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Design of a Cell-Phone Based Monitoring and Controlling System for Poultry Incubator

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ABSTRACT—
The invention of fully automated artificial incubators brings about the production of large number of birds that are enough for day to day demands. But operating such automated incubators are labor intensive even though they are automated in nature, an operator must always be close to the machine for any malfunction. This research presents another approach to the design of a cell-phone monitoring and controlling of the poultry incubator from the comfort of your home. The control was executed Through Short Message Services (SMS) to the incubator, which in turn executes the exact command and provides a customized feedback message to the master's cell phone. The control was tested from ten different countries (Egypt, Ethiopia, Indonesia, Kenya, Malaysia, Nigeria, Saudi, Turkish, U.K, and U.S.A) with the based station at Ahmadu Bello University (ABU) Nigeria. The tested commands were stored in the EPROM of the micro used. GSM modem was used to initiate communication between the remote and the based station. Such communication was achieved through an algorithm, which utilized attention (AT) commands. The GSM modem was interfaced with the incubator and tested for 19 days of continuous operation in the laboratory. With the proposed control system installed in conventional incubator, the incubator was found to be responded to commands in addition to maintaining the necessary ambient temperature of 37^0C and humidity of 65.1%, which are ideal parameters for incubation. A communication success of 91.3% was recorded through SMS messages using 9mobile SIM due to its service reception at the base station. This result shows that the cell phone-based monitor and control unit has a failure of only 8.7%. The control system was made using locally available components and materials, which gives a low cost of only 16,000 naira for a control unit.

KEYWORDS—cell phone, control, monitoring system.

INTRODUCTION

Eggs incubation are done by the mother bird by sitting on the eggs and use its body to produce the required temperature and humidity for embryo development. To achieve large number of birds production that will met with the market requirement, artificial incubators are come into play for the view to solve the market demand. Manual incubators, semi-automatic incubators and automatic incubators were both invented to ease the market demand and reduce labor but with all in place the presence of human is mandatory to always check the functionality of the incubator [1, 2]. Hence the need to provide an efficient incubator control that can be control and monitor from all over the world. The control will have the means of commanding the incubator and to query for the incubator's status when necessary.

Section II of this paper describes the design of the circuitry for the cell phone interface. Section III provide the design of the relay board, section IV provide the design of the computer interface. Section V concludes on the presented results.

DESIGN OF CELL PHONE INTERFACE FOR INCUBATOR

Figure I show the GSM modem (SIMCOM 304Z) circuit diagram. Six pins namely V_{CC}, GND, power key, transmitting, receiving and network indicating pin were used from the available SIMCOM 304Z pins. Receiving (R_X) and transmitting (T_X) pins of the modem are interfaced with the transmitting (T_X) pin 15 and receiving (R_X) pin 14 of the ATmega16.

The network pin of the SIMCOM 304Z is connected to LED via resistor and transistor configuration to indicate presence of network for the SIM used [3]. R_7 is a current limiting resistor to Q_1. Due to common fluctuation; of power supply that may power off the SIMCOM 304Z modem the value of R_6 and C_9 were suggested to be 100 kΩ and 470 µF [3].

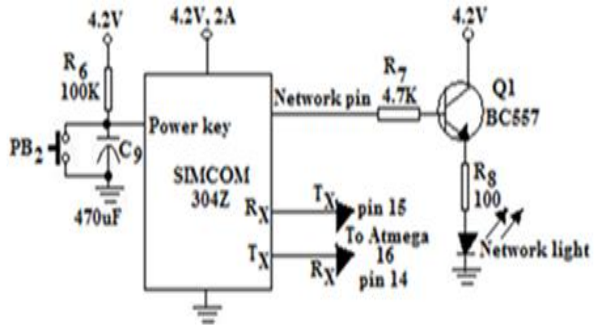

Figure V. Circuit Diagram of Cell Phone Control Interface

The resistor R_8 is a small emitter resistor for improving the noise immunity and its value can be arbitrarily selected from the range 100 Ω to 330 Ω as specified in the data sheet

of transistor Q_1 [4]. The smallest value in the range 100 Ω is used in this circuit.
The value of R_7 is obtained using equation (1) [4]:

$$R_7 = \frac{V_{CC} - V_{BE}}{I_B} \quad (1)$$

The base current to the transistor Q_1 is the output current from the SIMCON 304Z (at network indicator pin) which can produce up to 800µA and V_{BE} = 0.7 V, VCC = 4.2 V.
Using the equation (1), the resistor R_7 is obtained as R_7 = 4375 Ω. But a standard resistor value of 4.7 kΩ ± 10% is used which satisfies the requirement.
A summary of the components required and used is shown in Table I

Table I. Components of the Cell Phone Interface

COMPONENT	CALCULATED VALUE (kΩ)	STANDARD VALUE
R_6	------------	100 kΩ
R_7	4.3	4.7 kΩ
R_8	------------	100 Ω
C_9	------------	470 µF, 25 V
Q_1	------------	BC 557

F. Design of Atmega16 External Interfaces with Incubator

Figure II shows the schematic diagram of the ATmega16 external interface to the incubator controls. LM35 is used as the precious integrated - circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, because the subtraction of large constant voltage from its output to obtain convenient Centigrade scaling is not required.

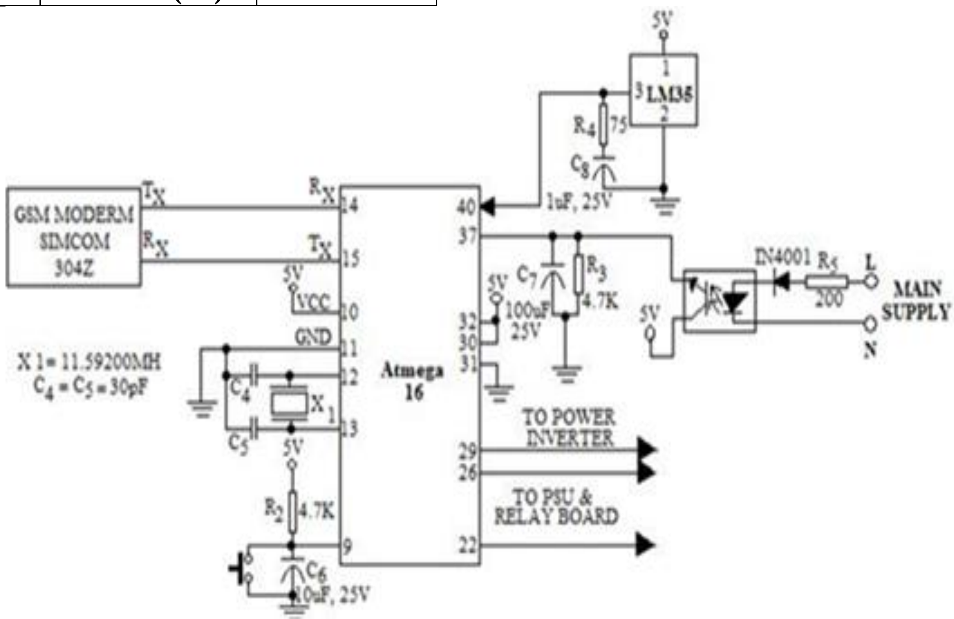

Figure VI. ATmega16 External Interfaces with Incubator

Since the LM35 is connected from the ATmega16 to the incubator chamber via a long conductor (wire), then a series or R-C damper of values 75 Ω (implemented as two parallel 150 Ω resistors) and 1 µF is connected from output pin 3 of the LM35 to ground pin 2. This temperature sensor is TTL compatible and is configured at Pin 40 of the ATmega16 (port A) ADC0. An opto-coupler is used to notify the ATmega16 the presence of mains supply from the utility company (PHCN). It isolates the AC from the ATmega16 pin 37 (PA3) port A. In the presence of the mains supply the photo transistor of the opto-coupler is activated and the ATmega16 sense it. Due to fluctuations of the mains supply that may occur, R-C combination (4.7 kΩ and 100 µF) in parallel from the output of the opto-coupler to ground is connected to act as a bleeder. Pin 27 (PC7) of port C goes to the power inverter to let it ON in absence of power supply and OFF in the presence of power supply. Pin 22 to 26 of ATmega16 goes to the PSU and relay board of Figure III through a driver UNL2003 which drives five (5) relays to control the incubator parameters.

R_2 and C_6 are 4.7 kΩ and 10 µF respectively, to hold pin 9 (Reset pin) always high in order to prevent unnecessary resetting of the microcontroller (ATmega16). Pin 13 (XTAL1) is the input to the inverting oscillator amplifier and input to the internal clock operating circuit while pin 12 (XTAL2) is the output from the inverting - oscillator amplifier. The crystal oscillator used is of value 11.59200 MHz. $\{X_1: \text{speed of microcontroller} \leq X_1\}$ and C_4 is C_5 is 30 ± 10 pF.
A summary of the components required and used is shown in Table II

Table II. Components of ATmega16 External Interfaces

DESIGN AND ANALYSIS OF RELAY BOARD WITH INCUBATOR

This This unit is made up of five (5) relays namely RL_1 to RL_5 which is used to control inductive loads, in this case they are used to control heater elements, incubator switch, egg tray turner, supply from inverter and that of PHCN as shown in Figure III. The relays are driven directly through the UNL 2003 which is a high-voltage, high-current Darlington arrays comprising of eight PNP Darlington pairs. Five (5) Darlington pairs are used.Diodes D_2 to D_6 are the freewheeling diodes used to prevent a reverse emf that may occur in the relays coil. RL_1 and RL_2 work simultaneously, i.e. they remain deactivated in the absence of PHCN and allow the inverter to feed the load (incubator) through the normally close terminals of the relays.

COMPONENT	CALCULATED VALUE	STANDARD VALUE
X_1	----------	11.59200 MHz
C_4-C_5	----------	30 PF
C_6	----------	10 µF, 25 V
C_7	----------	100 µF, 25 V
C_8	----------	1 µF, 25 V
R_2	----------	4.7 kΩ
R_3	----------	75 Ω
R_4	----------	4.7 kΩ
R_5	----------	200 Ω

In the presence of power from PHCN RL_1 and RL_2 will energize and the normally - open closes, these results in eliminating the inverter supply to the incubator and permitting the PHCN to feed the incubator. Moreover, this can also be seen on the LCD display either:

PS = ne (power supply is NEPA) when it's on PHCN
Or
PS = in (power supply is inverter) when it's on inverter.
PS = ne (power supply is NEPA) when it's on PHCN
Or
PS = in (power supply is inverter) when it's on inverter.

Similarly, it can also be monitored on the master cell phone whenever the incubator status is demanded from any cell phone. A command ***'INCSTS'*** should be text to the incubator on MSISDN (Mobile Subscriber Integrated Services Digital Number): **07035027339** and an immediate feedback will be received on the master's MSISDN: **08065183151** on almost all the incubator status, such as:

STATUS
PWR: ne (i.e. if the incubator is powered from the mains supply),
Or
PWR: in (i.e. if the incubator is powered by the inverter).

RL3 is connected to the egg turner tray and is by default deactivated which turns the egg trays in a clockwise direction (CW). The trays remain in that position until a command is received from a cell phone to turn the egg trays in a counter clockwise direction. Moreover, this can also be seen on the LCD display, either:

TR = CW (tray is clockwise) when the egg trays are turned clockwise or
TR = ACW (tray is anticlockwise) when the egg trays are turned anticlockwise.

Similarly, a command can be sent through SMS to turn the egg trays from any cell phone and receive a feedback on the master cell phone.

A command '***TETCKW***' should be sent to the incubator to turn the incubator CW
Or
'***TETACW***' to turn the incubator tray anticlockwise (ACW) direction and an immediate feedback will be received on the master cell phone as explained, such as:

STATUS
Turning the Tray in the anti-clockwise direction was successful
Or
Turning the Tray in the clockwise direction was successful.
The feedback depends on the command sent.

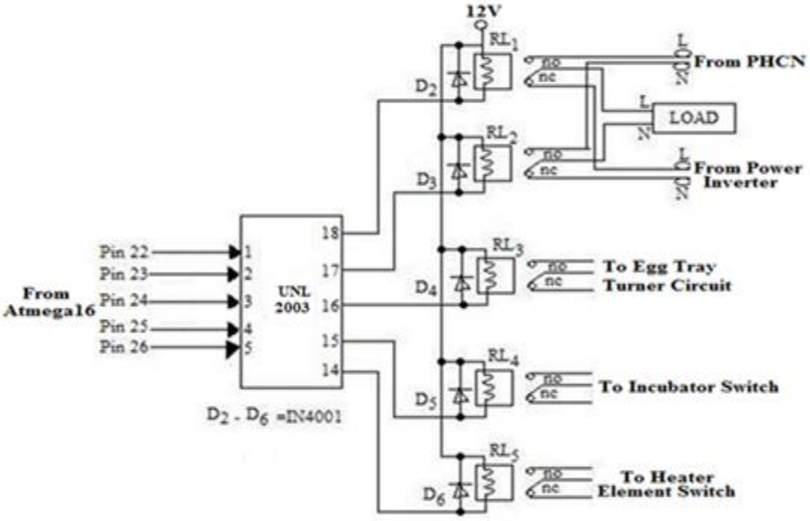

Figure VII. Relay Board Interface with Incubator

RL_4 is connected to the incubator mains power switch which is OFF by default and remains in that OFF position until it receives a command from a cell phone to switch it ON. This can also be seen on the LCD display which displays:

"IC = of" (incubator is OFF)
Or
"IC = on" (incubator is ON).

This depends on the deactivation or activation of the RL_4 respectively.

Similarly, it can be monitored on the master cell phone whenever the incubator status is demanded via an SMS command to the incubator:

"OFMYIN" (i.e. OFF my incubator)
Or
"ONMYIN" (i.e. switch ON my incubator)

An immediate feedback will be received on the master cell phone, i.e.:

"Switching the incubator OFF was successful" (i.e. when the incubator is switched OFF)
Or
"Switching the incubator ON was successful" (i.e. when the incubator is switched ON).

It can also be monitored when requesting for the overall incubator status by sending ***"INCSTS"*** via SMS to the incubator and receiving:

STATUS
INC: of (incubator is OFF),
INC: on (incubator is ON).

The feedback depends on the command sent to the incubator.

RL_5 is connected to the heater elements switch and it can only be activated when the temperature of the elements used is less than or equal to 38^0C. The relay RL_5 will be deactivated when the temperature is above 38^0C. In this design a temperature of 38^0C which is the most suitable incubating temperature required for chicken egg was achieved [3]. Moreover, this can also be seen on the LCD display, either:

HT = on (heater is ON)
Or
HT = of (heater is OFF).

This depends on the deactivation or activation of the RL_5 respectively.

Similarly, it can also be monitored on the master cell phone whenever the incubator status is demanded. A command ***'INCSTS'*** should be sent to the incubator and an immediate feedback will be received on the master cell phone as explained, such as:

STATUS
HTR: on (i.e. heater is ON),
Or
HTR: of (i.e. heater is OFF).

The feedback depends on the RL_5 energizing or de-energizing state.

DESIGN AND ANALYSIS OF COMPUTER (PC) INTERFACE CIRCUIT

The complete circuit diagram is as shown in Figure IV. The logged data can also be accessed by a PC through a PC interfaced to the main microcontroller. Because of voltage level differences of the devices, a MAX232 was used to provide voltage matching for the different types of logic used in the microcontroller and those in the PC. The MAX232 (RS232 to TTL converter) is a 16-pin dip integrated circuit (IC) that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to +5 V range, as power supply design does not need to be made more complicated just for driving the RS-232.

The PC interface is accomplished through a serial RS 232 connector as recommended in the datasheet of MAX232 application note.

The device is powered from the 5 V stabilized DC to pin 16 and with pin 15 to ground. It is recommended in the data sheet that $C_{10} = C_{11} = C_{12} = C_{13}$ ($1\ \mu F \leq C_{10} \leq 10\ \mu F$).

Terminal 9 is the receiving terminal while data transmission is accomplished through the transmitting pin 10 of the MAX232 device. The computer is expected to transmit instruction for request of data from the main microcontroller [5].

The microcontroller then copies the data from the EEPROM registers and transfers it to the PC for display [5]. The receiver of the MAX232 is connected to the transmitter of the microcontroller while the transmitting terminal of the MAX232 is connected to the receiving pin of the microcontroller.

The values of C_{14} and R_9 are within the range of $10\ \mu F \geq C_{14} \geq 1\ \mu F$ and $8.2\ K\Omega \geq R_9 \geq 4.7\ k\Omega$ respectively [5]. Hence C_{14} was selected as 10 µF and 4.7 kΩ was adopted as R_9.

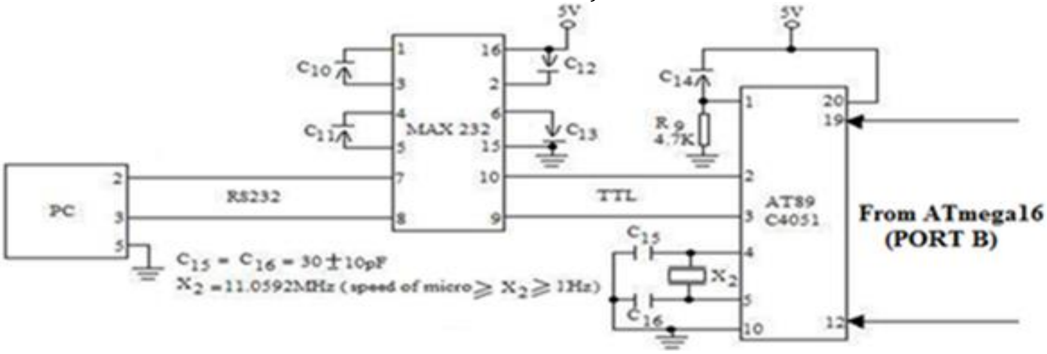

Figure VIII. PC Interface with the Incubator

A summary of the components required and used is shown in Table III

Table III. Component of the Computer (PC) Interface

COMPONENT	CALCULATED VALUE	STANDARD VALUE
X_1	------------	11.0592 MHz
C_{10}–C_{14}	------------	1 µF
C_{15}-C_{16}	------------	10 pF
R_9	------------	4.7 kΩ

RESULTS

The cell phone control-based incubator was implemented and tested through SMS from ten different countries (Egypt, Ethiopia, Indonesia, Kenya, Malaysia, Nigeria, Saudi, Turkish, U.K, and U.S.A). 91.3% success was recorded when different commands and queries were sent from different countries and 8.7% of failure was observed. The computer interface was also tested, and no failure was recorded.

CONCLUSION

The proposed cell phone incubator control was implemented and tested from ten different countries. The finding shows that the proposed system is of about 91% efficiency. With this achievement it can be concluded that the proposed method of cell phone control for incubator is encourage to the used by incubator builders to provide flexibility in the control and monitoring and to minimize labor.

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