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Design and Analysis of a Digital Field Strength Detector

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***Abstract* - Electric field discharge is rampant in our present society due to advancement in technology, telecommunication transmitters such as in Television, radio broadcasting stations, telephones etc, hence the strength of field released is high. With these in mind, it is therefore important to design a field strength meter which determines the amount of electric field strength around a location. Field strength meter is a measuring device which measures the signal strength caused by a transmitter. The need for field strength measurement is essential when designing and building transmitters. The field strength meter provides signal strength figures and allows us to compare and estimate the efficiency of a transmitter and its expected range. The system describe here, incorporate the use of coil, transistor, diodes, capacitors and resistors to achieving the aim of this project. The field strength meter sense or detect the strength of the field radiated or transmitted around, thereby switching LEDs to indicate the presence electric field in a particular area, be it an electronic device such as mobile phone etc, found in residential homes, high rise buildings, automobile systems. An electrically charged object produces an electric field, and this field has an effect on other charge objects in the vicinity.**

Keywords: Field, Radiation, Transmitter, Sensor

1.0 INTRODUCTION

In telecommunications, field strength meter is a measuring device which measures the electric field radiated by transmitters. The system provides signal strength values and allows us to compare and estimate the efficiency of a transmitter and its expected range. The system describe here, incorporate the use of coil, transistor, diodes, capacitors and resistors to achieving the aim of this project. The field strength meter automatically response to varying field by sensing or detecting the strength of the field radiated or transmitted around, to which switching LEDs are used to indicate the presence electric field in a particular area, be it an electronic device such as mobile phone or radio equipment etc, found in residential homes, high building s, automobile, electronic, manufacturing factories. It uses an antenna wired to the circuit and coil, the sensor then detects and controls the field in order to avoid manual searching of the electric field. The technology is used to eliminate monitoring using noise figure on other device. The system use to detect from daylight and night illumination (difference in contrast). Any electric charge object produces an electric field. This field has an effect on other charged bodies in the vicinity. Electric fields are caused by electric charges or varying magnetic fields. When measuring with a field strength meter it is important to use a calibrated antenna such as such as the standard antenna supplied with the meter. For precision, measurement the antenna must be at standard height. A value of standard height frequently employed for VHF and UHF measurement is 10 meters.

2.0 BACKGROUND

The field strength meter is actually a simple electronic receiver where signal is detected and fed to a micro ammeter, which has a graduated scale in dbμ. The frequency range of the tuner is usually within the terrestrial broadcasting band. Some field strength can also receive satellite frequencies. Most modern field strength meter have AF and VF circuit and can be used as standard receiver. Some FS detectors are also equipped with printers to record field strength. To measure using a field strength meter it is important to use a calibrated antenna that is standard. For accurate measurement the antenna must be of standard height. The transmitters have sufficient output to detect the radiation when the antenna is outstretched. Most field strength detectors are designed for connection to transmitters with an output of 1 to 1000 watts and are capable of detecting output in milliwatt range. For low output, we need a field strength that will be able to detect 1 to 50 milliwatts. In an ideal free space, the electric field strength is produce by a transmitter which has isotropic radiator.

Let, $E=\frac{\sqrt{30.P}}{d}$

Where E is the electric field strength in volts per meter

P is the transmitter power output in watts

d is the distance from the radiator in meters

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It is clear to show that field strength is inversely proportional to the distance between the transmitter and the receiver. However, this relationship is impractical for calculating the field strength produce by terrestrial transmitters, where reflection and attenuation caused by objects around the transmitter or receiver may affect the electrical field strength considerably.

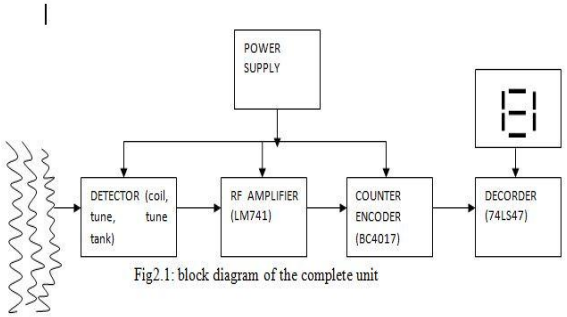

Fig2.1: block diagram of the complete unit

2.1 Detector Unit

The detecting unit consists of an antenna and a tune circuit which also comprises of a coil and a capacitor. The circuit picks up RF energy on its 5cm antenna and passes it to the tune circuit where all the frequencies, except one are lost in the coil. The only frequency to appear at the output of the tune circuit is the one that is equal to the natural resonant frequency of the tune circuit. This signal is passed to the RF amplifier stage where it is amplified. The coil for the tune circuit was chosen so that it is known for its fixed value of inductance. This allows us to further use a trimmer capacitor and put a scale around it on the casing so that you can read and select the frequency range. Even though the coil does not have a very good "Q" factor it will be ok in this case as the Q is not important. In other words the tuning will be fairly broad and you will have to find the "centre spot" to get the exact frequency. Even then, the frequency will not be exactly as the scale has not been individually calibrated. It was only design to give you an approximate value, and the display give the value in decibel of what was detected. The way in which the tune circuit works is quite amazing. The entire signal from radio stations, taxis, bugs, TV stations, cellular phones etc are picked up by the antenna and passed to the tuned circuit where they will set into operation.

2.2 Counter Unit

The counter unit consists of a single IC decade counter (CD4017) which has ten outputs. The ten output switches in sequence each time a pulse is fed in reference to the frequency pulse from the RF unit. This help in encoding the signal into digital figures in order to represent the signal in digit form. It primary function was to encode the amplifier signal from the RF unit into digital form for digital display in a continuous order related to the pulse frequency.

The counter is made up of.

i. CD4017 decade counter
ii. Speed diode (IN4148)

2.3 Decoder

This consist of a single IC 0-9 digital decoder (74LS47) which has a binary output and seven segment output. The binary input is fed up from the counter unit and the seven outputs are fed to a seven segment display.

The decoder is made up of

a. 74LS47 decoder driver

2.4 Display

The common display used in this circuit was a seven segment display connected to the output of a digital decoder. It comprises of seven output, each output provide a special code for any digit to be represented, thereby switching the right LED, arranged to show a figure. It primary function is to display digital figures.

3.0 Regulator

The regulators are of many types (LM731, LM78xx etc). For the circuit the 78xx series is used for 5v. Therefore, 7805 is used to deliver a steady 5v output.

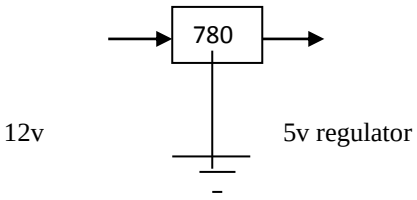

Fig 3.0: 7805 regulator

3.1 Ic Operational Amplifier Lm741

The LM741 series are general purpose operational amplifier which feature improved performance over industry standards like the LM709. They are directly, plug-in replacement for the 709C, LM201, MC1439 and 748 in most applications. The amplifier offer many features which make their application nearly foolproof overload protection in the input and output. The LM741C is identical to the LM741/LM741A except that the LM741C has their performance guaranteed over a 0ºc to +70ºc temperature range, instead of -55ºc to +125ºc

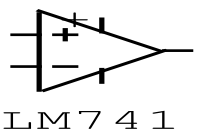

Fig 3.1 Operational Amplifier

3.2 Time Hold/Delay

The time hold by the capacitor C1 should be equal to RC time constant, which is (10 second), for standard application specification in the data sheet for C as reference value.

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$$T = RC \ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$T = R_1 C_1 = \frac{1}{4} \times 10 = 2.2\,sec \ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$\therefore R_1 = \frac{T}{C_1} = \frac{2.2sec}{100\mu F} \ldots\ldots\ldots\ldots\ldots\ldots 3$$

$$R_1 = 22000 \ldots\ldots\ldots\ldots\ldots\ldots 4$$

3.3 The Counter

The decade counter CD4017B is a 5-stage counter with ten decoded output and a carryout. The counter cleared its zero count by a logical "1" on their reset line. This counter is advance on the positive edge on the clock signal, when the clock enable signal is in the logical "0" state. Their configurations permit medium speed operation and assure a hazard free counting sequence. The ten decoded output are normally in the logical "0" state only at their respective time. The input pin is 14 for the clock pulse, pin 13 and 15 are the enable pin and reset pin respectively. These are configured to set the counter count sequentially when the enable and reset pin are grounded to allow pulse input to count. The output pin start from pin 1 to 12. 1 to 11 are the parallel output while pin 12 is 1/10 of each pin. The use are 1, 2, 7, and 4, they are connected to the display unit through the diode to make the appropriate binary cord for the input sequence. Pin 16 and 8 are power control terminals, which are connected to the positive and negative side of the power supply respectively.

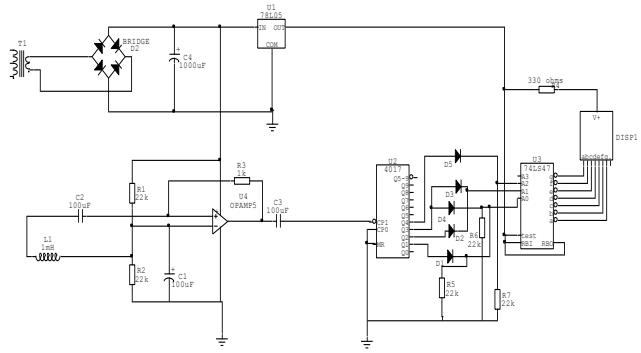

Fig 3.4: complete circuit diagram

4.0 TESTING AND RESULT

The chapter is base on testing, evaluation and assembling of component in relation to the design circuit. All components were tested individually and each of the sub-unit was build on the board and monitored before it was finally transformed to main construction board. This was done in order to verify its workability. The entire circuit was arranged logically according to design specification. The ICs, diode and display must be placed correctly and not over heated otherwise an IC socket should be place to avoid lose loose.

4.1 Testing

Various test were carried out before, during and after the construction the construction has been completed. The multi meter was extensively used. It was ensured that each of the components was tested and confirmed. The complete circuit has two basic test.

i. Power supply test
ii. Display unit test

The power supply test was carried out when all the component were connected and the unit was powered by main supply. The output voltage supply to circuit met the required voltage needed of the complete circuit. The display unit testing was carried out by testing the output of the decoder to give an exact code for the output representation.

4.2 Result

When the circuit was switch "ON" the display unit indicated the output in a digital form, but however if the electric field within the surrounding is large, it will result in interference.

5.0 CONCLUSION

The field strength detector was successfully constructed, and when tested it was found out that the system was able to detect the presence of an electric field from a transmitted device such as mobile phone when making a call or an incoming signal is intercepted. The resistor value for the RF amplifier feedback can be increase or be varied to improve and select a desirable amplification by either increase or decrease in it value. This is as a result of a negative feedback behavior of the operational amplifier, also the capacitor parallel to the non inverted, improve the sensitivity of the RF amplifier which speed up the entire circuit operation at high frequency.

5.1 Recommendation

Since the design has met its purpose, we can now go into real implementation of this system which can be use in advance. I therefore recommend the following

i. Since electric/magnetic field is hazardous to health it advisable to design a means of limiting the field after detected.
ii. It should be develop in such a way that, it will display the distance and specify whether the field is of a transmitter, phone etc
iii. A more smaller and portable field strength detector should be constructed for easy movement.

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