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Unmanned Patrolling Vehicle for Border Security

Kiran S Gachchinmath, EPCET, Bangalore, India ,kiransg.2215@gmail.com

Ms. Indumathi S, Assistant Professor, EPCET, Bangalore, India ,indusrinivasa@gmail.com

Mohan Kumar M, EPCET, Bangalore, India ,mohanarya211@gmail.com

Narendra Gowda D M, EPCET, Bangalore, India ,narendragowda12@gmail.com

Abstract: The necessity for robotics was recognized few decades ago. Ever since significant advancements has been made in this field. Unmanned patrolling vehicle is an invention of such advancements. Such developments will help our soldiers to observe the border zones especially in dangerous weather surroundings where it is difficult for the soldiers to survive, and it also helps to replace humans from dangerous situations like handling explosives and in bomb disabling vehicles where minor size is needed or where humans cannot go. There are other applications of such devices like they can be used in search and rescue operations where the robot will be used for monitoring, border patrol data collection, environmental threat detection, entry and lock check, and device inspection.

Keywords: DTMF, RFID identification, PIR sensors, ultrasonic rangefinder, UGV, UMPV, reed switch, MQ3.

I. INTRODUCTION

The search into the field of robotics began few decades ago. People back then were really involved with the very idea and the development of the robots. As the time progressed there has been a huge development in the field of robotics. In December 2003,"Mobile Autonomous Robot Software" research program was started by the company named Pentagon in an attempt to progress more advanced military robots. Unmanned Patrolling Vehicle (UMPV) is specially designed to be used in war arena and for border safety. Within that context, a telephone-operated vehicle system is one in which directional guidance is transmitted to the vehicle from an externally set human operator. An autonomous vehicle is one which decides its own path using onboard sensor and handling resources. The name supervisory control is often given to numerous control schemes which combines the given inputs from both an external human operator and onboard sensors to determine the track [1]. The key aim behind this development is to design a robotic vehicle that will help our soldiers to monitor the border areas particularly in dangerous climatic locations where it is very difficult for the soldiers to survive and to monitor war field. The clock monitoring of the war field is also made possible with the support of such vehicles. Several features like DTMF, RFID, reed switch, PIR sensors,MQ3 and ultrasonic rangefinders have been implemented to make the design more effective and reliable.

II. BLOCK DIAGRAM

A. Block Diagram of UMPV

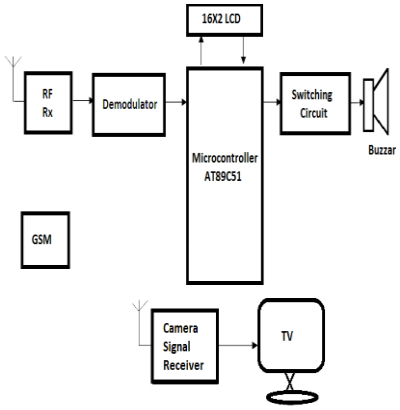

Fig 2.1.Block Diagram of Controlling Station

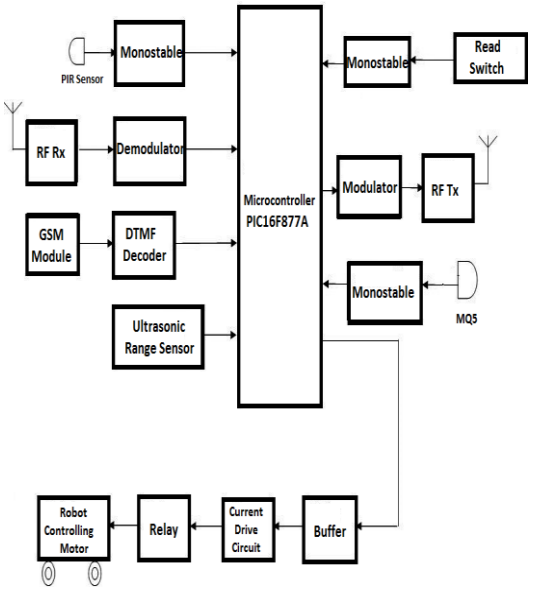

Fig 2.2.Block Diagram of Robot

III. OPERATION

Unmanned patrolling vehicle is planned to control

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wirelessly from the control room using DTMF (dual tone multi-frequency) signal of mobiles. By using the number buttons (2, 4, 6, 8) in mobile phone, we can control the forward, reverse, left, and right movement of the robot. The robot is fixed with a PIR sensor to detect the human presence in border areas. Once the presence of human is detected it checks whether the detected human is our soldier or not. For this process, a unique RFID (radio frequency identification) tag is provided to our soldiers that will help to recognize our soldiers and enemies in border area. The robot is built-in with a RFID reader to detect the RFID tag. When the robot detects any human presence it will check for the RFID tag to recognize whether the person detected is our soldier or an enemy and consequently the info will be sent to control station. The distance of the sensed obstacle is determined using the range finder. The robot is also fixed with a wireless camera which captures live video and transmit it to the control station. Capturing the images and tracking the movement of the enemy in border area can be done by using live cameras. Microcontroller is the heart of the design which controls all the operations. The Microcontrollers used are PIC16F877A and AT89C51.

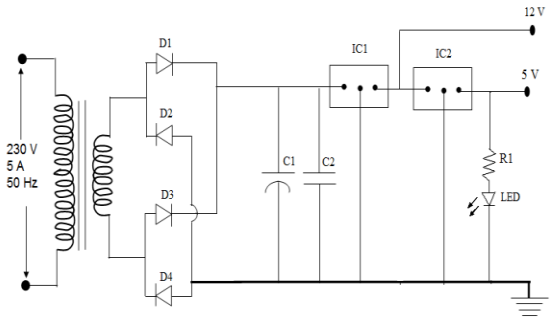

Fig. 3. Circuit diagram of +5v & +12v bridge rectifier regulated power

The design is provided with several monostable circuit to prove a steady input to the microcontroller. This is because the output from several sensors like the reed switch , MQ5 and PIR sensor may differ. To provide a stable input to the microcontroller, it can be achieved by using monostable circuits. The controlling of forward-backward and right-left motion of the unmanned patrolling vehicle is done by using DTMF signals. DTMF decoder is used to decode the DTMF signals that are received from the mobile phone to control the robot. During the robot movement, it spots any human presence in the range of about 10m using the PIR sensors. The distance of the object from the UMPV is determined by means of an ultrasonic range finder. Buffer, drive and relay circuit is a part of switching circuit. These circuits are used for the automatic switching of the RF transmitter and robot motor. Relay is the type of switch in which the buffer and driver is used to drive the relay. The voltage needed for the operation of the circuits used in this project is 12V and 5V. Current of 1A is necessary for the operation which is delivered using the power supply.

IV. COMPONENTS USED

A. RFID tag and receiver

As Radio Frequency Identification (RFID)is suitable for numerous applications in different fields, it has become essential part of our daily lives. Currently, there is a wide range of RFID applications which are available in the chip market for several fields such as healthcare, aviation, library system, shipping, supply chain, product security. An RFID system normally includes three parts: RFID tag, RFID reader and database. While the RFID tag saves information about an item, while the RFID reader can write and read the tag data saved in a database [2]. With the latest advancements in RFID technology, active tags are more preferred. On the other hand, an active tag has a built-in battery, which has a limited lifetime. Thus, effective utilization of energy will be crucial for active tags [2]. This RFID uses electromagnetic fields to automatically detect and track tags that are attached to the objects [2]. The RFID tags can be of 3 types i.e active, passive or battery-assisted passive. In this project, we are providing unique RFID tag for our soldiers that will help to recognize our soldiers and enemies in border parts. The robot is built-in with a RFID reader to detect the RFID tag. When the robot senses presence of a human, it checks for the RFID tag to recognize whether the person detected is our soldier or an enemy.

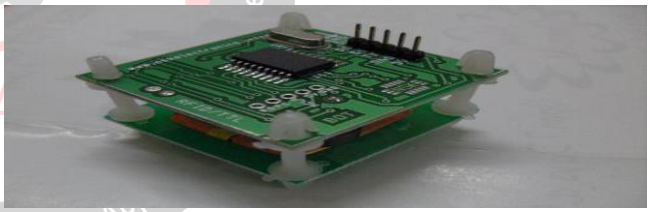

Fig. 4. RFID tag reader

B. RF module (Tx /Rx)

It is used for building the wireless communication, which can be used to drive an output from a remote place. RF module uses radio frequency to send signals. These signals are transmitted at a specific frequency and a baud rate. A receiver can only receive these signals if it is configured for that specific frequency. A 4channel encoder and decoder pair has also been used in this system. The input signals at the transmitter side are provided through four switches.

This radio frequency (RF) transmission system uses Amplitude Shift Keying (ASK) with transmitter/receiver (Tx/Rx) pair operating at 434 MHz's. The transmitter module takes series of inputs and transmits these signals through RF. The transmitted signals are received by the receiver module positioned away from the source of transmission. The system allows one-way communication

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between two nodes named as transmission and reception.

The RF module has been used in combination with a set of four channel encoder/decoder ICs. HT12E & HT12D are the encoder and decoder used in this project respectively. The encoder converts the parallel inputs which are taken from the remote switches into serialized set of signals. These signals are serially transferred through RF to the receiver point. The decoder is used after the RF receiver to decode the serialized format and to retrieve the original signals as outputs.

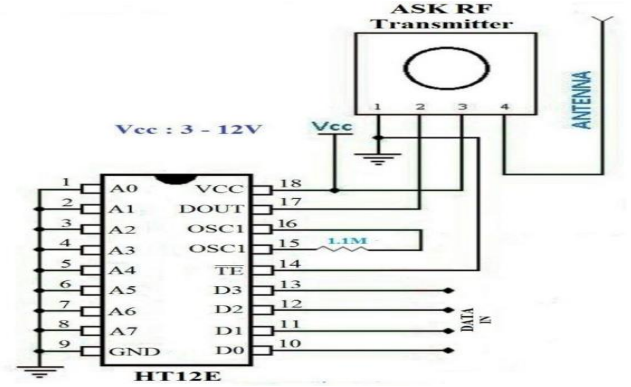

Fig 5. RF Transmitter circuit

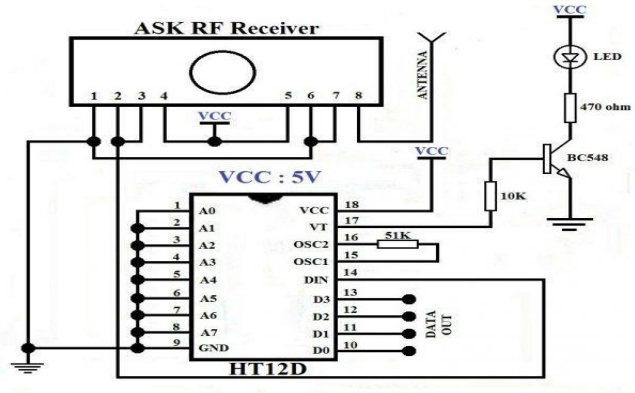

Fig 6. RF Receiver Circuit

C.DTMF (Dual tone multi frequency)

The Power Line Carrier Communication (PLCC) is the most amazing element of the telecommunication system. It works on the principle of fluctuating the line current in proportional to sound. The transducer that converts sound waves to an electrical signal is called a microphone, and the process which does the reverse function is called a speaker/earphone. The most critical function of any telecommunication system is signalling. The DTMF signals are sparse in the frequency area. Hence the sparse signal corresponding to the DTMF signal can be recovered from smaller number number of linear projections [3]

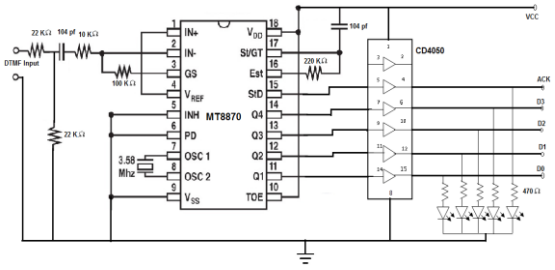

Fig 7. Circuit diagram of DTMF decoder

Generally alternating voltages of low value are used for signalling or ringing. In recent Power Line Carrier Communications, the rotary dial has been switched by pushbutton matrix dial. These Power Line Carrier Communications use ICs to produce the dc pulses. The pulse dialling is slower and vulnerable to noise. It takes atleast 10 seconds to dial a 6-digit number. This is very slow compared to the processing speed of modern electronic connections. Further, it has the following limitations: The subscriber can use signalling only up to the exchange, and end to end or subscriber to subscriber signalling is unlikely.

Merely ten codes, i.e. from 0 to 9 are possible. Time required to dial each number is different [3]. To overcome these limits, modern telecommunication uses two different tones, which resemble to a particular number. This is known as Dual Tone Multi Frequency [DTMF] dialling. If one dials, number '5', then two tones of 770 Hz and 1336 Hz is transmitted. These tones are sensed and decoded by the exchange and will be converted to the dialled digit, that is digit '5' in this case. The column relating to tone 1633 Hz will be used for special facilities like flash, pause etc.

The DTMF signals which are transmitted over the FM Transmitter/Receiver units can be received and decoded using a DTMF signal receiver/decoder IC such as UM92870 or KT3170 or Motorola's MT8870 [3]. The decoded outputs can be rightly used along with certain added circuitry to design a Call-Line-Identification-Product unit [popularly known as CLIP].

Table showing DTMF Low and High frequency tones and decoded output

Button	Low DTMF frequency (Hz)	High DTMF frequency (Hz)	Binary coded output			
			Q1	Q2	Q3	Q4
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0

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The four hexadecimal outputs obtained from the DTMF receiver/decoder IC corresponding to each digit on the FM Communication keypad together with the related dual-tone frequencies can be put in a table method for easy reference [3]. The frequencies assigned to the various digits and symbols of a push button keypad are globally accepted standards and are shown in Fig. 5 [3].

The On-Cradle and Off-Cradle status of the phone can be detected, based on the voltage state before the start of ringing (between 40 V and 52 V dc approximately). The voltage drops from 10 V to 12 V dc on lifting of the handset from the foundation. The ringing status can be detected by the use of either a coactively coupled rectifier bridge or an AC Opto-coupler.

D. Ultrasonic Range finder

A range finder is a device which measures the distance from observer to the target, in a process called as ranging [4]. Ultrasonic sensors are based on measuring the properties of sound waves with frequency that are above the human audible range [4]. The sensors typically work by generating a high-frequency pulse of sound and then receiving and calculating the properties of the echo pulse, flash, pause etc.

These ultrasonic range finders operate at its best in an angle of 30 degrees. They have electronic block compatible interface and operates at 5 V dc supply. They are breadboard friendly and consists of dual transducer. Added advantage of the ultrasonic range finder is that it contains a ready Arduino library [4].

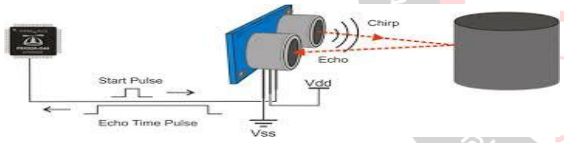

Fig 8. Basic working of Ultrasonic Range Finder

E. *PIR Sensor*

The passive infrared sensor generally known as PIR sensor is a type of sensor which measures infrared light (IR) that radiates from the objects [5]. PIR sensors uses the principle of pyroelectricity for its working which causes them to react to a change in incident radiation [5]. This property has been used in a varied range of applications including detection of humans in motion They are oftenly used in detectors. All the objects having a temperature exceeding absolute zero emit heat energy in the form of radiation. Usually this radiation will not be visible to human eye as it radiates infrared wavelengths, but it can be be detected only by electronic devices which are designed for such purposes [5]. The word passive in this instance talks about the fact that PIR devices will not generate or radiate any energy for detection purposes. They work completely by sensing the energy given off by other objects. PIR sensors will not detect or measure 'heat', as an alternative they detect the infrared radiation produced or reflected from an object [5].So these sensors are used to detect the human presence in border security zones.

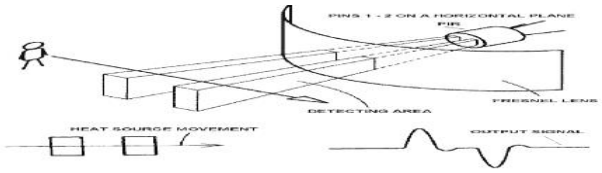

Fig 9. Working of PIR Sensor

Fig 10. PIR Sensor & Pin details

F. Microcontroller AT89C51

AT89C51 is an example of 8 bit microcontroller (ALU). It takes 4KB of internal ROM, 128 bytes of internal RAM and also zero flash memory. It contains 4 Ports, named as Port1, Port2, Port3 and Port4. Every single port consists of 8 bits. It contains 32 I/O lines, two 16 bit timers, 1 serialized communication port and 5 Interrupts (2 external & 3 internal).

AT89C51 is of CISC based and works on Harvard architecture. As compared to 8051 microcontroller it has certain additional features such as 4KB internal flash memory and also multi time programmable meaning that it can be reprogrammed up to 1000 times and EEPROM.

All the other features with pin configuration and architecture are same as 8051.

Pins 1 – 8: It is known as Port 1. Unlike from other ports, this port doesn't provide any other purpose. Port 1 is internally pulled up, quasi bi-directional Input/output port.

Pin 9: As made clear previously RESET pin is used to set the micro-controller 8051 to its primary values, where the micro-controller is functioning at the early beginning of

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application. The RESET pin has to be set high for two machine rotations.

Pins 10 – 17: It is known as Port 3. This port supplies a number of functions such as timer input, interrupts, serial communication indicators, control indicators for external memory interfacing WR & RD, etc. This is a local pull up port with quasi bi-directional port within.

Pins 18 and 19: These ports are used as a interface for an external quartz to provide system clock.

Pin 20: Titled as Vss– it denotes ground (0 V) association.

Pins- 21-28: It is known as Port 2 (P 2.0 – P 2.7) – other than serving as input/output port, senior order address bus indicators are multiplexed with this quasi bi-directional port.

G. Microcontroller PIC16F877A

It is a powerful which executes instructions at 200 nanosecond and yet easy-to-program (only 35 single word instructions). CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices.

The PIC16F877A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions. The synchronous serial port is designed as either 3-wire Serial Peripheral Interface or the 2-wire Inter-Integrated Circuit bus and a Universal Asynchronous Receiver Transmitter (USART). Every features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

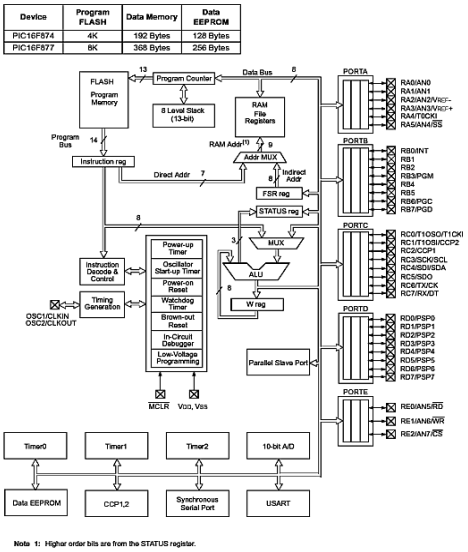

Fig 12. Internal Architecture of PIC16F877A

H. L293D Motor Driver IC

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Dual H-bridge Motor Driver integrated circuit (IC).

It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, Hence H-bridge IC are ideal for driving a DC motor.

In a single L293D chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a L293D motor controller.

There are two Enable pins on l293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It's like a switch.

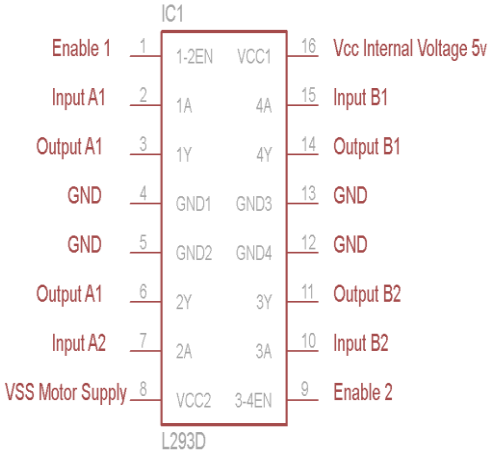

Fig 13. Pin Diagram of L293D Motor Driver

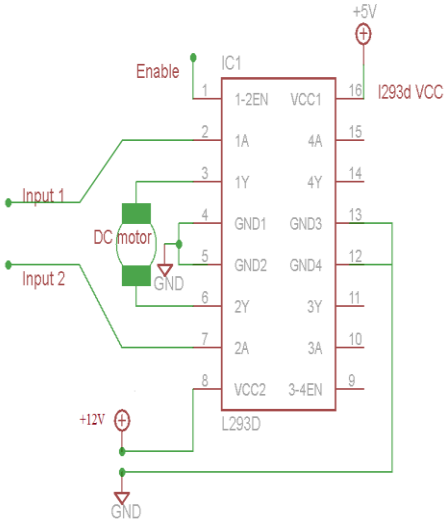

Fig 14. Circuit of L293D Motor Driver IC

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I. MQ3 SENSOR

This module is made using Alcohol Gas Sensor MQ3. It is a low cost semiconductor sensor which can detect the presence of alcohol gases at concentrations from 0.05 mg/L to 10 mg/L. The sensitive material used for this sensor is SnO2, whose conductivity is lower in clean air. It's conductivity increases as the concentration of alcohol gases increases. It has high sensitivity to

J. alcohol and has a good resistance to disturbances due to smoke, vapor and gasoline. This module provides both digital and analog outputs. MQ3 alcohol sensor module can be easily interfaced with Microcontrollers, Arduino Boards, Raspberry Pi etc.

This alcohol sensor is suitable for detecting alcohol concentration on your breath, just like your common breathalyzer. It has a high sensitivity and fast response time. Sensor provides an analog resistive output based on alcohol concentration.

Fig 16. MQ3 Sensor

K. Wireless Camera

A smart camera or an intelligent camera is a type of vision system capable of sensing images in 360degress and with addition to image capturing, it is capable of extracting application specific information from the captured images, along with generating event descriptions or making conclusions that are used in an intelligent and automated system [7]. A smart camera is a independent, standalone vision system with built-in image sensor in the housing of an industrial video camera. It comprises of all necessary communication interfaces.

Fig. 15. Wireless Camera

It is not essentially larger than an industrial or surveillance camera. A capability in machine vision usually means a grade of development so that these capabilities will be ready to be used on individual applications. This architecture has the advantage of a more solid volume compared to PC-based vision systems and regularly achieves lower cost, at the expense of a somewhat simpler user interface [7].

V. CONCLUSION

UMPVs are unmanned patrolling vehicles. These UMPVs are strongly proven that they can replace humans and provide extra advantages and flexibilities in all circumstances. They have transformed the idea of the land power in modern war times. The expenses are less, and they prevent the army for taking risks in war fields. They can enter environments which are unsafe to the human life and by means of predicting they can reduce the exposure risk of the army men. They are cheaper to purchase, low fuel consumption and needs low maintenance than the regular vehicle. The UMPV can be used as spying in border security under extreme climatic condition. Furthermore, they can be operated 24x7 hours, thereby increasing the efficiency of the entire surveillance system.

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