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EDUCATIONAL MOBILE-BASED ANTENNA DIRECTION CONTROL (ADC) SYSTEM FOR TECHNICAL UNIVERSITIES

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Abstract

Technical Universities in Iraq have communication laboratories as part of their curriculum, however, most of them suffer great shortage in models. One of the important models is Antennal direction control (position finder). In this paper, a proposed system is presented that interacts with the receiver antenna opposite the transmitter antenna through a designed mediator unit to set the optional position points. The receiver antenna is rolled around and spent backwards (clock- anti – clockwise) until it arrives at the best received position and stabilizes. The system is designed with high feasibility to its reliability with the use of software processes. The direction of the antenna has been achieved using a software process and a technique dependent on the optional point position detection approach to trace the received signals. In his method, the IF-AGC signal of the set has been used for the first instance as a sensing signal for the image quality and then will be possible to apply the set directly without any adjustment. In addition, the Arduino has been employed for Antenna movement and to reverse the direction of orientation, the system can be named as a helpmate and antenna pointer.

Keywords: ADC, optional point (OP), mobile application, antenna pointer, Arduino

Introduction

Bad TV reception happens due to weak signals from the TV stations. Low signal strength or 'weak signals' are the cause of only one kind of poor reception, this kind of poor reception really only occurs in about 15-20% of cases, the other 80-85% of cases are due to other things like antenna direction [1]. Moreover, the main drawback of a high gain antenna is that it should be very directional. So we have to make sure it's very carefully pointed at the station we want, because it will be very poor at receiving signals from any other direction. What if we want to receive weak signals from a number of stations, and they're all in different directions? There are two ways of solving these weak signal problems, in some situations where the direct-path signals are too weak even when we use a high gain antenna [1].

- One approach is to use a single high gain antenna with a controlled rotator system.
- The other approach is to have a number of fixed high gain antennas, each

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pointing at one of the stations, and with their signals either selected by a set-top: switch box, or combined using a device called a diplexer [2].

Late 1967 Samuel J. Cook developed a Radio Direction Finder to be used in a prototype system of Intrusion Alarm radios. The system had small direction-finding ant radios. The antenna, and it was based on the second approach mentioned above. Later then designers added a position-sensing potentiometer to a Radio Shack TV antenna rotator. They used AC synchronous motors that run at a predictable speed, and the control box simply runs the motor for the amount of time needed to turn the antenna from where the controller thinks it is to where the controller wants it to be. Of course, over time, the error in position grows and grows [3].

In 1981 A. Y. Shaheen developed (8085) microprocessor based Position Direction Finder. That development was targeted to employ Video-Detector output signals as sensing signals. Besides, it wasn't a general system, where he was forced to use AM/FM signal generator and Video-Peak Detector that did not give a stable result, since the video signal is affected by instantaneous changes of the picture [4]. Other systems have used storage memories to restore the antenna positions of the transmitter station in a specific area.
In the past decade, since the beginning of the DIRECTV satellite system in 1994 significant advances in antenna position control of satellites took place while TV antenna position control was ignored [5,6]. Nowadays many people prefer to use PCs in monitoring and controlling home systems with relatively low cost and more reliability.

This paper deals with the design of Monitoring, Converting and Interfacing Unit (MCIU) that can be used for general-purpose applications. The designed unit can be used in several implementations. One of them is directing the TV receiver antenna toward the transmitter antenna that is described in this article. Other applications include solar energy tracking, antenna pattern plotting, home system control, any medium power industry application...etc. The processing arrangement in this work makes use of the output sampling using optimal point detection method to track the transmitted wave. In this application we employ the IF-AGC voltage as a sensing signal for the first time, by this means we don't have to make any modification to the TV-set. The software that provides the control process was written using C++ language [7]. And the MCIU makes use of the PC's parallel port. The control system will swing the antenna right and left until it reaches the optimization position and will be settled there [8,9].

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1 The proposed System Components

The suggested system, shown in Figure 1, contains four units:

- The transducer unit (a TV-set in our implementation).
- The PC unit.
- The designed unit (MCIU).
- The motion unit.

In this system the analogue output of the receiver is fed to the ADC then it is interfaced to the PC through data buffers and the parallel port. In the computer the digital values are stored then processed by a program that is prepared previously to drive the antenna to the optimal position [10].

Two searching algorithms to carry out optimal point detection techniques could be used. In the first method the digital signal is stored then the program drives the DC motor (for rotating the antenna) to a new position with a controllable angle that can be determined by software. A new A/D conversion has occurred; the new digital signal is compared with the previous one. The DC motor turns left or right according to the comparison result. This process is repeated until the antenna reaches the position of the optimal point.

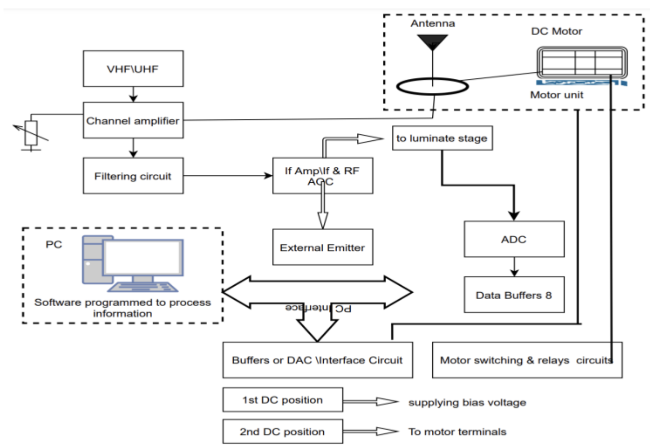

Fig.1 The block diagram of the designed system.

In the second algorithm the DC motor turns the antenna to an initial position. From that position the DC motor rotates the antenna in one direction till it reaches an end position, through this rotation a repetitively A/D conversion occurs with a controllable angle that

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can be determined by software. At the end position the program will calculate the optimal point position then it will drive the motor to settle there. The second method is better and will be implemented since the received signal has multiple optimal points [11].

1.1 The Transducer Unit

The block diagram of the transducer unit (the receiver) is shown in Figure 2. Practical applications were done on two different types of receivers: The first receiver uses a TV unit produced by PHILIPS Company "VHF-UHF channel selector/ELC2004, and IF-Module/4822 212 21087". And the second receiver has been built using discrete components similar to that designed in SIEMENS monochrome TV/16". The receiver unit contains the splitter, channel selector (RF stage), and the IF stage with the video detector.

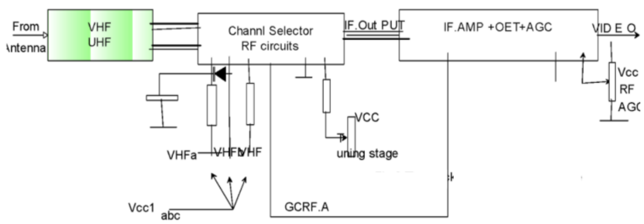

Fig. 2 The block diagram of the designed systemThe block diagram of the tuner.

In the **RF Stage**, The antenna signal will first be passed through a VHF/UHF splitter, Figure 2, where a channel in one of the three bands (VHF-a, VHF-b, or UHF) will be selected. A DC voltage from the band-switch is applied to the channel selector and this will energize the corresponding RF-amplifier and oscillator. The tuning of these amplifiers and oscillators is determined by an adjustable DC-voltage applied from the control circuitry in the tuning stage. The RF-amplifier is also affected by the RF-AGC voltage, which is supplied from the next stage to control the amplifier gain due to the quality of the received signal [12]. In this stage the received signal is amplified and mixed with a locally generated signal to produce a fixed IF-signal, which is supplied to the next IF-stage.

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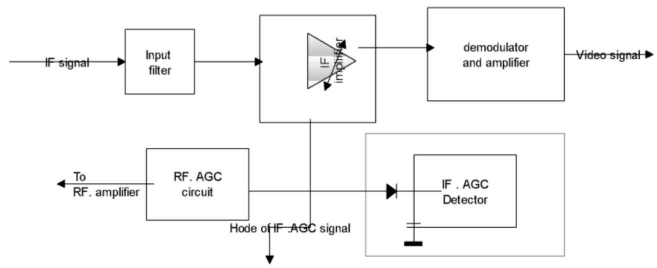

Fig. 3 The block diagram of the IF stage.

The **IF-stage**, the signal first passes through an input filter, which provides the necessary IF rejection and defines the IF pass-band, Figure 3. This filter is followed by an IF-amplifier with variable gain, which is determined by a voltage from the IF-AGC circuit. Following the IF-amplifier is the synchronous demodulator with its reference amplifier. The demodulated video signal is transferred to the next stage (Luminance) via an output amplifier [13].

The **IF-AGC and RF-AGC**, as shown in Figure 4, the IF-AGC detector supplies a pulse during the sync peaks of the video signal on the demodulator output. An assembly of diodes with resistor and capacitor detects the lower levels of these pulses, which are used as IF-AGC signals [14]. The state of RF-AGC depends on the condition of the IF-AGC. In the case of small aerial signals, the IF and RF-AGC voltages are high, so the output voltages to the amplifiers of the channel selector are high, and it provides maximum gain [7,8].

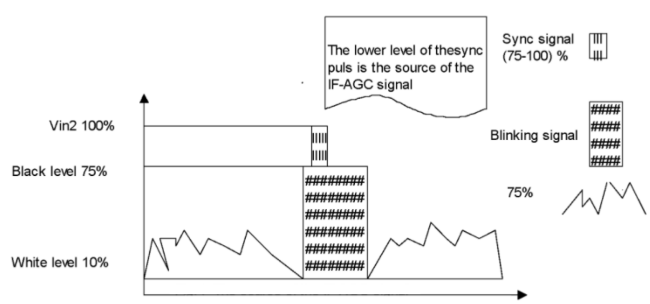

Fig. 4 The source of the IF-AGC signal.

AGC-voltage is proportional to the received signal and may be employed to indicate the quality of reception. Figure 4 shows from where that signal is derived.

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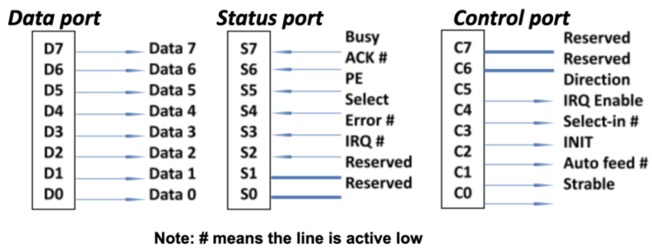

Fig. 5 A diagram shows the layout of each of the ports.

Arduino [15] is used to provide the interface to the 8-bit data input and to the command and status pulses. The base address for the parallel port(s) can be found by looking at memory location 0000:0408 (hexadecimal). The first 2-byte number at address 0000:0408 corresponds to the base address of LPT1. The second 2-byte number corresponds to LPT2, and so on. The base address for LPT1 in this case turns out to be 0X378.

The parallel port is divided up into three 8-bit ports. The base address corresponds to the Data port. The address base+1 corresponds to the Status port. The address base+2 corresponds to the Control Port. Figure 5 shows the layout of each of the ports [16]. The block diagram of the MCIU is shown in Figure 6.

This unit was designed with the following circuits:

- ADC circuit.
- Data buffering circuits.
- Status and command buffering circuit.
- Motor controlling circuits (switches & relays).
- Two DC Power Supplies.

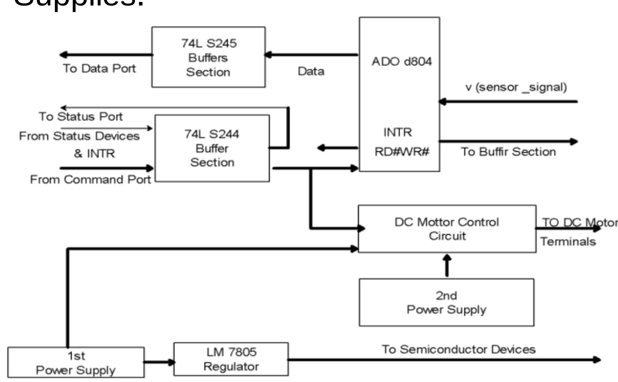

Fig. 6 The block diagram of the MCIU.

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An ADC0804 device was used in the design as an A/D conversion circuit shown in Figure 6. We prefer to use this device for the following reasons: Its 8-bit resolution type has superior features, such as fast conversion time (500ns), and small error. Its logic inputs and outputs meet both MOS and TTL voltage level specifications. It works with low voltage reference (down to 2.5V) and its input voltage range is (OV to 5V) with single 5V supply. It is a cheap and easy interface to the PC. It has an on-chip clock generator. It does not need zero adjustments. It has differential analogue voltage inputs [17].

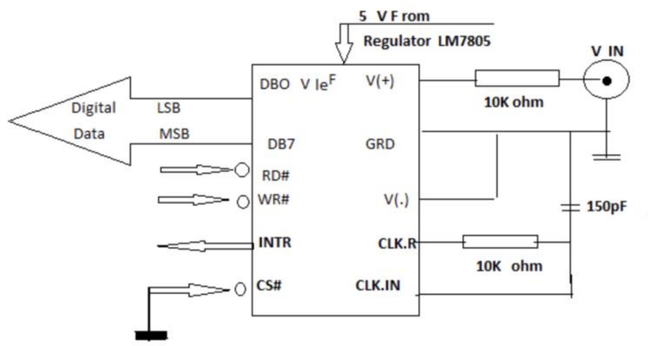

Fig. 7 The block diagram of the MCIU.

A Bi-direction buffers (74LS245) were used to interface the converted digital data to the PC through the data port. We used this device to provide protection for the port. It is an octal device suitable to be used with the ADC, it is a transceiver device and this feature may be needed for future applications. It minimizes external timing requirement, and is manufactured with PNP inputs which will reduce the DC-loading on bus lines [18].

This octal bus transceiver device allows data transmission from (A) lines to (B) lines only by connecting the DIR input to (1) level. To allow this transmission at reading process only, the enable input (E#) of this device must be connected to the (RD#) pin of the ADC0804, see Figure 7.

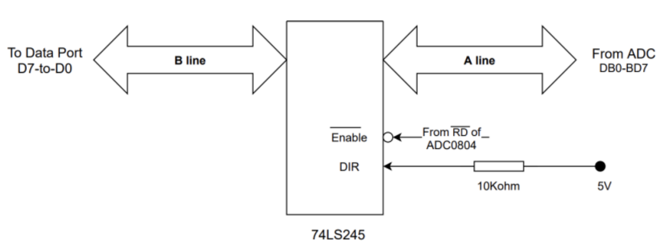

Fig. 8 The buffer device (74LS244) interfaces the peripheral devices to the PC.

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The Octal buffers (74LS244) device was used to interface the lines of the status and command ports of the PC with the peripheral devices (such as switches, relays, and ADC0804 pins), as shown in Figure 9 and 10. We used this device due to the following reasons: It provides protection for the port, It gives a choice of selected combinations of inverting and non-inverting outputs, and it is manufactured with PNP inputs and that will reduce the DC-loading on bus lines [18].

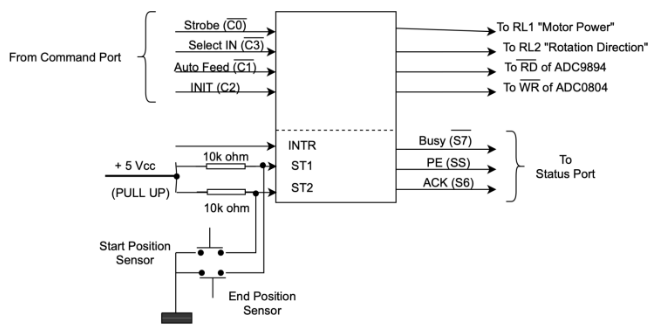

Fig. 9 The buffer device (74LS244) interfaces the peripheral devices to the PC.

Generally, in any TV-Antenna Position Finder system the implementation of (PC) will offer flexibility in software processing and will enable improvements. It is possible to use different high-level languages for software processing and that will help to simplify the design, reduce the error, and increase reliability. In the present application, the programming is done in C++ language.

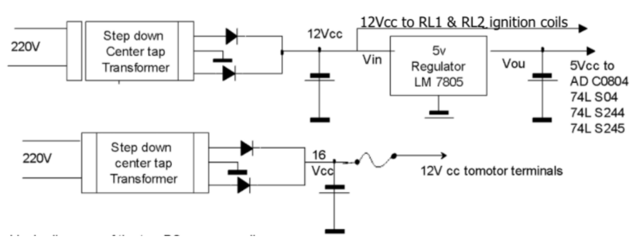

Fig. 10 The block diagram of the two DC power supplies.

The required algorithm to track the transmitted signal is clearly clarified in the following steps [20]:

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- Reading the data values (IF-AGC voltages) concerning the scanning zone (approximately 360° round the antenna shift) in steps (programmed by software) as output samples.
- Storing the data in an array.
- Displaying the data on the monitor.
- Evaluating the maximum value of the data (optimal point).
- Calculating the step order of the optimal position.
- Returning the motor back to the evaluated position and settling there.

2 **The Results**

The intent of this test is to exercise and check for the proper operation of the receiver function. The transfer function of the IF-amplifier, the result is shown in Figure 11. The variation of the IF-AGC voltages with the antenna position for three transmitter stations were tested, to see the effect of the antenna position versus the IF-AGC voltage, the results are shown in Figure 12.

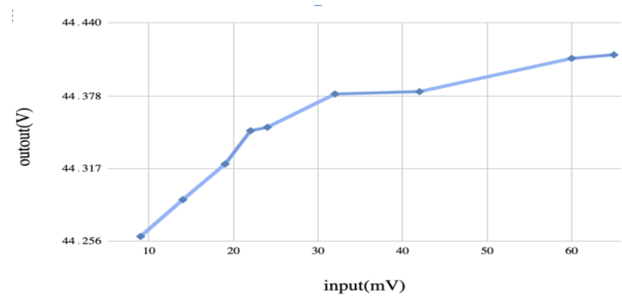

Fig. 11 Transfer characteristic of the IF-amplifier.

In order to be sure that the ADC circuit is working correctly we prepare a software program to display the converted data on the mobile then we apply different analogue values within the range (OV to 10V) and record the testing result. Later then we calculate the average of the linearity error and it is found equal to less than (+0.2%).

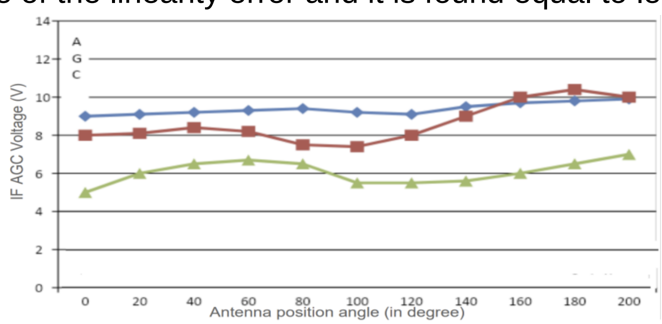

Fig. 12 The variations of the IF-AGC voltage with the antenna position for 3 stations in Iraq.

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Various experiments were applied to test the performance of the suggested system.

Experiments set 1: Tracking the position of pre-injected signals that are used as transmitted signals.
Experiments set 2: Plotting the reception patterns due to the IF-AGC as quality signal, for three stations in Iraq.
Experiments set 3: Finding the average values of the IF and RF-AGC amplitudes, and reception quality with respect to the antenna position, Figure 13 and 14.

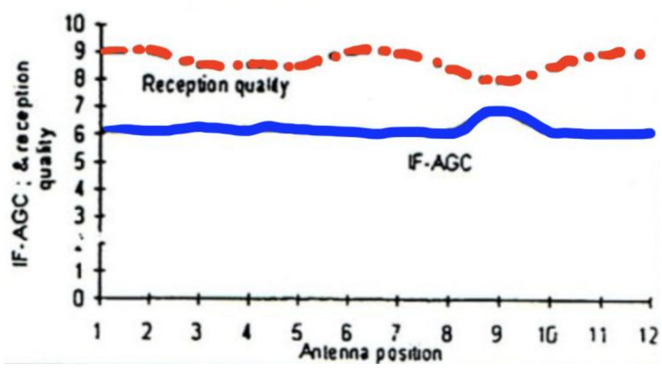

Fig. 13 RF-AGC amplitude and reception quality for antenna position - Iraq.

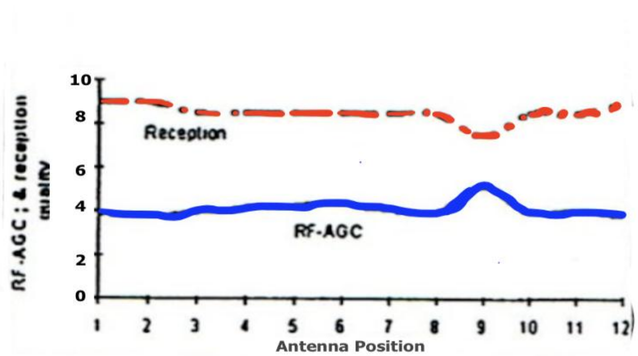

Fig. 14 IF-AGC amplitude and reception quality for antenna position - Iraq.

These experiments were repeated continuously in three different quarters of the city and for multi reception periods. The test results are concentrated in the following demonstration:

The output of the IF amplifier is directly proportional to the strength of the received signal till it reaches a saturation point. It is also varied with the antenna position and has

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at least two different optimal points due to the surroundings reflections. The linearity average error of the ADC circuit is calculated and it is found to be less than (+ 0.2%).

When pre-injected signals are supplied as sensing signals at different positions through the program execution the antenna is settled at the position of the maximum injected signal. The test results are concentrated in the following demonstration:

1. The output of the IF amplifier is directly proportional to the strength of the received signal till it reaches a saturation point. It is also varied with the antenna position and has at least two different optimal points due to the surroundings reflections.
2. The linearity average error of the ADC circuit is calculated and it is found to be less than (+0.2%).
3. When pre-injected signals are supplied as sensing signals at different positions through the program execution the antenna is settled at the position of the maximum injected signal.

3 **Conclusion**

In this paper an implementation of mobile-based antenna position finder using Arduino is achieved to direct a TV receiver antenna toward the transmitter's antenna. An effective technique to gather many samples (IF-AGC voltages) to seek the optimal point (maximum field strength) is achieved via proper software. The system is flexible, dependable and could be used for other applications by only modifying the software such as: Antenna Pattern plotting, Solar tracking. Monitoring and controlling home systems “Temperature. Illumination, Water level, Doors locking. ...etc.", Medium power industrial applications, and controlling Wo coordinates positioning systems.

As for the future research, it would be fruitful to undertake a more general investigation regarding what new value can be offered as a sensing signal and relying on other types of motors (Stepper Motor, for example).

Moreover, the following features are required to be investigated for the practical APΓE, Tracking the load change due to polarization, avoidance of interference in the adjacent received channels, Look-ahead control using real time, and consideration of voltage stability for the future works, using other evolutionary computation techniques.

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