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Detection of Enemy Intervention in Border and Battle Fields Using Smart Dust Technology

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ABSTRACT: Terrorism it is the greatest menace to the security of our nation which is subverting through borders. The borders of Bangladesh and Kashmir are quite composite and also they are large, such that any armed forces or even satellites also cannot be able to monitor the intervening terrorists. To solve these sorts of problems an effective solution is provided in this paper. The main objective of this project is to design a wireless sensor mote which is like small dust and comprises of numerous sensors with a controller in it. It has the capability to sense the intervention of the enemies through the battle fields and borders. The speciality of this mote is that it can be positioned in few hours over a large area with limited persons. A Network can be formed by these motes among themselves. The networks are light in size, promptly deployable and have a wireless connection to the outside world. On board hardware comprises of various sensors and a microcontroller to route the values of these sensors. For the purpose of communication we use a radio transceiver. A graphic LCD display is attached to the central monitoring mote in order to vision the trailing history of the targets**.**

I. INTRODUCTION

Detection of intervention is a foremost problem in tactical border. It is very much hard to detect the intervention in very large or dry areas because it is difficult to men to inspect those areas often. In this project the intruder is detected and also classified whether it is vehicle or human or vehicle in groups. This is done using the sensor motes which are wireless called as smart dust. Smart dust comprises of a controller, on board sensors which has the capability, to detect the intervention of enemies across the battlefields. These motes are the assembly of controllers and sensors. With the help of one or two men itself thousands of smart dust motes can be installed in few hours in the border. These motes are tiny sized and forms the network on their own and gives the information to outside world via wireless connection. Fig 1 shows Dust motes and Parent node in peer to peer network model.
The battery life of a smart dust mote can vary from a few hours to ten years depending on the size and capability of the device. A common mote communication scheme uses radio frequency signals to communicate over relatively short distances. This allows designers to minimize mote size and reduce power consumption. When communicating, the devices pass each message to a neighbouring mote, which, in turn, passes the message onto a neighbouring mote, and so on, until the message reaches the destination i. e the central monitoring mote. The networks of motes continue to perform even if some of its communication paths fail to operate. And once a mote is placed in an existing network, it adapts to blend in with the other nodes to form a larger network; and when a mote fails, the other devices in the network take over its load The hardware comprises of various sensors like thermal sensor, PIR sensor, metal detector, vibration sensor and a microcontroller for controlling all these sensors values and also a transceiver for the communication over a wireless network. The mote which consists of all this hardware is called the dust mote. A controlling node called the parent mote resides of a graphics display and a controller via which the view of tracking

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history is available. The parent node is the central monitoring node which is connected in peer to peer wireless network model.

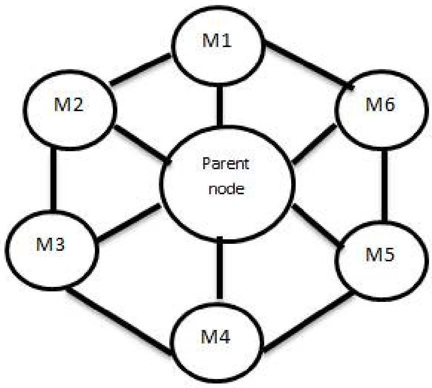

Fig.1 Dust motes and Parent node in peer to peer network model

As mentioned in above figure M1, M2, M3, M4, M5, M6, M7 are the motes which comprises of various controllers and sensors. These motes are used for detection and classification of the intruder and pass the information to the central node via wireless communication.

II. LITERATURE SURVEY

There are several works carried out in the area of border surveillance. For example Kishore Kumar explains in his paper how the intruder can be classified [1]. The detail description about the smart dust is done by Dough Steel [12].As an example, the study conducted by T. J. Nohara explains the use of commercial approach to the deployment of radar surveillance [3]. The literature says, "surveillance solutions must be multi-mission suitable, scalable, flexible, maintainable, upgradeable, interoperable, shareable, and affordable", which is very true when it comes to border surveillance and other security systems. Smart dust system satisfies the above mentioned features and its compact size is an added advantage when deployed in the battlefields. To give another example, the work done by C. Neumann and his colleagues explains about the protection of our borderlines as well as military camps using Radar surveillance methods [4]. The challenges of remote border monitoring have been detailed in the work conducted by P. Pratap and his colleagues [5]. The paper discusses three major issues to be addressed to build an effective ground surveillance system and the issues are „providing reliable and efficient power", „providing adequate and timely maintenance to minimize downtime" and „networking systems for effective data transmission". Concluding, the work says that a system that overcomes these challenges will provide a "cost-effective solution requiring minimal support infrastructure solution to meet border monitoring and protection needs." Smart dust system ensures that it meets these challenges, to be discussed in the following sections. The intruder can be tracked using the wireless sensor network is presented by Jisha R C,Maneesha[2].
Numerous other works were carried out in designing border surveillance systems and also improving on the existing methodologies. Most of the works carried out was about improving on the existing Radar technologies, using unmanned air vehicles and fibre optic sensing [3][4][6][7].This paper proposes a system based on smart dusts for border surveillance applications that can help solve many of the challenges posed by conventional systems especially concerned to power consumption, maintainability, safety and coverage. The system structure of the smart dust networks is presented in the next section followed by the hardware and software design in the third and fourth sections. The third section also details about the components used and it's set up. The software design section also includes a high level flow chart for the system and the forthcoming section describe the output obtained when the system was put under test. The final section describes the features, few concerns and some enhancements of the proposed project. Few papers use the concept of image processing. A. Greenbatt presents in his paper that automated detection systems for border intrusion exist, but many of them require expensive electronics and lengthy installation procedures. He introduces a novel image processing algorithm that detects and tracks moving targets and, when coupled with infrared sensors, can

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detect temperature changes in the earth that may indicate paths being constructed for border crossing under the surface [10]. Some papers use neural networks for detecting and classifying the intruders [9]. Sometimes the sensors which are used create a false alarm. This is detected and explained by Kondaveeti in his presentation. He enlightens that the sensors can respond to a variety of stimuli, sometimes reacting to meaningful events and sometimes triggered by random events which are considered false alarms. In order to avoid this a supplement of human intelligence in a sensor network framework that can assist in filtering and real-time decision making from the large volume of data generated [8]. Even fibre optics where used for the communication when an intruder is found. This comes under wired communication which is elucidated by J. C. Juarez [11]. Fibre optics cannot be used in dense areas, so the smart dust satisfies all these issues.

III. SMART DUST

Intrusion detection is a major problem in dense borders. Timely detection of intrusion is the very sensitive part in detecting the intrusion. When intrusion happens in large terrain or rough areas it is hard to detect, since surveying those areas through men becomes a difficult task. Intrusion detection in the given application normally deals with the detection of objects and classifies it in to human or vehicle or groups and track the enemy intrusion. Enemy intrusion is identified, classified and tracked by using the next generation intelligent ultra-small dust like wireless sensor motes which has multiple on board sensors and a controller, which has the ability to detect an enemy intrusion across borders and battlefields. These smart dust motes are the collection of sensors and a controller. Thousands of these smart dust motes can be deployed across the border in a few hours by one or two men. These motes are small in size and are rapidly deployable and they form a network on its own and give the result to the outside world through wireless connection.
On board hardware consists of variety of sensors such as vibration/seismic, magnetic, acoustic and thermal signature recognition, and microcontroller for processing these sensor values and a radio transceiver for communication over a wireless network. The mote consists of all this hardware is called the dust mote. The parent mote (controlling node) consists of a controller and a graphics display through which the tracking history can be viewed. The central monitoring node acts as a parent node and is connected in a peer to peer wireless network model. So that if there is a fault/mote is not working we can identify it and rectify it easily as all motes are connected in peer to peer network.
Smart Dust is commonly used as a synonym for tiny devices that combine sensing, computing, wireless communication capabilities, and autonomous power supply within a volume of only few cubic millimetres at low cost. The small size and low per-device cost allows an unobtrusive deployment of large and dense Smart Dust populations in the physical environment, thus enabling detailed in-situ monitoring of real-world phenomena, while only marginally disturbing the observed physical processes. Smart Dust is envisioned to be used in a wide variety of application domains, including environmental protection (identification and monitoring of pollutions), habitat monitoring (observing the behavior of animals in their natural habitats), and military systems (monitoring activities in inaccessible areas). Due to its tiny size, Smart Dust is expected to enable a number of novel applications. For example, it is anticipated that Smart Dust nodes can be moved by winds or can even remain suspended in air, thus supporting better monitoring of weather conditions, air quality, and many other phenomena. Also, it is hard to detect the bare presence of Smart Dust and it is even harder to get rid of it once deployed, which might be helpful for many sensitive application areas.
Smart Dust, creates a wireless network of Nano scaled sensors, called motes, across a battle space, like dust on furniture, yielding real-time information about enemy or friendly movements, habits, and intentions. Doctrinally, Smart Dust offers the advantages of ubiquity, flexibility, timeliness, and persistence of intelligence to military leaders, planners, and operators. The molecular size of motes minimizes their noticeable footprint providing access to locations normally unavailable to traditional persistent surveillance applications while still covering a large area at reasonable cost. Information delivered on demand at the speed of electronic communication to the strategic, operational, and tactical levels of warfare turns planning and execution unknowns into reliable facts. Furthermore, equipping each mote with different types of sensors offers instantaneous information flexibility for analysis conducted by soldiers in the field or analysts via reach back. Similar to the limitations of the enabling technologies, environment, sensor range, and frequency jamming constrain the usefulness of Smart Dust. High wind conditions overcome the static-electric effects of particle lifting dust, dirt, and Nano scaled sensors away from intelligence areas of interest. As Nano scaled motes settle into the crevices of the battle space, environmental elements of all sizes from ant hills to foliage to mountains limit the

line-of-sight range of wireless sensor networks. Furthermore, with a dependency on wireless communication, jammers or electro-magnetic pulses potentially disrupt the network's reliability and accuracy.

IV. DESIGN OF SMART DUST NETWORK

The given system consists of dust mote. These dust motes when communicating, passes each message to a neighbouring mote, which, in turn, passes the message onto a neighbouring mote, and so on, until the message reaches the destination i. e the central monitoring mote. The network of the motes continues to perform even if some of its communication paths fail to operate. And once a mote is placed in an existing network, it adapts to blend in with the other nodes to form a larger network; and when a mote fails, the other devices in the network take over its load and a central monitor mote which comprises of pic microcontroller and LCD Display. This central monitor mote receives the data's which are the sensor values from the dust mote through zigbee and keeps track of the history in the LCD Display.

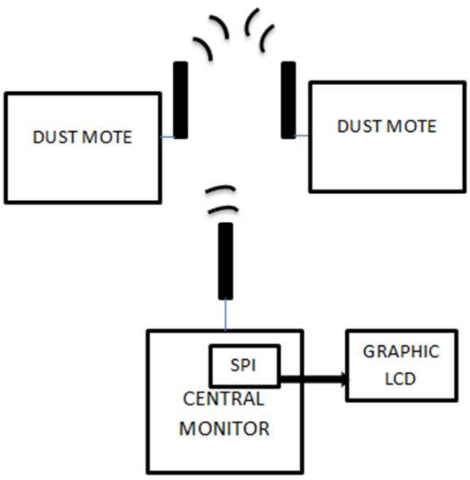

Fig.4 Smart Dust Motes System

The smart dust mote consists of several sensors like,

- MICROCONTROLLER: PIC 16F877A controls the smart dust mote.
- COMMUNICATION: Zigbee protocol for communication between motes.
- VIBRATION SENSOR: MEMS accelerometer to sense the vibrations.
- TEMPERATURE SENSOR: To sense the temperature.
- METAL DETECTOR: Enemies carrying weapons and migrating in vehicles can be found by this sensor.
- PIR SENSOR: The differentiation between man and animal can be detected by this sensor.
- RFID:RFID systems consist of three components in two combinations: a transceiver (transmitter/receiver) and antenna are usually combined as an RFID reader.A transponder (transmitter/responder) and antenna are combined to make an RFID tag. An RFID tag is read when the reader emits a radio signal that activates the transponder, which sends data back to the transceiver.

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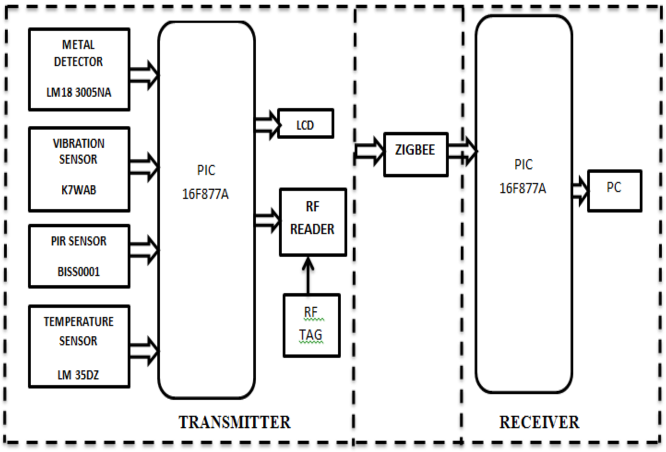

Fig.5 Block diagram of Smart Dust Mote

As shown in above figure all the sensors are connected to the microcontroller. When the intruder is a human being then the PIR sensor sends the information to the microcontroller that human is detected and at the same time if the intruder is carrying a metal with him/her then then the metal detector sends information like metal detected. If some vibrations like group of people or some vehicle is entering the border then the vibration sensor gives information like vibration found. If there is any forest fire the temperature sensor senses it and directs the information to the controller. Now controller collects all these information and transmits to the receiver via zigbee. The receiver displays all the gathered information in pc.

V. SIMULATION RESULTS

The Project simulations are done using Proteus simulation software.The Fig 6describes the change in metallic detector when a metal is detected at the transmitter. Here a high granularity potentiometer (RV2) is connected to Port A of Peripheral Interface Controller (PIC 16F877A). A LCD display is connected to the Port D of the pic microcontroller. Initially the value of the metallic detector will be as 0, if any metal is detected in the border the value of the metal detector gradually increases. When the strength of the metal increases the LCD display displays the highest value of 255 which indicates that the metal is detected. In this result RV2 represents the metal detector...

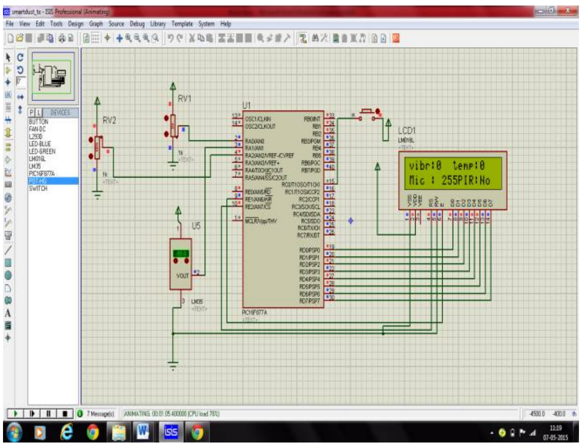

Fig 6 Detection of Metal at the transmitter side

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The Fig 7 shows the simulation result of the metal detector at the receiver. Whenever a metal is detected at the transmitter it sends the detected information to the receiver. The LCD display at the receiver which is connected to Port D of PIC 16F877A shows the status like wireless detected which spectacles that some metal is detected by the metal detector at the transmitter

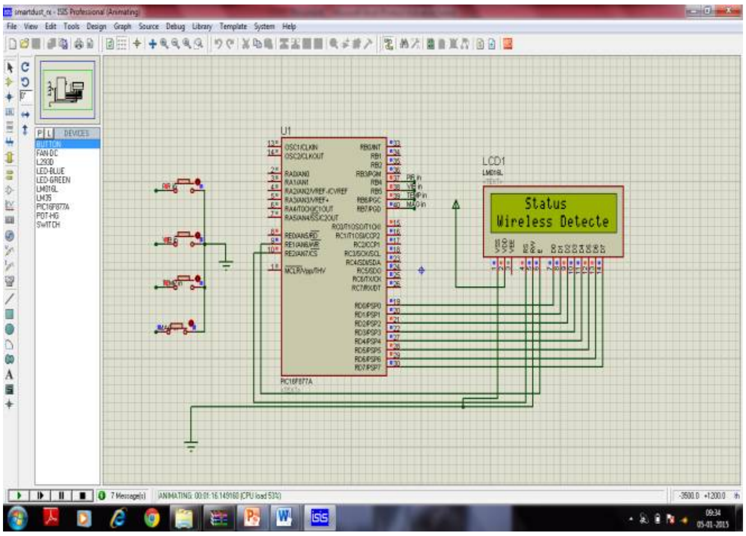

Fig 7 Detection of Metal at the receiver side

The Fig 8 describes the change in vibration sensor when some vibrations are detected at the transmitter. Here a high granularity potentiometer (RV2) is connected to Port A of Peripheral Interface Controller (PIC 16F877A). A LCD display is connected to the Port D of the pic microcontroller. Initially the value of the vibration sensor will be as 0, if any vibrations caused due to some group of intruders or due to some movement of vehicles, then the value of vibrations increases. When there is more vibration, then the LCD display displays the highest value of 127 which indicates that some group of intruder or some vehicle has been entered in the border. In this result RV2 represents vibration sensor

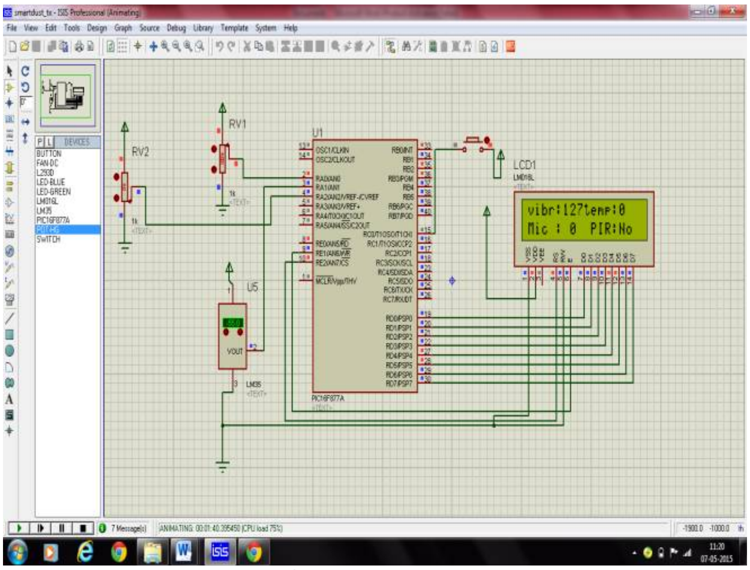

Fig 8 Detection of vibrations at the transmitter side

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The Fig 9 shows the simulation result of the vibration sensor at the receiver. When some vibrations caused due to group of intruder or due to some vehicles are detected at the transmitter, the controller sends the detected information to the receiver. The LCD display at the receiver which is connected to Port D of PIC 16F877A shows the status like Intruder Detected which specifies that some vibration is detected by the vibration sensor at the transmitter.

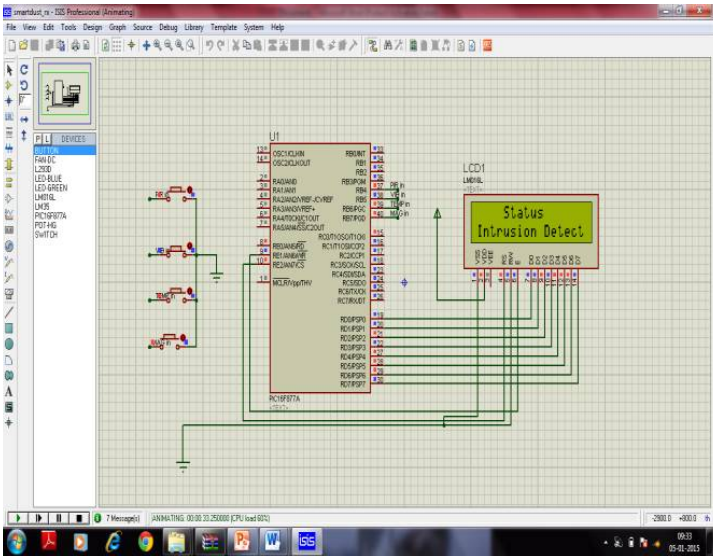

Fig 9 Detection of vibrations at the receiver side

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The Fig 10 shows whether the intruder is a human being or not with the help of PIR. Here a switch is connected to Port B of Peripheral Interface Controller (PIC 16F877A). A LCD display is connected to the Port D of the PIC microcontroller. At first the status of PIR sensor in the LCD display will be a NO, but when an intruder enters the border and if the intruder is a human being then the PIR sensor displays YES in the LCD display.

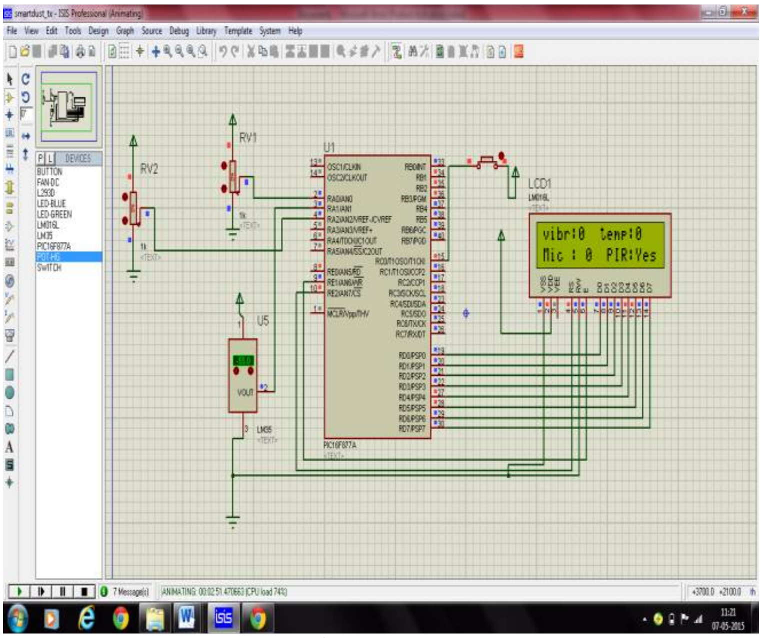

Fig 10 Detection of human at the transmitter side

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The Fig 11 shows the simulation result of the PIR sensor at the receiver. When some intruder is detected by the PIR sensor at the transmitter, the controller present at the transmitter side sends the detected information to the receiver. The LCD display at the receiver which is connected to Port D of PIC 16F877A shows the status like Human Detected which specifies that intruder has entered and that intruder is a human being.

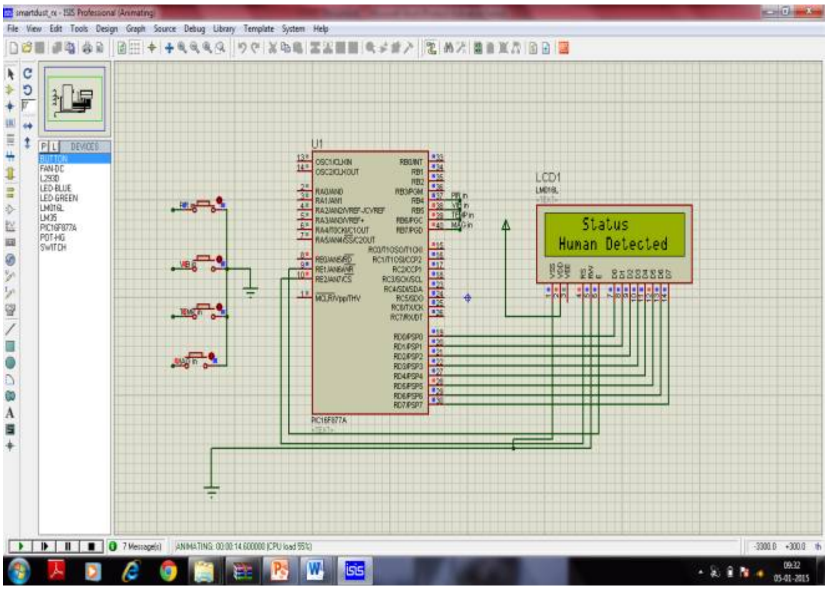

Fig 11 Detection of human at the receiver side

The Fig 12 shows the temperature range in the border. Here a temperature sensor LM35 is connected to Port A of Peripheral Interface Controller (PIC 16F877A). A LCD display is connected to the Port D of the PIC microcontroller. The temperature ranges from -55^{o}C to 150^{o} C. When the temperature value goes beyond 25^{o}C it is detected that some forest fire has occurred and the transmitter sends the information to the receiver.

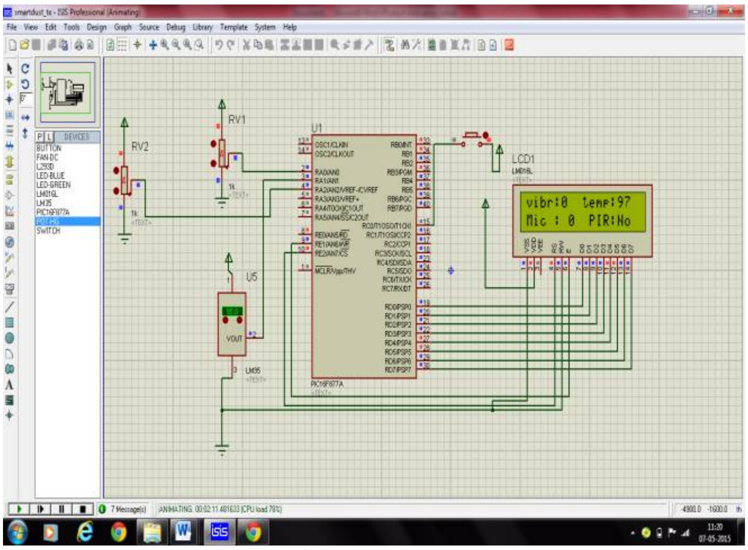

Fig 12 Detection of temperature range at the transmitter side

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The Fig 13 shows the simulation result of the temperature sensor at the receiver. When the temperature range goes beyond the normal temperature at the transmitter, the controller present at the transmitter sends the detected information to the receiver. The LCD display at the receiver which is connected to Port D of PIC 16F877A shows the status like fire detected which specifies that forest fire has occurred in the border.

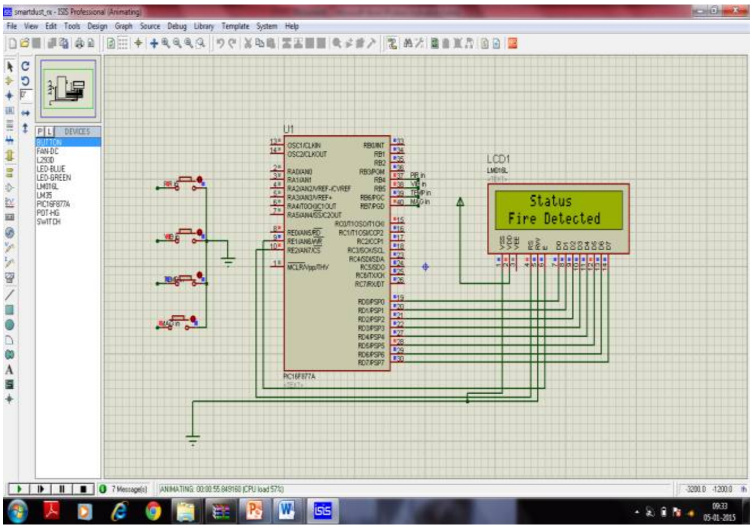

Fig 13 Detection of temperature range at the receiver side

VI. HARDWARE RESULTS

Fig. 14 shows the hardware setup of transmitter side of the smart dust mote. This mote comprises of a transformer, multi power supply, zigbee, pic controller and sensors. The sensors sense the various interventions like human being, vibrations, metals and forest fire. The information from sensors are collected by the microcontroller and then sent to the receiver via zigbee.

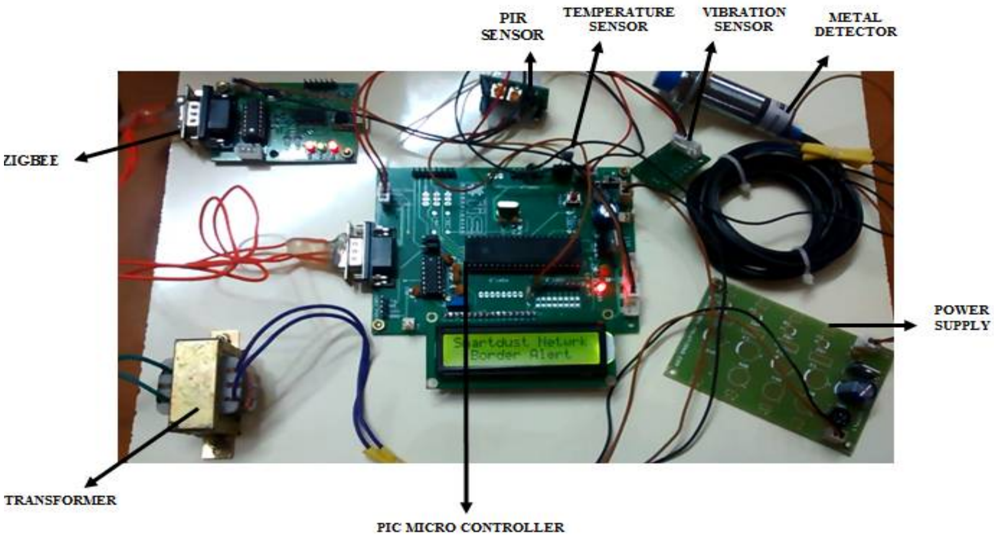

Fig 14 Transmitter side of the smart dust mote

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The receiver side hardware setup is shown in Fig.15 . It consists of a power supply, zigbee and a transformer. The receiver board is connected to a pc. When sum intruder is detected in the border the transmitter sends the information to receiver via zigbee. For example if a human is detected, then pc at the receiver side displays that the "human is detected".

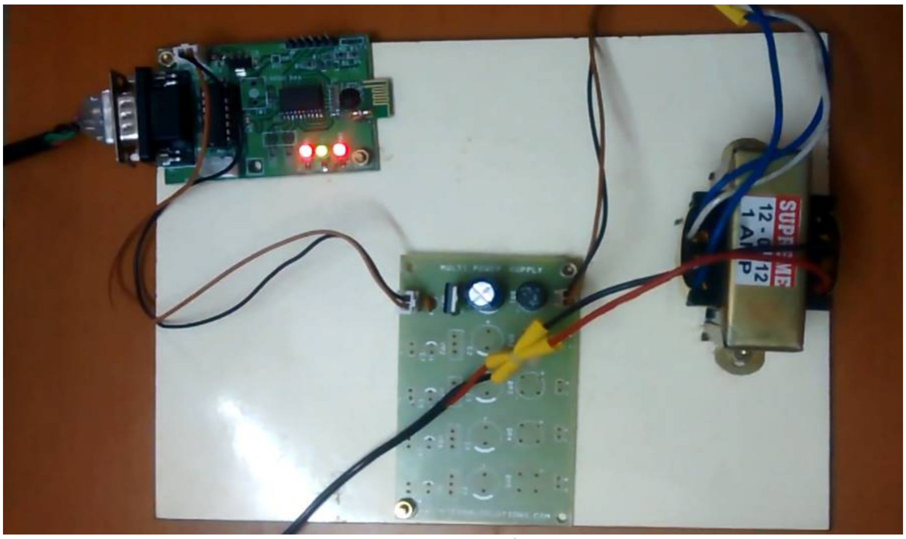

Fig 15 Receiver side of the smart dust mote

VII. CONCLUSION

In summary, enemy intrusion is detected by combination of sensors interfaced with the controller. In this project Temperature Sensor, Vibration sensor, Metallic detector and PIR sensor are used to detect enemy intrusions like human or group of persons and vehicle intrusion. By using this application, human life can be saved to greater extent, since these motes does the enemy intrusion and tracking job. The solutions presented here are by no means comprehensive but are representative of the systems engineering tasks that must be undertaken when designing a border monitoring system. One aspect of the design that was not considered here, but is a potential for future study is the type of towers used and the flexibility that can be achieved with a hybrid set of elevated platforms. A combination of fixed surveillance towers, fixed communications towers, and mobile surveillance systems can cover the border areas, provide the ability to respond quickly to potential threat situations and reduce cost. Another aspect for future consideration is the scalability of the border monitoring system. A modular design with built in flexibility for the integration of transportable, man-portable and unattended ground sensor solutions can allow quick response to changes in ingress routes or operational needs. A flexible system also provides the option to integrate sensors on a man-portable platform which can then be used in urban settings where permanent installation of large towers is not feasible.

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