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FireWatch: Infrasonic Wildfire Detection Device

Objective/Value proposition

Wildfire Mitigation

- Current best means of detecting fire are seeing and smelling smoke
- It is known that wildfire gives off infrasound waves in range (0-20Hz)
- Our aim is to set up a mesh network of smart nodes and dumb nodes that can detect infrasound
- The ability to provide a signal to firefighting services when the fire is still small, could save countless homes and wilderness areas
- Will drastically improve our ability to mitigate wildfires



Previous Project Work

Team from 2018

- Main Focus: Wireless Communication
- We unfortunately don't have much documentation/results from them.
- They did not focus on the infrasound sensing aspect.
- They purchased 4 Yagi single dipole directional antennae for Xbee

Project Requirements

Project Requirements: Microcontroller

- Small form factor
- Lora Radio
- GPS
- Analogue to Digital Converters (ADC)
- Small but powerful processor (CPU)
- Low power modes

Project Requirements: Mesh Network

- Send/Receive data over long distances
- Know which nodes are active and dead
- Send data quickly and reliably

Project Requirements: Enclosure

- Fit within a 6in diameter cube
- Be able to withstand natural elements, drops from 100ft, and be shatter proof
- The total system shall weigh no more than 10 lbs
- The mechanical components shall be designed to operate indefinitely, including weather resistance except for fire damage
- Material must be able to resist sun and weather for extended time periods

Project Requirements: Infrasonic Sensor

• Accurately detect infrasonic waves generated by wildfire

- Will require adequate amplification
- Vref output must be between 0 2 Volts
- -3 db cut-off frequency within 10 20 Hz
 - Cut out unwanted noise, such as wind
- As cheap as possible



Risk Mitigation

Risk Mitigation: Possible Risks

- Cyber Security
- Environmental Impacts
- Wildlife Impacts





Current Design Work & Project Learning

System Diagram

• Why TTGO T-Beam?

- Cheap
- Common components
- Well-documented
- Necessary peripherals on board



MCU / Peripheral diagram



GPS - uBlox NEO 6M



GPS - Important features

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- Real time clock
- 2.5 M location accuracy

• Power save mode - 75% lower power usage!

Parameter	Symbol	Module	Min	Тур	Max	Units	Condition
Max. supply current ¹⁵	Ісср	All			67	mA	VCC = 3.6 V ¹⁶ / 1.95 V ¹⁷
	Icc Acquisition	All		47 ¹⁹		mA	
	Icc Tracking	NEO-6G/Q/T		40 ²⁰		mA	
	(Max Performance mode)	ModuleMinTypMaxUnitsConditionAll67mA $VCC = 3.6 V^{16} / 1.95 V^{17}$ sitionAll47^{19}mAng mance mode)NEO-6G/Q/T40^{20}mANEO-6M/P/V39^{20}mAng mance mode)NEO-6G/Q/T38^{20}mANEO-6G/Q/T38^{20}mANEO-6M/P/V37^{20}mAng mode / 1 Hz)NEO-6G/Q12^{20}mANEO-6G/Q12^{20}mA					
Average supply current ¹⁸	SymbolModuleMinTypMaxUnitsConditionIccpAll67mA $VCC = 3.6 V_{1.95 V^{17}}$ Icc AcquisitionAll47 ¹⁹ mAIcc Tracking (Max Performance mode)NEO-6G/Q/T40 ²⁰ mAIcc Tracking (Max Performance mode)NEO-6G/Q/T39 ²⁰ mAIcc Tracking (Eco mode)NEO-6G/Q/T38 ²⁰ mAIcc Tracking (Eco mode)NEO-6G/Q/T38 ²⁰ mAIcc Tracking (Eco mode)NEO-6G/Q12 ²⁰ mAIcc Tracking (Power Save mode / 1 Hz)NEO-6G/Q12 ²⁰ mA	$VCC = 3.0 V^{10} / 1.8 V^{17}$					
	(Eco mode)	NEO-6M/P/V		37 ²⁰		mA	- 1.0 V
	Icc Tracking	NEO-6G/Q		12 ²⁰	mA		
	(Power Save mode / 1 Hz)	NEO-6M		11 ²⁰		mA	

LoRa Protocol



Why? Low Bandwidth, Low power, long range

LoRa packet structure

- Preamble up to 65000 symbols to synchronize packet reading
- Optional header
 - Payload length
 - CRC
- Payload
 - Up to 255 bytes of data
- Optional CRC
 - Cyclic redundancy check
 - Detect transmission errors

•	nPreamble Symbols	nHeader Sym	bols		
	Preamble	Header (explicit mode on	CRC	Payload	Payload CRC
		CR = 4/8		CR = CodingRate	
		SF = Spr	eadingF	actor	

Radio Module - SX1276



Radio module configuration parameters

- Transmit power
 - 2 to 20 dB default 17 dB
- Spreading Factor
 - High spreading factor increases range and power usage
- Preamble length
 - Up to 65000 bits
- Sync word
 - Kind of like a password for our network
- CRC on/off

LoRa Demo

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• Carlos has a simple demonstration of our Dev. Boards communicating

Control Flow Diagrams















Option 1	Message Type	Sender ID	Origin ID	Payload Length	Payload
Option 2	Sender ID	Message Type	Origin ID	Payload Length	Payload
Option 3	Sender ID	Origin ID	Message Type	Payload Length	Payload
Message Type:	Sender ID:		Origin ID:		Payload Length:
Message Type:Sender ID:What type of message are we receiving? Is it a temperature reading? Infrasonic sensor reading? Are you still there request?The sender its MAC action could be the Bytes? Or Sample MAC		ID is compromised of dress (6 Bytes). It e lower or upper Ill the Bytes? .C: DE:AD:BE:EF:12:34	Same as the S can be all O's. the message o ID . If it's set t message origi node.	Sender ID except it All 0's to indicate origin is the Sender o anything else the mated from another	Bytes to indicate Payload in Bytes. use 1 Byte for a to possible values 0-
Payload					

Payload:

The data being sent in Bytes. Amount is set by the Payload Length.

Lora Message Structure Diagram

the length of the For now we can otal of 256 255.

Amplifier Demo

Design Validation

Senior Capstone Design					
Project:	Infrasonic Wildfire Detector		Primary Author:	FireWatch Team	
Team:	FireWatch		Date:	10/22/2020	
Design Validation Plan & F	Results (DVP&R)				
Requirement	Test	Test Subject	Target Date	Result	Recommendation
Will survive a 20 foot drop.	Drop 20 ft and inspect.	Shell prototype with weight inside.	3/20/21	TBD	TBD
Will survive a 20 foot drop.	Solid Model Simulation	CAD model	11/30/20	TBD	TBD
Send Messages between 1 Smart Node and 1 Dumb Node	Generate random test messages to send between Smart and Dumb nodes. Keep a running count of messages sent vs received.	Smart, Dumb nodes	12/1/20	TBD	TBD
Send Messages between 1 Smart Node and 2 Dumb Nodes	Generate random test messages to send between Smart and Dumb nodes. Keep a running count of messages sent vs received.	Smart, Dumb nodes	12/8/20	TBD	TBD
Send Messages between 1 Smart Node and "The Internet"	Generate random test messages to send between Smart and Internet. Keep a running count of messages sent vs received.	Smart nodes	1/18/20	TBD	TBD
Infrasonic sensor can detect 1 - 5 Hz sound waves (crown fires)	Generate and detect an infrasonic sound wave	Infrasound Sensor	2/1/20	TBD	TBD
Infrasonic sensor can detect 1 kHz - 5 kHz sound waves (surface fires)	Generate and detect an infrasonic sound wave	Infrasound Sensor	2/1/2020	TBD	TBD
Bonus: Sensor detects an actual fire	Light a fire and see readings	Infrasound Sensor and Nodes	4/10/21	TBD	TBD

Infrasound Sensor Testing

- Our plan is to generate infrasound using a function generator and a subwoofer
- We will feed the subwoofer low frequency signals and try to detect them with our infrasound sensor



Project Management

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Preliminary Design Work6 weeks28-Sep3D modeling/3D printing 14 weeks21-Sep </td <td></td> <td></td>		
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Project:	FireWatch	1												
Last Updated	9/17/2020)												
				Y	ear				Item					
Expense Items	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total					
Equipment/Tools:														
Sound equipment		\$ 300	Li –						\$ 30	D				
Travel:														
Safety net						\$ 100			\$ 10 \$ -	D				
Supplies / Parts / Services:														
Microcontrollers		\$ 73.2	1						\$ 7	3				
Fabrication Materials		\$42.38	\$ 200						\$ 24	2			7	
Misc Electronics		\$ 4	\$ 250						\$ 25	4				
PCB			1			\$ 200			\$ 20	D				
Radio equipment			1		\$ 300				\$ 30	D				
Long-range Antenna?			1				\$ 400		\$ 40	D				
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Future Plans

- Build sensor circuit on breadboard and test microphone capsules
- Design and Print PCB
- Drop Test 3D printed model
- Improve design and 3D print larger scale
- Testing and Code Validation
- Purchase Batteries and Test Longevity