. Remove power supply. 2. Connect a voltage source that is 0.3V below that of the original power supply to the power terminals. 3. Observe that the PWD LED is off. Warning: Ensure the positive terminal of the supply is connected to the positive power terminal of the device. The transmitter chip cannot handle negative voltage supply.
[T 5]	**[R 5]**	Ant Signal Out	1. Turn on transmitter. Probe the antenna output and check for an AC signal.

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6.2 Tracker Testing Procedure

Table 15 lists the procedures for testing the tracker.

Table 15. Tracker Testing Procedures

Test Case	Requirement Tested	Function or Component	Procedure
[T 6]	**[R 35]**	POWER Switch	1. Ensure battery is connected. 2. Turn the On/Off switch to ON position. 3. Probe the power plane for power supply voltage and check if power LED is on.
[T 7]	**[R 36]**	TAG CHANNEL Selection Switch	1. Switch all tag channel bits to 1. 2. Probe tag channel lines for power supply voltage at each of channel line.
[T 8]	**[R 44]**	Tracker PWD LED indicator	1. Remove power supply. 2. Connect a voltage supply that is 0.3V below that of the original power supply to the power terminals. 3. Observe that the PWD LED is off. Warning: Ensure the positive terminal of the supply is connected to the positive power terminal of the device. The transmitter chip cannot handle negative voltage supply.
[T 9]	**[R 37]**	ALARM ON/OFF Button	1. Turn off the alarm setting. 2. Tie the alarm buzzer signal line to a voltage source. 3. Turn on the alarm setting. The buzzer should be now on. 4. Turn off the alarm setting. The buzzer should be now off.
[T 10]	**[R 42]**	TRACK ON/OFF Button	1. Turn off the range setting. 2. Tie the range signal line to 2.5V. 3. Turn on the range setting. All range indicator LEDs should now be on.
[T 11]	**[R 45]**	Tag PWD LED Indicator	1. Tie the Tag PWD LED signal line to a voltage source. The Tag PWD LED should now be on.
[T 12]	**[R 43]**	TAG SOS LED Indicator	2. Tie the TAG SOS LED signal line to a voltage source. The Tag Emergency LED should now be on.

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6.3 System Test Procedure

Table 16 lists the procedures for testing the system as a whole.

Table 16. System Testing Procedures

Test Case	Requirement Tested	Function or Component	Procedure
[T 13]	**[R 46]**	Ant In (Tracker)	1. Turn on the tag and tracker. 2. Probe Ant In signal on the tracker to check for an AC signal.
[T 14]	**[R 41]**	Range Indicator	Perform the following procedure in an open area (with more than 400 feet line-of-sight distance): 1. Turn on the tag and tracker. 2. Set the same channel on the tag and the tracker. 3. Push the track on/off button to turn on the tracking mode. All range indicator LEDs should now be on, since the tag and tracker are close together. 4. Place the tag at a fixed location. 5. Move the tracker away from the tag and observe that fewer LEDs are on as you move away from the tag. At approximately 400 feet, all LEDs should be off. Perform steps 1 to 5 in an area with obstruction. The range at which all LEDs are off should be less than 400 feet.
[T 15]	**[R 39][R 40]**	ALARM RANGE selector ALARM MODE button (Away/Close Options)	Perform the following procedure in an open area (with more than 400 feet of line-of-sight distance): 1. Turn on the tag and tracker. 2. Turn on the alarm setting on the tracker. 3. Set the same channel on the tag and the tracker. 4. Switch to away option on the tracker. 5. Place the tag at a fixed location. 6. Set the alarm activation range to 25% of the maximum setting.

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			7. Move the tracker away from the tag. At ~100 feet, the alarm buzzer should turn on. 8. Increase the alarm activation range to 50% of the maximum setting. The alarm buzzer should turn off. 9. Move the tracker away from the tag. At ~200 feet, the alarm buzzer should turn on. 10. Increase the alarm activation range to 75% of the maximum setting. The alarm buzzer should turn off. 11. Move the tracker away from the tag. At ~300 feet, the alarm buzzer should turn on. 12. Increase the alarm activation range to the maximum setting. The alarm buzzer should turn off. 13. Move the tracker away from the tag. At ~400 feet, the alarm buzzer should turn on. 14. Switch to close option on the tracker. 15. Perform the opposite of steps 8 to 14.
[T 16]	**[R 4][R 43]**	Emergency Signal	1. Turn on the tag and tracker. 2. Push the emergency button on the tag. The emergency LED on the tracker should turn on.
[T 17]	**[R 3][R 45]**	Tag PWD Indicator	1. Turn on the tag and tracker. 2. Remove battery from tag. 3. Connect a voltage source to the power terminals of tag. 4. Reduce voltage supply to 2.7V and see if tag PWD LED on tracker turns off. Warning: Ensure the positive terminal of the supply is connected to the positive power terminal of the device. The transmitter chip cannot take a negative voltage supply.

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7 Conclusion

The functional specifications listed for phase 1 will be implemented in the demo prototype, while the phase 2 requirements will be added if time permits. In addition, some of the limitations occuring in phase 1 will also be solved in phase 2. We are currently in the design stage of development and will proceed into the implementation stage within two weeks. The implementation details of the phase 1 functions will be discussed further in the design specifications for MicroTracker.

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