

# Design of a Remote GSM based Datacenter Monitor.

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**Abstract:** *Datacenters contain high capacity computers known as servers and routing equipment. These servers are very sensitive and expensive. The Datacenter Monitor monitors the power supply to the data center, the temperature output of all the air conditioners in the center and incorporates a proximity sensor which activates an image capture process when the door of the center is approached. This captured image is sent to the manager in the form of an MMS Message. The system utilizes temperature sensors and power sensors to monitor the air-conditioning units and the power supply to the datacenter. The status of these monitored devices is sent to the datacenter manager through the GSM network a SMS messages. The status reports are also displayed on an alarmed indicator board outside the datacenter. The system enables the monitoring of devices in datacenters and their status from any remote location and thereby leads to a faster response time in the event of a fault condition.*

*Keywords: Datacenter, GSM, Power sensors, Temperature sensors, Servers*

## 1. INTRODUCTION

A data center also called a server farm is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and security devices. Data centers play very critical roles in communication networks of organizations [1]. They contain high capacity computers known as servers and routing equipments. These servers are very expensive and sensitive. The number of processors in the servers and the fact that the

often work round the clock, generate a lot of heat and require a constant and high capacity cooling system to ensure that the temperature in these data centers or server rooms are kept constantly within acceptable temperature levels. [2-3] In view of this the power supply to the server rooms which comprises of the public utility supply and a bank of uninterruptible power supply (UPS) systems must ensure that there is no outage of power supply in the server room. The security of the server room is another crucial issue as unauthorized access in this room can result in a compromisation of the organization data or a vandalization of companies' communication infrastructure [4-7]. This work aims at developing a system for automated remote monitoring of the data centers by providing the datacenter manager with status report as soon as the preset limits of the temperature and power supplies are exceeded. This system also incorporates an alarmed indicator board to ensure onsite monitoring of data centers. The advantage of this system is reinforced by the fact that the operating temperature of server rooms is not conducive for continuous human occupation and the manual human observation of the data center cannot provide a timely and effective monitoring of data center.

## 2. PROPOSED SYSTEM

The block diagram of the system is shown in Figure 1 and the detailed block diagram showing the sensor blocks is shown in Figure 2. The system comprises of sensors for monitoring the temperature of the air-conditioning units, sensors for monitoring the UPS and public

utility power supply systems and a proximity sensor for detecting human presence and around the door of the data center. (This is interpreted by the system as access into data center). The signals of the different sensors are transmitted via wireless to the microcontroller unit and the receiver bank which is made up of bank of receivers with specific filters for each frequency. Each sensors output is amplified and used to control a wireless transmitter whose output is passed through the receiver bank and then to the microcontroller as shown in Figure 2. The microcontroller under the control of the control program sends out status report in the form of SMS over the GSM network with the aid of the GSM modem to the Data Center Manager's phone. The use of the GSM network for purpose of transmitting monitoring signals in the form of SMS signals has been found to be reliable as shown by [8-11]. The microcontroller activates the camera to take snap shots of the door area when the proximity sensor activated. This picture is then transferred to the microcontroller for onward transmission to the Data Center Manager (DCM) as a multimedia message (MMS message). The system also incorporates an alarmed indicator board placed outside the server room. This board generates an alarm tone whenever there is a change from the desired status of the different parameters of the data center environment

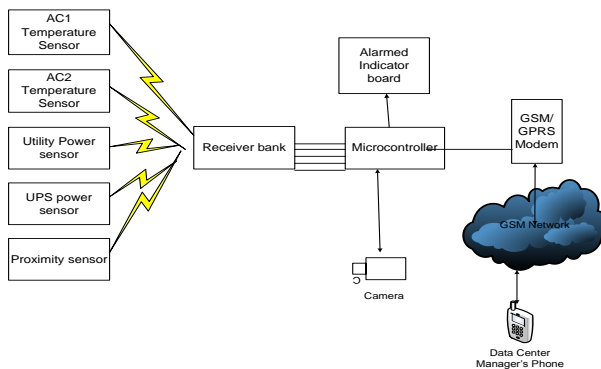


Fig 1. System block diagram

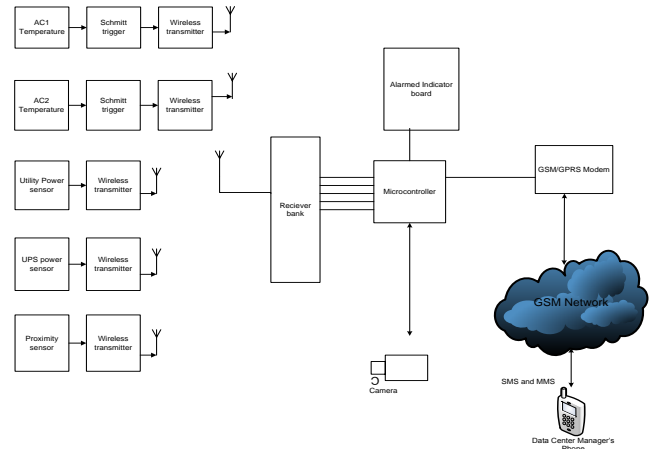


Figure 2 System diagram showing details of sensor blocks

### 3. SYSTEM DESIGN

This section provides the details of the design of the different component parts of the system.

#### A. The temperature sensor block

The temperature sensor is realized using a negative temperature coefficient sensor as shown in Figure 3

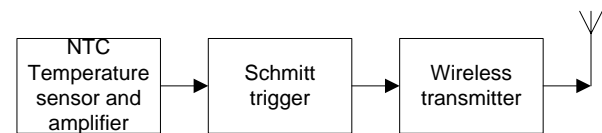


Figure 3: Temperature sensor block diagram

A negative temperature coefficient (NTC) temperature sensor is utilized to monitor the temperature of the air-conditioning units [12]. When the air-conditioning (A/C) set fails, the temperature around the A/C rises and the NTC temperature sensor output drops. This drop in output of the temperature sensor is sent to the Schmitt trigger. The function of the Schmitt trigger is to switch the sensor output to a defined voltage level when its output gets to a specified range/level. This level is defined after calibration to deactivate the wireless transmitter and this deactivation of transmission indicates

the failure of the air conditioning unit. This AC temperature sensing unit does not require any cabling as it can be clipped on to the air-conditioning unit so that the NTC temperature sensor accesses the airflow from the a/c vents. A failure in transmission will indicate either a failure of the air conditioner's cooling or a low battery condition. Either way the system will be checked.

### B. The power supply sensor (PSS)

This sensor monitors the presence of utility supply to the server room. The utility supply includes both the public utility supply and the UPS supply. The power supply sensor block is shown in figure 4

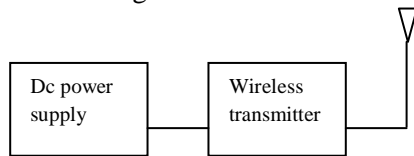


Figure 4. Power Supply Sensor (PSS) block diagram.

This block consists of a dc supply unit and a wireless transmitter. The unit is plugged into a power socket for the monitoring of the public utility supply while another unit is used to monitor the UPS supply.

The PSS unit transmits a signal to the microcontroller indicating the availability of the UPS supply or the public utility supply. Failure of any of these sources is transmitted by a failure of the wireless transmission and this is interpreted appropriately by the microcontroller and the alert messages indicating the failure of the monitored sources are sent to the Data Center Manager.

### C. Proximity sensor

The proximity sensor unit comprises of a proximity sensor, an amplifier and a transmitter as shown in figure 5. The proximity sensor switches off the transmitter when it is activated.

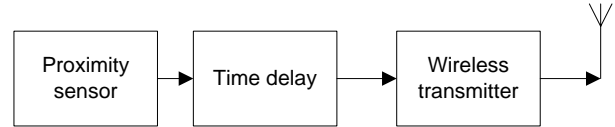


Figure 5. Proximity block sensor diagram

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic or electrostatic field, or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal [13]. When the proximity sensor is activated, it initiates a time delayed break in the transmission of the wireless transmitter for as long as the proximity sensor is activated. During this break in transmission, the microcontroller activates the camera to take the snapshot of the entrance of the data center. These snapshots are sent to the Data Center Manager in the form of MMS messages

### D. Wireless transmitter

The wireless transmitter is a sine wave transmitter designed to be powered by 3V batteries. The carrier frequency for each sensor unit is different and the transmitters with the fixed frequencies are de-activated by the different sensors upon attaining the preset values. The circuit diagram of the wireless transmitter is shown in Figure 6. The transmitter is an LC based transmitter designed to be switched on by the sensors. The circuit diagram for the transmitter is shown in Figure 6

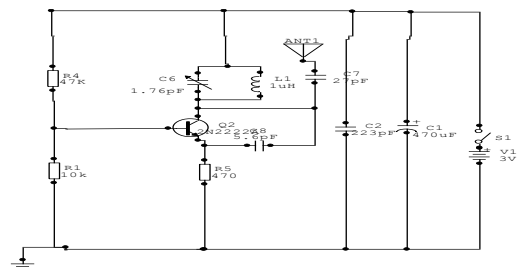


Figure 6. Transmitter circuit diagram

The resonant frequency of the LC transmitter [14] is derived from the equation 1

$$F = \frac{1}{2\pi\sqrt{LC}} \quad 1$$

The transmitter frequency is selected to be 120MHz to ensure a small antenna size for all the sensors and subsequent sensor transmitters are spaced 5MHz apart. This is to ensure that there is no overlap between the different sensors signals and to also reduce the selectivity requirements of the filters.

The design procedure involves inserting the transmit frequency value in equation 1, selecting a value for either L or C and computing for the other component.

Selecting the value of the inductance (L) to be 1uH, the value of the required capacitance is computed as from equations 2

$$120\text{MHz} = \frac{1}{2\pi\sqrt{LC}} \quad 2$$

$$120\text{MHz} = \frac{1}{2\pi\sqrt{1 \times C \times 10^{-6}}}$$

$$C = \frac{1.76 \times 10^{-18}}{1 \times 10^{-6}} = 1.76 \times 10^{-12}$$

The required capacitance is  $= 1.76 \times 10^{-12} = 1.76\text{pF}$  With the inductor value selected to be  $L=1\mu\text{H}$

The transmitter for the second sensor is set to transmit at 125MHz thus the value of the corresponding capacitor is derived as follows

$$\sqrt{1 \times 10^{-6} \times C} = \frac{1}{2\pi \times 125 \times 10^6} = 1.27 \times 10^{-9}$$

$$1 \times 10^{-6} \times C = 1.62 \times 10^{-18}$$

$$C = \frac{1.62 \times 10^{-18}}{1 \times 10^{-6}} = 1.62\text{PF}$$

The Table 1 lists the values of the capacitor and inductor for the transmitter attached to the

different sensors and the corresponding transmitter output frequency.

Table1. Inductor and capacitor values for the transmitters.

Sensor	L(inductor Value)	C(Capacitor Value)	Frequency
Air Conditioner sensor 1	1 uH	1.76pF	120MHz
Air Conditioner sensor 2	1 uH	1.62pF	125MHz
Public Utility Sensor	1 uH	1.5pF	130MHz
UPS sensor	1 uH	1.39pF	135MHz
Proximity sensor	1 uH	1.29pF	140MHz

With this arrangement the transmitters are controlled by the sensors thus the sensors either activate or deactivate the transmitters. A deactivation of the transmitters causes the stoppage of transmission and this is interpreted by the microcontroller as a fault condition. The transmitters are powered by 3V recharge able batteries and an output waveform of the transmitter when the monitored parameter is working normally is shown in Figure 7 while Figure 8 is the wave form when the monitored parameter and unit has failed.

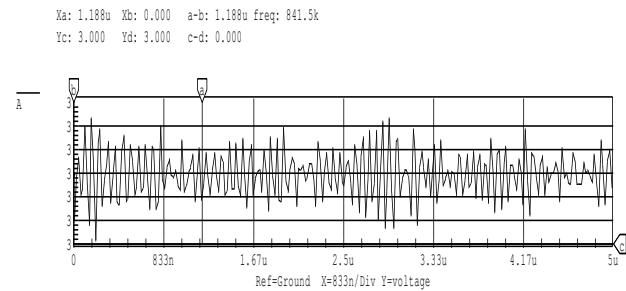


Figure 7: The monitored device is functioning normally

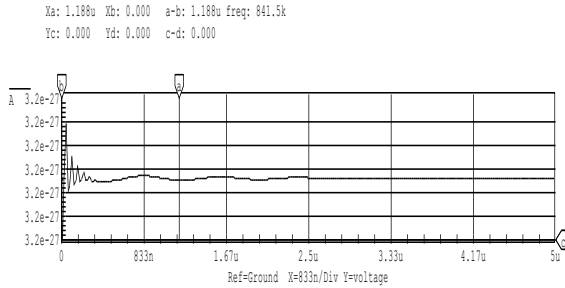


Figure 8: The monitored device has failed

The results in Figures 7 and 8 show that the transmitter's output is a sine wave with a peak value of 3V when the monitored device working normally. This transmission is received by the receiver banks while during fault conditions the transmitter frequency collapse to zero (0) and the amplitude to  $3.2 \times 10^{-27}$  V, which is far below the sensitivity value of the receiver indicating a fault condition.

#### E. Receiver Bank

The Receiver block diagram shown in Figure 9 consists of a Low Noise Amplifier (LNA) and bank of filters each tuned to the center of the carrier frequency of the sensor/transmitters with a 1MHz bandwidth. The LNA has a bandwidth covering 119.5MHz to 140.5MHz (21MHz bandwidth). The LNA is an amplifier which amplifies the received signal with a very minimal amount of noise added to the received signal and it reduces the overall noise figure of the systems due to its high gain value [15]. The filters are selected to respond to signals from specific transmitters. The Table 2 shows the specification of the filters

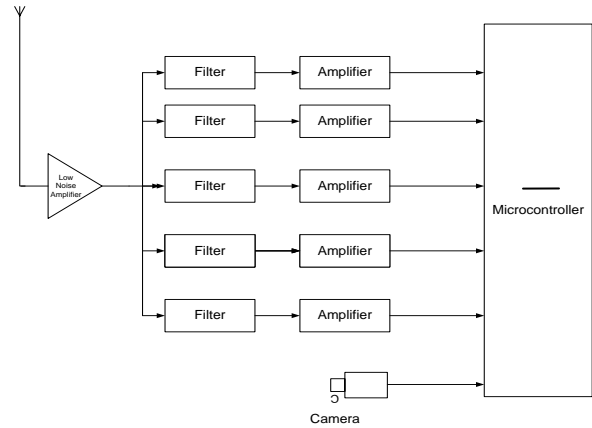


Figure 9: Receiver block diagram

Table 2 Filter specifications for the Receiver block

Sensor	Transmitter Frequency	Filter frequency bandwidth
Air Conditioner sensor 1	120MHz	119.5-120.5MHz
Air Conditioner sensor 1	125MHz	124.5-125.5MHz
Public Utility Sensor	130MHz	129.5-130.5MHz
UPS sensor	135MHz	134.5-135.5MHz
Proximity sensor	140MHz	139.5-140.5MHz

Total required bandwidth spans from 119.5MHz – 140.5MHz. The output of the filters are amplified and fed to the input ports of the microcontroller.

#### F. Microcontroller

The Microcontroller is a single chip containing a microprocessor, memory (RAM & ROM), input/output ports, timers and serial ports and it is designed for embedded control applications. The prime use of a microcontroller is the control of a

machine or system using a fixed program stored in the ROM and this program does not change over the life time of the system.[16]

The chip used in this design belongs to the Intel 8051 micro controller family. The core of the 8051's slot CPU is made up of 8 bit Registers, 4 Kilobytes of ROM, 128 bytes of RAM, 2 Timers, 32 I/O Pins, 1 Serial Port. The Intel 8051 Microcontroller can also access external memory and this is particularly useful because the snapshots taken by the camera will be stored in an external memory location. The 8051 family of microcontrollers can address 64K of external data memory and 64K of external program memory. These may be separate blocks of memory, so that up to 128K of memory can be attached to the microcontroller. The 8051 has two separate read signals, RD# (P3.7) and PSEN#. The first is activated when a byte is to be read from external data memory, the other, from external program memory. Both of these signals are so-called active low signals. That is, they are cleared to logic level 0 when activated. All external code is fetched from external program memory. The Program that controls the overall system is loaded onto the external memory chip.

#### *G. GSM Modem*

A GSM Modem is a wireless modem that works with a GSM wireless network to transfer data. It can be an external device or a PC card. External GSM Modems are connected to the PC through a serial cable or a USB cable. Like the GSM Phones, a GSM modem requires a SIM card from a wireless operator to enable it transfer data through the operators' network. GSM modems are controlled by a special set of commands known as AT commands [18]. With these commands the GSM Modem can be used to:

Read, write and delete SMS messages.

Send SMS messages.

Monitor Signal strength.

Reading, writing and searching phone book entries.

A GSM modem has a limitation of accessing 6 to 10 SMS per minute. [18] To increase this capacity, a GPRS modem is required. The GPRS modem supports GPRS technology for data transmission and it has a higher data rate than the GSM with a capacity of handling up to 30 SMS per minute. The GPRS modem also has the capability of handling MMS messages.

#### **4. SOFTWARE DESIGN:**

The software design comprises of the development of the algorithm, the system flow charts and the final control program which is loaded onto the system memory.

##### Algorithm

- 1) Initialize system
- 2) Read A/C sensors status:
  - high (A/C is cooling )
  - low (A/C isn't cooling)- send alert A/C not cooling
- 3) Read public power supply sensor status
  - high (Public utility available)
  - low (Public utility not available)- send alert 'NEPA failed'
- 4) Read UPS sensor status
  - high (UPS available)
  - low (UPS not available)- send alert 'UPS failed'
- 5) Read Proximity sensor status
  - high (no access)
  - low (access)- send alert 'data center accessed'
  - switch on the camera
  - Take snapshot and store picture as an MMS message
- 6) Read MMS data – transmit data as MMS.
- 7) Re start entire process

## A. System Flowchart

The system flow chart is shown in Figure 13.

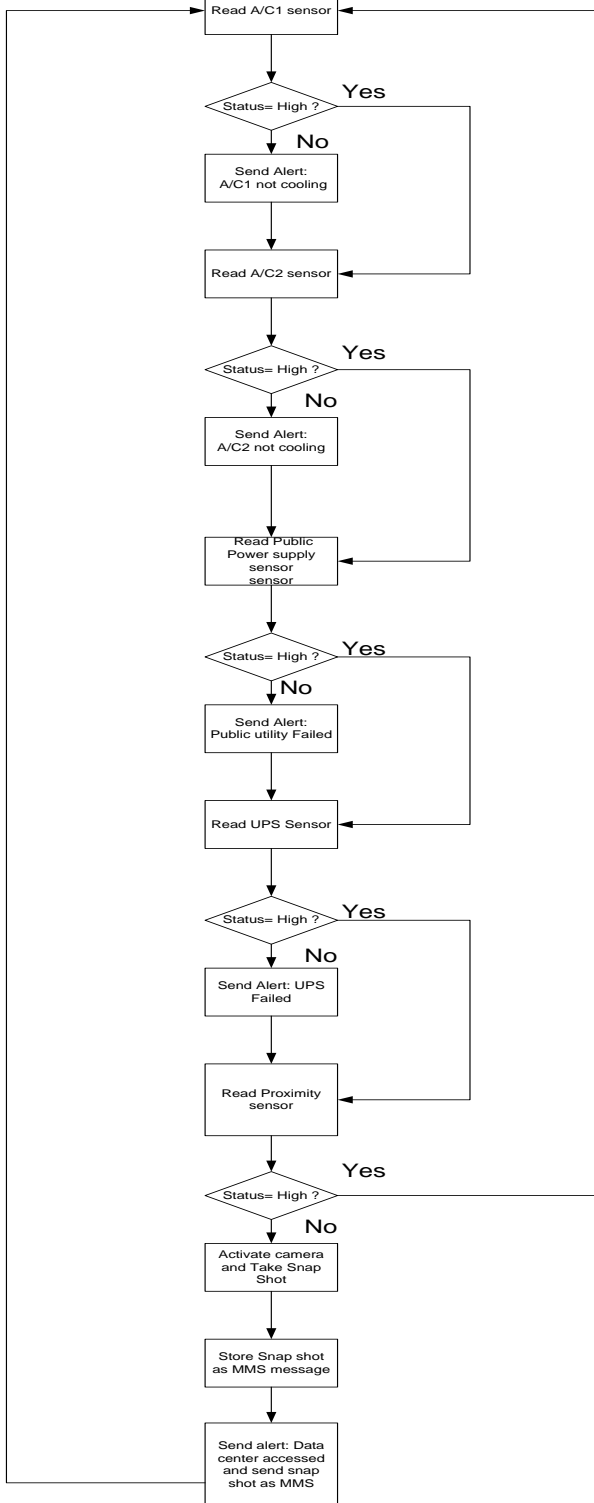


Figure 13: System Flowchart

## 5. EXPECTED RESULTS

The alerts generated by the sensors are packaged by the microcontroller and transmitted through the GSM modem. The modems are controlled by the AT commands and preset messages are sent to predetermined phone number(s). The information flow is unidirectional and it conveys both SMS and MMS messages. The expected results are the alert messages indicating the status of the air conditioning units, the public utility supply and the UPS supply systems. It also includes an MMS which contains the picture of whoever is at the door of the datacenter.

## 6. CONCLUSION

The system is designed to monitor the status of air-conditioning sets, the public utility supply, the UPS power supply status and the access status of the data centers. This system is relevant in view of the critical status of the data rooms, the requirements of precise operating conditions of the server rooms makes it necessary for both outside personnel to be informed whenever there is a change of desired conditions. This system ensures that the manager is kept informed of the status of the data center and enables a more efficient management of the datacenter. This system can also be deployed to enable monitoring of multiple offsite datacenters by one datacenter manager.

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