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DESIGN AND IMPLEMENTATION OF TRACKING SYSTEM USING WIRELESS AND LASER TECHNOLOGIES

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ABSTRACT: - This paper describes the design and the implementation of a novel tracking system that does not depends on the use of GPS-GSM tracking techniques or radar systems. The designed tracking system integrates both of wireless signals in VHF frequency band and laser beams to realize the tracking principle of an object movement, such as vehicles or pedestrian movement within any areas to determine its position precisely by using low cost and easy to install modules. The designed system consists of three modules; the transmitter module, the analyzer module, and the central monitoring module. It was concluded that the designed tracking system can be used efficiently in urban areas with high buildings that prevents the propagation of GPS satellites signals, valleys in mountainous region, underground areas and desert lands that is not covered by GSM mobile networks.

Keywords: Tracking System, GPS, VHF Transmitter, Laser, Analyzer Module, Central Monitoring Module.

1. INTRODUCTION

Tracking process is considered as important criterion for many applications and purposes such as the management of transportation processes [1], security applications, navigation, emergency warning, and roadside assistance. Radar systems are regarded as the initial systems that are used for tracking targets and for determining its position, speed and attitude. Radar systems that are utilized especially for tracking airplanes, missiles, ships and objects in the open areas use high power microwave signals in the order of hundreds of watts to detect the echo of the reflected fraction of the transmitted signal from the tracked target to determine its position. The use of high power signals in radar systems, their high cost and bulky volumes make the utilization of radar systems for general civil tracking purposes is not suitable for cities with high population rate [2].

The majority of the designed tracking systems are realized currently by depending on the technology of Global Positioning System (GPS) to locate the position of the tracked object and to send its coordinates to the observer by using the Global System for Mobile communications (GSM) Network [3 - 6]. Special alarming units are integrated with GPS system to inform the observer that the tracked object is out of certain limit [7]. Theses tracking system cannot function efficiently in many cases such as the lake of four GPS satellite signals that occurs predominantly in the cities centers, streets with high buildings, underground metro stations, tunnels, and the valleys in mountainous areas. Furthermore, sending coordinates information of an object position by using GSM networks may face many problems such as the busyness of the network with high data traffic or the limited coverage area of the used network such as in the case of LAN networks [8], desert and countryside areas. Therefore, all these circumstances may lead to break the continuity of the tracking process and losing the position of tracked object.

1. The Hardware of the Proposed System

The tracking system is implemented by designing and utilizing three main modules, the first module is the wireless 146 MHz signal transmitter module that is carried by the tracked object. The second module contains four analyzer units to form 1 km^2 area of a square-shape tracking cell as shown in figure 1. The designed tracking system utilizes the division method of the total required area to squares which contain the analyzer unit in each corner of these 1 km^2 tracking cell, each one of the analyzer units receives the transmitted signal, analyzes its power level by using a scale of eight level. Each level represents 125m real distance on the earth from the analyzer unit.

The analyzer unit encodes the determined power level on a 830nm 250mw Infrared laser transmitter that is directed to the third module which is the central monitoring module. The central monitoring module decodes the four encoded laser beams to extract the information of the power level of the wireless signal that received by each analyzer unit. As a result, the central monitoring module locates the real position of the tracked object on the earth by displaying digitally the power level number that depends on how far is the tracked object from each analyzer unit. The details of each system modules will be explained in the next sections.

1.1. The Transmitter Module

The tracked object position can be determined by measuring the signal power of the transmitter module that is proportional to real distances on the earth. The transmitter module is attached to the tracked object and it is used to generate 3 Watt VHF signal with a frequency of 146 MHz. This frequency is selected to be generated in order eliminate the possibility of interfering with other broadcasting bands such FM band (88 - 108) MHz and TV broadcasting band (174 – 218) MHz as allocated in the radio spectrum of the united states [9]. The required frequency is generated by the oscillator section of the transmitter that is built by connecting two reversed-bias varactor diodes with inductor and BF214 transistor. The frequency of the oscillator section can be tuned by varying the capacity of the varactor diodes through changing the supplied voltage using 10 KΩ variable resistor as shown in Figure 2.

The frequency stabilization is realized by using a buffer section that contains two BF214 transistor circuits. These transistors circuits are used to amplify the signal voltage and current in order to prevent the frequency modification that could happen between the oscillator section and the preamplifier section when the final Q_5 section is adjusted. Q_4 circuit is used as an amplifier section to deliver enough power to the final Q_5 RF power transistor.

Each section is enclosed by a metallic shield to reduce the magnetic fields interference that could destabilize the oscillator section. The transistor Q_5 is used 2N3924 to amplify the output RF signal of preamplifier from 85 -100 mW to about 3 watt. The generated signal is then fed to an 50Ω Omni directional antenna with a length of 70cm, the Omni directional antenna is used to utilize its spherical power pattern to transmit an efficient signal that can propagate in all directions over one square kilometer.

1.2. The Analyzer Module

The analyzer module contains four analyzing units, these units analyze the transmitter module signal power to eight power levels, each level represent 125m on the earth surface. The transmitted signal of the tracked object is received by the antenna of the analyzer unit which is 50Ω Omni directional antenna with a length of 70 cm.

The signal is then filtered by using band pass filter to allow the 416MHz signal only to pass to the demodulating logarithmic amplifier AD3807 that is used as an indicator of the received signal strength. In fact, the AD3807 is an RF-to-DC converter. The log amplifier's output is a DC representation that is proportional to the logarithm of the input signal's RF envelope. The different DC analog voltage levels of AD8307 output is sensed by the monolithic integrated circuit LM3914 as shown in figure 3.

The LM3914 drives ten LEDs depending on the level of the input voltage and provides a linear analog display. Instead of connecting ten LEDs, the output terminals of LM3914 are connected to PIC16f84A Microcontroller except the -70dbm output terminal which can be activated by noise signals. The PIC16f84A microcontroller is used to encode each different power level on the 830nm Infrared semiconductor laser beam with a special code by using the Pulse Code Modulation PCM technique. PCM technique is programed according to NEC protocol [10] with a carrier frequency of 38 KHz by using micro C language. The encoded laser beam with the codes of power levels of VHF signal is then directed to the central monitoring module.

1.3. The Central Monitoring Module

The central monitoring module contains four laser decoder circuits, each one of them decodes the encoded laser beam that is directed to it from the opposite analyzer module as shown in figure 4. The laser decoder circuit contains an IR wavelength optical filter to allow 830nm laser to pass to the detector only, a biconvex lens 25mm diameter, 45mm focal length is used to focus the incoming expanded beam on the active region of the TSOP4838 phototransistor.

The PIC16f84A microcontrollers in the central monitoring module are programed with another micro C program to decode the encoded laser and to extract the information of the eight power levels. The outputs of PIC16f84A microcontrollers are connected to 74LS147N decimal to BCD integrated circuit in order to encode the numbers from the decimal system to BCD system. The final result of the measured power level of the VHF signal is displayed digitally on the seven-segment screen by connecting the outputs of the 74LS147N IC to 74LS47 seven-segment driver IC.

An experimental test of the tracking system performance is achieved to track an object that moves in an arbitrary path within the tracking cell as shown in figure 5; each analyzer module exhibits a linear response to the change in the power of the received signal that is proportional to a real distance on the earth.

The responses of the analyzers units are displayed successfully on the seven-segment screen of the central monitoring module, therefore, the position of the tracked object can be determined from the level number that is shown on the seven-segment, which indicates the distance of the object from the analyzer module. The Analyzer responses are illustrated in table 1. The sensitivity of the analyzer modules can be increased and adjusted according to the urban environments that are intended to be covered by the tracking system. The digit (1) is allocated to represent the highest level of the signal power which is greater than 10 dbm when the tracked object is very near form the analyzer module (about 320 cm). The other digits (2-7) are allocated to represent the lower levels of the indicated signal power (0 to -60 dbm) respectively when the tracked object moves toward or far from the analyzer module, where every power level represents a real distance of 125 m on the earth for free space transmission. The digit (8) is allocated to represent the lowest level of the signal power (-70 dbm) when the tracked object is at a distance of 1015 m form the analyzer module.

2. Conclusions and Future Work

In this paper, an efficient and low cost tracking system is designed and implemented successfully by using wireless and laser technologies without need to utilize the GPS system. The accuracy of the tracking system can be increased by increasing the number of the analyzer units in the tracking cell, also optical fibers are preferred to be used to eliminate the effect of fog, rain, snow, and dust storms on the equality of the laser beam as a future development. The designed tracking system can be used efficiently in urban areas with high buildings that prevents the propagation of GPS satellites signals, valleys in mountainous region, underground areas and desert lands that is not covered by GSM mobile networks.

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Table (1): The Responses of Analyzer Units.

No.	A	B	C	D
1	6	3	8	8
2	5	4	8	8
3	4	5	8	8
4	3	6	8	8
5	2	7	8	8
6	1	8	8	8
7	2	8	7	8
8	3	8	6	8
9	4	8	5	8
10	5	8	4	8
11	6	8	3	7
12	7	8	3	6
13	8	8	4	5
14	8	7	5	5
15	8	6	6	5
16	8	5	7	5
17	8	4	8	5
18	8	3	8	6
19	8	2	8	7
20	8	1	8	8

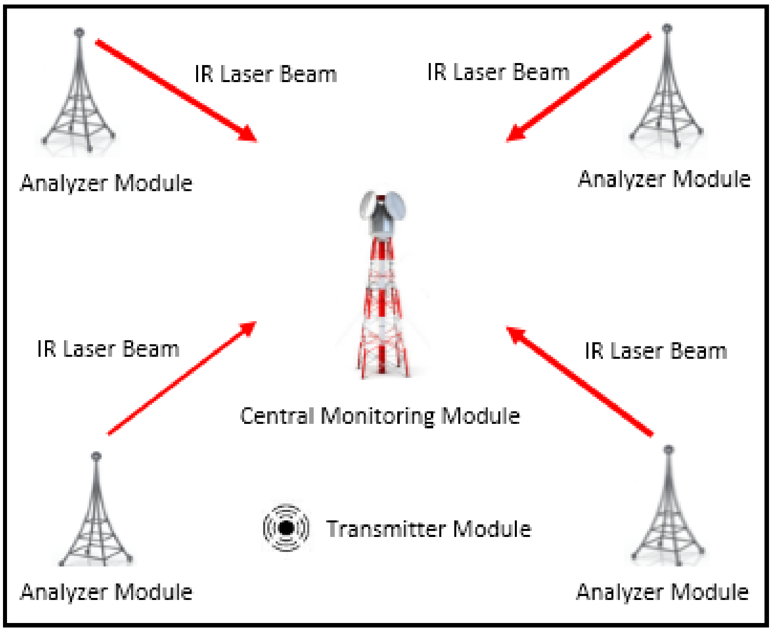

Figure (1): The Structure of 1 Km^2 area Tracking Cell.

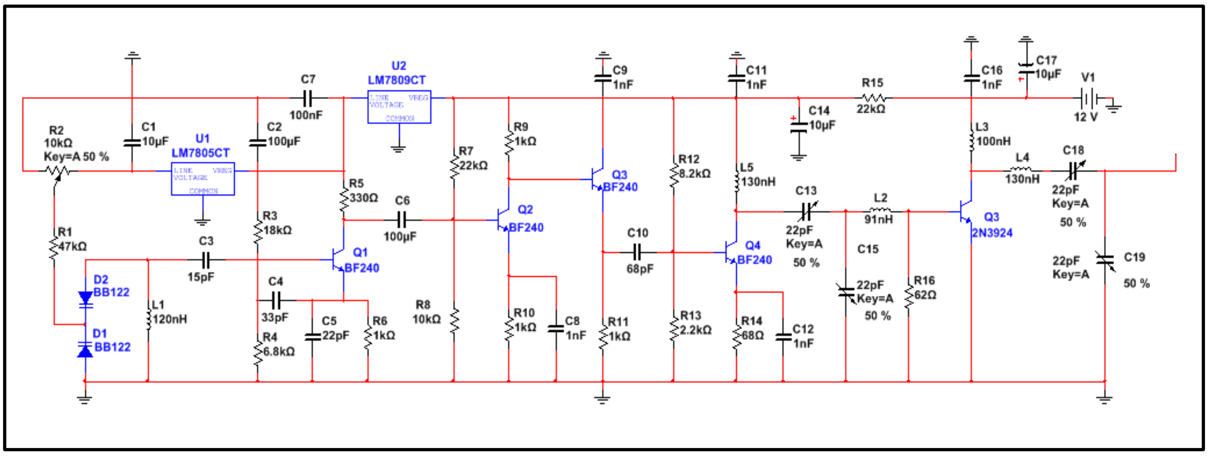

Figure (2): The 416MHz Signal Transmitter.

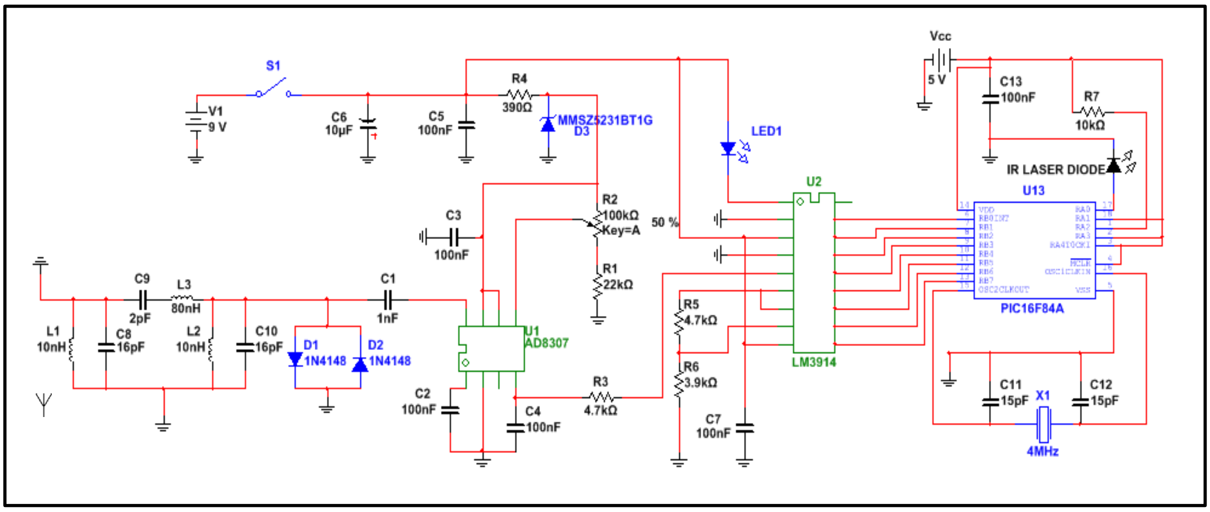

Figure (3): The Electronic Circuit of the Analyzer Module.

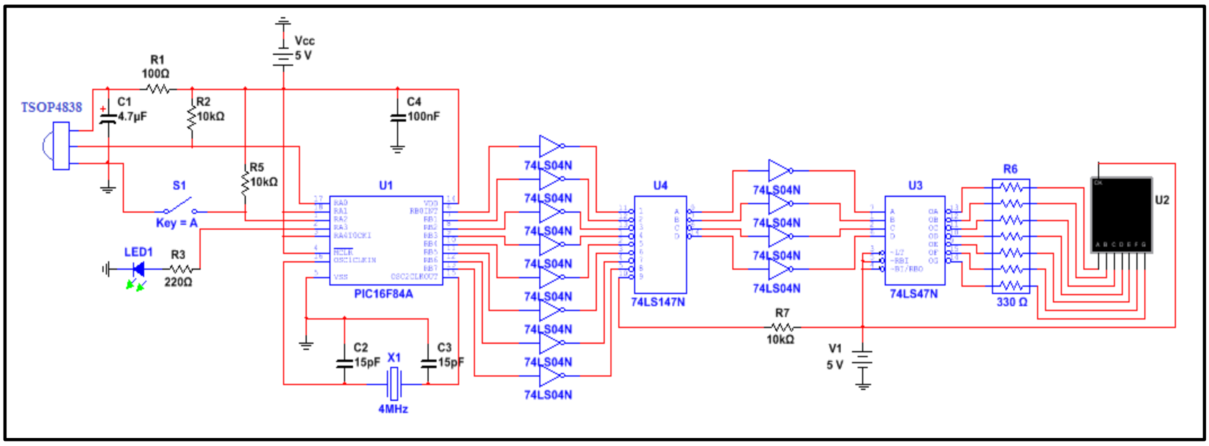

Figure (4): The Electronic Circuit of the Laser Decoder.

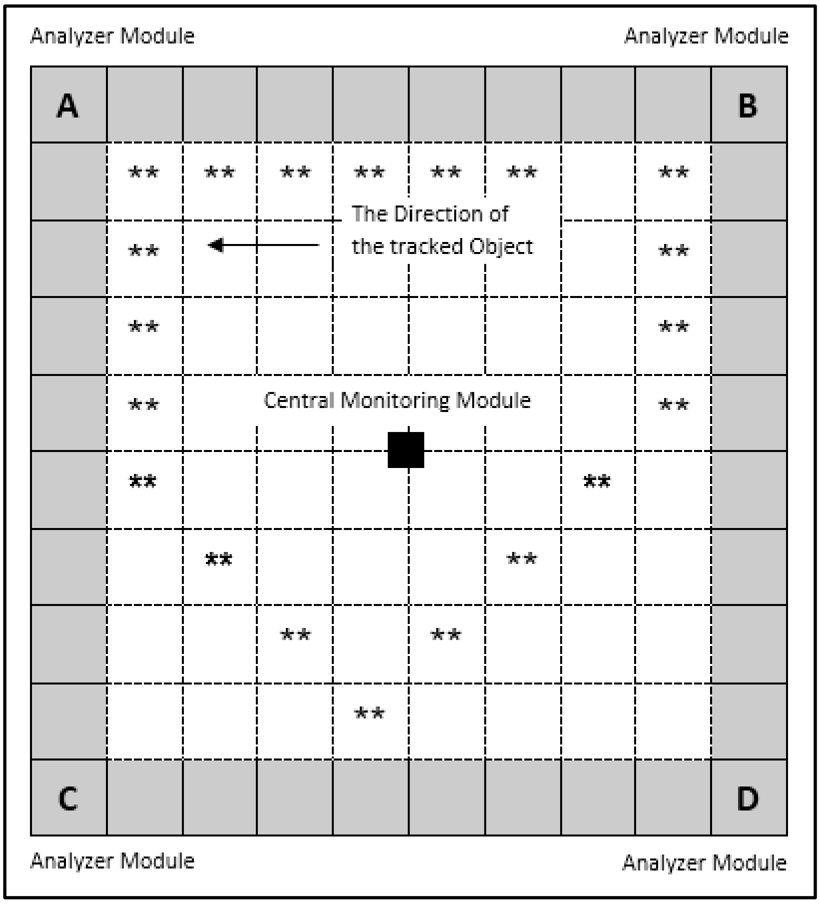

Figure (5): The Path of the Tracked Object.

تصميم وتنفيذ نظام تعقب باستخدام تكنولوجيا الموجات اللاسلكية وتكنولوجيا الليزر

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الخلاصة:-

يصف هذا البحث تصميم وتنفيذ نظام تعقب مبتكر لا يعتمد في عمله على استخدام تقنيات التعقب المعتمدة على نظامي التموضع العالمي (GPS) واتصالات الهاتف النقال (GSM) أو التقنيات المستخدمة في أنظمة الرادار، حيث ان نظام التعقب المبتكر يوظف عملية دمج استخدام تكنولوجيا الإشارات اللاسلكية في حزمة (VHF) الترددية مع استخدام تكنولوجيا حزم الليزر لتحقيق مبدأ التعقب لحركة الأهداف مثل حركة المركبات والأشخاص ضمن أي مساحة لتحديد موقعها بدقة باستخدام وحدات النظام التي تتميز بسهولة تنصيبها وانخفاض كلفتها، حيث يحتوي نظام التعقب المصمم على ثلاثة وحدات رئيسية وهي : وحدة الارسال و وحدة تحليل الإشارة و وحدة المراقبة المركزية، وقد استنتج ان نظام التعقب المصمم من الممكن استخدامه بكفاءة في المناطق الحضرية مثل المدن التي تحتوي على المباني العالية التي تعتبر السبب الرئيسي في عرقلة عمل نظام التموضع العالمي (GPS) من خلال منع انتشار إشارات الأقمار الصناعية التي يعتمد عليها نظام (GPS) في عمله، وكذلك من الممكن استخدام نظام التعقب المصمم في مساحات الوديان في المناطق الجبلية والمساحات تحت الأرض وأيضا المساحات الصحراوية التي لا تتوفر فيها تغطية نظام اتصالات النقال العالمي (GSM).