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A Temperature Repaid Shrewd Sensor for Agrarian Industry

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ABSTRACT

A temperature remunerated brilliant sensor for the agrarian business. This undertaking presents the plan and advancement of a shrewd nitrate sensor for checking nitrate focus in surface and groundwater. A temperature repaid interdigital capacitive sensor has been created in the ongoing review to quantify nitrate at low fixations. A convenient, novel detecting framework has been fostered that could be utilized nearby as an independent gadget, as well as an IoT-based remote observing brilliant sensor hub, to quantify nitrate focus in surface and groundwater. Electrochemical Impedance Spectroscopy was utilized to recognize and show nitrate focuses, by assessing the impedance change read by the interdigital transducer submerged in the surface water tests. The test tests were assessed by business gear (LCR meter) and the planned framework. These outcomes were additionally approved involving standard research center strategies to evaluate nitrate fixations in water tests. The planned framework showed a decent direct connection between the deliberate nitrate fixations (which went from 0.01 to 0.5 mg/L) to those deliberate by the business gear in the gathered water tests. Be that as it may, the flow framework can possibly be utilized to gauge nitrate fixations in water tests, continuously. The framework can transfer the deliberate nitrate information on a site in view of IoT. This framework could be utilized to incorporate water quality by observing locales inside ranches, or between streams, waterways, and lakes. For the in-situ establishment, a powerful box containing the entire framework would be introduced at the checking site.

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Introduction

In an agricultural country like India, the concentration of nitrate in surface and groundwater is concerning and has been identified as a critical issue facing India's future [1]. Dairy farming, disposal of human and animal sewage, urban runoff and industrial waste to land or into waterways has been identified as sources of nitrate [2]. Nitrate-nitrogen (NO3–N) is a fundamental element for the growth of all plants and animals, as it is a major component of the supply of protein. It is used in the agricultural sector to increase plant and livestock production. However, nitrate can become an issue if its concentration in surface water rises above a certain threshold, and this issue is commonly associated with agricultural areas [3,4]. In India, cattle urination from dairy farming is the largest source of nitrate contamination as the highly concentrated nitrate deposits leach into groundwater, which ultimately increases the nitrate concentration of surface water [5].

Concentrations in surface waters can stimulate the growth of unwanted algae and aquatic plants [6]. High nitrate-N concentrations change the pH of the water and lower oxygen concentrations, affecting aquatic life and degrading fish habitats [7]. Elevated nitrate concentrations in drinking water, can also lead to blue baby syndrome [8]. According to Environment Protection Agency (EPA), the acceptable level of nitrate-N in drinking water is 10 mg/L [9]. The spectrophotometric method is commonly used to detect nitrate-nitrogen (NO3-N) in water using specific chemical reagents [10,11]. In other research, vanadium has been utilized for the reduction of nitrate ions by acidic Griess reaction [12]. Other detection methods include ion chromatography palladium nanostructures planar electrode sensors ion selective electrodes and optical fiber sensors [13-18]. In situ detection of nitrate in nitrate moisture using impedance spectroscopy, have also been reported [19,20]. The regional councils around India monitor water samples from rivers, lakes and groundwater in a routine manner. The samples are collected by staff at a regular interval of time, usually on a monthly basis [21].

The concentrations of nitrate-N is measured by spectrophotometric method. Typically, nitrate-N concentrations change with increasing and decreasing stream or river flows. Therefore, a monthly sampling regime may not adequately represent the actual nitrate-N profile.

This could influence the understanding of the seasonal effects on nitrate-N loss as well as total loads of nitrate-N estimated to be leaving a catchment. This information is critical for regional councils to implement policy and management accurately. Although high-frequency nitrate sensors are commercially available, these sensors cost in the order of $7,500-35,000 USD and are designed to measure nitrate concentrations of > 1 mg/L, which is often not sensitive enough for India waterways. Therefore, there is a clear need for low-cost, low concentration, real-time, smart nitrate sensors and sensing systems, to measure nitrate concentrations in water. The objective of this research is to extend our earlier work to develop a low-cost, in-situ real-time monitoring system based on the planar interdigital sensor.

The purpose is to achieve continuous assessment of nitrate-N in water to improve our understanding and measurement of seasonal and annual losses of nitrate to waterways [21,22]. The earlier work as reported in provides experimental results of the prototype sensor, which are obtained under laboratory environmental condition [21]. The earlier reported system provided good accuracy under a controlled environment. However, the ambient temperature under field conditions vary considerably. Therefore, the performance of the developed system suffered due to temperature fluctuations. Therefore, a compensation of the effect of temperature was required in the current system. The system can transfer measured data to a cloud server for further analysis, saving staff time in collecting samples.

The availability of Internet of Things (IoT) allows the system to be developed as part of a distributed network. The main contributions of this paper are 1. The use of a temperature compensated interdigital capacitive sensor to measure nitrate at low concentrations and 2. The development of a low-cost (the estimated amount of the whole system's cost is less than $100 USD) sensing system for continuous nitrate measurement which links to an IoT-based cloud server through an integrated WiFi connection. The experimental development, evaluation and validation of the systems performance are explained.

Literature Review

Wireless Sensor Networks (WSN), sometimes called Wireless Sensor And Actuator Network (WSAN) is a wireless network consisting of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes. To cooperatively pass their data through the network to a main location. The more modern networks are bidirectional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. When deployed in the field, the microprocessor automatically initializes communication with every other node in range, creating an ad hoc mesh network for relaying information to and from the gateway node. This negates the need for costly and ungainly wiring between nodes, instead relying on the flexibility of mesh networking algorithms to transport information from node to node.

In this paper a Precision Agriculture has the benefit of providing real time feed-back on a number of different crop and site variables. As its name implies, Precision Agriculture is precise in both the size of the crop area it monitors as well as in the delivery amounts of water, fertilizer, etc. This technology can isolate a single plant for monitoring in the tens or hundreds of square feet. The WSN system requires a centralized control unit with user interface. Precision Agriculture requires a unique software model for each geographical area, the intrinsic nitrate type and the particular crop or plants. For example, each location will receive its own optimum amount of water, fertilizer and pesticide. It's generally recommended that data collection be done on an hourly basis. Frequent data collection doesn't't provide additional useful information for the software model and becomes a burden to the Wireless Sensor Network in terms of power consumption and data transmission. Less frequent monitoring may be acceptable for certain slow growth crops and areas that have very stable, uniform climate conditions.

The data collection, monitoring and materials application to the crops allows for higher yields and lower cost, with less impact to the environment. Each area receives only what is required for its particular space, and at the appropriate time and duration. A general Agricultural application can be employed for: Large crop area monitoring, Forest / Vegetation monitoring, Forest fire prevention, Biomass studies, Tracking Animals, Crop Yield Improvement.

Introduction of Embedded System

An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers. Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result.

An Embedded System is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a specific function. A good example is the microwave oven. Almost every household has one, and tens of millions of them are used every day, but very few people realize that a processor and software are involved in the preparation of their lunch or dinner.

This is in direct contrast to the personal computer in the family room. It too is comprised of computer hardware and software and mechanical components (disk drives, for example). However, a personal computer is not designed to perform a specific function rather; it is able to do many different things. Many people use the term general-purpose computer to make this distinction clear. As shipped, a general-purpose computer is a blank slate; the manufacturer does not know what the customer will do wish it. One customer may use it for a network file server another may use it exclusively for playing games, and a third may use it to write the next great American novel.

Frequently, an embedded system is a component within some larger system. For example, modern cars and trucks contain many embedded systems. One embedded system controls the anti-lock brakes, other monitors and controls the vehicle's emissions, and a third displays information on the dashboard. In some cases, these embedded systems are connected by some sort of a communication network, but that is certainly not a requirement.

At the possible risk of confusing you, it is important to point out that a general-purpose computer is itself made up of numerous embedded systems. For example, my computer consists of a keyboard, mouse, video card, modem, hard drive, floppy drive, and sound card-each of which is an embedded system. Each of these devices contains a processor and software and is designed to perform a specific function. For example, the modem is designed to send and receive digital data over analog telephone line. That's it and all of the other devices can be summarized in a single sentence as well.

Overview of Embedded System
Every embedded system consists of custom-built hardware built around a Central Processing Unit (CPU). This hardware also contains memory chips onto which the software is loaded. The software residing on the memory chip is also called the 'firmware'.

The same architecture is applicable to any computer including a desktop computer. However, there are significant differences. It is not compulsory to have an operating system in every embedded system. For small appliances such as remote control units, air conditioners, toys etc., there is no need foran operating system and you can write only the software specific to that application.

For applications involving complex processing, it is advisable to have an operating system. In such a case, you need to integrate the application software with the operating system and then transfer the entire software on to the memory chip. Once the software is transferred to the memory chip, the software will continue to run for a long time you don't need to reload new software. Now, let us see the details of the various building blocks of the hardware of an embedded system. As shown in Fig. the building blocks are:
- Central Processing Unit (CPU)
- Memory (Read-only Memory and Random Access Memory)
- Input Devices
- Output devices
- Communication interfaces
- Application-specific circuitry

Central Processing Unit (CPU)
The Central Processing Unit (processor, in short) can be any of the following: microcontroller, microprocessor or Digital Signal Processor (DSP). A micro-controller is a low-cost processor. Its main attraction is that on the chip itself, there will be many other components such as memory, serial communication interface, analog-to digital converter etc.

So, for small applications, a micro-controller is the best choice as the number of external components required will be very less. On the other hand, microprocessors are more powerful, but you need to use many external components with them. D5P is used mainly for applications in which signal processing is involved such as audio and video processing.

Memory
The memory is categorized as Random Access 11emory (RAM) and Read Only Memory (ROM). The contents of the RAM will be erased if power is switched off to the chip, whereas ROM retains the contents even if the power is switched off. So, the firmware is stored in the ROM. When power is switched on, the processor reads the ROM; the program is program is executed.

Input Devices
Unlike the desktops, the input devices to an embedded system have very limited capability. There will be no keyboard or a mouse, and hence interacting with the embedded system is no easy task. Many embedded systems will have a small keypad-you press one key to give a specific command. A keypad may be used to input only the digits. Many embedded systems used in process control do not have any input device for user interaction; they take inputs from sensors or transducers 1'fnd produce electrical signals that are in turn fed to other systems.

Output Devices
The output devices of the embedded systems also have very limited capability. Some embedded systems will have a few Light Emitting Diodes (LEDs) to indicate the health status of the system modules, or for visual indication of alarms. A small Liquid Crystal Display (LCD) may also be used to display some important parameters.

Communication Interfaces
The embedded systems may need to, interact with other embedded systems at they may have to transmit data to a desktop. To facilitate this, the embedded systems are provided with one or a few communication interfaces such as RS232, RS422, RS485, Universal Serial Bus (USB), IEEE 1394, Ethernet etc.

Application-Specific Circuitry
Sensors, transducers, special processing and control circuitry may be required fat an embedded system, depending on its application. This circuitry interacts with the processor to carry out the necessary work. The entire hardware has to be given power supply either through the 230 volts main supply or through a battery. The hardware has to design in such a way that the power consumption is minimized.

Design of Hardware
This chapter briefly explains about the Hardware implementation of A Temperature Compensated Smart Sensors for Agricultural Industry. It discusses the circuit diagram of each module in detail.

LPC2148 (ARM7) Microcontroller
The LPC2148 microcontrollers are based on a 32 bit ARM7TDMI-S CPU with real time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory of 512kB. For critical code size applications, the alternative 16-bit Thumb mode reduces the code by more than 30 % with minimal performance penalty.

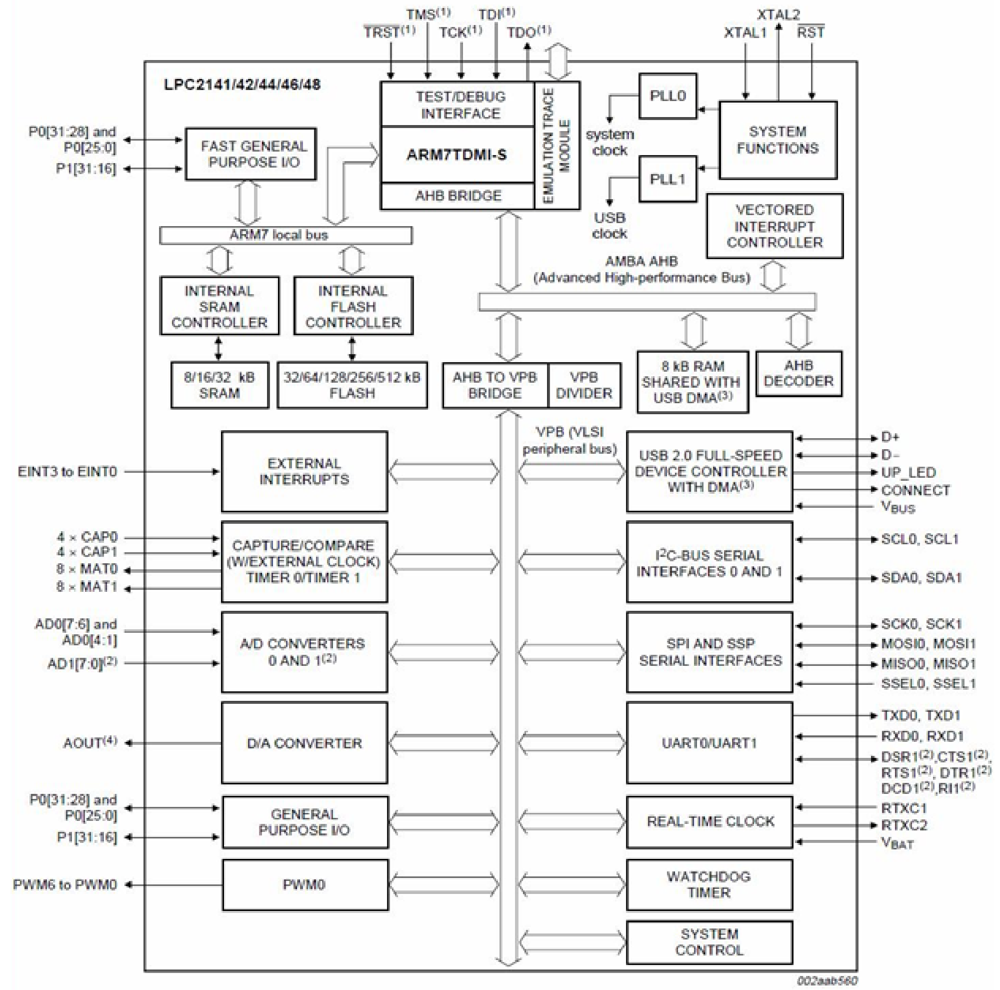
Due to their tiny size and low power consumption, LPC2148 microcontrollers are ideal for the applications where miniaturization is a key requirement, such as access control and point-of-sale. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTS, SPI, SSP to I2Cs and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for industrial control and medical systems.

Features of LPC2148 Microcontroller
- 16/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 8 to 40 kB of on-chip static RAM and 32 to 512 kB of on-chip flash program memory.
- 128 bit wide interface/accelerator enables high speed 60 MHz operation.
- In-System/In-Application Programming (ISP/IAP) via on-chip boot-loader software. Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1 ms.
- Embedded ICERT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high speed tracing of instruction execution.
- USB 2.0 Full Speed compliant Device Controller with 2 kB of endpoint RAM.
- In addition, the LPC2146/8 provide 8 kB of on-chip RAM

accessible to USB by DMA.

- One or two (LPC2141/2 vs. LPC2144/6/8) 10-bit A/D converters provide a total of 6/14 analog inputs, with conversion times as low as 2.44 µs per channel.
- Single 10-bit D/A converter provides variable analog output.
- Two 32-bit timers/external event counters (with four capture and four compare
- channels each), PWM unit (six outputs) and watchdog.
- Low power real-time clock with independent power and dedicated 32 kHz clock input.
- Multiple serial interfaces including two UARTs (16C550), two Fast I2C-bus
- (400 kbit/s), SPI and SSP with buffering and variable data length capabilities.
- Vectored interrupt controller with configurable priorities and vector addresses.
- Up to 45 of 5 V tolerant fast general purpose I/O pins in a tiny LQFP64 package.
- Up to nine edge or level sensitive external interrupt pins available.
- 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100 µs.
- On-chip integrated oscillator operates with an external crystal in range from 1 MHz to 30 MHz and with an external oscillator up to 60 MHz.
- Power saving modes include Idle and Power-down.
- Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization.
- Processor wake-up from Power-down mode via external interrupt, USB, Brown-Out Detect (BOD) or Real-Time Clock (RTC).
- Single power supply chip with Power-On Reset (POR) and BOD circuits:

CPU operating voltage range of 3.0V to 3.6V (3.3 V ± 10 %) with 5V tolerant I/O pads (figure 1 and figure 2).



(1) Pins shared with GPIO.
(2) LPCC2144/6/8 only.
(3) USB DMA controller with 8 kB of RAM accessible as general purpose RAM and/or DMA is available in LPC2146/8 only.
(4) LPC2142/4/6/8 only.

Fig 1. LPC2141/2/4/6/8 block diagram

Figure 1: Block Diagram Of LPC2148 Microcontroller

Pin Diagram of LPC 2148 Micro Controller

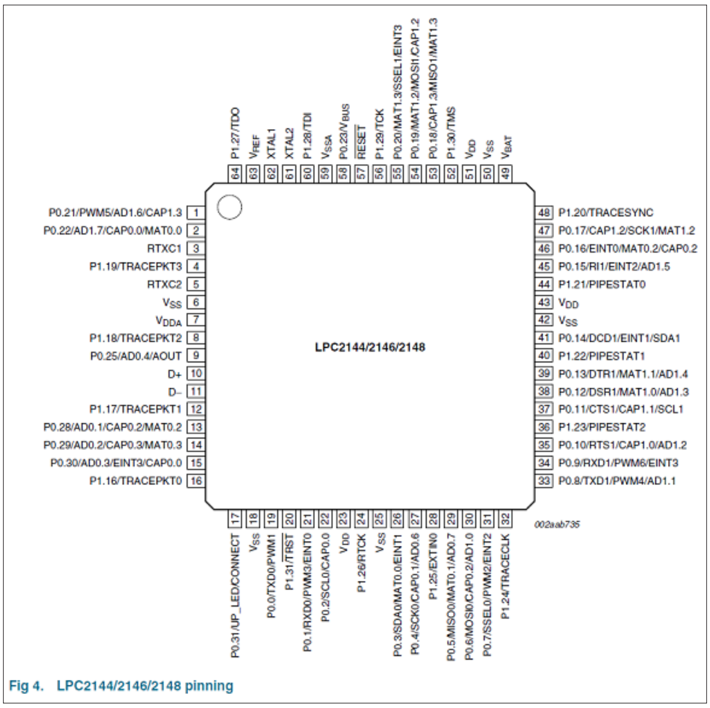


Figure 2: Pin Diagram of LPC2148 Microcontroller

General Description

The APR9600 device offers true single-chip voice recording, non-volatile storage, and playback capability for 40 to 60 seconds. The device supports both random and sequential access of multiple messages. Sample rates are user-selectable, allowing designers to customize their design for unique quality and storage time needs. Integrated output amplifier, microphone amplifier, and AGC circuits greatly simplify system design. The device is ideal for use in portable voice recorders, toys, and many other consumer and industrial applications.

APLUS integrated achieves these high levels of storage capability by using its proprietary analog/multilevel storage technology implemented in an advanced Flash non-volatile memory process, where each memory cell can store 256 voltage levels (Figure 3). This technology enables the APR9600 device to reproduce voice signals in their natural form. It eliminates the need for encoding and compression, which often introduce distortion.

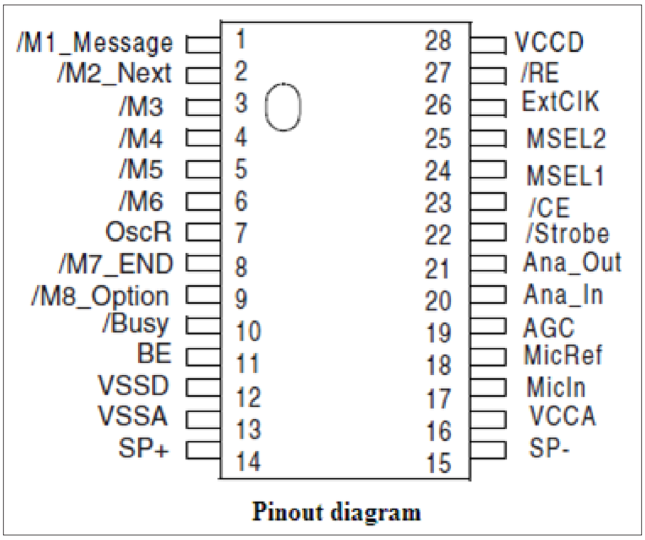


Figure 3: Pinout Diagram

Functional Description

The APR9600 block diagram is included in order to give understanding of the APR9600 internal architecture. At the left hand side of the diagram are the analog inputs. A differential microphone amplifier, including integrated AGC, is included on-chip for applications requiring its use. The amplified microphone signal is fed into the device by connecting the Ana_Out pin to the Ana_In pin through an external DC blocking capacitor. Recording can be fed directly into the Ana_In pin through a DC blocking capacitor, however, the connection between Ana_In and Ana_Out is still required for playback. The next block encountered by the input signal is the internal anti-aliasing filter. The filter automatically adjusts its response according to the sampling frequency selected so Shannon's Sampling Theorem is satisfied.

After anti-aliasing filtering is accomplished the signal is ready to be clocked into the memory array. This storage is accomplished through a combination of the Sample and Hold circuit and the Analog Write/Read circuit. These circuits are clocked by either the Internal Oscillator or an external clock source. When playbackis desired the previously stored recording is retrieved from memory, low pass filtered, and amplified as shown on the right hand side of the diagram. The signal can be heard by connecting a speaker to the SP+ and SP- pins. Message management is controlled through the message control block represented in the lower center of the block diagram (Figure 4).

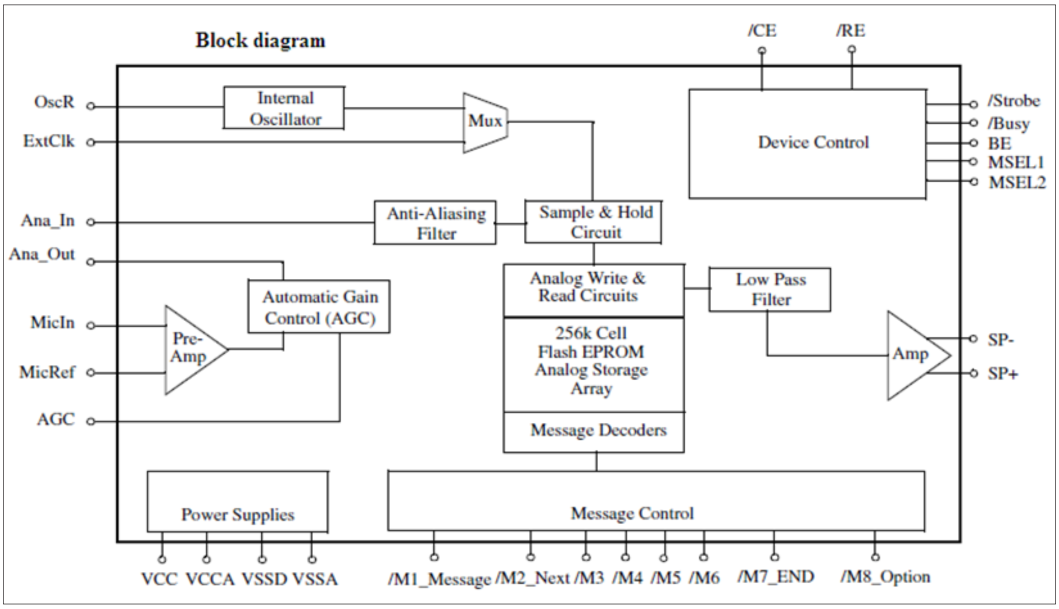


Figure 4: Block Diagram

Water Level Sensor
Water sensor brick is designed for water detection, which can be widely used in sensing the rainfall, water level, even the liquate leakage. The brick is mainly comprised of three parts: An Electronic brick connector, a 1 MΩ resistor, and several lines of bare conducting wires. This sensor works by having a series of exposed traces connected to ground and interlaced between the grounded traces are the sunstrokes. The sensor traces have a weak pull-up resistor of 1 MΩ. The resistor will pull the sensor trace value high until a drop of water shorts the sensor trace to the grounded trace. Believe it or not this circuit will work with the digital I/O pins of your Arduino or you can use it with the analog pins to detect the amount of water induced contact between the grounded and sensor traces. This item can judge the water level through with a series of exposed parallel wires stitch to measure the water droplet/water size . This item can easily change the water size to analog signal, and output analog value can directly be used in the program function, then to achieve the function of water level alarm. This item have low power consumption, and high sensitivity, which are the biggest characteristics of this mdoule. This item can be compatible with Arduino UN0 Arduino mega 2560.

Nitrate Moisture Sensor
Nitrate moisture sensors measure the volumetric water content in nitrate [1]. Since the direct gravimetric measurement of free nitrate moisture requires removing, drying, and weighting of a sample, nitrate moisture sensors measure the volumetric water content indirectly by using some other property of the nitrate, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and nitrate moisture must be calibrated and may vary depending on environmental factors such as nitrate type, temperature, or electric conductivity. Reflected microwave radiation is affected by the nitrate moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners. Nitrate moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in nitrates called water potential; these sensors are usually referred to as nitrate water potential sensors and include tensiometers and gypsum blocks.

Pins Functions
There are pins along one side of the small printed board used for connection to the microcontroller. There are total of 14 pins marked with numbers (16 in case the background light is built in). Their function is described in the table 1 below:

Table 1: Their Function is Described

Function	Pin Number	Name	Logic State	Description
Ground	1	Vss	-	0V
Power supply	2	Vdd	-	+5V
Contrast	3	Vee	-	0 –Vdd
	4	RS	0	D0 – D7 are interpreted as commands
			1	D0 – D7 are interpreted as data
Control of operating	5	R/W	0	Write data (from controller to LCD)
			1	Read data (from LCD to controller)
	6	E	0	Access to LCD disabled Normal operating Data/commands are
			1	
			From 1 to 0	
Data / commands	7	D0	0/1	Bit 0 LSB
	8	D1	0/1	Bit 1
	9	D2	0/1	Bit 2
	10	D3	0/1	Bit 3
	11	D4	0/1	Bit 4
	12	D5	0/1	Bit 5
	13	D6	0/1	Bit 6
	14	D7	0/1	Bit 7 MSB

LCD Basic Commands

All data transferred to LCD through outputs D0-D7 will be interpreted as commands or as data, which depends on logic state on pin RS: RS = 1 - Bits D0 - D7 are addresses of characters that should be displayed. Built in processor addresses built in "map of characters" and displays corresponding symbols. Displaying position is determined by DDRAM address. This address is either previously defined or the address of previously transferred character is automatically incremented. RS = 0 - Bits D0 - D7 are commands which determine display mode. List of commands which LCD recognizes are given in the table 2 below:

Table 2: List of Commands which LCD Recognizes

Command	RS	RW	D7	D6	D5	D4	D3	D2	D1	D0	Execution Time
Clear display	0	0	0	0	0	0	0	0	0	1	1.64mS
Cursor home	0	0	0	0	0	0	0	0	1	X	1.64mS
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	40uS
Display on/off control	0	0	0	0	0	0	1	D	U	B	40uS
Cursor/Display Shift	0	0	0	0	0	1	D/C	R/L	x	X	40uS
Function set	0	0	0	0	1	DL	N	F	x	X	40uS
Set CGRAM address	0	0	0	1	CGRAM address						40uS
Set DDRAM address	0	0	1	DDRAM address							40uS
Read "BUSY" flag (BF)	0	1	BF	BF DDRAM address							-

Introduction to Keil Software

This is free software (evaluation version) which solves many of the pain points for an embedded system developer. This software is an Integrated Development Environment(IDE), which integrated text editor to write program, a compiler and it will convert your source code into HEX file. Here is simple guide to start working with Keil µVision which can be used for:

- Writing programs in C/C++ or Assembly
- Compiling and assembling programs
- Debugging programs
- Creating HEX, AXF and BIN file
- Test program without real hardware

Software Steps

Here is step by step guide to create fresh new project for ARM7 LPC2148 Microcontroller using MDK-ARM µVision4.

Creating Project in Uvisiov 4:

- Once we've installed Keil, click on Keil µVision4 icon. This will appear on desktop after installation Keil.
- Click on **Project** menu, and then hit on **New uVision Project**
- Create new project folder named as **Blinky**.

Selection of Device:

- Select target Device vendor. In this case select Device NXP (founded by Phillips).
- Expand NXP icon and select specific chip i.e. LPC2148 After this, a dialog box will pop-up on screen. This will ask you whether to copy startup code for LPC2148. Click on **Yes**.

Add Startup File for LPC2148

- Then we'll get basic workplace to get start with writing code in. When we expand **Target1** in left project pane. We see **Startup.s** is already added which is necessary for running code in Keil.

Note

Code will not run without Startup.s file. Because startup code executes immediately upon reset of the target system and performs the following listed operations.

1. Defines interrupt and exception vectors
2. Configures the CPU clock source (on same device)
3. Initializes the external bus controller
4. Copies the exception vectors from ROM and RAM for systems with memory remapping
5. Initializes other low level peripherals, if necessary
6. Reserves and initializes the stack for all modes
7. Reserves the heap

File Creation

- Now click on **File** menu and hit on **New**.
- Write code to blink LED in C and File Name.c **Save**

Add C File to Project

- Once we save file as **blinky.c**. We'll quickly get complete code with syntax highlighted.
- Now we can add blinky.c file by adding it to **Group Source 1**.

Hex file Creation

- Now right click on **Target 1** and hit on **Options for target "Target 1"**
- In **Options for target "Target 1"**. In **output** tab, click on check box **Create HEX File**.
- Then go to Linker tab. Click on **Use Memory Layout for Target Dialog**
- Then hit on **Rebuild** All target files
- Now we can see Build output. If we check project directory at this point. We'll find generated HEX file.

Conclusion

A temperature compensated interdigital capacitive sensor has been developed in the current study to measure nitrate at low concentrations. A portable, novel sensing system has been developed that could be used on-site as a stand-alone device, as well as IoT-based remote monitoring smart sensor node, to measure nitrate concentration in surface and ground water. Electrochemical Impedance Spectroscopy was employed to detect and display nitrate concentrations, by evaluating the impedance change read by the interdigital transducer immersed in the surface water samples. The test samples were evaluated by commercial equipment (LCR meter) and the designed system. These results were also validated using standard laboratory techniques to assess nitrate concentrations in water samples. The designed system showed a good linear relationship between the measured nitrate concentrations (ranged from 0.01 to 0.5 mg/L) to those measured by the commercial equipment in the collected water samples. However, the current system has the potential to be used to estimate nitrate concentrations in water samples, in real-time. The system can upload the measured nitrate data on a website based on IoT. This system could be used to integrate water quality monitoring sites within farms, or between streams, rivers, and lakes. For the in-situ installation, a robust box containing the whole system would need to be installed at the monitoring site.

Description

This chapter deals with working and circuits of "**A Temperature Repaid Shrewd Sensor for Agrarian Industry**". It can be simply understood by its figure 5.

Block Diagram

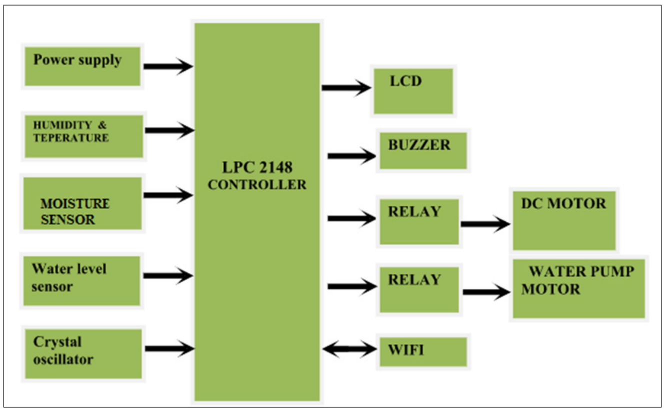


Figure 5: Block Diagram

Software Requirements

- Keil uVision4 IDE
- Flash Magic
- Embedded c language

Hardware Requirements

- LPC2148 BASED OUR OWN DEVELOPED BOARD
- POWER SUPPLY
- Nitrate Moisture Sensor
- Humidity Sensor
- Wifi modem

- Max232
- Buzzer
- LCD
- RELAYS
- WATER PUMP MOTOR
- DC Motor
- Temperature Sensor

Working

Figure 5 shows the block diagram of the designed system. In this system, the sinusoidal waveform was generated by using PWM (pulse width modulation) output combined with a bandpass filter which is based on the concept of the Direct Digital Synthesis (DDS) method. This method was implemented by breaking a waveform into discrete points digitally [23]. Two hundred and fifty-six (8 bits) points were used to produce a sinusoidal waveform that gave a compromise between resolution and frequency. The operating frequency was fixed at 122.5 Hz. The voltage across Rs is very low. To amplify the voltage as well as to reduce the noise, an amplifier (of gain 10) cum filter circuit. The value of the series resistor is 10-kilo ohms, which is significantly small, compared to total impedance.

The details of the operation of the circuit shown in Fig. has been explained in. The voltage across the series resistor Rs, is alternating in nature. To rectify the amplified voltage, a precision rectifier, as shown in Figure 5. Block diagram of the designed system Fig, has been used. The operation has been explained in [21]. In order to calculate the real and imaginary part of the impedance of the sensor, the phase difference between the input voltage, Vin and the current, Is is calculated. The calculation is done inside the microcontroller. The phase difference between Vin and Is is calculated by passing the signals Vin and Is through a zero-crossing detector as shown in Figure 6.

The two square waves are connected to external interrupts of the microcontroller and time difference is calculated internally. The time difference is then converted into the appropriate phase angle. After obtaining the phase difference (ϕ) between Vs and Is, the components of impedance are calculated as

$$R = Z \times \cos\emptyset \ (4) \quad X = Z \times \sin\emptyset \ (5)$$

Figure 5.

Equivalent circuit diagram of interdigital sensor R and X are the real part and imaginary part of the total impedance of the circuit, as shown in Figure 5. The actual resistive component of the sensor is given by equ. 6 $Rsensor = R - Rs$ (6) Finally, the resistive component is used to calculate the temperature and eventually, calculating the nitrate concentration. C. Control of Pump and Valve Sample water to be tested for nitrate concentration was pumped in to and out of the sample container, to avoid the sensor being continuously dipped in water. This is achieved using a pump and valve. The operation of the circuits has been explained in [21].

Control of water flow, pump and valve control D. IoT-based Smart System The IoT offers promising solutions to transform the operation and role of existing industrial technologies. IoT is already having an impact in the areas of agriculture, food processing, environmental monitoring, security surveillance and others. The proposed Arduino Yun has integrated WiFi which can provide instant connectivity to the Internet. WiFi offers high bandwidth, large coverage area, non-line-ofsight transmission, easy expansion, cost-effectiveness, robustness and small distribution of Links. An external antenna (2.4 GHz) is added to increase the transmission signal strength. The collected data is transmitted to Thingspeak which is the open data platform for the IoT. HTTP POST protocol has been used to send data directly to the specified server. The final IoT-based smart sensing system with a smart sensor which has been used to measure nitrate and upload the data on the designated website [25-26].

References

1. Di H, Cameron K (2012) How does the application of different nitrification inhibitors affect nitrous oxide emissions and nitrate leaching from cow urine in grazed pastures? Nitrate Use and Management 28: 54-61.
2. Dymond J, Ausseil AG, Parfitt R, Herzig A, McDowell R (2013) Nitrate and phosphorus leaching in New Zealand: a national perspective. New Zealand Journal of Agricultural Research 56: 49-59.
3. Kellman L, Hillaire-Marcel C (2003) Evaluation of nitrogen isotopes as indicators of nitrate contamination sources in an agricultural watershed. Agriculture ecosystems & environment 95: 87-102.
4. Thorburn PJ, Biggs SJ, Weier KL, Keating BA (2003) Nitrate in groundwaters of intensive agricultural areas in coastal Northeastern Australia. Agriculture ecosystems & environment 94: 49-58.
5. Dairy NZ (2013) Nutrient management on your dairy farm. Available: https://www.dairynz.co.nz/media/757901/nutrient_management_on_your_dairy_farm.pdf
6. Davies Colley RJ, Wilcock RJ (2004) Water quality and chemistry in running waters 111.
7. Ghani A, Müller K, Dodd M, Mackay A (2010) Dissolved organic matter leaching in some contrasting New Zealand pasture nitrates. European Journal of Nitrate Science 61: 525-538.
8. WHO Organization (2017) Water-related diseases. Available: http://www.who.int/water_sanitation_health/diseasesrisks/diseases/methaemoglob/en/
9. Agency EP (2017) Ground Water and Drinking Water. Available: https://www.epa.gov/ground-water-anddrinking-water/table-regulated-drinking-water-contaminants
10. Narayana B, Sunil K (2009) A spectrophotometric method for the determination of nitrite and nitrate. Eurasian Journal of Analytical Chemistry 4: 204-214.
11. Horita K, Satake M (1997) Column preconcentration analysis-spectrophotometric determination of nitrate and nitrite by a diazotization–coupling reaction. Analyst 122: 1569-1574.
12. Miranda KM, Espey MG, Wink DA (2001) A rapid, simple spectrophotometric method for simultaneous detection of nitrate and nitrite. Nitric oxide 5: 62-71.
13. Dudwadkar A, Shenoy N, Joshi J, Kumar SD, Rao H, et al. (2013) Application of ion chromatography for the determination of nitrate in process streams of thermal denitration plant. Separation Science and Technology 48: 2425-2430.
14. Pham X-H, Li CA, Han KN, Huynh-Nguyen B-N, Le T-H, et al. (2014) Electrochemical detection of nitrite using urchin-like palladium nanostructures on carbon nanotube thin film electrodes. Sensors and Actuators B: Chemical 193: 815-822.
15. Wang X,Wang Y, Leung Y, Mukhopadhyay SC, Tian M, (2015) Mechanism and experiment of planar electrode sensors in water pollutant measurement. IEEE Transactions on Instrumentation and Measurement 64: 516-523.
16. Schazmann B, Diamond D (2007) Improved nitrate sensing using ion selective electrodes based on urea-calixarene ionophores. New Journal of Chemistry 31: 587-592.

17. Pellerin BA, Bergamaschi BA, Downing BD, Saraceno JF, Garrett JD, et al. (2013) Optical techniques for the determination of nitrate in environmental waters: Guidelines for instrument selection, operation, deployment, maintenance, quality assurance, and data reporting. US Geological Survey 2328-7055.
18. Ensafi AA, Amini M (2012) Highly selective optical nitrite sensor for food analysis based on Lauth's violet–triacetyl cellulose membrane film. Food Chemistry 132: 1600-1606.
19. Yunus MAM, Ibrahim S, Altowayti WAH, San WP, Mukhopadhyay SC (2015) Selective membrane for detecting nitrate based on planar electromagnetic sensors array, in Control Conference (ASCC), 10th Asian 1-6.
20. Pandey G, Kumar R, Weber RJ (2013) Real time detection of nitrate moisture and nitrates using on-board in-situ impedance spectroscopy in 2013 IEEE International Conference on Systems, Man, and Cybernetics 1081-1086.
21. Alahi ME, Xie L, Zia AI, Mukhopadhyay S, Burkitt L (2016) Practical nitrate sensor based on electrochemical impedance measurement, in Instrumentation and Measurement Technology Conference Proceedings (I2MTC), IEEE International 1-6.
22. Xie L, Zia AI, Mukhopadhyay S, Burkitt L (2015) Electrochemical impedimetric sensing of nitrate contamination in water," in 2015 9th International Conference on Sensing Technology (ICST) 257-262.
23. Mamishev AV, Sundara-Rajan K, Yang F, Du Y, Zahn M (2004) Interdigital sensors and transducers. Proceedings of the IEEE 92: 808-845.
24. Rahman MSA, SC Mukhopadhyay, Yu P-L, Goicoechea J, Matias R, et al. (2013) Detection of bacterial endotoxin in food: New planar interdigital sensors based approach. Journal of Food Engineering 114: 346-360.
25. Zia AI, Syaifudin AM, Mukhopadhyay S, Yu P, AlBahadly I, et al. (2013) Electrochemical impedance spectroscopy based MEMS sensors for phthalates detection in water and juices. Journal of Physics: Conference Series 439: 012026.
26. Miller RL, Bradford WL, Peters NE (1988) Specific conductance: theoretical considerations and application to analytical quality control: US Government Printing Office.