

PREMATURE INFANT INCUBATOR ALERT SYSTEM VIA SMS

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ABSTRACT

To make security and comfort for babies, parents of babies, and hospital personnel when the premature baby in the incubator room, Premature Infant Incubator Alert System via SMS has been made. The system would stabilize the temperature and relative humidity when the value is not in accordance with a predetermined value and immediately sends a warning message to the destination mobile number. The time taken by the system to send a warning message to the destination mobile phone number is 8 to 25 seconds. The system uses sensors SHT11, light bulbs, fans, GSM modem, and ATmega8535 microcontroller.

Keywords: *Incubator, Premature Baby, SHT11 Sensor, GSM Modem, microcontroller ATmega8535.*

1. INTRODUCTION

The newborn baby needs time to adjust their condition with the outside world. This is sensitive time to new baby born especially premature babies. Premature babies [1-2] need special attention to make babies still alive. One of procedures to make premature babies still alive is put them into the incubator, the period premature babies in the incubator according to soundness, durability and system of organs of them. The incubator is one of tools to help premature babies to adjust with the outside world, because condition in the womb is very different with outside world, especially condition of temperature. Temperature in the womb is approximately 36 - 37°C but in outside world is approximately 27°C - 28°C. Temperature in the incubator is maintained according to age and weight of premature baby, for example; age of baby is 1 - 10 days and weight of baby is less than 1500 gram, the temperature in the incubator is maintained of 35°C[3] and relative humidity is maintained of 50% RH - 75% RH[4][5]. Using the incubator the premature babies hope will be adjusting their condition with outside world and the babies can survive. In conventional infant incubator temperature settings using the manual method are still nursing the baby will turn on the heater to a

temperature suitable for the baby if the temperature is below or above the indicator / alarm will sound so that the nurse should immediately turn on / turn off the heater. What if at the time the indicator / alarm sounds nurse is not in place or away from the baby incubator space ? This would cause a danger to the infant psyche.

In this study, we design an incubator system prototype can send a warning message via SMS. The incubator system consists of LCD, SHT11 sensor, light bulb, fan, GSM modem, and microcontroller ATmega8535. The purpose of this study is to design a system that can send a warning SMS from incubator to mobile phone when the temperature in the incubator is below/ above 35°C and relative humidity are below 50% RH and above 75% RH. This system can improve the security of the system to errors on baby infant incubator, so as to avoid the occurrence of death in infants due to temperature and humidity are not appropriate in an incubator, so as to create a sense of security and comfort for babies, parents of infants and hospital personnel on when the baby is put into an incubator.

2. SYSTEM DESIGN

2.1 The Conventional Infant Incubator System

The conventional incubator system only uses light bulb to maintain temperature in the incubator. Reality and design the conventional incubator system can be seen in figure 1 and figure 2.



Figure 1. Conventional Infant incubator system in reality[5]

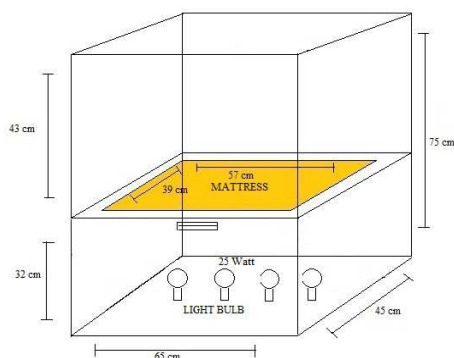


Figure 2. Design of the conventional Infant incubator system

The conventional incubator system uses manually system to regulate temperature in the incubator. The device used to regulate temperature in this incubator is switch, the switch is used to turn on and turn off the heating system. The size of incubator used in this device is 65 cm x 45 cm x 75 cm. The heating system in the before incubator only using 4 light bulb which has power 25 Watt, because that the system needs a long time to increase the temperature in the incubator. The system uses thermometer to read the temperature in the incubator because the before incubator system does not has the temperature sensor.

Temperature setting of incubator to the premature babies is regulated according to age and weight of babies can be seen in Table 1.

Table 1. Temperature setting of incubator[3]

Weight	Temperature			
	35°C	34°C	33°C	32°C
<1,5 kg	1 - 10 days	11 days - 3 weeks	3 - 5 weeks	>5 weeks
1,5 - 2,0 kg		1 - 10 days	11 days - 4 weeks	>4 weeks
2,1 - 2,5 kg		1 - 2 days	3 days - 3 weeks	>3 weeks
>2,5 kg			1 - 2 days	>2 days

2.2 The Premature infant incubator alert system via SMS

To develop the before incubator system, we use fan, light bulb, SHT11 sensor, LCD, Microcontroller and GSM modem to be an automatically maintain temperature and relative humidity and the system has the incubator condition warning system via SMS in figure 3 and figure 4.

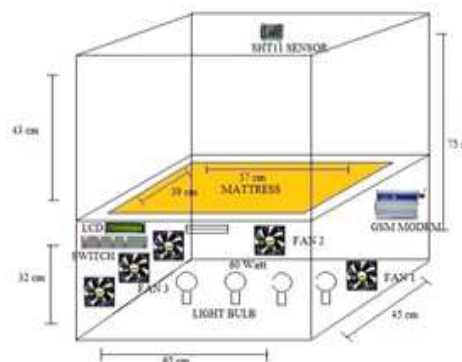


Figure 3. Design of the new Infant incubator system



Figure 4. The new infant Incubator system in reality

The device uses aluminum foil and 3 fans (FAN 3) in the heating room to speed up the heating process in the incubator room and the incubator system uses 2 fans (FAN 1 and FAN 2) to

maintain the relative humidity in the incubator. The SHT11 sensor is used to read the condition of temperature and humidity in the incubator[7]. The LCD is used to show command to choose the desired condition. The switches are used to regulate input of temperature and relative humidity and to activate the warning system of incubator. In this device using 5 switches, 4 switches is used to choose the condition of temperature and relative humidity and 1 switch is used to activate the warning system of incubator. ATmega8535 microcontroller [8] serves as the receiver set point of the switch and the data from sensor SHT11 for later comparison. The results of the comparison data is sent to the GSM modem. The GSM modem is used to send a warning message when the system cannot maintain the temperature and relative humidity in the incubator[9].

According to the function of the incubator system, it can be divided into several blocks, seen in figure 5.

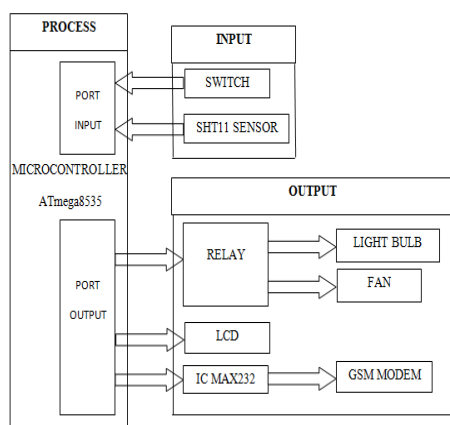


Figure 5. Block diagram of Infant incubator system

2.3 The General Working Principle of Premature infant incubator alert system via SMS

The general working principle of this incubator system: the first is the LCD show a command to select the switch which will used as set point to maintain the temperature and relative humidity and the switches is used to activate the SHT11 sensor to read condition of temperature and relative humidity in the incubator in the incubator. Display of LCD to select set point can be seen in figure 6.

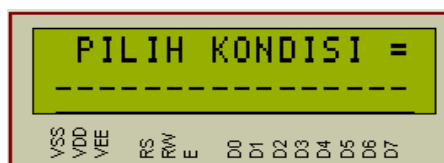


Figure 6. Display of LCD to select set point

There are 4 switches used as set point, switch1 to maintain the condition at 32°C and 50% RH – 75% RH, switch2 to maintain the condition at 33°C and 50% RH – 75% RH, switch3 to maintain the condition at 34°C and 50% RH – 75% RH, and switch4 to maintain the condition at 35°C and 50% RH – 75% RH.

After the switch which used as set point has selected and the SHT11 sensor has activated, the data from switch and SHT11 sensor will be processed and the data will be compared by microcontroller. When the condition of temperature read by SHT11 sensor is lower than the set point so the microcontroller will turn on the light bulb and when the condition of relative humidity read by SHT11 sensor is higher than the set point so the microcontroller will turn on fan. The program to maintain the temperature and relative humidity in the incubator can be seen in figure 7.

```

If ((PINB.0==1)&&(PINB.2==0)&&(PINB.3==0))
{
if (PINB.4==0) {
if(temp_val.f<=35)
{PORTD.7=0;PORTD.6=1;PORTD.5=1;PORTD.4=0;}
if(temp_val.f>35)
{PORTD.7=1;PORTD.6=0;PORTD.5=1;PORTD.4=1;}
if((temp_val.f<=35)&&(humi_val.f>=75))
{PORTD.7=1;PORTD.6=1;PORTD.5=1;PORTD.4=0;}
if((temp_val.f>35)&&(humi_val.f<50))
{PORTD.7=0;PORTD.6=0;PORTD.5=0;PORTD.4=0;}
if((temp_val.f<=35)&&(humi_val.f<50))
{PORTD.7=0;PORTD.6=1;PORTD.5=1;PORTD.4=0;}
if((temp_val.f>35)&&(humi_val.f>=75))
{PORTD.7=1;PORTD.6=0;PORTD.5=1;PORTD.4=0;}
}
}
    
```

Figure 7. The program to maintain the temperature and relative humidity in the incubator system

Next, when the condition of temperature and relative humidity read by SHT11 sensor as high as the set point, in this condition the baby placed into the incubator room and in this condition the incubator condition warning system is activated by

activate the switch5. Program to activate the warning system can be seen in figure 8.

```

If((PINB.0==1)&&(PINB.1==0)&&(PINB.2==0)
&&(PINB.3==0))
{
if (PINB.4==1) {
}
}

```

Figure 8. Program to activate the warning system

The system will send a warning message when the condition of temperature and relative humidity in the incubator cannot be maintained that is the condition of temperature and relative humidity is up and down significantly. Diagram block of the warning system of baby's incubator via SMS can be seen in figure 9.

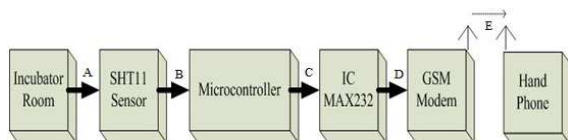


Figure 9. Diagram block of the warning system of baby's incubator via SMS

- A. The condition of temperature and relative humidity in the incubator room will be read by SHT11 sensor. The data read by SHT11 sensor is the data digital signal.
- B. The data read by SHT11 sensor into the microcontroller, in the microcontroller the data from SHT11 sensor will be compared with the set point. The system will send a warning message when the condition of temperature and relative humidity in the incubator cannot be maintained that is the condition of temperature and relative humidity is up and down significantly.

The program to send a warning message can be seen in figure 10.

```

If((PINB.0==1)&&(PINB.1==0)&&(PINB.2==0)
&&(PINB.3==0))
{
if (PINB.4==1) {
if(humi_val.f==75.5){kirimSMS("humidity is too
high");}
if(humi_val.f==49.5){kirimSMS("humidity is too
low");}
}
}

```

```

if(humi_val.f==34.5){kirimSMS("humidity is too
low");}
if(humi_val.f==35.5){kirimSMS("humidity is too
high");}
if((temp_val.f>=35.5)&&(humi_val.f==49.5)){kirim
SMS("temperature is too high and humidity is too
low");}
if((temp_val.f==35.5)&&(humi_val.f<=49.5)){kirim
SMS("temperature is too high and humidity is too
low");}
if((temp_val.f<=34.5)&&(humi_val.f==75.5)){kirim
SMS("temperature is too low and humidity is too
high");}
if((temp_val.f=34.5)&&(humi_val.f>=75.5)){kirimS
MS("temperature is too low and humidity is too
high");}

```

Figure 10. The program to send a warning message

- C. The data from microcontroller into IC MAX232, the IC MAX232 is an IC interface for RS – 232 transmitter / receiver. To send a SMS by GSM modem using communication RS – 232 transmitter / receiver, in the IC MAX232 the power 5 volt from microcontroller be converted to be power 12 volt.
- D. The data from IC MAX232 into the GSM modem, the signal from IC MAX232 is data digital signal. In the GSM modem the data digital signal is changed to be a data analog signal by a modulation process.
- E. After the information signal is modulated, the signals can be sent and will be demodulated when it has arrived to the destination phone number. The warning message which received by phone according to the error condition of temperature and relative humidity in the incubator.

3. TESTING AND ANALISYS

Figure 11 shows the prototype of a Premature infant incubator alert system via SMS.

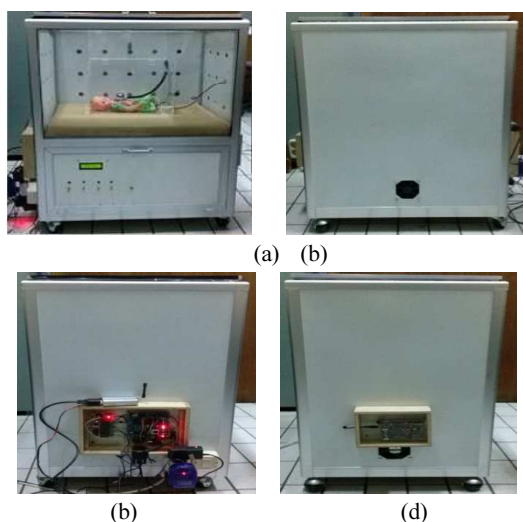


Figure 11. The incubator system(a) front, (b) behind (c) left side and (d) right side

3.1 Testing of SHT11 Sensor

Testing of sensor is done by comparing the value of data read by sensor and the value of data read by thermometer. Table 2 is the value of data read by sensor and thermometer.

According to table 2 and figure 12, the biggest difference of the value of data read by sensor with the value of data read by thermometer is 1.5°C. There is a difference data read by SHT11 sensor and thermometer is not too far. This is equal with tolerance of sensor measurement for temperature with scale (30 – 40) °C is (± 0.5 - ± 1)°C (Sensorion, 2008). So the data read by SHT11 sensor in this device is correct.

Table 2. The value of data read by thermometer and sensor

NO	THERMOMETER(°C)	SHT11 SENSOR(°C)
1	32.3	33.3
2	34.3	34.5
3	34.4	34.34
4	34.5	34.58
5	35	35
6	35.4	34.77
7	35.8	34.8
8	36.4	34.96
9	36.5	35.3
10	36.7	35.2

Figure 12 is a chart of the value of data read by sensor and the value of data read by thermometer.

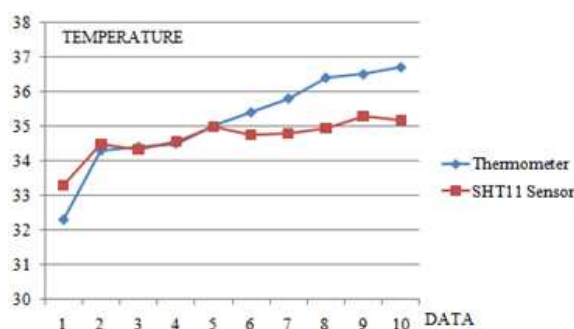


Figure 12. The chart of data read by thermometer and sensor

From table 2 can be determined error percentage from data read by SHT11 sensor using the equation:

$$\text{Error percentage} = \left| \frac{\text{SHT11 data} - \text{Thermometer data}}{\text{Thermometer data}} \right| \times 100\%$$

Error percentage of data read by SHT11 sensor can be seen in table 3. According to table 3, the error presentation of data read by SHT11 sensor is 1.9 %.

3.2 Testing The Premature Infant Incubator Alert System via SMS

Testing is done by measure the times needed to send a message to destination number. In this testing we use 3 destination hand phone number. Table 4 is the times needed by three destination hand phone numbers to receive a warning message. The measuring is done when the condition of temperature and relative humidity in the incubator based on the error condition that has determined by the system.

Table 3. Error presentation of data read by SHT11 sensor

NO	THERMOMETER(°C)	SHT11 SENSOR(°C)	Error (%)
1	32.3	33.3	3.09
2	34.3	34.5	0.58
3	34.4	34.34	0.17
4	34.5	34.58	0.23
5	35	35	0
6	35.4	34.77	1.77
7	35.8	34.8	2.79
8	36.4	34.96	3.95
9	36.5	35.3	3.28
10	36.7	35.2	4.08
Average error			1.9

Table 4. The times needed by three destination hand phone numbers to receive a warning message

CONDITION		TIME		
TEMPERATURE (°C)	HUMIDITY (% RH)	HP NUMBER1 (IM3)	HP NUMBER2 (Simpati)	HP NUMBER3 (3)
32	50 - 75	12 second	20 second	22 second
33	50 - 75	7 second	24 second	18 second
34	50 - 75	11 second	15 second	25 second
35	50 - 75	8 second	12 second	22 second

According to table 4, the longest times the destination hand phone number to receive a warning message is 25 second. This shows condition warning system of incubator can be used in this device. The measuring is done by using three hand phone and three destination hand phone number ; Hand phone number1 using provider IM3, hand phone number2 using provider Simpati and hand phone number using provider 3. The warning message in hand phone which using provider IM3, simpati, and 3 to three destination numbers can be seen in figure 15.

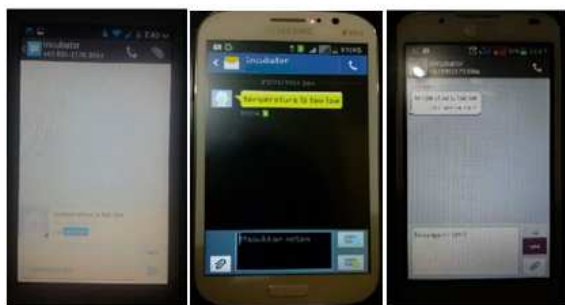


Figure 15. The warning message in hand phone which using provider (a) IM3, (b) Simpati and (c) 3

4. CONCLUDING REMARKS

The test results showed that the premature infant incubator alert system via SMS would stabilize the temperature and relative humidity when the value is not in accordance with a predetermined value and immediately sends a warning message to the destination mobile number. The time taken by the system to send a warning message to the destination mobile phone number is between 8 to 25 seconds. These results of this study will be implemented to the community through maternity hospitals / clinics in Indonesia.

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