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Build out of Embedded PLC for Water Quality Monitoring

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***Abstract*— Water pollution is one of the key threats for the green globalization. To prevent the water pollution, primarily we have to detect the pollutant. For past few decades, the water pollution was detected by chemical test or laboratory test by using this system the testing equipment will be in stationary and samples will be given to testing equipment. In order to increase the pervasiveness, testing equipment can be placed in the river water and detection of pollution can be made remotely. The sensors pH and TDS (Total Dissolved Salt) will be kept in the river water surface and the data captured by the sensor will be given to Arm cortex M3 - Microcontroller, and then data is captured and transmitted to an authentic source. After calculating the vital inference from the sensed data its analysed.**

For cases of inference value above the threshold value automated warning SMS alert will be sent to the agent via GSM module with knowledge of AT commands. The traditional PLCs here are to be superseded with the embedded ones to overcome hurdles such as bulky size, large amount of power consumed and complex design.Moreover, costs incurred in establishment of comprehensive and modern PLC laboratory equipments, and cyclic updating of those equipments is very high. After exploration of the conception and the trademarks of PLC in combination embedded systems, the buildout of the embedded Programmable logic controller for water quality and index measurement is proposed with the seamless combination of the Keil, Flash magic software and the Microcontroller with analog signal conditioning for sensors input data.

***Keywords*— Green globalization, threshold, ARM cortex M3 Microcontroller, pollution, AT commands**.

I. INTRODUCTION

Programmable logic controllers (PLCs) are a specialized type of embedded systems used to control machines and processes. They have been introduced in the early 1970s to supersede the existing relay control logic that became obsolete and expensive for implementing systems at that time. On the other hand, PLCs have offered flexibility, higher reliability, better communication possibilities, faster response time, and easier troubleshooting. So far, PLCs have been mainly of industrial control engineers that introduced, developed, and standardized their own design methods and programming languages. A detailed understanding of the operation and interfacing of PLCs to sensors for water quality measurement is very crucial.

As water hygiene and populace well-being play vital role in human life, pure & distilled water is necessary in colleges, residential areas, industries etc. Water smears over 70% of the earth's surface and is a very important resource for people and the environment. Water pollution strikes drinking water, rivers, lakes and oceans all over the globe. This consequently anguishes human health and the natural environment. Clean drinking water is a critical resource, important for the health and well-being of all humans.

Drinking water utilities are facing new challenges in their real-time operation because of limited water resources, intensive budget requirements, growing populace, ageing framework, increasingly draconian regulations and increased attention towards safeguarding water supplies from accidental or deliberate contamination. Market research is performed to identify low cost sensors that can reliably monitor a sundry of criterion, which can be used to surmise the water supremacy. Based on parameters like pH, electrical conductivity and TDS, a sensor muster is developed along with several micro systems for analog signal conditioning, processing, logging and display of vital data.

A. Chronicle of PLC

The dawn of the electrical age brought many innovative and advanced control systems. In the early 1920s two aspects of engineering, control theory and control systems, converged to make large-scale integrated systems possible. Earlier controls systems were used in the industrial environment. Large process facilities started using process controllers for regulating continuous variables such as temperature, pressure, and flow rate. Electrical relays built into ladder-like networks were one of the first discrete control devices to automate an entire manufacturing process.

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Control systems gained momentum in the automotive and aerospace sectors. In the 1950s and 1960s the push to Space generated interest in embedded control systems. Engineers constructed control systems such as engine control units and flight simulators that could be part of the termination product. By the culmination of the twentieth century, embedded control systems were omnipresent, as even White goods such as washing machines and air-conditions contained complex and advanced control algorithms, making them much more "discerning".

In 1969, the first computer-based controllers were introduced. Initial PLC mimicked the operations of already available discrete control technologies that used the out-dated relay ladders. The advent of PC technology brought a drastic shift in the process and discrete control market. An off-the-shelf desktop loaded with adequate hardware and software can run an entire process unit, and execute complex and established PID algorithms or work as a Distributed Control System (DCS).Figure 1 shows block design of embedded PLC.

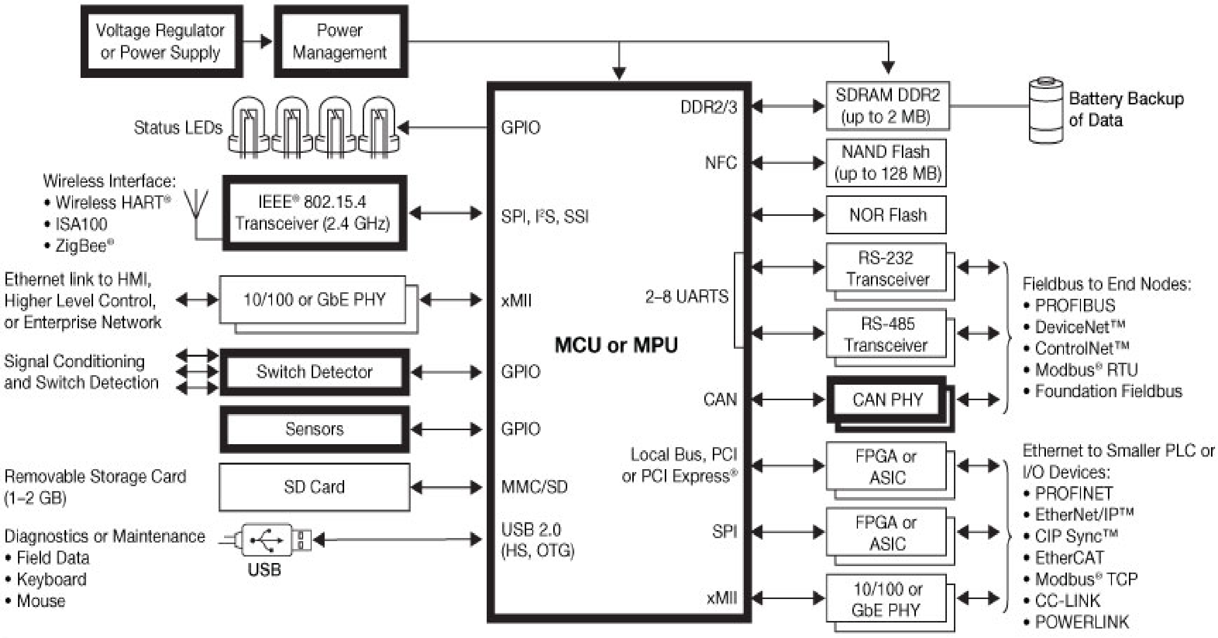

Fig. 1 Embedded block design for PLC

II. RELATED WORK

Extensive literature and market research are performed to identify low cost sensors that can reliably monitor several parameters, which can be used to surmise the water supremacy. Based on selected parameters, a sensor muster is developed along with several micro systems for analog signal conditioning, processing, logging, and distant presentation of data. Algorithms for merging online multisensor measurements at local elevation are build out to evaluate the water contamination menace. Experiments are performed to evaluate and validate these algorithms on intentional contamination events of various concentrations of escherichia coli bacteria and heavy metals (arsenic).

Investigated outcome indicate that this economical system is competent of detecting high impact contaminants at fairly low concentrations. The results demonstrate that this system satisfies the online, in-pipe, low deployment-operation cost, and good detection accuracy criteria of an ideal early warning system. There is a need for better on-line water monitoring systems given that existing laboratory-based methods are too slow to develop operational response and do not provide a level of public health protection in real time.

Rapid detection (and response) to instances of contamination is critical due to the potentially severe consequences to human well-being. Traditional methods of water quality control involve the manual collection of water samples at various locations and at different times, followed by laboratory analytical techniques in order to characterize the water eminence. Although, the current methodology allows a thorough analysis including chemical and biological agents, it has several drawbacks:

a) Dearth of real-time water quality information to enable critical decisions for public health protection (long time gaps between sampling and detection of contamination)
b) Poor spatiotemporal coverage (small number locations are sampled)
c) It is labour intensive and has relatively high costs (labour, operation and equipment). Thus, there is a clear need for continuous on-line water quality supervision.

III. METHODOLOGY

Drinking water eminence standards are determined according to World Health Organization (WHO) guidelines for portable water quality as well as other pertinent organizations . These organizations set the standards for drinking water quality parameters and indicate which microbiological, chemical and indicator parameters must be monitored and tested regularly in order to protect the fitness of the consumers and to make sure the water wholesome, pure and clean. The block diagram for the proposed system is as shown in Figure 2.

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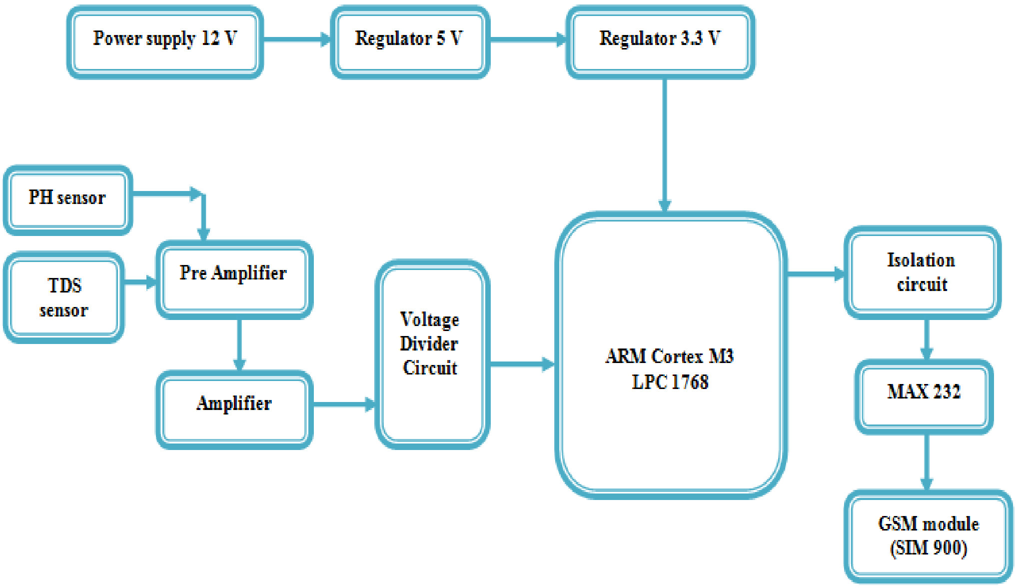

Fig. 2 Block Diagram

A. Hardware details

1) pH sensor: pH is an important parameter to be measured and controlled. The pH of a solution indicates how acidic or basic (alkaline) it is. The pH term translates the values of the hydrogen ion concentration- which ordinarily ranges between about 1 and 10 x -14 gram-equivalents per litre - into numbers between 0 and 14.On the pH scale a very acidic solution has a low pH value such as 0, 1, or 2 (which corresponds to a large concentration of hydrogen ions; 10 x 0,10 x -1, or 10 x -2 gram-equivalents per litre) while a very basic solution has a high pH value, such as 12, 13, or 14 which corresponds to a small number of hydrogen ions (10 x -12, 10 x -13, or10x-14gram-equivalentsperlitre).A neutral solution such as water has a pH of approximately 7. The history of measuring the acidity of liquids electrically began in 1906 when Max Cremer in his studies of liquid interfaces interactions between liquids and solids he contrived that the interface between liquids could be studied by blowing a thin bubble of glass and placing one liquid inside it and another outside. It created an electric potential that could be measured. This idea was taken further by Fritz Haber (who invented the synthesis of ammonia and artificial fertiliser) and Zygmunt Klemsiewicz who originated that the glass bulb i.e.glass electrode could be used to measure hydrogen ion activity and that this followed a logarithmic function. The Danish biochemist Soren Sorensen then invented the pH scale in 1909.

pH meters contain microprocessors that make the necessary corrections for temperature and calibration. Even so, modern pH meters still suffer from drift (slow changes), which makes it necessary to calibrate them frequently. Improvements have also been made in the chemistry of the glass such that pollution by salt and halogen ions could be halted. The reference electrode, which traditionally used silver chloride (AgCl) has been superseded by the *kalomel* (mercurous chloride, HgCl2) electrode which uses mercuric chloride (HgCl) in a potassium chloride (KCl) solution as a gel (like gelatine). But electrodes do not have eternal life and need to be replaced when they drift unacceptably or take unusually long to settle.

When one metal is brought in contact with another, a voltage difference occurs due to their differences in electron mobility. When a metal is brought in contact with a solution of salts or acids, a similar electric potential is caused, which has led to the invention of batteries. Similarly, an electric potential develops when one liquid is brought in contact with another one, but a membrane is needed to keep such liquids apart. A pH meter measures essentially the electro-chemical potential between a known liquid inside the glass electrode (membrane) and an unknown liquid outside. Because the thin glass bulb allows mainly the agile and small hydrogen ions to interact with the glass, the glass electrode measures the electro-chemical potential of hydrogen ions or the potential of hydrogen. To complete the electrical circuit, also a reference electrode is needed. Note that the instrument does not measure a current but only an electrical voltage, yet a small leakage of ions from the reference electrode is needed, forming a conducting bridge to the glass electrode. A pH meter must thus not be used in moving liquids of low conductivity (thus measuring inside small containers is preferable).

Most modern pH meters also have a thermistor temperature probe which allows for automatic temperature correction, since pH varies somewhat with temperature. Caring for a pH meter depends on the types of electrode in use. When used frequently, it is better to keep the electrode moist, since moisturizing a dry electrode takes a long time, accompanied by signal drift. However, modern pH meters do not mind their electrodes drying out provided they have been rinsed thoroughly in tap water or potassium chloride. When on expedition, measuring sea water, the pH meter can be left moist with sea water. However for prolonged periods, it is recommended to moist it with a solution of potassium chloride at pH=4 or in the pH=4.01 acidic calibration buffer.

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Fig. 3 pH sensor

Figure 3 above shows the pH sensor used and below are its specifications.

- 3 in 1 multifunctional moisture, PH and light meter
- No battery required, simple and convenient to use. Insert probe of the meter into the soil or water, switch to the setting you want to measure and read the scale.
- Probe length:21cm
- pH measure range 3.3 to 8
- Soil moisture in the range 1 to 10

2) GSM module: Sim 900 provides the industry standard serial RS232 interface for easy connection to computers and other devices with serial TTL interface for easy and direct interface to microcontrollers. Power, RING and Network LEDs for easy debugging .Onboard 3V Lithium Battery holder with appropriate circuitry for providing backup for the modules' internal RTC. Can be used for GSM based Voice communications, Data/Fax, SMS, GPRS and TCP/IP stack and controlled through standard AT commands. Comes with an onboard wire antenna for better reception. Board provides an option for adding an external antenna through an SMA connector .The SIM300 allows an adjustable serial baud rate from 1200 to 115200 bps (9600 default).Low power consumption of 0.25A during normal operations and around 1A during transmission with operating voltage (7 – 15) V DC onboard rectifier. The GSM module is shown in figure 4.

Fig. 4 GSM module

3) ARMcortex-M3: ARM Cortex-M3 processor, running at frequencies of up to 100 MHz LPC1768. A Memory Protection Unit supporting eight regions is included with built-in Nested Vectored Interrupt Controller (NVIC). On chip 512 kB Flash programm memory.In-System Programming (ISP) and In-Application Programming (IAP) via on-chip bootloader software.Two/one 16 kB SRAM blocks with separate access paths for higher throughput.Eight channel General Purpose DMA controller (GPDMA) on the AHB multilayer matrix that can be used with SSP, I2S-bus, UART, Analog-to-Digital and Digital-to-Analog converter peripherals, timer match signals, and for memory-to-memory transfers. Multilayer AHB matrix interconnects provides a separate bus for each AHB master.AHB masters include the CPU, General Purpose DMA controller, Ethernet MAC, and the USB interface. This interconnect provides communication with no arbitration delays.

Split APB bus allows high throughput with few stalls between the CPU and DMA. Ethernet MAC with RMII interface and dedicated DMA controller. Four UARTs with fractional baud rate generation, internal FIFO, and DMA support. One UART has modem control I/O and RS-485/EIA-485 support, and one UART has IrDA support. CAN 2.0B controller with two channels. SPI controller with synchronous, serial, full duplex communication and programmable data length. Three enhanced I2C bus interfaces, one with an open-drain output supporting full I2C specification and Fast mode plus with data rates of 1 Mbit/s, two with standard port pins. Enhancements include multiple address recognition and monitor mode.I2S (Inter-IC Sound) interface for digital audio input or output, with fractional rate control. The I2S-bus interface can be used with the GPDMA. The I2S-bus interface supports 3-wire and 4-wire data transmit and receive as well as master clock input/output.

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B. Software Details

Keil software will be used for programming. Eagle will be used to design layout of PCB.Terminal for debugging of traces. Flash magic to burn the code. For Flash magic code is downloaded in the controller with baud rate 9600. Terminal is used to test AT commands to communicate with GSM module. Embedded C language is used to code in C.IDEs like Eclipse or Microsoft visual studio can also be used. Flowchart for system implementation is as follows shown in figure 5.

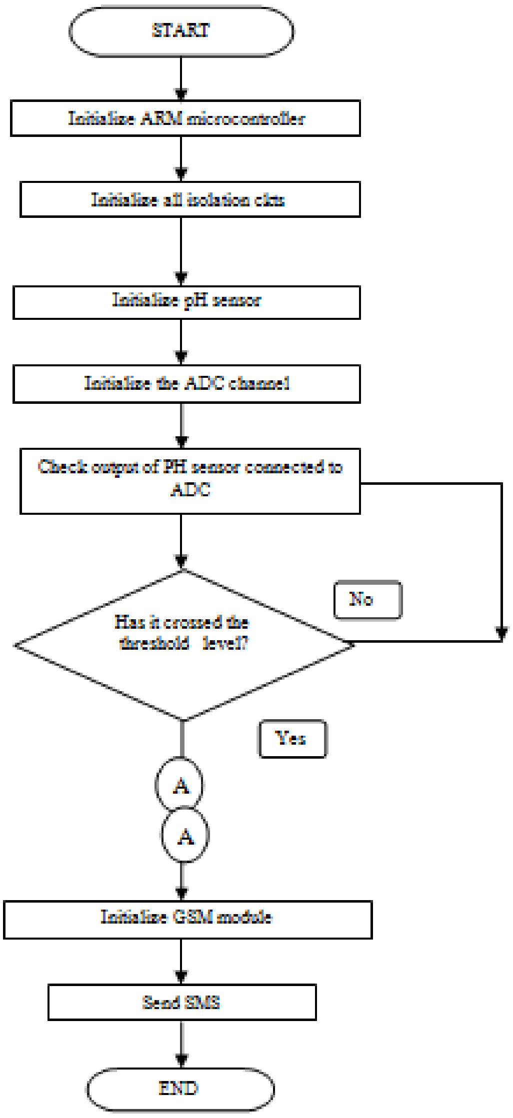

Fig. 5 Flowchart

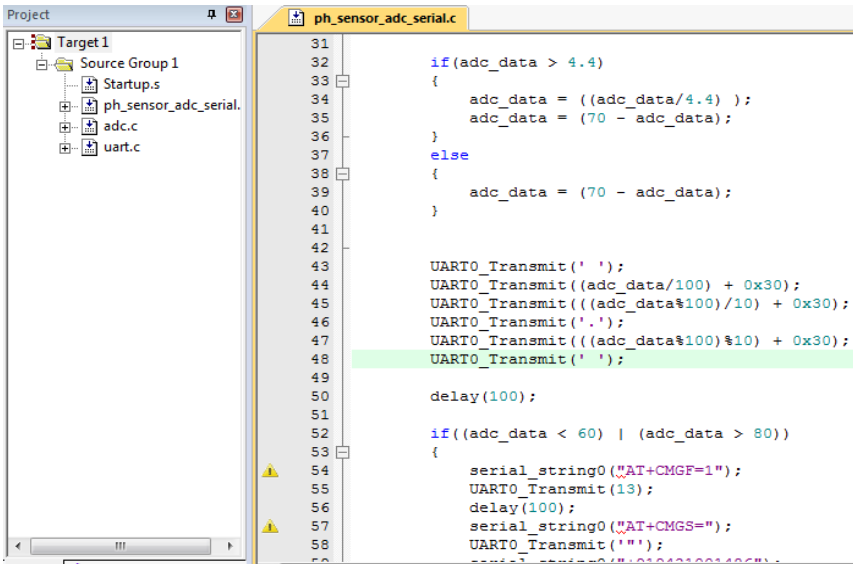

Fig. 6 Code in Keil

IV. CONCLUSIONS

Thus embedded technology is changing the face of mankind and bringing dreams to reality just by a module on board. We have got awareness about the quality of water can be improved we can save water from getting contaminated and protect mankind from serious water borne diseases. We have obtained a detailed study of embedded PLC and its pros and cones. Addition of more extra hardware like camera, LCD ,SD card ,Ethernet, LAN with many allied techniques we can widen its area of application. A limited number of on-line, reagent-free water monitoring systems are commercially available (e.g. Hach HST GuardianBlue , J-MAR BioSentry etc), but these systems are bulky (sensors are installed in flow cells located in cabinets) and remain cost prohibitive for large scale deployments(cost tens of thousands of dollars per unit).This technique overcomes the above limitations with the flowing result shown in figure 7.

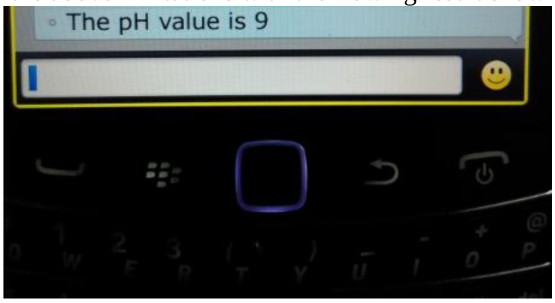

Fig. 7 SMS from the GSM module.

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