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An Embedded Design for Patient Monitoring and Telemedicine

Malabi Singh, Mihir Narayan Mohanty and RN Das Choudhury

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ABSTRACT: Application in the area of medicine related to engineering application increases day by day. It motivates for a new research area in telemedicine. Telemedicine mostly used for patient monitoring as well as diagnosis of diseases of remote area patients. In this paper, we have taken a step to develop an embedded system to provide a partial solution to such problem. The paper emphasizes on basic parameters of diagnosis of a patient that may cause a measure loss in the patient. The basic parameters considered as body temperature, pulse rate, and the blood glucose level measurements for monitoring and diagnosis. These parameters have been acquired using sensors through the hardware component of Arduino mega 2560. This analytical result can help the doctor for diagnosis, monitoring and suggestion for the patient from doctor's work station. The work has been carried out with an embedded software (Arduino 0022 compiler) and labview platform.

Index Terms: Arduino MEGA 2560, Data Acquisition, Embedded internet communication, Telemedicine.

I. INTRODUCTION

Some of the work on telemedicine has been done since a decade. Also, some have been proposed with SMS (Short Message Service) alerting system [1]. They have suggested that, the message duration on storage for DTN (Delay Tolerant Network) nodes was longer due to which all DTN node need to have a larger storage capacity. Therefore, Telemedicine systems have been used in recent years and occupied a space in current research. Most of the authors modified the work as design of system for telemedicine using ARM7 processor [2-6]. In [7], authors have specifically worked for diagnosis of diabetics. Various processes have been designed not only for telemedicine, but also the design process has enriched for monitoring and various diagnosis purpose [8-9]. As such technique consumes more power, less reliable, it does not come with IDE (Integrated Development Environment) and libraries and more complex circuit. Microcontrollers from AVR family offer a wide variety of internal peripheral interfaces which makes it easy to communicate with other devices. In this work, the design methodology has chosen with Atmel 2560 processor.

Unlike the choice of microcontroller for a specific application is a great challenge. For this design purpose we have chosen Arduino 2560 board. Arduino board is based on 8-bit AVR microcontroller.

It consumes less power (in μ range) and has higher degree of reliability as it comes with an IDE. The libraries are designed for several applications. The important features of arduino2560 board are listed as follows.

1. Atmega 2560 has flash memory of 256 KB which isused for storing purpose. From 256 KB flash memory (8 KB memory used for boot loader, 8 KB used for SRAM and 4 KB memory used for EEPROM).

2. It supports numbers of OS (Operating System) including Windows, Linux, and Macs.

3. ATmega2560 has two 8-bit counters which are effectively identical in operation and three more of the 16-bit timers (named 3, 4, and 5). Each timer has 3 PWM channels.

4. Operating speed is 16 MHz

The paper is organized as follows: Section II presentsthe design methodology. SectionIII describes result and analysis. Finally, conclusion is drawn and reported in Section IV.

II. DESIGN METHODOLOGY

The design methodology in this paper has categorized as two types.

i) Hardware Design, (ii) Software Design

Initially the hardware design is considered with the components and circuits. Each one is described briefly. The sensor circuits for specific application have been designed separately as shown in Fig.1. For such design the suitable board has been considered as Arduino Mega 2560. Each of those units is explained along with the design procedure and as follows

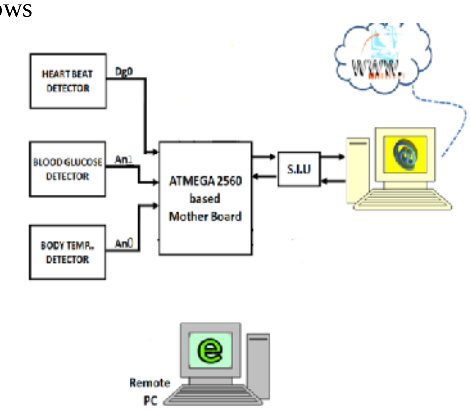

Fig. 1. Block diagram of proposed system design.

A. Temperature Sensor

LM35is a three pin device.Pin1 is for power supply, $V_{CC.}$ Pin 2 is meant for output and will measure the output voltage. Pin3 is grounded.

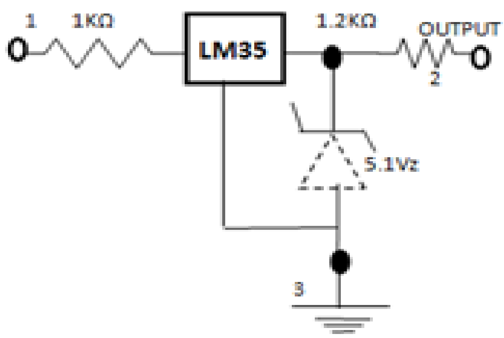

Fig. 2. Pin connection of LM35 temperature sensor.

As shown in Fig.2, pin 1 is connected to 1kΩ resistor. Pin2 is connected to 1.2 KΩ resistances. Pin 3 is connected tozener diode of 5.1Vfor suitable circuit operation.

B. Heartbeat Sensor

The sensor consists of an IRlight emitting diode transmitter and an IR photo detector acting as the receiver as shown in Fig.3. The IR light passes through the tissues. Variations in the volume of blood within the finger modulate the amount of light incident on the IR detector. Two practical configurations could be implemented to achieve this function. In this design, both the IR transmitter and receiver could be placed on the same plane and the finger would function as a reflector of the incident light instead. The IR receiver monitors the reflected signal in this case. The IR filter of the photo transistor reduces interference from the mains of 50Hz. Fig.4 shows the pulse detection circuit. The IR LED is forward biased through a resistor to create a current flow. The values of resistors are chosen so that they produce the maximum amount of light output. The photo-resistor is placed in series with the resistor to reduce the current drawn by the detection system and to prevent short-circuiting the power supply when no light is detected by the photo resister. Here we are getting digital output. In the proposed design 60000ms is considered as delay, so that after 1 min it will start counting from beginning. The signal conditioning circuit as shown in Fig. 5 consists of two identical active low pass filters with a cut-off frequency of about 2.5 Hz. This means the maximum measurable heart rate is about 150 bpm. The operational amplifier IC used in this circuit is LM358, a dual Op-Amp chip from Microchip. It operates at a single power supply and provides rail-to-rail output swing. The filtering is necessary to block any higher frequency noises present in the signal. The gain of each filter stage is set to 101, giving the total amplification of about 10000. A 1uF capacitor at the input of each stage is required to block the dc component in the signal.

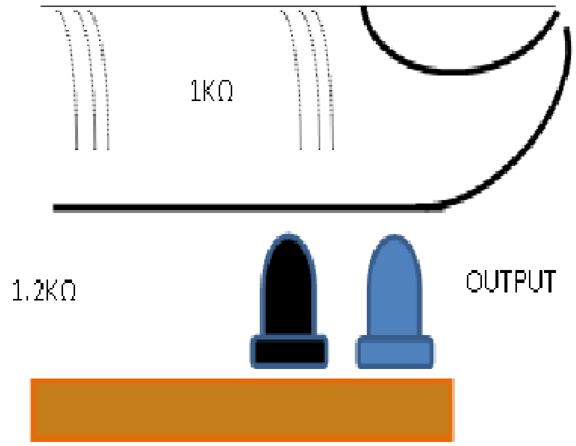

Fig. 3. Fingertip heartbeat sensor.

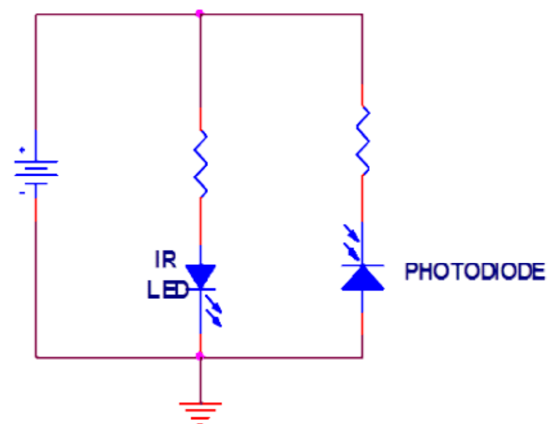

Fig. 4. Circuit diagram of fingertip sensor.

The two stage amplifier/filter provides sufficient gain to boost the weak signal coming from the photo sensor unit and convert it into a pulse. An LED connected at the output blinks every time a heartbeat is detected. The output from the signal conditioning goes to the T_0/C_0 input of ATMEGA.

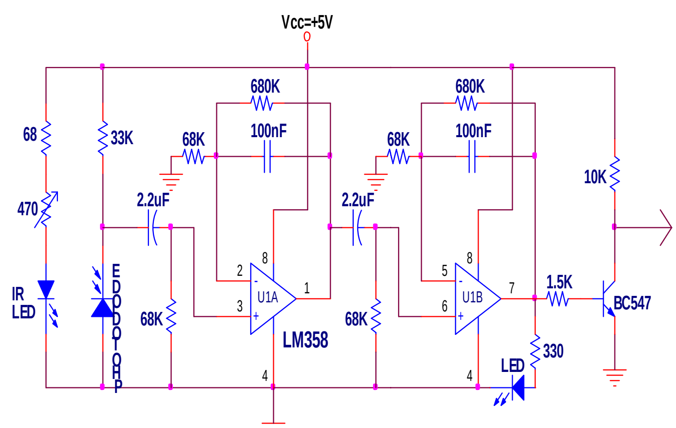

Fig. 5. Circuit diagram of heartbeat sensor.

C. Glucose Sensor

Glucose sensor indicator as shown in Fig.6, is a way of testing the concentration of glucose in the blood (glycemia).particularly important in the care of diabetes mellitus, a blood glucose test is performed by piercing the skin (typically, on the finger tip) to draw blood, then placing the blood on a chemically active disposable strip which indicates the result either by changing colour or changing an electrical characteristic, the latter being measured by an electronic meter. Improved technology for measuring blood glucose is rapidly changing the standards of care for all diabetic people. There are several methods of blood glucose testing currently available. LM324 is considered for experiment.

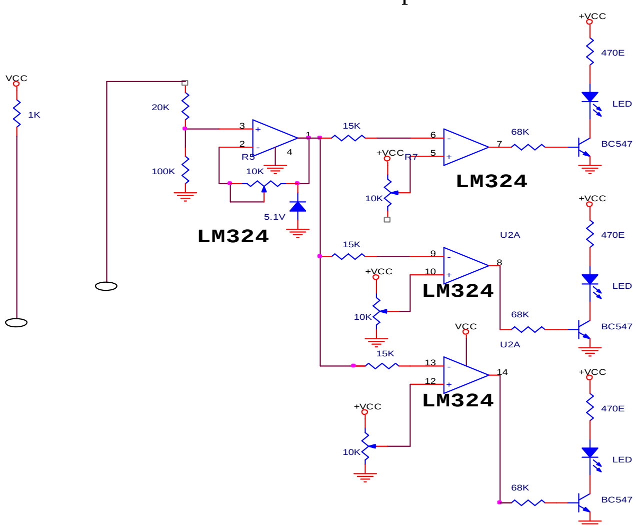

Fig. 6. Circuit diagram of blood glucose sensor.

In this sub section its aspect is to detect the amount of glucose in the blood for that conductive strip is being used for our purposes, one strip is taken as a reference strip with a source voltage 5V. As we know that blood is a good conductor of electricity and another conductive is taken as a detector electrode, whenever the glucose in the blood changes the internal resistance of the blood changes. That output electrical signal is very weak for that an op-amp (LM324) is being used which is configured as a non-inverting with a variable gain (10k). Further that output signalis fed to the voltage comparator. With the increase in the blood glucose the amount of electrical signal decreases because the internal resistance of the blood increases. Here voltagecomparators are used for the detection of the amount of blood glucose (100mg, 200mg,& 300mg).

At normal condition, the output of the non-inverting amplifier voltage is1V. That signal output goes to the three comparator simultaneously. Whenever we increase the blood glucose value to a 100mg the output signal of the amplifier decreases to 0.7Vdc thus that signal is fed to the inverting terminal of the first comparator with a set voltage of 0.71Vdc to the non-inverting terminal. Thus in this condition the first comparator goes high which remains in +Vsat. Same as for 200mg and 300mg.

As mentioned earlier, there are two parts in this design methodology one is based on interface of biosensors with Arduino 2560 board and other is application software developed on Labview platform for monitoring and interfacing to the Hardware and internet as shown in Fig.7.

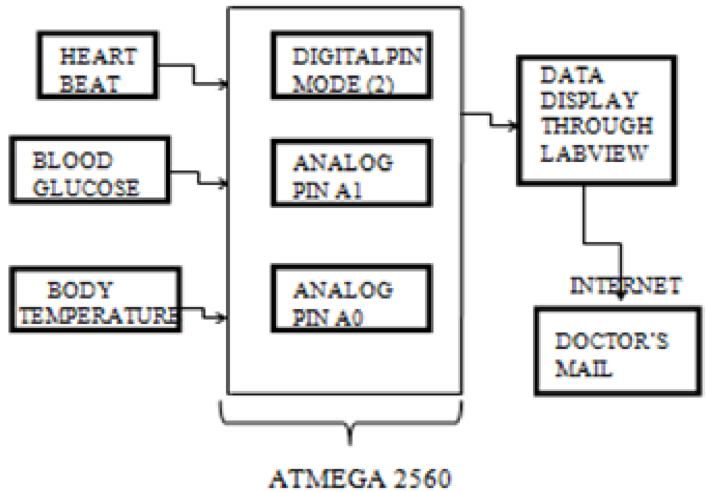

Fig. 7. Block diagram of system's software part.

In software design methodology Arduino 0022 compiler is used to interface all sensors with Arduino Mega 2560 board. The system is interfaced with three sensors (temperature, Heartbeat, and glucose sensors).These sensors are used to measure body temperature, pulse rate, and blood glucose of a patient. Two ADC channels A0, A1, and one Interrupt Input INT0 (External Interrupt0) is used for connecting the sensors. The Channel A0 & A1 is connected to Temperature sensor, Glucose sensor, and the Heart bit sensors is generating TTL pulse so it is interfaced to the INT0. The embedded controller is designed with a Atmega2560 is programmed to read the analog channels as follows, Temperature channel is reading a calibrated output of the sensor having 10mv/°C.The mathematical relation for the channel is as follows;

$$\text{Body temperature} = (\text{sensor Value}*0.4575) \quad \text{... (1)}$$

Blood Glucose channel is connected to ADC (A1) channel. Glucose sensor is reading a calibrated output of the sensor having 1V for 30mg glucose.

The Heartbeat sensor is meant to generate TTL pulse and the controller INT0 input is configured for falling edge sensitivity. The controller is running an ISR (Interrupt Sub Routine) on Real time basis for counting the heart beat for a sampling period of 60 sec. The data is converted into decimal and separated with characters like 'a' 'b'. It will form a serial data sequence. The controller transmitsthe datasequence as a string at a baud rate of 9600 to PC. The Labview Software is used in such a manner to acquire and manage data.

Next to the hardware design, software design is explained.This design is approached using Labview software package andthe result is noted. It is used for communication of the information for necessary action.

SOFTWARE DESIGN (USING LABVIEW PLATFORM)

In configuration section there are four parts as follows,

1. Configuration of Serial Port
   The port address like COM8 depends on the availability of the com port in the PC
2. Configuration of SMTP(Simple mail transfer protocol) server and enabling an e-mail account.
   - Senders e-mail address e.g. sender@gmail.com
   - Receiver e-mail address e.g. receiver@gmail.com
   - And SMTP authentication password (********) of sender
   - Path of the attachment file to be send to the receiver.
   - E>>mydata>>TeleMedicine.xlsx
3. Providing the path for creating /appending the data storage file.
   - E>>mydata>>TeleMedicine.xlsx
4. Setting up of threshold limits.

The biomedicalparameters are received and arecompared with the limit. So there are two set points are to adjust the knobs for different parameters.For the part of software design, proposed system block diagram is shown to acquire the data from sensors and display as a string separately. The block diagram can be described as follows. In this case, it has three channels. One is for temperature sensor, second one is for heart beat sensor and last one is for glucose sensor as shown in Fig.8. Here also the data are taken from sensors at baud rate of 9600. Data which are coming out from sensor are of 8 bit. COM8 port is used to read all data from sensor and write all data to PC. Stop bit is used to indicate the end of frame or string.When an email is sent to doctor’s work station that time stop bit will indicate the end of frame or string. After indication from stop bit, termination character terminates read operation from serial device. End read on termination character enables the serial port to end the read operation, when it detects the termination character. When the serial port operation is performed, the byte to read control detects the byte to read from serial port. Actual byte read will detect the actual number of byte and read from the port. Visa set input-output buffer size sets the input-output buffer size.If there is any error in status, code or string it will give output as error and will be sent to error out. From this it will object the current operation. In case there is no error, then it will send visa resource name to visa read block which read specified number of bytes from device and returns the data to read buffer. Data are passed as string to the match pattern block. If it found any match, then can be splitted the string into three sub strings. From this, the data are sent to the string number block and converts string to a number. Two values are set as upper limit and lower limit. The value is compared in between the two values. If the corresponding values lies in range then LED will blink otherwise data are written to specified file name and email is sent to doctor’s work station for analysis purpose.

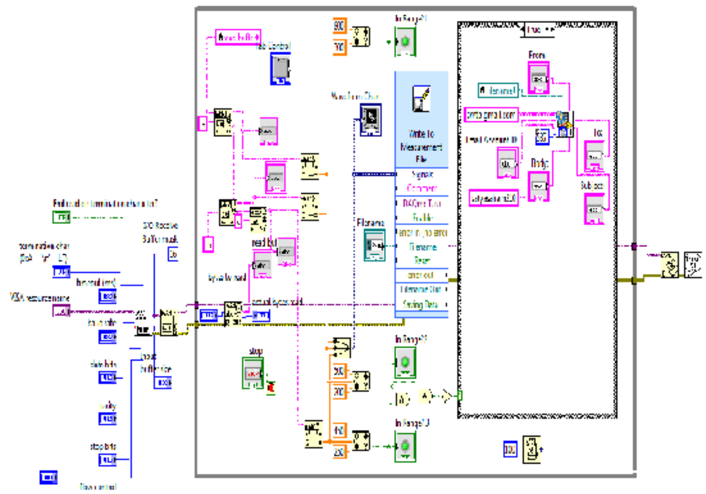

Fig. 8. Block diagram of proposed system using labview platform.

All three sensor data are sent to the merge signal block and then sent to the waveform chart. After this all data are written to a specified file name (.lvm format) for storing purpose.

After configuration of the software, it is moved into RUN mode to read the data in a string format. The string is attached with special character for distinguishing the different sensor data and store separately. ATmega 2560 microcontroller sends 8 bit data frame with 9600 baud rateand the software is configured to delay of one second and receive the same data. This time interval is too large to process all the data separately. Within thisinterval the data are stored in separate columns of the spread sheet and compared with the set values if found any abnormality then close the spread sheet and attach the file to the email and send to the receiver from the senders mail ID. After doing this job automatically the same file opened in a append mode and starts acquiring the data from the sensors as usual.

III. RESULT AND ANALYSIS

Three sensors are designed separately to acquire data from patient in remote area. LM35 temperature sensor is used to get body temperature with respect to environment temperature. In room temperature, body temperature lies in between 35°C to 36°C. In this system body temperature is taken in each second interval. Body temperature is generated for 51 seconds. From the graph as shown in Fig.9, it can be analyzed that patient’s body temperature is normal having values in between 34°C to 36°C. In this graph as shown in Fig.9, x-axis denotes time in seconds and y-axis indicates body temperature in degree centigrade unit.

Fig.10 represents graphical presentation of heartbeat of patient. Normal heart beat of a human body is in between 72-110bpm. In this graph heart beat is taken in each minute. As shown in Fig.10, x-axis represents pulse rate and y-axis represents time.

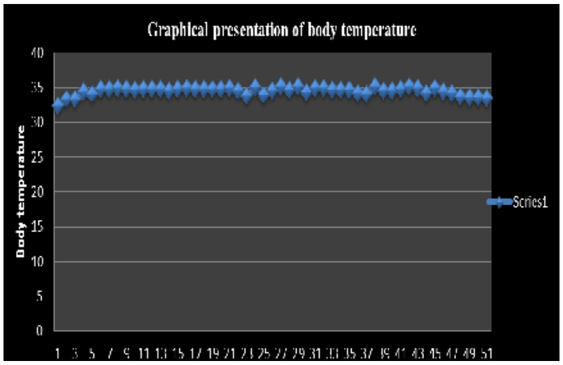

Fig. 9. Graphical presentation of measured body temperature.

Table 1.

TIME(MINUTE)	PULSE RATE
1	97
2	100
3	110
4	100
5	101
6	100
7	108
8	96
9	103
10	102

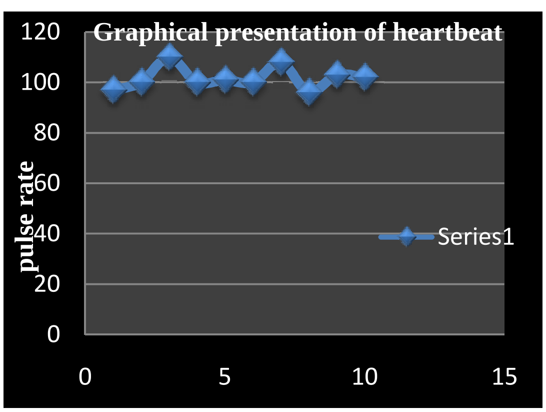

Fig. 10. Graphical presentation of measured heart beat.

As shown in Table 2 which represents data for glucose sensor. In this glucose sensor as the adding of glucose is increases voltage range is decreases. By taking all the values a graph is plotted as shown in Fig.11. In this graph x-axis indicates as voltage in mv range and y-axis denotes weight of glucose in mg unit.

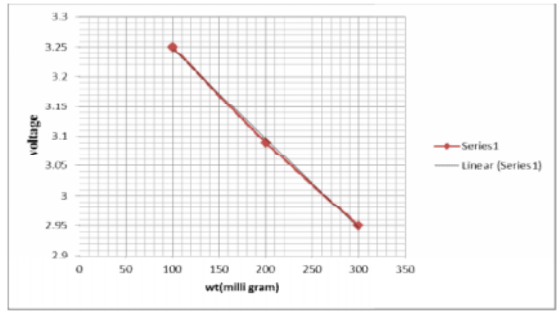

Fig. 11. Representation of Glucose measurement

Table 2

WEIGHT(mg)	VOLTAGE(v)`
100	3.25
200	3.09
300	2.95

Fig.12 is the graphical representation of all sensors data in labview platform. From graph it can be determined that red colour line represents the blood glucose level in patient body which is of 82.48 mg/l. Green colour line represents body temperature of patient which is of 36.98°C. Heart rate is of 114 bpm. All the medical parameters of patient are normal.

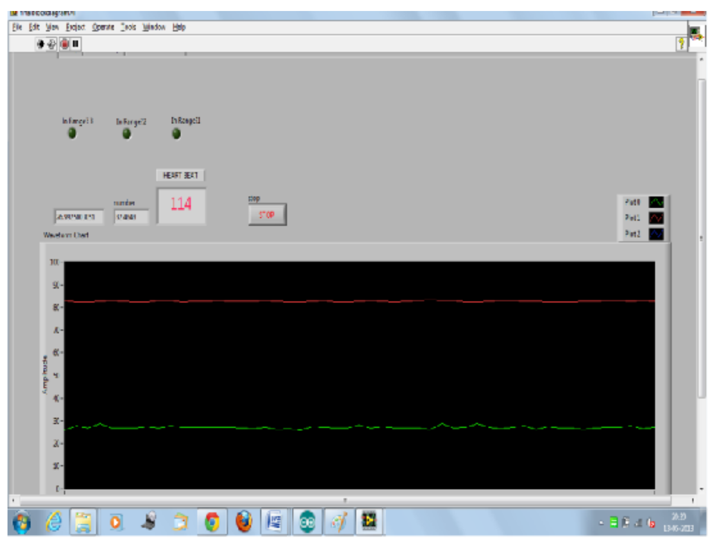

Fig. 12. Graphical presentation of sensor's data in labview platform.

IV. CONCLUSION

The system is tested in the laboratory with biomedical samples and the results obtained are quite satisfactory. The Arduino compiler is similar to C/C++ compiler and development of embedded software is quiet faster and more accurately it handles data after multiplication and division.

The sensor calibration is little bit poor which need more concentric work on it, as our basic work objective is to focused on design of Embedded system and its interface with internet network. The labview based development of the software is quit faster and has easy access to any data base software, as the biomedical signals are non-recurring or non-periodic signals, it always requires a large no of samples for analysis. The system functionality is quite satisfactory and the error observed in reading is quiet negligible in comparison to the experimental tolerance limit.

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