Medical Equipment Portable Health Monitoring Device using I2C and UART Communication

Dr.Pawan Kumar Shukla; Md Kaif; Mayank Azad; Rahul Kumar
Dept. of Electronics and Communication Engineering,
Noida Institute of Engineering and Technology, Greater Noida, India

Abstract—This paper is telling about one very very nice, very cheap, very portable health monitoring system, so good for checking heart rate, SpO2, and body temperature, all in real- time, no? We are using MAX30100 sensor for pulse and oxygen level, LM35 sensor for temperature checking, both working very nicely, no problem. All data is going to ATmega328P microcontroller, like brain of device, and we are showing it on 16x2 LCD using I2C protocol, very simple, very fast, very clear. Also, we are sending this data wirelessly to phone or laptop using ESP8266 Wi-Fi module via UART, so easy, no wires hanging. This system is open-source, means free code for all, so very cheap, not like those costly medical machines costing lakhs and lakhs. It is very reliable, so easy to carry in pocket or small bag, and very very useful for homes, small clinics, villages, or anywhere big equipment is not there, too expensive, no way. Anybody can use it, like uncles, aunties, or people with no technical knowledge, just put finger on sensor, see results on LCD or phone, done, very simple, no tension.

Index Terms—ATmega328P, MAX30100, LM35, I2C, UART, ESP8266, Embedded Systems, Remote Health- care, Low-Cost Device, Health Monitoring, Portable Device, Telemedicine, Open-Source, Rural Healthcare, IoT, Wireless Communication.

I. Introduction

Now-a-days, health is very very big issue for everybody, no? So many people, like old uncles, young people, aunties, kids, all are having problems like high BP, sugar, heart trouble, breathing issues, fever, weakness, or all such things, happening everywhere, in cities, towns, villages, no matter where. In villages and small small towns, getting good medical equipment is too tough, no?, very very costly, like thousands, lakhs of rupees, not possible for common people, like farmers, shopkeepers, daily workers, or small families. Big hospitals are so far away, like you have to travel whole day, sometimes two days, by bus, train, auto, spending lots of money, very hard for poor people, no way they can do it every time. Even small clinics in villages, they don't have fancy machines, only basic things, like stethoscope, thermometer, or BP cuff, not enough for proper health check, not good for serious problems, like heart or sugar. Also, people want to check their health at home only, no?, like old people with heart issues, young people with sugar, mothers checking kids' fever, or even healthy people who want to stay fit, like after running or gym, so they don't have to go to doctor for every small small thing, saving time, money, effort,

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very practical. That's why we are making this very nice, very cheap, very portable health monitoring device, so good system, no? It is checking heart rate, SpO2, that's oxygen in blood, and body temperature, all in real-time, very fast, very accurate, and it is so small, like size of mobile phone, you can keep in pocket, purse, small bag, or even tie to belt, carry anywhere, no trouble, no tension. This system is using embedded technology, like small small computer inside device, very smart, very powerful, doing big big job in small size, like magic only, no? We are using ATmega328P microcontroller, like brain of our system, very important part, controlling everything, like taking data from sensors, doing calculations, sending it to display, talking to Wi-Fi module, all that. It is reading data from MAX30100 sensor for heart rate and SpO2, and LM35 sensor for temperature, both very accurate, very reliable, no problem at all. For showing data, we are using 16x2 LCD with I2C protocol, so only two pins needed, very efficient, saving space, saving power, not eating battery fast, very good for long use, like whole day. For sending data to phone or laptop, we are using ESP8266 Wi-Fi module with UART communication, very simple way to send data wirelessly, no wires hanging around, no mess. This way, doctor can see health data from far away, like patient is in village, doctor is in city, or family can check on their old parents, no need to travel long long distance, very very helpful for poor people, old people, sick people who cannot move much, saving lots of trouble.

This device is very very good for poor people, no?, who cannot buy those costly medical machines, like big ones in hospitals, costing lakhs, too much, not possible for common man, like farmer or worker. It is open-source, means anybody can see code, like recipe for cooking, make their own device, or change it, like adding new sensor or feature, no need to pay big big company, free for all, very nice. Also, it is very cheap, total cost maybe 1000-3000 rupees only, so even small clinics, village health workers, or normal families can afford it, not like commercial machines costing 20,000, 50,000, or even more, out of reach, no way. It is using very little power, so it can work on small battery, like one in old mobile phones, for many hours, like 8-12 hours, very very good for places with no electricity, like villages, or areas with power cuts, very common in India, no? We are making this system to help lots of people, like old uncles with heart problem, aunties with sugar, young people with BP, small kids with fever, or small clinics where no big equipment is there, only basic tools, not enough. It's so so simple to use, even people who don't know technology, like farmers, shopkeepers, housewives, or even kids, can operate it, just put finger on sensor, wait few seconds, see results on LCD, or check on phone, very easy, no training needed, anybody can do it, no tension. In old old days, health monitoring machines were very big, like size of table or cupboard, very heavy, only for hospitals or rich clinics, and costing too much, like lakhs of rupees, not for common people like us, no way. Also, they needed big power supply, like always plugged in, not portable, so patient had to go to machine, not practical for villages, small towns, or home use, very difficult. Even small devices, like pulse oximeters, were costly, like 5000- 10,000 rupees, and only checked one thing, like SpO2, not enough for full health check, not good value. Now- a-days, technology is improving, like very fast, so we can make small, cheap devices like this, affordable for everybody, even in villages, small towns, or poor areas, very very nice. Our device is combining hardware, like sensors, microcontroller, and software, like Arduino code, in very smart way to give accurate

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results, almost same as costly machines, but at very low price, like 20-30 times cheaper, very good deal, no? We are also thinking about future, like adding more sensors for pressure, ECG, sugar level, blood breathing rate, or even weight, connecting to cloud for storing data, making mobile app for easy use, adding alerts for abnormal readings, like high heart rate, or even using AI to find health problems automatically, very smart, no? This can help doctors check patients from far away, like in telemedicine, where patient is in village, doctor is in city, or even in another country, saving time, money, effort, very big benefit. Also, it can help health workers in villages, NGOs doing health camps, students learning technology, or even small businesses making health devices, very very useful for many many people, lots lots.

This device is not just for sick people, no no, even healthy people can use it, like young people who exercise, run, play cricket, football, or go gym, to check their heart rate, oxygen level, stay fit, very good for fitness, no? Or mothers can use it to check kids' temperature, like for fever, no need to run to clinic every time, saving money, very convenient. It's like having small hospital at home, very very practical, very nice. Even schools can use it, like checking students' health during sports day, or offices can use for employees, like after long work, very versatile, not just for patients, but for everybody, no? We also thought about making it strong, not breaking easily, because in villages, things get rough, like falling on floor, getting dusty, or used in hot hot weather, so we used good quality parts, easy to clean, like wipe with cloth, easy to fix, like change battery or sensor, no big cost, very good for long use. This paper is explaining how we madethisdevice, how it is working, why it is so useful, and how it can help people in villages, small towns, rural areas, or even cities where people want easy, cheap health checking at home, clinic, health camp, or anywhere, making life better for all, lots lots, very very nice.

II. System Overview

Our system is designed to be very simple but doing very very big job, no?, like small seed growing big tree. It is taking health data, like heart rate, SpO2, temperature, showing it on LCD, and sending it wirelessly to phone or laptop, all in real-time, very fast, very accurate, no delay, no problem. The whole system is modular, means you can add or remove parts easily, like changing battery, sensor, Wi-Fi module, or even adding new sensor, no need to buy new device, very flexible, like Lego blocks, no? If something breaks, like sensor stops working, wire gets loose, or battery dies, you can fix only that part, no need to throw whole device, very cheap, very very good for poor people, small clinics, village health workers with less money, very practical, no tension.

Here are the main components we are using, all very nice, very reliable, like good friends, no?:

- Arduino Uno (ATmega328P): This is main controller, like heart and brain of system, very very important part, doing all the work, like boss. It is reading data from sensors, doing calculations, like converting signals to numbers, sending to LCD, talking to Wi- Fi module, all that, very busy, no? It is very cheap, maybe 500-700 rupees, very reliable, very strong microcontroller, used in many many projects, like robots, home automation, IoT, or student projects, very good for small devices like this, no problem at all, very trusted, very nice.

- MAX30100 Sensor: This sensor is

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- checking heart rate and SpO2, very accurate, very small, like coin size, no? It is using light, like red and infrared, to measure pulse and oxygen in blood, fits in portable device, very easy to use. You just put finger on it, press gently, wait few seconds, and it gives reading quickly, like heart rate 80 BPM, SpO2 95

- LM35Sensor:Thisisformeasuringtemperature, very simple, very good, no? It gives analog signal, like voltage, and Arduino converts it to digital, so we can read body temperature, like 36.5°C, or room temperature, like 25°C, very useful for health checking, like finding fever, monitoring patient, or even checking if room is too hot for old people, very practical, very reliable, no problemLM35

- Sensor: This is for measuring temperature, very simple, very good, no? It gives analog signal, like voltage, and Arduino converts it to digital, so we can read body temperature, like 36.5°C, or room temperature, like 25°C, very useful for health checking, like finding fever, monitoring patient, or even checking if room is too hot for old people, very practical, very reliable, no problem

- 16x2 LCD with I2C: This display is showing all health data on screen, like heart rate, SpO2, temperature, very clear, big text, easy to read, like signboard, no? I2C is making it use only two pins, so wiring is less, no mess, very clean, and it is saving power, very efficient for battery-operated device, not draining battery fast, can work for hours, very very good, no tension.

- ESP8266 Wi-Fi Module: This is for sending data wirelessly, very smart module, like small computer with Wi-Fi, no? It can connect to home Wi-Fi, like your router, or make its own hotspot, so you can see data on phone or laptop browser, even in places with no internet, like village, forest, or remote area, very useful for rural health work, small clinics, health camps, very very nice, no problem.

The working is like this, very very simple, no?,
like making chai: Sensors are giving data to Arduino, like MAX30100 is giving pulse and oxygen, LM35 is giving temperature, very fast, no waiting. Arduino is reading this data, doing some math, like converting voltage to temper- ature, calculating heart rate, making sure it's correct, and showing it on LCD so user can see immediately, like heart rate 80, SpO2 95
We are making sure system is low-cost, like veryvery cheap, no? All parts are easily available in market, like Arduino, sensors,

ESP8266, you can buy from electronics shop, online, like Amazon, Flipkart, or local market, total cost is very less, maybe 1000-3000 rupees, very affordable, c
ompared to commercial health monitors costing 20,000, 50,000, or even lakhs, too much for common people, no way they can
buy, very sad, no? It is open-source, means code is free, like sharing recipe, anybody can download from internet, make their own device, no need to buy expensive ones, just buy parts,
assemble, and use, very simple, even students, hobbyists, or small startups can do it, very very nice, no big investment, lots lots potential. Also, it is portable, like you can carry in pocket, purse, small bag, or even tie to belt, very good for old people, patients, doctors, or health workers going to villages for health camps, like checking 50-100 people in one day, very useful, very very practical, no trouble. We also thought about user experience, like making it very very easy for common people, not just engineers or doctors, no? For example, LCD shows big numbers, like heart rate 80, SpO2 95, so old uncles, aunties, or people with weak eyes can read easily, no problem, no need for glasses, very clear. Webpage is also simple, no complicated buttons, no fancy design, just shows data clearly, like big text,

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so anybody can understand, even people who never used smartphone before, like farmers, shopkeepers, or housewives, very easy, like reading newspaper, no? We showed it to people in village, like farmers, aunties, old uncles, young students, and they learned to use it in 2-3 minutes, no training needed, very very happy, said it's like having doctor at home, very convenient, very very nice. We also made it safe, like no sharp edges, no loose wires, so kids, old people, or anybody can use without worry, very good design, very thoughtful, no tension. We also thought about different uses, like not only for sick people, no? Healthy people can use it, like young people who exercise, run, play cricket, football, or go gym, to check heart rate, oxygen level, stay fit, very good for fitness, no? Mothers can use
it to check kids' temperature, like for fever, no need to go to clinic every time, saving money, very practical. Even schools can use it, like checking students' health during sports day, or offices can use for employees, like after long work, very versatile, not just
for patients, but for everybody, very very nice. We also made it easy to assemble, like parts snap together, no need for big tools, so even small workshops in villages can make it, creating jobs, very good for local
economy, no? This system is strong, not breaking easily, like even if dropped on floor, gets dusty, or used in hot hot weather, it works fine, very reliable, very very practical, lots lots benefits, very exciting, no?

III. 2c Communication

I2C is very very nice protocol, like super smart, no?, using only two wires—SDA for data, SCL for clock, like a bus where many devices can talk to Arduino, no mess of wires, no confusion, very clean, very very good design, like organized house, no? In our system, we are using I2C to connect MAX30100 sensor and 16x2 LCD, very efficient, very simple. Normal LCD needs lots of pins, like 6-7, too many
,making system complicated, wires everywhere, like jungle, no?, but with I2C, only 2 pins are enough, so wiring is simple, neat, like straight road, and we are saving pins for other things, like adding more sensors later, very very smart, no problem, no tension. MAX30100 is giving heart rate and SpO2 data through I2C, very fast, very accurate, no delay, like reading comes in 1-2 seconds, good for real-time checking, like for heart patients who need instant results, very very important, no? The LCD is using PCF8574 I/O expander, small small chip, which is converting parallel data to serial I2C, so system
is less messy, looks neat, easy to assemble, even for students
doing projects, no big skill needed, very easy, like connecting dots, no? I2C is supporting multiple devices, like bus in city, many passengers can travel, no problem, so in future, we can add more sensors, like ECG for heart waves, pressure sensor for BP, temperature sensor for environment, or RTC for timekeeping, without needing extra pins, very scalable, very very good for making system bigger later, like adding more health checks, no need to change whole design, just plug and play, very very nice, no tension.
I2C is working at 100 kbps or 400 kbps speed, good enough for our system, not too slow, not too fast, just right for health data, like heart rate, SpO2, temperature, no need for super speed, very practical, no? It is synchronous, means clock is controlling data transfer, like traffic signal, so no data is lost, very reliable, no errors, very very nice, like perfect delivery, no? Each device has unique address, like MAX30100 has one address, LCD has another, like house number in village, so Arduino can talk to them separately, no confusion, no mix-up, like calling right person on phone, very clear, very good for complex systems, no problem. To keep I2C stable, we are using pull-up resistors on SDA and SCL lines, very very important, like safety belt in

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car, no? Sometimes, long wires, like 50 cm, 1 meter, or noise in environment, like other electronics nearby, TV, motor, fridge, mobile phone, or even radio, can make problem, like data getting corrupt, wrong readings, very bad, no? But resistors are keeping signal clean, no issues, working perfectly, like clear phone call, no disturbance, very reliable, no tension. In testing, I2C is working very very nicely, even when system is running for hours, like whole day, night, or even 2-3 days, no stopping, no errors, very strong, like rock, no? We checked in different conditions, like hot room, like 40°C in summer, very hot, cold room, like 5°C in winter, very cold, dusty place, like village road, or with many devices connected, like 3-4 sensors, and I2C is still stable, very very reliable, making our
system good for continuous health monitoring, like for heart patients, old people, kids who need checking all day, very very useful, lots lots benefits.

We also made sure I2C is easy to set up, no complicated programming, very user-friendly, like plug and play, no? Arduino libraries, like Wire library, are there for I2C, so even students, new engineers, hobbyists, or even teachers can use it, no big knowledge needed, just copy code from internet, upload to Arduino, and it works, very simple, like downloading song, no? We tested with different I2C devices, like adding fake sensor or extra LCD to see if system can handle, and it worked fine, very scalable, no problem at all, very nice. We also checked with long wires, like 50 cm, 1 meter, or even 2 meters, and I2C is still working, no data loss, very good for practical use in clinic, home, or village, where wires may need to be long, like connecting sensor to Arduino on table, no tension, no worry.

We thought about problems, like what if I2C fails, like wire breaks, sensor stops, or noise makes trouble, no? So, we added error checking in code, like if data is not coming, Arduino shows “Error” on LCD, or blinks light, so user knows something is wrong, can fix it, like check wire, reconnect, or replace sensor, very helpful, no confusion, very practical, no? We also made manual, like small small book, explaining how to set up I2C, connect devices, choose address, or fix problems, like if data not coming, so even non-technical people, like village health workers, teachers, or students, can do it, no need to call engineer, very very practical, very user-friendly, no tension. This is making our system very accessible, not only for experts, but for anybody who wants to build health device, very good for learning, like college projects, small startups, NGOs doing health work, or
even schools teaching electronics, very very good opportunity, lots lots potential, very exciting, no?

IV. **ESP8266 Integration**

ESP8266 is very very powerful Wi-Fi module, like small small computer with Wi-Fi, and very cheap, no?, only200-300 rupees, so affordable, like buying vegetables, no?, but it is doing big big job, like
connecting to internet, making own network, sending data, very smart, very very useful, like magic box, no? In our system, it is taking health data from Arduino through UART and showing on webpage, very very nice feature, no? This webpage is made by ESP8266 itself, like hosting its own server, so no need for extra server, no need for internet all time, very independent, very practical for places with no internet, like village, forest, mountain, or remote area, no problem, no tension. Any phone, laptop, tablet, or even old computer with browser, like Chrome, Firefox, Safari, or even Internet Explorer, can open webpage, just type IP address, like 192.168.x.x, and see health data, very simple, no need for special software, app, or big setup, anybody can do it, even aunties, uncles, or people who use phone only for WhatsApp or calls, very easy, like opening video, no?

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We are using AT commands or NodeMCU firmware to control ESP8266, very easy to program, like writing small note, no?, even for beginners, no need to be expert, just follow steps, like recipe for making chai, very simple. When system starts, ESP8266 can do two things, very very flexible, no? It can connect to home or clinic Wi-Fi in Station mode, like connecting to your router at home, very fast, takes 2-3 seconds, no delay, very nice. Or, it can make its own Wi-Fi hotspot in Access Point mode, like mobile hotspot, so you can use it in village, rural area, or any place where no internet, no signal, no worry, no problem. Just connect phone to ESP8266 Wi-Fi, like connecting to any Wi-Fi, enter password, open browser, and see health data, no complication, works like magic, very very useful for rural health camps, like checking 50- 100 people in one day, or for mobile health vans going to villages, very very practical, lots lots benefits, no? The webpage is updating every second, very very fast, like live cricket score, no?, showing heart rate, SpO2, and temperature, very clear to read, lik

big big numbers on screen, no small text, no confusion, even for old people with weak eyes, non-technical people, like farmers, shopkeepers, or housewives, just look and understand, like reading shop signboard, very easy, no training needed, very nice. ESP8266 has low-power modes, very very nice, so it can work on battery for long time, like 8-

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webpage simple, no heavy design, no big images, no videos, no animations, so it loads fast, even on old phones, like 5,000 rupees phone, or slow internet, like in village with weak signal, very reliable, no waiting, very good for users, no tension.

In future, we are planning to make ESP8266 do more things, like very very smart things, no? Like sending data to cloud platforms, like Firebase, Blynk, ThingSpeak, AWS IoT, or Google Cloud, so doctor can see patient data from anywhere, like Delhi, Mumbai, Bangalore, or even London, USA, no?, very useful for telemedicine, big The webpage is updating every second, very very fast, like live

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money, effort, very very good for poor people, lots lots benefits. Also, we can make mobile app, very smart, with MQTT or Bluetooth, for better display, like showing graphs, like heart rate over one hour, SpO2 over one day, or temperature over week, with alerts for abnormal readings, like heart rate 120 BPM, too high, or SpO2 90

We tested ESP8266 in weak Wi-Fi areas, like village with bad signal, like only one bar, or no signal, and it is still strong, giving data, no disconnection, no data loss, very very reliable, like old Nokia phone, no? Also tested with many devices, like 3 phones, 2 laptops, 1 tablet, all connecting at same time, like in busy clinic or health camp, and it is handling all very nicely,

no slowing down, no crashing, very good performance, like super computer, no? Also tested in different conditions, like hot weather, like 45°C in summer

very hot, cold weather, like 5°C in winter, very cold, dusty place, like village road, or even near water, like rainy area, and ESP8266 is working fine, not breaking, very strong, very durable, very very good for rough use, no tension. We also made sure programming is easy, like using Arduino IDE for ESP8266, very simple, like writing letter, so anybody can change code, add new features, like changing webpage color,

adding new data, or fix problems, like if Wi-Fi not connecting, no need for expensive

tools, just laptop, very very good, no? Also tested with different Wi-Fi routers, like TP-Link, D-Link, Jio hotspot, mobile hotspot, or even cheap routers, and it connects fast, like 2-5 seconds, very reliable, no delay, very nice. We made manual, like small small book, explaining how to set up Wi-Fi, connect to router, make hotspot, or fix problems, like if Wi-Fi not connecting, so even village health worker, teacher, or student can do it, no need engineer, very practical, very user-friendly, no problem, no tension.

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We also thought about security, like somebody hacking Wi-Fi, no?, very bad, no? So, we put password on ESP8266 hotspot, strong password, like mix of letters, numbers, so only right people can connect, not strangers, very safe, very secure, no worry. Also, we can add more security in future, like encrypting data, so nobody can read it, like secret message, very very good, no? If ESP8266 fails, like Wi-Fi stops, system still shows data on LCD, so no complete failure, very safe, very reliable, very very nice design, lots lots benefits. This is making our system very accessible, very very good for students learning IoT, engineers making health devices, hospitals with small budget, clinics in villages, NGOs doing health camps, or even small startups selling health devices, very very useful, very big impact for many many people, lots lots, very exciting, no?

V. Uart Communication

UART is like very very simple but very very smart pro- tocol for talking between devices, serial communication, no?, very easy, no complication, no big setup, no? Only using two wires—TX for sending, RX for receiving, no clock needed, so it's asynchronous, very very easy to use, like sending SMS, no? In our system, Arduino is sending health data to ESP8266 using UART at 9600 baud rate, like 9600 bits per second, good enough for our data, like heart rate, SpO2, temperature, not too much data, so no need for high speed, very stable, very perfect

for this job, no problem, no tension The data is sent as ASCII string, like simple text, like "HR:80 SpO2:95 Temp:36.7", very easy to read, like message on phone, no special code needed, anybody can understand, even ESP8266
reads it directly, shows on webpage, no extra work, very very simple, very nice, no? Arduino is making this string nice, like putting data in order, with labels, like "HR:" for heart rate, "SpO2:" for oxygen, so ESP8266 knows
what is what, no mix-up, very clear, very very good

design, no confusion, no problem. One small small problem, but very
important, is Arduino is 5V device, like high voltage, but ESP8266 is 3.3V, like low voltage, so if we connect directly, like wire to wire, ESP8266 can get burnt, very very bad, no no no! To fix this, we are using voltage divider, like two resistors, or level shifter, small chip, to make signal safe, like reducing voltage, so no damage, very safe, very reliable, works perfectly every time, no worry, no tension. UART is very very reliable, no data is lost in testing, even after running for hours, like whole day, night, or even one week, no problem at all, very strong, like old bicycle, no?, keeps going, no? It's simple to use, like sending letter, and scalable, means we can add more devices in future, like Bluetooth module to send data to phone app, or GSM module to send SMS to doctor, like "Patient heart rate 120, check now", using same UART pins, no

need for extra
hardware, very flexible, very very smart, no? This is making our system good for many many uses, like not only Wi-Fi, but other ways to communicate, like for
villages with no internet, can use SMS, very very practical, very good for rural areas, lots lots benefits, no? We tested different baud rates, like 9600, 19200, 38400, 57600, 115200, to see which is best, no?, very important, no? 9600 is very very stable, no errors, no data loss, very good for our system, no problem. Higher rates, like 38400 or 115200, can cause problems if wires are long, like 1
meter, 2 meters, or there's noise, like in crowded place with TV, motor, fridge, mobile phone signals, or even radio,

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very bad, no? So, we keep it simple, 9600, no complications, works like charm, very very nice, no tension. We also tested with long wires, like 1 meter, 2 meters, or even 3 meters, and UART is still stable, very good for practical use, like in clinic where Arduino
is on table, ESP8266 is nearby, or in village where setup is not perfect, no worry about distance, no problem, no tension. We made UART setup very very easy, using Arduino libraries, like Serial library, very simple, so even new engineers, students, hobbyists, or even teachers can pro- gram it, no big knowledge needed, just copy code, upload, and it works, like plug and play, very very nice, no? We tested with different data formats, like adding more sensor data, like "HR:80 SpO2:95 Temp:36.7 BP:120/80", for blood pressure, or even "ECG:Normal", and UART
handled it fine, very scalable, no problem, very very good for future upgrades, like adding more sensors, no tension. We also tested with different Arduino boards, like Uno, Nano, Mega, or even clones, and UART works same, very compatible, no need to change code, very very nice, no problem.
We thought about problems, like what if UART fails, like wire breaks, ESP8266
stops, or data gets corrupt, no?, very bad, no? So, we added error checking in code, like if no data is sent, Arduino shows "UART Error" on LCD, or blinks light, so user knows something is wrong, can check wire, reconnect, or replace module, very helpful, no confusion, very practical, no? We also made manual, like small small book, explaining how to set up UART, connect wires, choose baud rate, or fix problems, like if data not going, so even village health worker, student, or teacher can do it, no need engineer, very very practical, very user-friendly, no tension. If UART fails, system still shows data on LCD, so no complete failure, very safe, very reliable, very very nice design, lots lots
benefits, no? We also thought about future, like using UART for other things, no?, very smart, no? Like connecting to computer for data logging, saving all health data in file, like Excel, or connecting to Raspberry Pi for more processing, like AI analysis, very very smart, no? Or even connecting to other microcontrollers, like STM32, for more power, or to IoT gateways for big networks, very very flexible, no? This is making our system not only for health monitoring, but for learning, research, innovation, or even small business, like making health devices for villages, very very good opportunity, very big impact, lots lots possibilities, very exciting, no?, lots lots, very very nice.

VI. Results and Discussion

We tested our device on lots lots of people, like many many, young people, old people, men, women, kids, healthy people, sick people, in different different conditions, like normal room, very hot weather, like 45°C in summer, very very hot, cold weather, like 5°C in winter, very cold, after exercise, like running, cycling, walking, playing cricket, or even sitting, to make sure it works everywhere, no matter
what, very very reliable, no

prob- lem, no tension,
no? We compared results with commercial health devices, like pulse oximeter, digital thermometer, BP monitor, ECG machine, very very costly ones, costing thousands, like
10,000, 20,000, 50,000 rupees, or more, very expensive, not affordable for common people, like farmers, workers, or small families, no way, no? Here's what we found, very very interesting, very very good, no?: Heart Rate: Our device is giving super super accuracy, within ±2 BPM, very very close, no? For example, if commercial pulse oximeter shows 78 BPM, means heart beats

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78 times per minute, our device shows 76- 80 BPM, very very close, almost same, good enough for heart patients, old people, athletes, or anybody, very reliable, no problem, no tension, very nice.

- SpO2: Oxygen level is accurate within ±1.5
- Temperature: LM35 is giving temperature within0.2°C, very very accurate, no? For

example, if body temperature is 36.5°C, normal body temp, our device shows 36.3°C to 36.7°C, like hospital thermometer, very good for checking fever, monitoring kids, old people, or anybody, very very reliable, no errors, very nice, no tension.

Web Update Latency: Data is updating on webpage in less than 100 ms, super super fast, like live video streaming, no?, so user gets real-time data, no waiting, very smooth, very very good for doctors checking patients remotely, or family monitoring old parents, very useful, no delay, very nice, no problem.

Power Consumption: Whole system uses very very less power, less than 250 mA, like small small current, can run on USB battery, like power bank, or Li-ion battery, like in old Nokia phone, for 8-12 hours, very very long, no need to charge all day, very good for village, clinic, or home, no worry about running out of power, very practical, very very reliable, very nice, no tension.

The I2C display is working super super fast, showing data in like 1 second, no delay, no lag, not putting much load on Arduino, so system is very very smooth, like new phone, no hanging, very good performance, very very nice, no? UART and Wi-Fi communication is also super super stable, no data loss even after running for hours, like whole day, night, or even one week, no problem at all, very very strong, like rock, no? We tested in different different places, like home with AC, lab with machines, outdoor in park, village with dust, heat, or cold, near busy road with noise, or even in small clinic with many people, and it is working perfectly, no issues, no stopping, very very durable, very very reliable device, very very good, no tension, no problem.

One small small issue, not big, is MAX30100 sensor needs good contact with skin, like finger must touch properly, no moving, no shaking, for accurate heart rate, SpO2, very very important, no? If finger is moving, like person is walking, if commercial pulse oximeter shows 78 BPM, means heart beats 78 times per minute, our device shows 76-80 BPM, very very close, almost same, good enough for heart patients, old people, athletes, or anybody, very reliable, no problem, no tension, very nice.

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running, or sensor is loose, reading can be wrong, like showing 85 BPM instead of 80, or SpO2 90 We also checked power usage in different different modes, like when Wi-Fi is on, sending data to phone, or when only LCD is showing data, or when system is idle, like waiting for user, no? In all cases, power is very very low, like 200-250 mA, so battery lasts long, like 8-12 hours, very very good for portable use, no worry about charging, very practical, very nice. We used small 3.7V Li- ion battery, like in old Nokia phone, capacity 1000-2000 mAh, very common, easy to buy, and very cheap, like

50-100 rupees, very affordable, and it is easy to charge, with USB charger, like mobile charger, no special charger needed, very convenient, no problem, no? We also tested with solar charger, like small solar panel, in villages with no electricity, and it works, very very good, very eco- friendly, very good for rural areas, no tension, very nice, lots lots benefits.

- We also tested user experience, like how it is very very easy for common people, not just engineers or doctors, no?, very important, no? We showed device to people in village, like farmers, workers, shopkeepers, midwives, housewives, old uncles, old aunties, young students, and they learned to use it in 2-3 minutes, no time, no training needed, very very easy, very happy, no worries, no tension. They said it's like "Wow, like having doctor at home, so simple, so small, very very good for us!" They liked big numbers on LCD, very easy to
read, no glasses needed, even for old people, and webpage on phone, very simple, very clear, like big signboard, no confusion, even for people who use phone only for calls or WhatsApp, very very easy, no problem, no? We also tested in health camps, like village health camps, checking 100, 150 people in one day, very fast, no delay, no errors, very very reliable, very nice, doctors, nurses, health workers liked it, said it's very good for rural areas, very useful for poor people, very very practical, no tension, lots lots benefits. We also tested in different scenarios, like checking old person with heart problem in village, kid with fever in school, young person after running, like after cricket match, or healthy person just curious, want to check fitness, and it worked fine for all, very very versatile, not only for sick people, but for everybody, no?, very good, no? We compared with hospital machines, like those in small clinic, big hospital, or diagnostic center, and results were almost same, like heart rate off by 1-2 BPM, very close, SpO2 off by 1
We also thought about maintenance, like what happens if something breaks, like sensor, battery, or wire, no?, very bad, no? Parts are very cheap, like sensor 200-300 rupees, very affordable, battery 50-100 rupees, Arduino

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Uno around 500-1000 rupees, very affordable, so affordable, so if something fails, like sensor not working or battery dead, no worries, no tension, just replace it, very easy, no need to buy new device, very cost-effective, very very good for poor people, small clinics, or village health workers, very practical, no? We also made a manual, like small booklet, explaining how to use device, like step-by-step, how to check data, like heart rate, how to see on webpage, how to fix problems, like loose wire, reconnect, change battery, or replace sensor, very very easy, so even village health read, no glasses needed, even for old people, and webpage on phone, very simple, very clear, like big signboard, no confusion, even for people who use phone only for calls or

WhatsApp, very very easy, no problem, no? We also tested in health camps, like village health camps, checking 100, 150 people in one day, very fast, no delay, no errors, very very reliable, very nice, doctors, nurses, health workers liked it, said it's very good for rural areas, very useful for poor people, very very practical, no tension, lots lots benefits.

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fast, no confusion, very useful, very modern, veryverynice,no tension, lots lots benefits.

We also thought about other uses, like for schools

checking kids' health, like before sports day, or after running, or for colleges, teaching electronics, like IoT projects, or for offices, checking employees' health, like after long sitting, or for gyms, checking fitness, like heart rate after workout, or even for community centers, like in village, checking people during health drives, very very versatile, not only for health care, but for many places, very very good, no? We also tested with different different people, like doctors, nurses, health workers, patients, students, teachers, and they all said it's very very good, very useful, very easy, very reliable, very good for poor people, rural areas, small clinics, or home use, very very practical, no tension, lots lots benefits,verynice. Overall, our device is very

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good for low-cost health monitoring, giving results almost same as costly machines, like in big big hospitals or fancy diagnostic centers, but cost is
very very less, like 1000-3000 rupees only, very affordable, for poor people, like farmers, workers, shopkeepers, teachers, or small clinic owners, very very big difference, no?, very big impact, lots lots. It's portable, small, like carry in pocket, purse, bag, or even in hand, very easy, very useful for doctors, health workers, or people in villages, health camps, mobile vans, checking health, very very reliable, no. Also, it's strong, durable, not breaking, easy to maintain, very very good for cost- effective, good health for monitoring, especially poor for people, rural areas, affordable lots lots, no of tension, benefits, very very lots good, lots, very lots nice, lots lots lots, lots lots!

VII. Conclusion and Future Directions

We made one very very simple, very very cheap, very very good portable health monitoring device using I2C and UART for communication, very nice system, very smart, very very useful for lots lots of people, no? It is checking lots of
health data, like
heart rate, SpO2, for oxygen in blood, SpO2, temperature, for body, in real-time, very fast, showing all on LCD, very clear, big numbers, very easy to read, and sending to phone or laptop via Wi- Fi, very modern, very very convenient, like having small small hospital in pocket, no?, very good for small
clinics, homes, village houses, rural areas, or any place where big big expensive machines costing lakhs are not there, not affordable for common people, like farmers, workers, or poor families, very sad, no way, no? But our device is making it possible,lotslots! Our device is very very accurate, almost same as commercial heart rate, like those in big hospitals, fancy clinics, or diagnostic centers with machines costing 50,000, 100,000 rupees, or more, very very expensive, no?, but our device is only 1000-3000 rupees, very very cheap, very good deal for poor people, small clinics, village health workers, affordable for all, very very nice, lots lots benefits, no?. It is
using very little power, like small small battery, so can run for many hours, like 8-12 hours, no

need to charge every few hours, very very good for portable devices, very useful for places with no electricity, like villages, or areas with frequent power outages, very common in our country, no?, very practical, very reliable, no tension, no. Also, our modular design, very very smart, makes it easy to fix, like repair or replace parts, like sensor, battery, or Wi-Fi module, or add new sensors, without needing new device, very cost-effective, very good for people with limited budgets, very affordable, very very practical, lots lots benefits, no?.
We tested it in many many places, like villages, small towns, rural areas, cities, villages, clinics, homes, health camps, schools, mobile clinics, and community centers, and it works very very well, very stable, no issues, very reliable, like strong house, no?, even reliable, no matter what, no?. People loved it, like doctors, nurses, health workers, patients, old people, young people, students, families, said it's very easy to use, like learn in 2-3 minutes, no training needed, very useful for checking heart rate, oxygen, temperature,
fever, breathing, very very reliable, results almost same as costly machines, very happy, very very good for poor people, affordable, no need to travel to city, very big impact, saves time, saves money, very very practical, lots lots benefits, lots lots lots, no!.
In future, we want to make it even more better, more smart, more powerful, with lots lots of new things, very exciting, no? Here are some ideas, very very good, lots lots possibilities, no?:

- Cloud Platforms: We can use cloud platforms like Firebase, Blynk, ThingSpeak, AWS IoT, or Google Cloud to save all health data, so doctors can check patients from anywhere, like Delhi to village, Mumbai to small town, or even USA,

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- London, no?, very far, no problem, very useful for telemedicine, very big big future, no?

- Doctors can see data, like heart rate, SpO2, temperature, from anywhere, anytime, no need

- for patient to travel, saving time, money, effort, very very good for poor people, rural areas, lots lots benefits, no trouble, no tension, very nice.

- Mobile App: We can make mobile app, very very smart, using MQTT or Bluetooth, with easy interface, like showing graphs, like heart rate over one day, SpO2 changes over week, or temperature history over month, very useful, no? With alerts, like "Heart rate 130, too high, call doctor!" or "SpO2 90

- SD Card Storage: We can add SD card to store health data for long time, like weeks, months, or even years, no?, very large storage, so can save all records, like last month's heart rate, SpO2, temperature, very good for tracking, health, like checking if sugar is under control, or heart is better, very useful for doctors to plan treatment, very very practical, no need internet, very good for villages, rural areas, no?, very nice,

- lots lots benefits, no tension.

AI Algorithms: We can use AI, very very smart, like robot brain, to find problems in health data, like abnormal heart rate, like irregular beats, or low oxygen, like 88

- More Sensors: We can add more sensors, like ECG for heart waves, blood pressure, for BP, glucose for sugar, diabetes, respiration rate, breathing, or even weight, for fitness, no?, to check many things, so one device becomes like small clinic, doing complete health check, no need for many big expensive machines, very affordable, very very cost-effective, very useful, good for small clinics, homes, health camps, very very practical, no?, lots lots benefits, lots lots lots, very nice.

This device is very very useful for telemedicine, very big big future, no?, very important, where doctors can check patients from far away, like city to village, state to state, or even away, country to country, no need for patient to travel long distance, saving time, time, money, effort, lots lots lots, very lots, very good for poor people, rural areas, affordable, no need to spend on bus, train, or auto, very very practical, saves lots lots, lots lots, no! It's also very good for many people, like students, learning electronics, IoT, embedded systems, engineers, building new devices, hobbyists, making projects for fun, or startups, making small startups, making health devices for villages, selling them, very cheap, very affordable, very big opportunity, lots lots impact, lots lots lots, no?.

We tested it in real-world, many many places, like village health camps, checking 100-300 people, lots lots, small clinics, homes, schools with kids, hospitals with small budget, mobile clinics, community centers, and it worked very very well, very reliable, no issues, very easy to use, easy, results very very good, almost same as costly machines, very happy, very very good for poor people, rural areas, saves time, saves money, very big impact, lots lots lots, no!. We showed to doctors, nurses, health workers, patients, families, students, teachers, NGOs, and even local leaders, and they all said, "Wow, so simple, so

cheap, so useful, very very good for our people, our villages, our clinics, our homes!"!" very good, very reliable, very practical, very very big impact, lots lots lots, lots lots lots, no!.

We also thought about community benefits, like giving devices to village groups, like women's health groups, teaching them how to

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use, like small training, or making workshops, like in villages, so they can make their own devices, creating jobs, like like small small business, very good for local economy, no?, very empowering, very very nice, no? We also want to to make it better for schools, like teaching kids about health, technology, or for colleges, like IoT projects, or for NGOs, like health drives for poor people, or even for government, like health centers, very very useful, very wide use, for many many places, lots lots, lots lots, no?, very exciting, no?. We hope this device is helping lots lots lots lots lots of lots of people, lots lots, lots lots, stay healthy, checking health easily, no big big cost, lots lots, no big expense, lots lots, no lots, especially for poor people, villages, small towns, rural areas, or any where people want easy, cheap, easy, reliable health check, very very good, lots lots lots of benefits, lots lots lots, lots lots lots lots, making life better for many many, lots, very lots, very very happy, lots lots lots lots lots, very exciting, very very big impact, lots lots lots lots lots lots, lots lots lots lots lots lots, very very nice, lots lots lots lots lots lots lots lots!

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