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Impedance Source Converter Based Real Time Water Quality Management System Using Green IoT

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Abstract:In order to ensure the safe supply of the drinking water the quality needs to be monitored in real time. In this paper, design and development of a low cost model for real instance monitoring of the water quality using Green IoT (Internet of Things) is presented. Internet of Things is an ecosystem of connected physical objects that are accessible through the internet. In IoT, particularly sensor devices are mainly positioned in an extremely resource constrained environment and therefore it becomes essential to extend the capability and the life expectancy of these kind of devices in terms of energy consumption. Energy efficiency in the Internet of Things has been attracting a lot of attention from the researchers and designers over the last couple of years, paving the way for an emerging area called Green IoT.There are various aspects such as key enablers, communications, services, and applications of IoT, where efficient utilization of energy is needed to enable a Green IoT environment. In order to conserve energy, a renewable source (solar) is used to power various sensors for measuring the physical and chemical parameters of the water. The novelty in the design is exhibited by connecting an impedance source network between the source and the boost converter to improve the boost factor.

Keywords: Key enablers, Green IoT, Impedance Source Network

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I. INTRODUCTION

Over the recent years, online water quality monitoring is being majorly used in many countries which are known to have serious issues relating to environmental pollution. The water is curbed and an important reserve for industrial field, agricultural field and all the other existing creatures on the earth including humans. Any of the changes in quality of the water will be sternly affecting the health of the human beings, mammals and even affects the ecological balance among one other existing creatures. In 21st century there are lots of inventions, but at the same time pollution challenges, global warming and so on are also being emerged, because of this there is no risk free drinking water for the mankind. The consuming water is much more important and precious for creatures like humans, so quality of water needs to be monitored in real time. Even though, the present techniques examine the chemical, physical and biological factors. It has several drawbacks 1.)It requires workforce and is costly 2.)Substandard spatiotemporal reporting. So, there is a requirement for developing better methodologies to monitor the quality of water parameters in real time. The WHO (World Health Organization) investigated, in India among 78 million individuals are enduring due to not having safe water. WHO likewise evaluated that 22% of sicknesses are related to dangerous water in India. Consequently, different water quality parameters, for example, water level indicator, conductivity, pH, moistness and temperature should be checked progressively. The water parameter pH demonstrates whether water is acidic or essential. Immaculate water has a 7 pH value, if it is under 7 then it shows causticity and if more than 7 it demonstrates alkalinity. The ordinary scope of pH is from 6 to 8.5. In drinking water if the typical scope of pH is not kept up then it makes the bothering to the skin, eyes and mucous membranes. It even causes the skin diseases. The conductivity is characterized by the capacity of water to pass an electrical momentum. In water it can be influenced by different broken down solids for example, Cl, Nh3, Nacl, Ca, etc. Humidity shows the measure of water vaporpresent in air.

Green IOT Based Real Time Water Quality Monitoring noticeable all around[1]. It is thought to be a decent measure of the nature of water. Water warmth shows the temperature in water. The decay of water assets is turning into a typical human issue. The traditional methods of water quality screening include the accumulation of water test from various areas manually. These water tests are tried in the research facility utilizing the logical innovations. Such methodologies are particularly tedious and didn't really to be considered as effective. Moreover, the current approaches include analysis of different kinds of parameters of water quality such as chemical and physical. Conventional methods of the water quality detection have the disadvantages like long waiting time for results, low measurement precision, high cost, and complex methodology. Therefore, there is a need for continuous monitoring of water quality parameters in real time. The online water checking advances have gained a critical ground for source water reconnaissance and water plant operation. The use of these advancements having high cost connected with setting up and alignment of a vast circulated exhibit of observing sensors. The proposed calculation will be connected on to the new framework[8]. By 2025, we will be seeing millions of devices or sensors connected over the internet, so in parallel there will be a lot of power consumption from the devices and the sensors, and at the same time, amount of CO_2 emission in the environment would be high. So by then we will be in need of certain techniques based on conserving power and utilizing resources efficiently. Now during those critical times, the concept of green IoT comes into the picture. As the name itself suggests green IoT, it mainly focuses on utilizing resources efficiently (related to hardware and software), energy saving algorithms (scheduling based) and use of alternate sources of energy (solar, wind etc). These green IoT techniques will be helping us to conserve power and will help us to follow the principle of Go Green. By focusing on the above issues, we need to develop and design a low cost water purity monitoring system that can monitor water quality in real time using green IoT environment. The currently available method has several disadvantages. They are related to substandard spatiotemporal reporting, low measurement precision, complicated methodology. It requires work force and is costly. Energy efficient scheduling algorithms are not being implemented yet which will help us to conserve power. Alternate source of renewable power is not available. Concept of green IoT has not been applied which would result in much efficient systems with less CO2 emission In this paper a novel method of design and development of Green IoT based water management system incorporating different power conservation techniques discussed[5].

II. PROPOSED SYSTEM BLOCK DIAGRAM

The proposed system consists of raspberry pi 3 as core controller as shown Fig.1. The operating system used by raspberry pi is raspbian Jessie. The software used along with the pi controller are puty and vnc viewer. The sensors used are temperature sensor, humidity sensor, ph sensor, conductivity sensor, water level sensor[2].

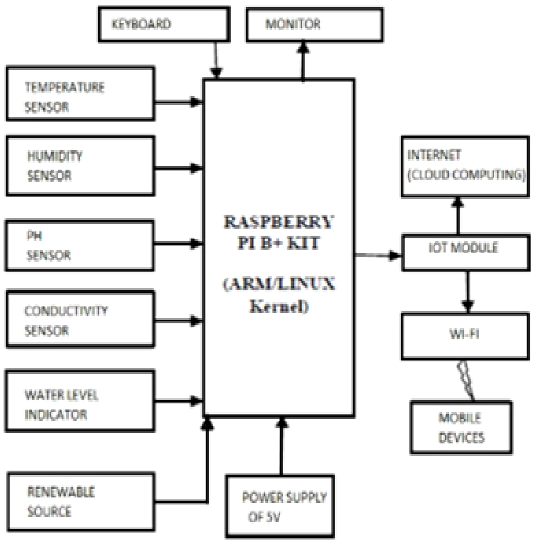


Figure1 Block diagram of Proposed System

The concept of green IoT is being applied in the proposed system[8]. An efficient scheduling of the sensors is done in the background based on efficiency scheduling algorithm. In this algorithm we are focusing on the power conservation by changing the duty cycles of sensors. The duty cycles of the sensors will be varied based on the output values. The values for scheduling different duty cycles will be set initially based on which we will be having three different operating states namely on state, pre off state and on state. The processed values will be sent over the internet, where database is provided for maintaining the real time sensor values along with power consumed graph[3]. The sensor values are sent over the internet by using **Amazon Web Services**. A trial account is created and a**url address** is being assigned.By using the assigned url we can view the sensor data anywhere across the world [4].As the concept of green IoTthe solar panel of 20 watt capacity is used to power the raspberry pi. In case of low voltages from solar panel, a boost converter with impedance source network is used along with the solar panel to boost the lower voltages[7]. The switch in boost converter will be driven by a pulse generated by the PIC controller. A PIC controller is using its PWM(pulse width modulated) output for controlling the MOSFET switches.

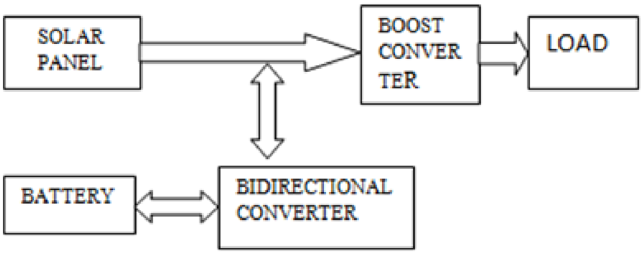


Figure 2 Block diagram of power source

The block diagram for alternate power source consists of solar panel, bidirectional converter, boost converter and a battery is shown in fig 2.A bidirectional converter is the one which helps to switch the power sources between solar panel and battery. In case of low or zero output from solar panel, the bidirectional converter will be switching the power supply connection from solar panel and will provide the power supply from battery to the boost converter.

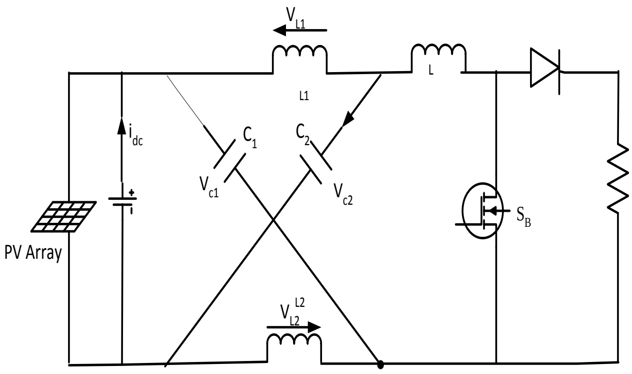


Figure3 Boost Converter with impedance source network

PV powered Z-source converter employs a symmetrical LC impedance network to connect a PV array to the boost converter as shown in Figure 3. It consists of PV array as voltage source, lattice network, converter and the load. PV array voltage is fed to the impedance network. The impedance network is a two port network that consists of split inductors L1 and L2 connected in series and capacitors in diagonal arms. This lattice network can buck or boost the input voltage depending on the boost factor. It can also act asa second order filter. The output voltage from impedance network is fed to boost converterwhich drives the load.

The boost converter with impedance source network provides required boost factor to power the converter. The switch shown in fig 3 is the MOSFET which can be switched at higher switching rates to get ripple free DC signal.

III. ANALYSIS OF IMPEDANCE SOURCE DC-DC CONVERTER

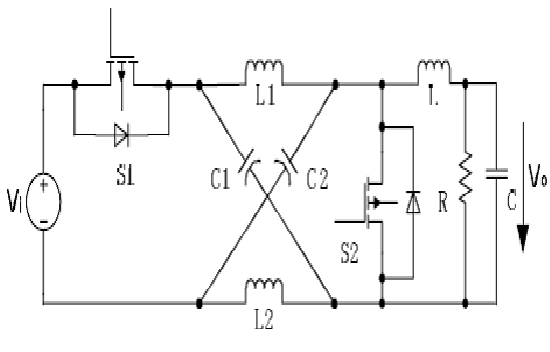


Figure 4

The boost converter can operate with PWM duty ratio control as that of the conventional dc-dc converters. In the voltage-fed operating mode (Voltage source is PV array), the active part of the switch S2and the diode of the switch S1are turned on and off.In complement, the other two devices areswitched on when the power flow is reversed. Table 1shows the steady stateinput-output voltage gains of these converters as a function of the duty ratio D of the active device. By controlling the duty ratio, the output voltage can be regulated as desired. Duty cycle ratio D is given by T_{ON}/T. The voltage transfer ratio is given by {(1-D)/(1-2D)}.

TABLE I:VOLTAGE TRANSFER RATIO OF IMPDEANCE SOURCE NETWORK

D	**Voltage Transfer Ratio**
0.1	1.125
0.2	1.333
0.3	1.75
0.4	3

The table shows voltage transfer ratio for different values of duty cycle ratio D. When the duty ratio is ≥0.5,the converter reaches negative gain region.

To simplify the analysis, we can consider the power flows from source to load, and the reverse case load to source is not considered. Then theexistence of the active part of the switch S1 and the diode of the switch S2, as shown in Fig.4 is not considered.

There are twostates exist in this circuit as shown in Fig.5 (a) and (b). In Z-source inverter/converter topologies, the Z-network of the Z-source dc-dcconverter is symmetrical, that is, the inductorsL1 and L2 and capacitors C1 and C2 have the same inductance (L) and capacitance (C), respectively.From the symmetry and the equivalent circuits, we have

$V_{C1}=V_{C2}=V_C$ and$V_{L1}=V_{L2}=V_L$

In state 1, the switch S1is turned on and S2 isturned off.The dc source charges the z-networkcapacitors, while the inductors discharge andtransfer energy to the load. The interval of theconverter operating in this state is (1-D)T, where Dis the duty ratio of switch S2, and T is the switchingcycle, shown in Fig.5(a) then,

$V_C=V_i-V_L$, , $V_o=V_i-2V_L$ (1)

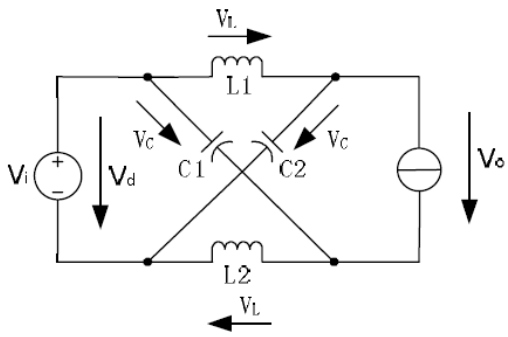


Figure 5(a)State 1: S1is on and S2is off

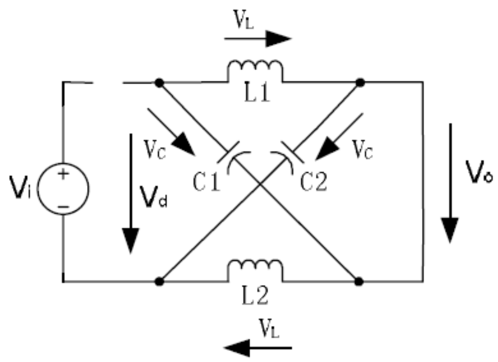


Figure 5(b)State 2: S1 is off and S2 is on

In state 2 Fig.5(b), the switch S2is turned on and S1isturned off. The z-network capacitors discharge,while the inductors charge and store energy torelease and transfer to the load. The interval of theconverter operating in this state is DT. Thus $V_c=V_L, V_0=0$

(2)

Where $V_i$is the value of the dc voltage source.

In steady state the average voltage across inductor is zero. Hence by combining (1) & (2)

$Vc/Vi = (1-D)/(1-2D)$

(3)

Peak value of the output voltage = $2Vc-Vi = Vi/1-2D$

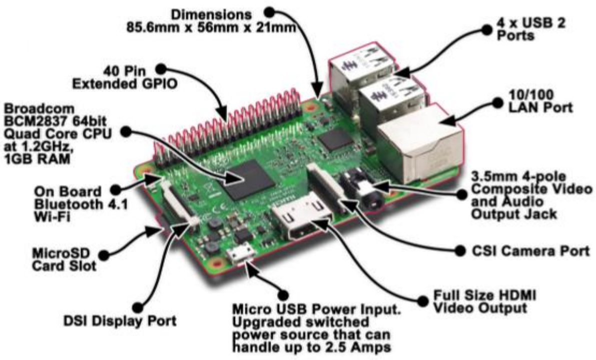
(4)

Averageoutput voltage of converter $Vc=(1-D)/(1-2D)V_i$

(5)

IV. HARDWARE DETAILS

The Raspberry Pi 3 Model B features a quad-core 64-bit ARM Cortex A53 clocked at 1.2 GHz. This puts the Pi 3 roughly 50% faster than the Pi 2. Compared to the Pi 2, the RAM remains the same – 1GigaByte of LPDDR2-900 SDRAM, and the graphics capabilities, provided by the Video Core IV General processing unit. The Pi 3 now includes on-board 802.11n Wi-Fi and Bluetooth 4.0. Wi-Fi, wireless keyboards, wireless mice network out of the box.



www.raspberrypi.org/products/raspberry-pi-3-model-b/

Temperature and Humidity sensor

DHT11 Fig.4 is 3.3V operated, advanced temperature and dampness sensor is a composite sensor containing an aligned computerized signal output of the temperature and moistness. Utilization of a committed advanced module technology and the heat sensing technology to guarantee high unwavering quality and superb long haul solidity. The sensor incorporates a resistive feeling of wet segments and a NTC temperature estimation gadget

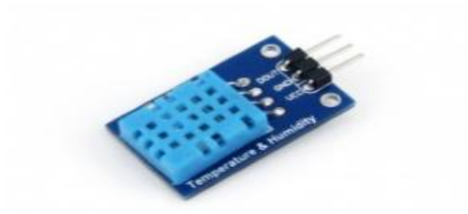


Figure 4: Humidity Sensor

Conductivity sensor

The degree to which a specified material conducts electricity, calculated as the ratio of the current density in the material to the electric field which causes the flow of current is known as electrical conductivity. YL-69 Fig.5 soil moisture sensor has two probes through which electric current passes in soil, then read the resistance of soil for reading moisture level. Water makes the soil more prone to electric conductivity resulting less resistance in soil where on the other hand dry soil has meager electrical conductivity thus more resistance in soil. Utilizing these properties, the sensor is composed. Inside the sensor there are hardware for measuring the resistance and generate voltage proportional to resistance.

Figure 5 Conductivity Sensor

pH Sensor

pH is a numerical scale which is used to determine the causticity or basicity of a fluid arrangement. It is around the negative of the base 10 logarithm of the molar fixation, measured in units of moles per litre, of hydrogen particles. More precisely it is the negative of the logarithm to base 10 of the action of the hydrogen particle. Acidic solutions are having pH under 7 and basic solutions are having pH more than 7. Normal water will have a pH of nearly equivalent to 7. The pH value may be less than 0 or more than 14 for exceptional solids and liquids.

Figure 6 pH Sensor

Water level Sensor

Water level Sensor is an electrical ON/OFF Switch, which works consequently when fluid level runs up or down as for indicated level. So the Signal subsequently accessible from the Float Sensor can be used for control of a Motor Pump or a partnered electrical component like solenoid

PIC Controller

The maximum operating frequency for PIC controller is 20 MHz. It has flash program memory of 8KB for storage .A total of 5 input /output ports A, B, C, D, E are used. Port A is 8 bit wide and bidirectional. It is used for analog inputs. Port B is 8 bit wide and it is used for data transmission. Port C is 8 bit wide and bidirectional. It is used for control registers. Port D is 8 bit wide and bidirectional. It is used as data port. Port 3 is 3 bit wide. It is generally for read, write and chip selection. It has two serial and one parallel communication port

Solar Panel

The solar panel used in the project is of 20 watt, 12v. This module is using high quality Multi-crystalline solar cells. They are exceptionally useful in drip chargers and little engine control supplies. The 20 watt module is excellent for controlling fans and wellspring pumps, charging 12 volt batteries for telemetry or for battery balance.

V. RESULTS AND DISCUSSION

The proposed system consists of raspberry pi 3 as core controller. The operating system used by raspberry pi is raspbian Jessie. The softwares used along with the pi controller are puty and vnc viewer. The sensors used are temperature sensor, humidity sensor, ph sensor, conductivity sensor, water level sensor. The concept of green IoT is being applied in the proposed system. A efficient scheduling of the sensors is done in the background based on scheduling efficiency algorithm. In this algorithm we will be focusing on the power conservation by changing the duty cycles of sensors. The duty cycles of the sensors will be varied based on the output values. The values for scheduling different duty cycles will be set initially based on which we will be having three different operating states i.e on state, pre off state and on state. The processed values will be sent over the internet, where database is provided for maintaining the real time sensor values along with power consumed graph[6]. The sensor values are sent over the internet by using Amazon Web Services. A trial account is created and anurl address is being assigned, by using the assigned url the sensor data can be viewed anywhere across the world. As the concept of green IoT, renewable sourcesof20 watt solar panel[10],[11],[12] is used.

Figure 7 Testing of Sensor Interface

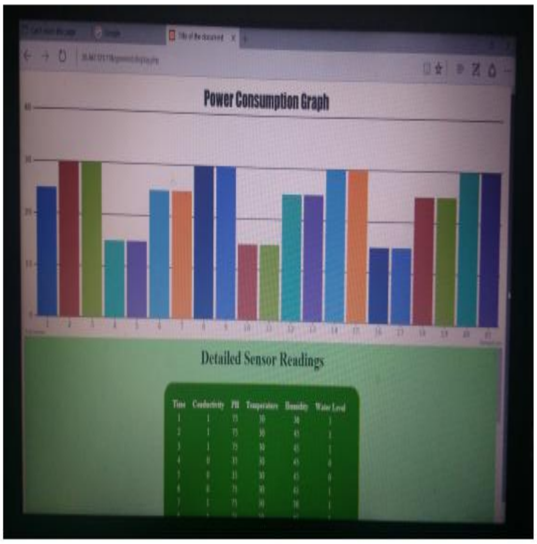


Figure 8 Power consumption graph and Sensor reading

The projected algorithm is divided into three different stages as pre off state, on state, off state. Fig.8 shows the three states. The overall energy consumption in on state is relatively much higher because the sensor will be running with complete potential and abundant power consumption will be occurring for fully equipped devices. On the other hand the power consumption in pre off state and off state is much lower because of the reduced task load on the sensors and the devices. The devices will be performing with partial potential thus power consumption is less.The general energy utilization is verymuch acceptable in all the three phases on account of the proposed IoT system model. The undertaking burden and duty of the physical sensors and devices are lesser in the physical layer which is having positive effect with respect to power utilizations for information handling inside the proposed technique model. The proposed technique virtualizes the IoT devices and handling of different assignments in the devices which are migrated from the physical layer to application layer. As the application is based on real time, the continuous readings from the sensors on the assigned url will be available[9],[15]. If the new values are needed, then the previous values needs to be erased by using erase.php command .In 1, 2, and 3, the readings are for the pure water which will have a ph of 7.5 with a conductivity of 1. The 4 and 5 readings are for the acidic solution, which will be showing a ph value of 3.5. These all values are extracted and a power consumption graph is plotted according to the environmental readings.

TABLE 2: Power Consumed Under Different pH Values

Cases	Total power Consumed
1	25 watts
2	30 watts
3	30 watts
4	15 watts
5	15 watts
6	25 watts
7	25 watts

The table 2 shows the amount of power consumed in different cases. In first case a normal water at ph of 7.5, the amount of power consumed is 25 watts. In the second case as the humidity getting varied the difference of 5 watts in power consumption compared to the earlier case. In third case the condition remains the same. In fourth case the water replaced by a acidic solution with a pH of 3.5, the total amount of power consumed is 15 watts. In fifth case the conditionremains the same. In sixth case water replaced by acidic solution with the basic solution, the total amount of power consumed in this case is 25 watts. Similar values are observed in seventh case also. The total amount of power consumed in the above depends on the sensor values, if temperature is higher, greater amount of power required to sense. In the same for acidic solution and basic solution, the power required to sense the solution is more. Over all say that few watts of power can be conserved depending on the external conditions[13].

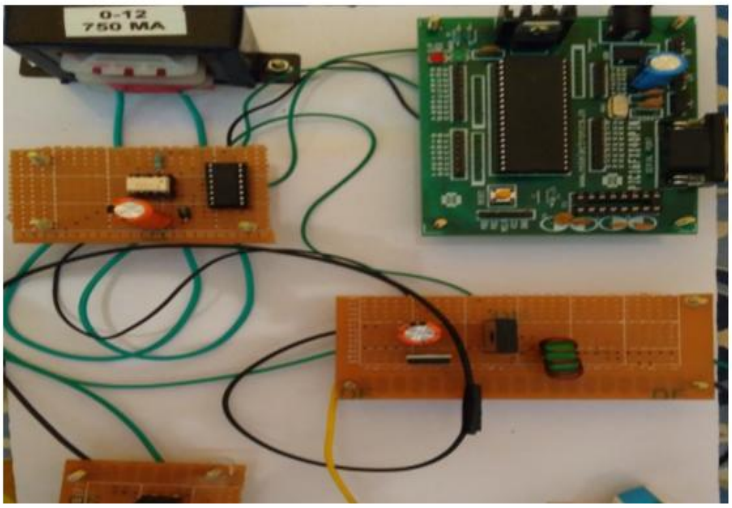


Figure 9 Proto Model of proposed system

VI. CONCLUSION

In view of the investigation of existing water quality checking systems and situation of green IoT, we can state that proposed framework is more appropriate to screen water quality parameters in real time. The proposed system introduces sensor network which measures the different water quality parameters based on the environment and water quality. Furthermore, to monitor data from all over the world, IoT environment is provided using raspberry pi for creating gateway and also cloud computing technology to monitor data on the internet[13]. The proposed IoT framework demonstrate the advancesin Green-IoT by consolidating the power utilizations inside an IoT network. The execution assessment proposes energy effective plan and framework model to support green communication in IoT. Therefore, the system will be low cost, faster, more efficient and real time user friendly.

VII.FUTURE SCOPE

This paper shows the approach for water monitoring by using Green IoT techniques. The future work can be enhancedby scheduling the Raspberry Pi for a particular time to switch on and off. As the proposed system is limited to a tank or smaller areas, the future work will focuson larger areas like pond. Further theartificial intelligence can be used by which the sensor readings will not be processed if the values are repeated.

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