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Design and Implementation of Electromagnetic Wave Detector

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الإهداء

إلهي لايطيب الليل إلا بشكرك ولايطيب النهار إلى بطاعتك .. ولاتطيب اللحظات إلا بذكرك .. ولا تطيب الآخرة إلا بعفوك .. ولا تطيب الجنة إلا برؤيتك

(الله جل جلاله)

إلى من بلغ الرسالة وأدى الأمانة .. ونصح الأمة .. إلى نبي الرحمة ونور العالمين ..

(سيدنا محمد صلى الله عليه واله وصحبه وسلم)

إلى من كلله الله بالهيبة والوقار .. إلى من علمني العطاء بدون انتظار .. إلى من أحمل أسمه بكل افتخار .. أرجو من الله أن يمد في عمرك لترى ثماراً قد حان قطافها بعد طول انتظار وستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى الأبد ..

(والدي العزيز)

إلى ملاكي في الحياة .. إلى معنى الحب وإلى معنى الحنان والتفاني .. إلى بسمة الحياة وسر الوجود

إلى من كان دعائها سر نجاحي وحنانها بلسم جراحي إلى أغلى الحبايب

(أمي الحبيبة)

الـــى الحب كل الحب.... إخوتي وأخواتي

الـــــى كافة الأهل والأصدقاء

الـــــــى من مهدوا الطريق أمامي للوصول إلى ذروة العلم

وكانوا عوناً لي في كل شده

أخوتي و أساتذتي

بسم الله الرحمن الرحيم

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

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SUPERVISOR CERTIFICATE

I certify that the preparation of this project entitled " **Design and Implementation of Electromagnetic Wave Detector** " was made under my supervision on the **Communication Engineering Department In The University Of Diyala** . As a partial fulfillment of the requirement needed for the award of the **B.Sc** degree in **Communication Engineering.**

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CERTIFICATION OF EXAMINATION COMMITTEE

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CONTENTS

No	Subject	Page
A	Contents	I
B	List of Figures	III
C	List of Abbreviations	IV
	Chapter One : Introduction	
1.1	Introduction	1
1.2	Aim of the Project	3
	Chapter Two :Theoretical Concepts	
2.1	Introduction	4
2.2	Omni directional Antenna	4
2.3	Omni directional Wi-Fi Antenna	5
2.3.1	AD8313 Integrated Circuit	5
2.3.2	Vibration Motor	7
2.4	Arduino Microcontoller	9
2.5	Liquid Crystal Display (LCD)	10
	Chapter Three: Experimental Work	
3.1	Introduction	13
3.2	The Connection of Power Meter Circuit	13
3.3	The Connection of the Serial I^2C LCD	14
3.4	The Connection of Vibration Motor	14
3.5	Solar battery charger	15
	Chapter Four : Results and Discussing	
4.1	Experimental Results	17
4.2	Tests of Signal Power	17
	Chapter Five : Conclusions And Future Works	
5.1	Conclusions	19
5.2	Future Work	19
	References	20

LIST OF FIGURES

No.	Name of Figure	Page
1.1	N9000A CXA Spectrum Analyzer Measure the Power of Frequencies Ranging from (90 MHz – 7.5 GHz)	2
2.1	On the Right AD831 Size and On The Left AD8307	6
2.2	Vibration Motor	8
2.3	Arduino Uno Microcontroller	10
2.4	Arduino Liquid Crystal Display	12
3.1	The Connection of the Microwave Signal Power Meter Circuit	13
3.2	The Connection of the I^2C Liquid Crystal Display	14
3.3	The Connection of the Vibration Motor	15
3.4	Solar battery charger	15
3.5	5v Solar battery charger	16
4.1	The Measured Power of the Microwave Signal is -60 dBm, when the distance is about 10 meters	17
4.2	The Measured Power of the Microwave Signal is -30dBm, when the distance is about 5 Meters.	18
4.3	The Measured Power of the Microwave Signal is -10 dBm when distance is about 1 meter.	18

List of Abbreviations

Abbreviation	Abbreviated Words
VHV	Very high frequency
UHF	Ultra high frequency
CDMA	Code division multiple access
GSM900	Global system for mobile communication 900 MHZ (second generation)
GSM1800	Global system for mobile communication 1800 MHZ (third generation)
BT	Bluetooth
WIFI	Wire fidelity
LCD	Liquid crystal display
I^2C	Inter-integrated circuit
FCC	Federal Communication Commission
PC	Personal Computer
RF	Radio Frequincy

Abstract

Radio Frequency Power Measurement is a broad topic that has been of importance to designers, operators and users. With today's complex modulation schemes, increased popularity of wireless transmission and pulsed communication modes,the need to accurately and efficiently measure RF power has become crucial to achieve certain regularity steps to restrict and to prevent the usage of communication devices in prohibited places like exam holes and for data securingpurposes. Therefore, the objective of the project is to develop and to implement a low cost microwave frequencies signal power measuring device with a frequency range of (100MHz- 2.5GHz) which covers the communications bands of (VHF, UHF, CDMA, GSM 900, GSM 1800, Bluetooth and Wi-Fi). The development and the implementation is achieved by utilizing AD8313 IC, LM9314, Arduino Uno, Arduino LCD, vibrator motor and solar cell power supply. The developed microwave signal power measurement system works successfully with a detection rang greater than 10 m withdetection sensitivity to the power of signal ranging from (-70 dbm to +10 dbm).

الخلاصة

يعتبر مفهوم قياس قدرة الإشارة الراديوية من المواضيع المهمة التي تهم المصممين والمصنعين والمستخدمين، ومع كثرة استخدام مبادئ التضمين المعقدة والانتشار الواسع لأجهزة الاتصالات اللاسلكية وانماط الاتصال النبضي، أصبحت الحاجة لأجهزة قياس قدرة الإشارة الراديوية دقيقة وفعالة شيء ضروريا لاتخاذ خطوات تنظيمية محدده كمنع استخدام أجهزة الاتصالات في القاعات الإمتحانية إضافة لأغراض تأمين البيانات. بناءا على ما تقدم، كان هدف المشروع هو تطوير وتنفيذ جهاز كشف قدرة الإشارات اللاسلكية منخفض الكلفة بنطاق تردد (100 ميكا هيرتز – 2.5 جيجا هيرتز) والذي يغطي حزم الاتصالات التالية (VHF, UHF, CDMA, GSM 900, GSM 1800, Bluetooth and Wi-Fi). أن عملية التطوير والتنفيذ قد تمت باستخدام الدائرة المتكاملة AD8313و الدائرة المتكاملة LM9314 والمتحكم الدقيق من نوع أردوينوأونو وشاشة الكريستال السائلة المتوافقة مع المتحكم الدقيق أردوينو ومحرك هزاز و مصدر الطاقة الشمسية لتجهيز الطاقة الكهربائية لجهاز القياس. وقد وجد ان جهاز قياس القدرة المطور قد عمل بنجاح لمدى كشف اكثر من 10 امتار وحساسية كشف تمتد من dbm 70-إلىdbm 10+ .

1.1 Introduction

RF Power Measurement is a broad topic that has been of importance to designers and operators since the earliest days of wire line and wireless communication and information transmission. With today's complex modulation schemes, increased popularity of wireless transmission and pulsed communication modes, the need to accurately and efficiently measure RF power has become crucial to obtaining optimum performance from communication systems and components [1].

In the communication and wireless industries, there are usually a number of regulatory specifications that must be met by any transmitting device, and maximum transmitted power is almost always near the top of the list. The Federal Communications Commission (FCC) and other regulatory agencies responsible for wireless transmissions place strict limits on how much power may be radiated in specific bands to ensure that devices do not cause unacceptable interference to others. Although the real need is usually to limit the actual radiated energy, the more common and practical regulatory requirement is to specify the maximum power which may be delivered to the transmitting antenna[2].

A microwave power meter is an instrument which measures the electrical power at microwave frequencies typically in the range 100 MHz to 40 GHz that is used for communications applications.Usually a microwave power meter will consist of a measuring head which contains the actual power sensing element or an antenna, connected via a cable to the meter proper, which displays the power reading. The head may be referred to as a power sensor or mount. Different power sensors can be used for different frequencies or power levels [2].

Historically the means of operation in most power sensor and meter combinations was that the sensor would convert the microwave power into an analogue voltage which would be read by the meter and converted into a power reading. Several modern power sensor heads contain electronics to create a digital output and can be plugged via USB into a PC which acts as the power meter [1].Microwave power meters have a wide bandwidth, so they are not frequency-selective. To measure the power of a specific frequency component in the presence of other signals at different frequencies a spectrum analyzer is required. Figure (1.1) shows spectrum analyzer device.

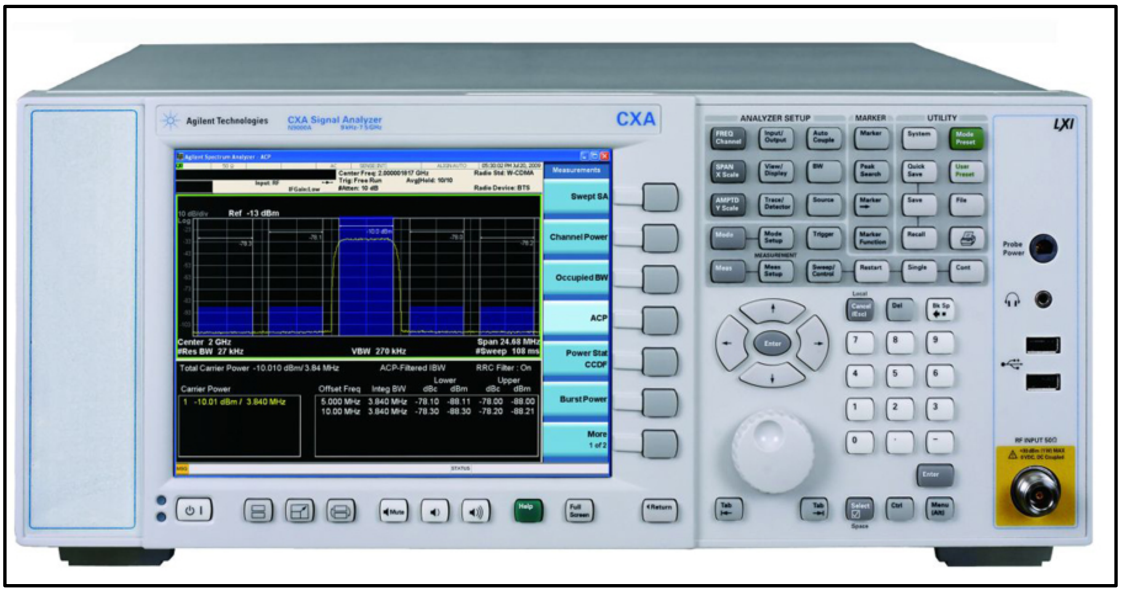


Fig 1.1:- N9000A CXA Spectrum Analyzer Measure the Power of Frequencies Ranging from (90 MHz – 7.5 GHz)

There are a variety of different technologies which have been used as the power sensing element. Each has advantages and disadvantagesThermal sensors can generally be divided into two main categories, thermocouple power sensors and thermistor-based power sensors. Thermal sensors depend on the process of absorbing the RF and microwave signal energy, and sense the resulting heat rise. Therefore, they respond to true average power of the signal, whether it is pulsed, CW, AM/FM or any complex modulation. Thermocouple power sensors make up the majority of the thermal power sensors sold at present. They are generally reasonably linear and have a reasonably fast response time and dynamic range. The microwave power is absorbed in a load whose temperature rise is measured by the thermocouple. Thermocouple sensors often require a reference DC or microwave power source for calibration before measuring; this can be built into the power meter. Thermistor-based power sensors such as the Agilent 8478B are generally only used in situations where their excellent linearity is important, as they are both much slower and have a smaller dynamic range than either thermocouple or diode-based sensors.Thermistor-based power sensors are still the sensor of choice for power transfer standards because of their DC power substitution capability (Agilent 2006). Other thermal sensing technologies include microwave calorimeters and bolometers,and quasi-optic pulsed microwave sensors [2].

Many microwave power heads use one or more diode(s) to rectify the incident microwave power, and have extremely fast response. The diode would generally be used in its square-law region and hence give an output voltage proportional to the incident RF power. In order to extend their dynamic range beyond the square-law region, linearity correction circuits or multiple diode stacks are used [3].

Power meters generally report the power in dBm (decibels relative to 1 milliwatt), dBW (decibels relative to 1 watt) or watts, There are two main types of microwave power meters are

- Average power meter – measures true average power of the signal and displays the power much like a digital voltmeter.
- Peak and average power meter - has the feel of an oscilloscope. It displays profile or envelope power of the signal versus time and can make triggered measurements. In addition to peak, average and peak-to-average power measurements, high end models can make automated pulse measurements of a pulsed RF signal such as pulse average power, rise time and falltime, pulse width, duty cycle, pulse repetition rate, overshoot, droop, edge delay measurements. It can also make marker measurements as well[4].

1.2 The Aim of project

The project aims to develop and to implement a low cost microwave power meter that measures the power of microwave frequencies signals of communications systems ranging from (100 MHz – 2.5 GHz) by utilizing of Arduino Uno microcontroller, Arduino LCD, vibrator motor and solar energy power supply to prevent the attempts of electronic cheating in exam holes.

2.1 Introduction

In this chapter, the theoretical concepts of microwave signal power measurement will be explained, furthermore, the technical specifications and the physical description of the elements that are used to implement the project will be mentioned in the next pages.

2.2 Omni directional Antenna

An Omni directional antenna is a wireless transmitting or receiving antenna that radiates or intercepts radio-frequency (RF) electromagnetic fields equally well in all horizontal directions in a flat, two-dimensional (2D) geometric plane. Omni directional antennas are used in most consumer RF wireless devices, including cellular telephone sets and wireless routers [5].

In theory, a vertically oriented, straight conductor such as a dipole antenna measuring no more than 1/2 wavelength from end-to-end always exhibits Omni directional properties in a horizontal (azimuth) plane. Multiple collinear (in-line) vertical dipoles also exhibit Omni directional behavior in the azimuth plane; they can offer improved performance over a single dipole in some applications. If the conductor axis is not oriented vertically, then the antenna radiates and receives equally well in all directions in the plane through which the conductor passes at a right angle. However, this ideal state of affairs exists only in the absence of obstructions or other nearby conducting objects. In practice, surrounding objects (such as the user of a cell phone set or a computer next to a wireless router) distort the radiation and reception pattern [5].

In the usual context, a so-called Omni directional antenna does not perform equally well in all possible directions in three-dimensional (3D) space. Such a device, which can exist only in theory but can be approached in practice, is called an isotropic antenna or isotropic radiator.
Antennas that offer enhanced performance in some directions, at the expense of other directions, are called directional antennas or directional radiators. The most common example is the dish antenna used with satellite Internet, satellite

television, and space-communications installations. Other examples include the Yagi antenna, quad antenna, billboard antenna, and helical antenna.

2.3 Omni directional Wi-Fi Antenna

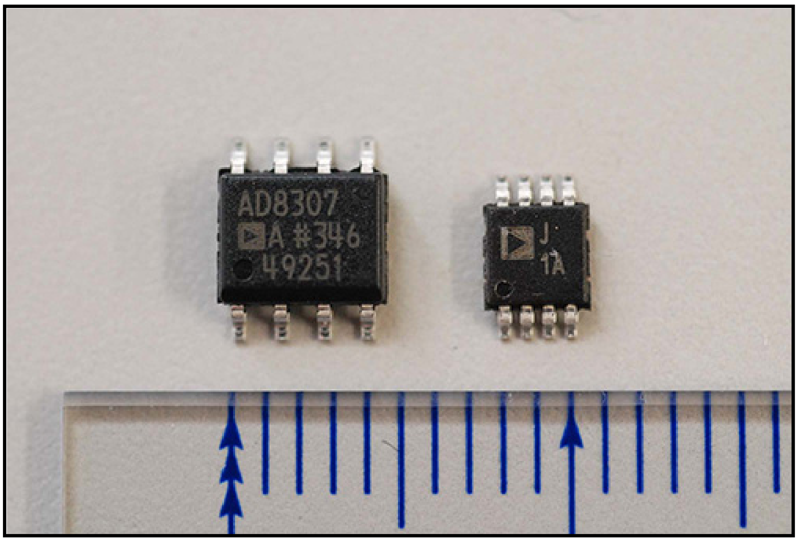
As previously discussed, the only truly Omni directional antenna is an isotropic source, a theoretical single point source that radiates equally in all directions. Thus, if the radiations could be observed, they would look like a sphere that is very dense at the center point, and less dense as the distance from the center point increases. If such an antenna existed, it might have a purpose in outer space, but would not be very useful on earth.

Here on this planet, antennas that radiate equally well in all directions parallel to the earth's surface are said to be "Omni directional," and most are vertically polarized. A perfect vertically polarized Omni directional antenna would emit a radiation pattern in the shape of a torus, with the antenna at the very center. Of course, there are no perfect antennas, and therefore no perfect torus radiation patterns; all real-world antennas have some pattern deficiencies [6].

Three of the most common vertically polarized Omni directional antennas are the half wavelength dipole, the quarter wavelength ground plane, and the collinear array. This article will briefly discuss all three in the context of Wi-Fi communications in the 2.4 GHz frequency band, and will show a homebrew example of each.

2.4 AD8313 Integrated Circuit

The RF Power Meter presented is based on the AD8313 Log detector manufactured by Analog Devices. In GSM phones AD8313 is used as a Log Detector, part of the Power Control Loop circuit as shown in Figure (2.1). Generally could be easy identified near the Power Amplifier module.AD8313 is a Logarithmic Detector which can accurately convert an RF signal at its input to an equivalent decibel-scaled value at its DC output.The DC output is “linear in dB” with a basic slope of 20mV/dB. The slope can be adjusted in a range from 18mV/dB to 30mV/dB.The linear input range of AD8313 is between -60dBm and 0dBm, which corresponds to a DC output between 0.6V to 1.6V (pin 8).The following operational amplifiers (LM324) are translating the DC output range of AD8313 (0.6V to 1.6V on Pin nr 8) to a scaled range read by the Voltmeter (-6V to 0V).The scaled range has a resolution of 100mV/dB.For example the minimum input value (-60dBm) corresponds to a read voltage value of -6.0V, -59dBm corresponds to -5.9V, -58dBm corresponds to -5.8V, and so on up to 0V that corresponds to 0dBm (as in the table below).The frequency range of AD8313 is between 100MHz to 2.5GHz, but the range that not requires a dynamic slope adjustment is between 100MHz to 1.4GHz.The resolution of the RF Power Meter is better than +/- 1dB; only near 0dBm power input, the resolution is approximately +/- 2dB.The RF input has an impedance of 50 ohms provided by the 53 ohms resistor in parallel with the internal impedance of the AD8313.For calibration inject first at the input an 800MHz signal at -60dBm and adjust P2 for -6V reading on the output Voltmeter.After that increase the input level up to 0dBm and adjust P3 for 0V reading on the output Voltmeter.The slope can be adjusted by the P1 semi-resistor.Careful design of the RF input layout should be done for minimizing parasitic which can produce un-wanted resonances that affects the linearity vs frequency of the log-detector. Tolerance of the resistors is +/-1%.A calibrated attenuator at the input can be used to increase the maximum input power, without damaging the detector [7].



Fig(2.1): On the Right AD831 Size and On The Left AD8307

The AD8313 is a complete multistage demodulating logarithmic amplifier that can accurately convert an RF signal at its input to an equivalent decibel-scaled value at its dc output. The AD8313 maintains a high degree of log conformance for signal frequencies from 0.1 GHz to 2.5 GHz. Application is straightforward, requiring only a single supply of 2.7 V to 5.5 V and the addition of a suitable input and supply decoupling. Operating on a 3 V supply, its 13.7 mA consumption (for TA = 25°C) is only 41 mW. A power-down feature is provided; the input is taken high to initiate a low current (20 µA) sleep mode, with a threshold at half the supply voltage.

The AD8313 is fabricated on Analog Devices, Inc., advanced 25 GHz silicon bipolar IC process and is available in an 8-lead MSOP package. The operating temperature range is −40°C to +85°C.

2.5 Vibration Motor

Basic Concepts of Vibration . All bodies having mass and elasticity are capable of producing vibration. The Vibrator is shown in Figure (2.2). The mass is inherent of the body and elasticity causes relative motion among its parts. When body particles are displaced by the application of external force, the internal forces in the form of elastic energy are present in the body.

These forces try to bring the body to its original position. At equilibrium position, the whole of the elastic energy is converted into kinetic energy and body continues to move in the opposite direction because of it. The whole of the kinetic energy is again converted into elastic or strain energy due to which the body again returns to the equilibrium position [8].

In this way, vibratory motion is repeated indefinitely and exchange of energy takes place. Thus, any motion which repeats itself after an interval of time is called vibration or oscillation.

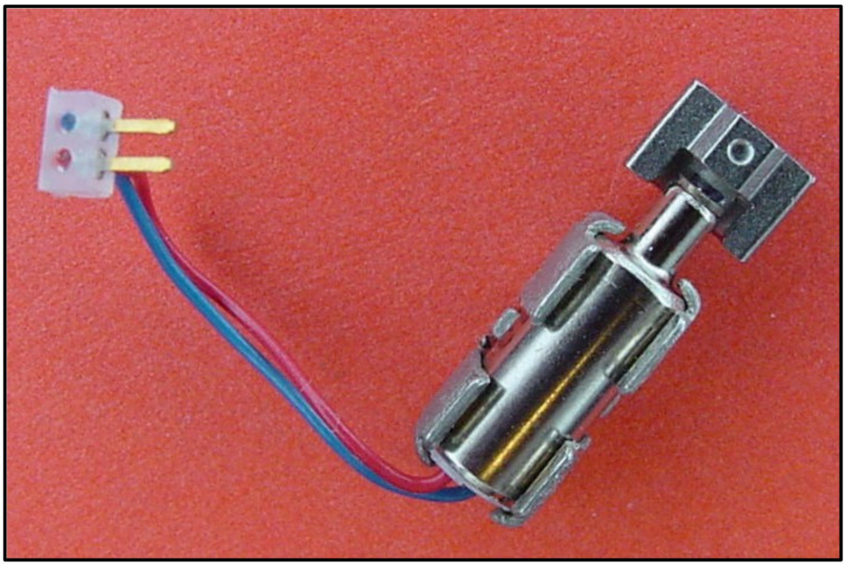


Fig. (2.2): Vibration Motor

Importance of Vibration Study in Engineering .The structures designed to support the high speed engines and turbines are subjected to vibration. Due to faulty design and poor manufacture, there is unbalance in the engines which causes excessive and unpleasant stresses in the rotating system because of vibration. The vibration causes rapid wear of machine parts such as bearings and gears. Unwanted vibrations may cause loosening of parts from the machine. Because of improper design or material distribution, the wheels of locomotive can leave the track due to excessive vibration which results in accident or heavy loss. Many buildings, structures and bridges fall because of vibration. If the frequency of excitation coincides with one of the natural frequencies of the system, a condition of resonance is reached, and dangerously large oscillations may occur which may result in the mechanical failure of the system.

Importance of Vibration Study in Engineering .Thus undesirable vibrations should be eliminated or reduced upto certain extent by the following methods : – Removing external excitation, if possible – Using shock absorbers. – Dynamic absorbers. – Resting the system on proper vibration isolators.

2.6 Arduino Microcontoller

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions,see the index of Arduino boards [9].

Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply. 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA. GND. Ground pins.

• Arduino Uno

• Arduino Leonardo

• Arduino LilyPad

• Arduino Mega

• Arduino Nano

• Arduino Mini

• Arduino Mini Pro

• Arduino BT

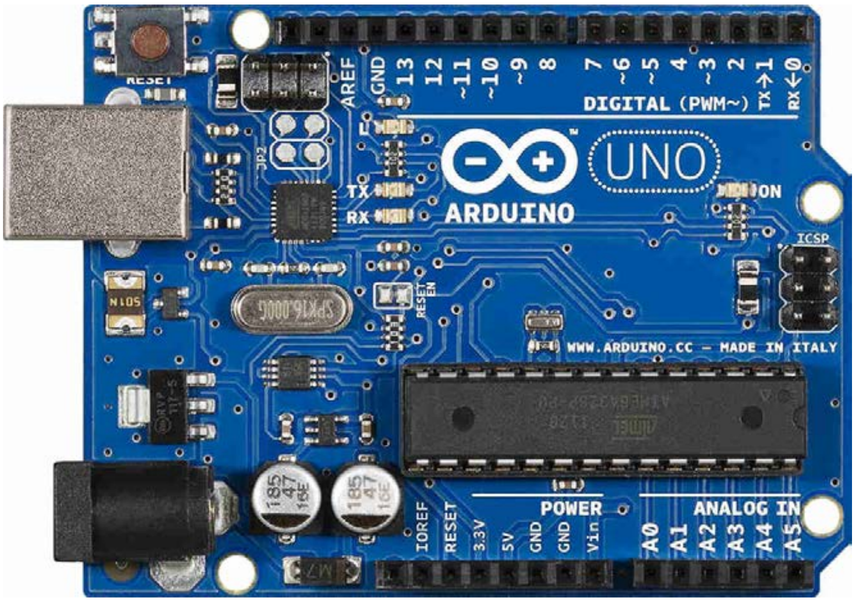


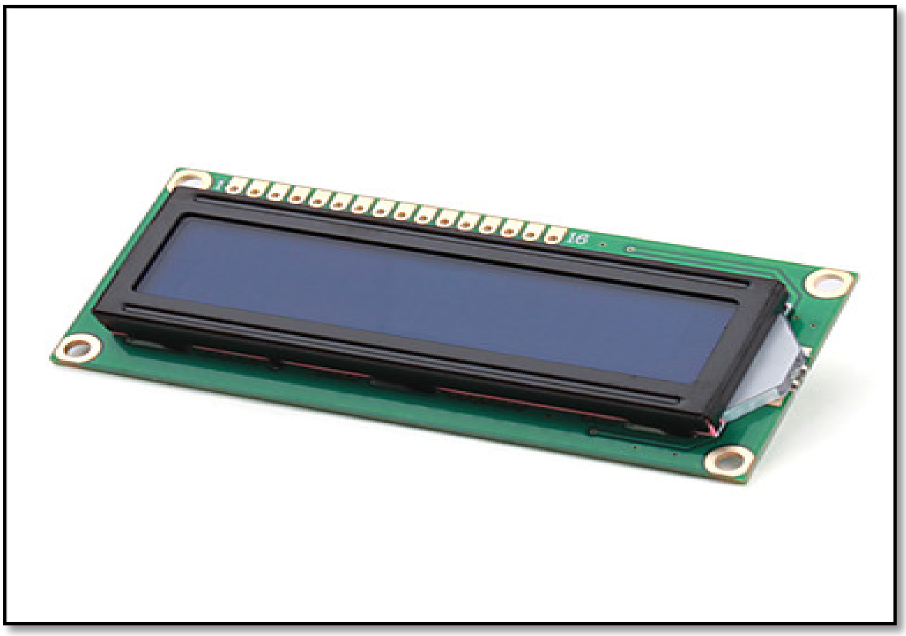
Fig. (2.3): Arduino Uno Microcontroller

2.7 Liquid Crystal Display (LCD)

To fully understand how to interface an Arduino microcontroller to an LCD screen, it is important to understand how an LCD functions. An LCD display is composed of pixels made up of liquid crystals. Liquid crystals exist in a state that’s between a solid and a liquid. At any time liquid crystals can be in a variety of phases, most notably the nomadic phase or the Semitic phase. In the nomadic phase the crystals act more like a liquid, allowing the molecules of the crystals to rearrange themselves while remaining oriented in a uniform direction. In the Semitic phase, the molecules can form into layers that can move past one another relatively easily. Molecules of a certain layer can move freely within that layer, but cannot move to adjacent layers. When the liquid crystals exist in the nomadicphase they tend to adapt a twisted up structure, which can be straightened out when electricity is applied to them. In an LCD, a liquid crystal pixel lies between two glass filters, one behind it and another in front at 90 degrees. When electricity is applied to the liquid crystals the twisted structures that have naturally formed are straightened out. This rotates any light passing through 90 degrees, thus allowing it to pass through the two glass filters. Figure 1: Liquid crystals in their “on” (Right) and “off” (Left) states In order to give some context on how it is possible to program an LCD screen to display certain information the Arduino microcontroller should be briefly discussed. The Arduino model that is the topic of this application note is the Arduino Uno. The Arduino Uno board consists of ATmega328 microcontroller, 14 digital input/output pins, 6 analog inputs, a 16 MHz resonator, a USB connection, a power jack, and an ICSP header. For this project the most important features of the board are the microcontroller, which allows for the building ofObjective The object of this application note is to demonstrate how an Arduino microcontroller can be used to interface with an LCD screen. Method Interfacing an Arduino microcontroller with an LCD display consists of two parts, wiring and programming [10] .

A typical LCD display consists of 16 pins that control various features of the screen. A table that shows the pins and describes each function can be seen in Table 1 below. The Arduino microcontroller can output voltages of either 5 V or 3.3 V, so the LCD can be powered by wiring VSS and VDD to the ground and 5 V pins on the microcontroller. It is possitadjust the contrast of the screen by wiring a variable resistor to V0 located at pin 3 on the screen. The RS, R/W, and E pins are wired to pins 12, ground, and 11 respectively on the Arduino [11].

A liquid crystal display, or LCD, is a video display that utilizes the light modulating properties of liquid crystals to display pictures or text on a screen. Since their invention in 1964, LCD screens have grown to be used in a very wide variety of applications, including computer monitors, televisions, and instrument panels. One way to utilize an LCD is with an Arduino microcontroller. By wiring an Arduino microcontroller to the pins of an LCD display it is possible to program the microcontroller to display a desired text string or image on the screen. The LCD is shown in figure below.



Fig(2.4):Arduino Liquid Crystal Display

3.1 Introduction

As mentioned in Chapter 1, The target of the project is to develop and to implement microwave power meter device to detect the power level of the signals in the frequency range of (100 MHz-2.4GHz), which means It covers seven communication bands (VHF, UHF, CDMA, GSM 900, GSM 1800, Bluetooth and Wi-Fi).The designed circuit is implemented by connecting the detector circuit with Arduino and I2C LCD serial monitor instead of LEDs to display the power level of a detected signal as a digital form, the experimental connection is explained in the following section.

3.2 The Connection of Power Meter Circuit

The microwave power meter circuit is implemented by connecting the Omni directional antenna to utilize its spherical radiation pattern to receive microwave signal from all directions, two 1N5711 diodes are connected to realize the principle of RF protection of the circuit, the received signal is then fed to the logarithmic amplifier IC AD8313. The power level of the signal is then determined by using LM3914 IC. Nine output levels of power signal ranging from (-70 dBm to +10 dBm) are then connected to the digital pins of Arduino Uno (D2 – D10) in order to display the power level digitally on I^2C LCD serial display.

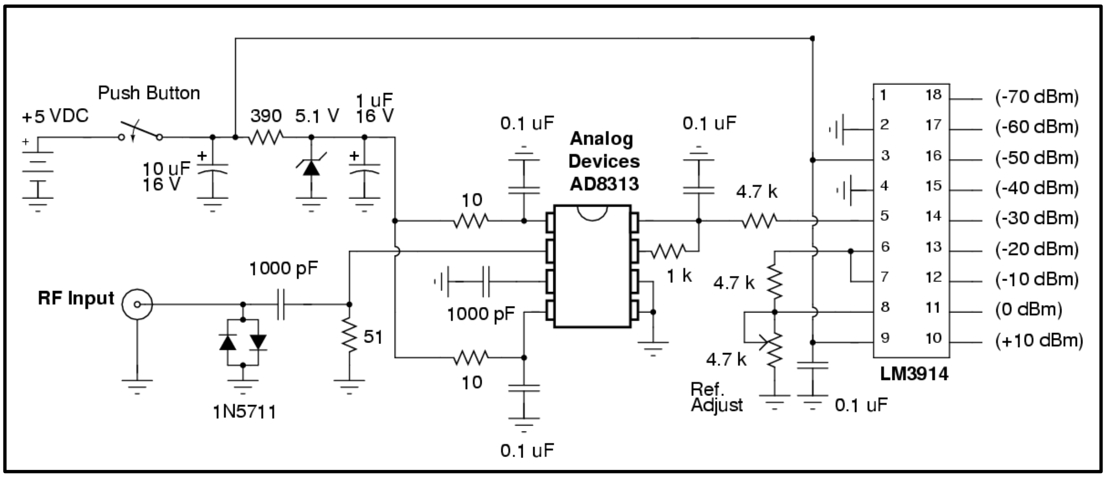


Fig. (3.1): The Connection of the Microwave Signal Power Meter Circuit

3.3 The Connection of the Serial I^2C LCD

The serial I^2C liquid crystal display is used to display the signal power level in a digital form. The connection of I^2C LCD requires only four pins on the Arduino board which are 5V, GND, A4, A5 as shown in Figure (3.2) to be ready to display the data produced by the Arduino microcontroller.

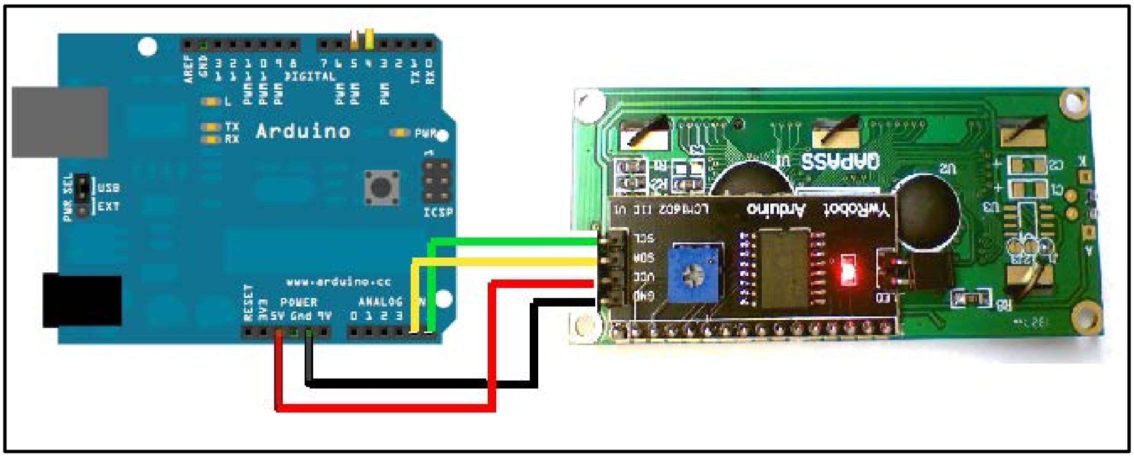


Fig. (3.2): The Connection of the I^2C Liquid Crystal Display

3.4 The Connection of Vibration Motor

A vibration motor provides the ability to alert the carrier of the microwave signal power meter a notification that the power meter device is very near form the source of the signal silently.

The connection of the vibration motor is implemented by using 2N2222 transistor to amplify the current of the vibrator motor, 1N4001 to protect the vibrator and to provide a suitable voltage, 0.1µf capacitor to ease the movement of the motor rotor from the static. The motor voltage is supplied by Arduino Uno microcontroller and the motor is activated by digital pin number 11, the connection of vibrato motor is shown in Figure (3.3) .

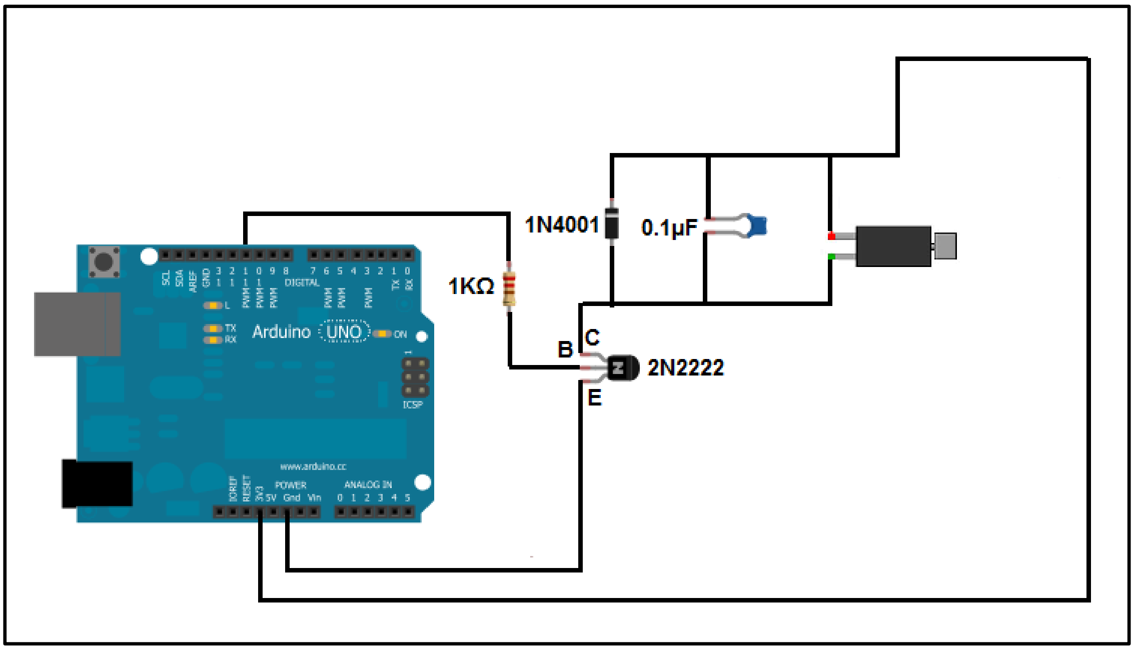


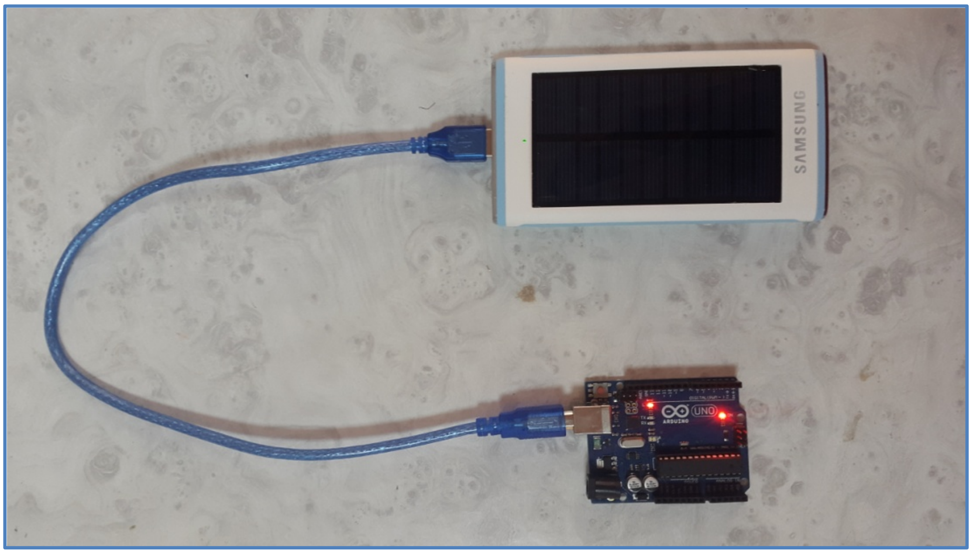
Fig. (3.3): The Connection of the Vibration Motor

3.5**Solar battery charger**

Solar power is a very fast growing industry. As a result, there has been a long running shortage of silicon for solar panels, which has traditionally led to high solar panel prices. Based on volume purchasing power, BatteryStuff.com is proud to offer competitive pricing for smaller solar panel battery charger items that are often in short supply, as shown in figure (3.4).

Fig(3.4): Solar battery charger

The mid-sized 5-10 watt panels range from panels with cigarette lighter adaptors, to panels from mounting, to industrial unbreakable panels. These are designed to maintain mid-size batteries and are recommended for use in electric gate openers, fence chargers, dual battery starting systems, and industrial equipment.



Fig(3.5): 5V Solar battery charger

4.1 Experimental Results

In this chapter, the performance of the project circuits are tasted to study their behaviors when they are connected together in order to realize the detection concept. The tests of signal power test are achieved in the laboratories of the communications engineering department in our college.

4.2 Tests of Signal Power

In order to test the efficiency of the power measurement device, The microwave signal power at a Bluetooth frequency of 2.4GHz is measured in three different positions where the first position is about 10 meter from the device, the measured power is -60 dBm as shown in Figure (4.1).

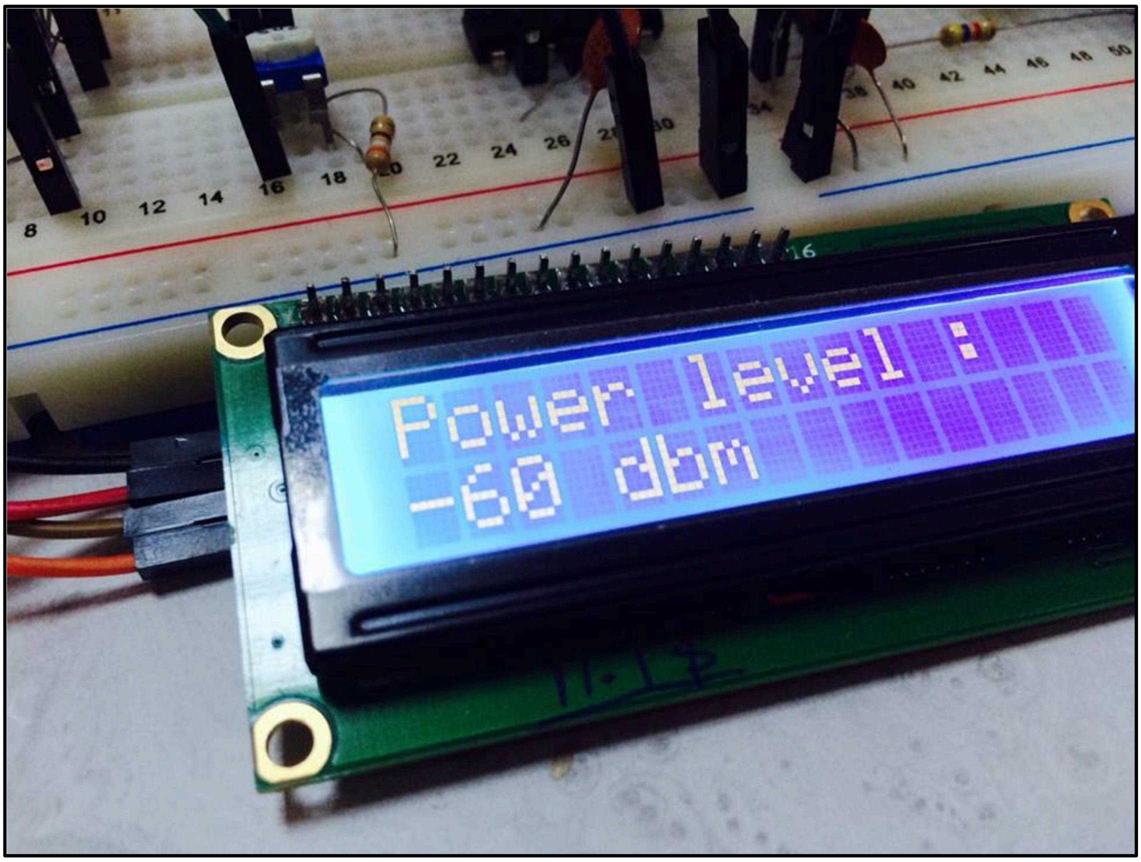


Fig. (4.1): The Measured Power of the Microwave Signal is -60 dBm, whenthedistance isabout 10 meters

The second position is about 5 meter from thedevice, the measured power is -30 dBm as shown in Figure (4.2).

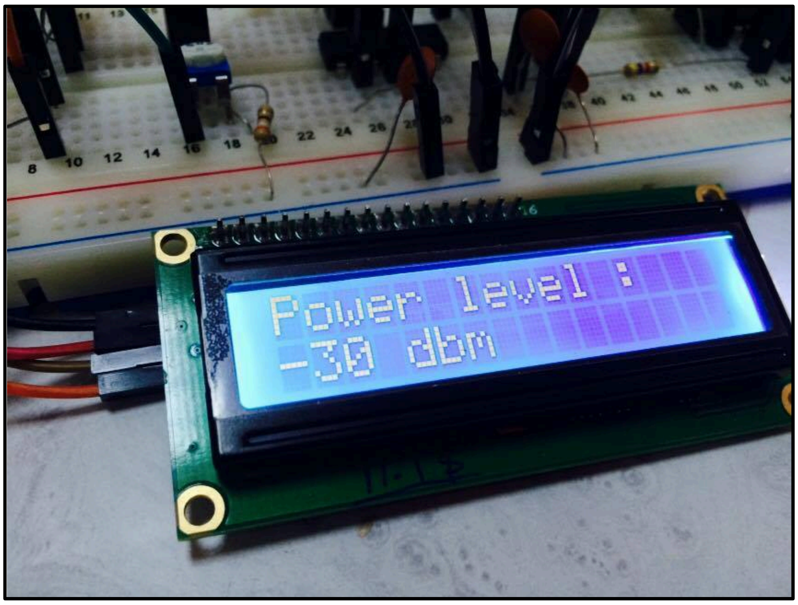


Fig. (4.2): The Measured Power of the Microwave Signal is -30dBm, when the distance is about 5 Meters

The third position is about 1 meter from the device, the measured power is -10 dBm as shown in Figure (4.3).

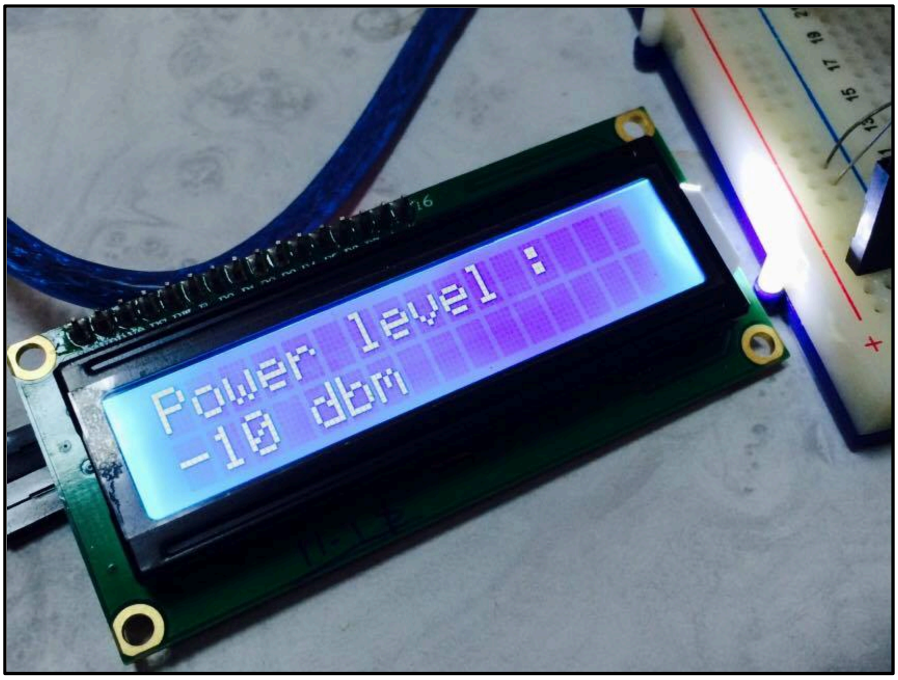


Fig. (4.3): The Measured Power of the Microwave Signal is -10 dBm when distance is about 1 meter

5.1 Conclusions

The developed power meter device works successfully as it designed and implemented. The measurement circuit of signal power works efficiently and measures electromagnetic signals power from -60 dbm to +10 dbm for the range of (100MHz-2.4GHz). Furthermore the circuit can covered more than seven bands and finally the power level that represents actual signal power is displayed on LCD serial monitor.

Additionally, the detect system are designed and implemented to be in small size and light weight and with solar battery charger in order to eliminate the need of using DC power supply source. Also, the vibrator motor works successfully when a signal of highest power level (+10 dBm) is detected to indicate that the developed power meter is very near from the source of the microwave signal.

5.2 Future Work

Many new techniques can be added to the circuit of the project, these techniques are hoped to be designed next years. The new techniques are:-

1. Using band pass filter to measure power of a specific range of frequencies.
2. Using printed antenna to receive the microwave signals.
3. Design a power meter circuit for frequencies less than 100 MHz.

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Appendix

Specification of LM3914

The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V.

The circuit contains its own adjustable reference and accurate 10-step voltage divider. The low-bias-current input buffer accepts signals down to ground, or V−, yet needs no protection against inputs of 35V above or below ground. The buffer drives 10 individual comparators referenced to the precision divider. Indication non-linearity can thus be held typically to 1⁄2%, even over a wide temperature range.

Versatility was designed into the LM3914 so that controller, visual alarm, and expanded scale functions are easily added on to the display system. The circuit can drive LEDs of many colors, or low-current incandescent lamps. Many LM3914s can be “chained” to form displays of 20 to over 100 segments.

Both ends of the voltage divider are externally available so that 2 drivers can be made into a zero-center meter.
The LM3914 is very easy to apply as an analog meter circuit.

A 1.2V full-scale meter requires only 1 resistor and a single 3V to 15V supply in addition to the 10 display LEDs. If the 1 resistor is a pot, it becomes the LED brightness control. The simplified block diagram illustrates this extremely simple external circuitry. The LM3914 is rated for operation from 0°C to +70°C.

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