DESIGN AND DEVELOPMENT OF GSM BASED AUTOMATED SPRAY IRRIGATION SYSTEM PROTOTYPE

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of B.Sc. in Agricultural and Biological Engineering

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Dedication

Every challenging work needs self-efforts as well as guidance of elders especially those who were very close to our heart.
My humble effort I dedicate to my sweet and loving

Father & Mother

Whose affection, love, encouragement and prays of day and night make me able to get such success and honor.

Along with all hard working and respected

Teachers
Abstract

The fast growing information technologies simplifies the daily life of users everywhere, thus applying these technologies in the field of irrigation is a must in the present times. The GSM based automated spray irrigation system provide a simple approach to automated irrigation. This project makes use of the GSM (Global System for Mobile Communication) to provide the wireless control and to inform the user about extreme field condition. The objective of this study is to design and develop a GSM based automated instrumentation system utilizing microcontroller, flow meter and moisture sensor via wireless system in addition to design and develop spray irrigation system to be integrated to the proposed instrumentation system. The proposed GSM based automated spray irrigation system prototype consists of two main components hardware and software. The hardware consists of two components instrumentation system and spray irrigation system. Instrumentation system based on microcontroller, flow meter, moisture sensor, LCD and GSM. Spray irrigation system that consists of spray nozzles system, irrigation piping, solenoid valve and a wooden box to plant inside it. The software consists of a C++ code to link the various components together. The main component is the microcontroller which links the various materials used conducting the signals which operates the spray irrigation system and the GSM based wireless control. A GSM based automated instrumentation system was successfully designed
and developed to be utilized in the spray irrigation system. With the existing system remote agricultural fields could be easily operated, monitored and controlled with a relatively low cost.
المستلخص

تقنيات الاتصالات سريعة النمو تبسيط الحياة اليومية للمستخدمين في كل مكان، وبالتالي تطبيق هذه التقنيات في مجال الري أمر لا بد منه في الوقت الحاضر. نظام الري بالرش الآلي تلقائي القائم على تقنية ال (جي اس ام) يوفر مقارنة بسيطة للري الاتوماتيكي. هذا المشروع يستفيد من ال (جي اس ام) للاتصالات المتصلة لتوفير تحكم لاسلكي وإعلام المستخدم عن حالة الحقل المتطرفة.

الهدف من هذه الدراسة تصميم وتطوير نظام قياس آلي تلقائي قائم على ال (جي اس ام) باستخدام معالج دقيق، حساس التدفق المائي، حساس المحتوى الرطبي من خلال نظام لاسلكي.

نظام الري بالرش الآلي تلقائي القائم على تقنية ال (جي اس ام) المقترح يتكون من عنصرين رئيسين هما المكونات الميكانيكية والمبرمجة. تتكون المكونات الميكانيكية من نظام قياس ونظام ري بالرش. نظام القياس يتكون من معالج دقيق، حساس التدفق المائي، حساس المحتوى الرطبي، شاشة عرض و جهاز (جي اس ام)، أما مجمعة نظام الري بالرش يتكون من رشاشات، أنابيب ري، صندوق خشبي و صمام كهربائي.

بربط العناصر المختلفة في المشروع استعمل برنامج بلغة (سي ++). العنصر الأساسي في المنظومة هو المعالج الدقيق حيث يربط المكونات معاً ونقل الإشارات للتحكم في عملية الري و عملية التحكم اللاسلكي في المنظومة بواسطة ال (جي اس ام). تم تصميم وتطوير نظام القياس الآلي تلقائي القائم على تقنية ال (جي اس ام) وربطه بنظام الري بالرش بنجاح. بواسطة النظام المطور يمكن المراقبة والتحكم في المشاريع الزراعية البعيدة بسهولة وتلكفة منخفضة نسبيًا.
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Immeasurable appreciation and deepest gratitude for the help and support are extended to the following persons who in one way or another have contributed in making this study possible.

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CHAPTER 1

Introduction

An automated irrigation system refers to the operation of the system with no or just a minimum of manual intervention beside the surveillance. Almost every system (drip, sprinkler, surface) can be automated with help of timers, sensors or computers or mechanical appliances. It makes the irrigation process more efficient and workers can concentrate on other important farming tasks. On the other hand, such a system can be expensive and very complex in its design and may needs experts to plan and implement it.

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Table 1 shows the inputs and outputs of irrigation process.
1.1 Background

An automation of irrigation systems has several positive effects. Once installed, the water distribution on fields or small-scale gardens is easier and does not have to be permanently controlled by an operator. There are several solutions to design automated irrigation systems. Modern big-scale systems allow big areas to be managed by one operator only. Sprinkler, dripper subsurface drip irrigation systems require pumps and some high tech-components and if used for large surfaces skilled operators are also required. Extremely high-tech solutions also exist using GIS and satellites to automatically measure the water needs content of each crop parcel and optimize the irrigation system. But automation of irrigation can sometimes also be done with simple, mechanical appliances: with clay pot or porous capsule irrigation networks or bottle.

High-Tech Principles

Automation of irrigation systems refers to the operation of the system with no or minimum manual interventions. Irrigation automation is justified where a large irrigated area is divided into small segments called irrigation blocks and segments are irrigated in sequence to match the discharge available from the water source. There are six high-tech automation systems, which are described below.

Time Based System

Irrigation time clock controllers, or timers, are an integral part of an automated irrigation system. A timer is an essential tool to apply water in the necessary quantity at the right time. Timers can lead to an under- or over-irrigation if they are
not correctly programmed or the water quantity is calculated incorrectly (CARDENAS-LAILHACAR 2006). Time of operation (irrigation time – hours per day) is calculated according to volume of water (water requirement - liters per day) required and the average flow rate of water (application rate – liters per hours). A timer starts and stops the irrigation process (RAJAKUMAR et al. 2008 and IDE N.Y.).

**Volume Based System**

The pre-set amount of water can be applied in the field segments by using automatic volume controlled metering valves (RAJAKUMAR et al. 2008). An example for a volume based irrigation method is described in ZELLA et al. (2008).

**Open Loop Systems**

In an open loop system, the operator makes the decision on the amount of water to be applied and the timing of the irrigation event. The controller is programmed correspondingly and the water is applied according to the desired schedule. Open loop control systems use either the irrigation duration or a specified applied volume for control purposes. Open loop controllers normally come with a clock that is used to start irrigation. Termination of the irrigation can be based on a pre-set time or may be based on a specified volume of water passing through a flow meter. (Adapted from BOMAN et al. 2006)

**Closed Loop Systems**
A simple version of a closed loop control system is that of an irrigation controller. A moisture sensor interrupts the irrigation process. When soil-moisture drops below a certain threshold, the sensing device closes the circuit, allowing the controller to power the electrical valve and the irrigation starts. Source: BOMAN et al. (2006)

In closed loop systems, the operator develops a general control strategy. Once the general strategy is defined, the control system takes over and makes detailed decisions on when to apply water and how much water to apply. This type of system requires feedback from one or more sensors. Irrigation decisions are made and actions are carried out based on data from sensors. In this type of system, the feedback and control of the system are done continuously. Closed loop controllers require data acquisition of environmental parameters (such as soil
moisture, temperature, radiation, wind-speed, etc.) as well as system parameters (pressure, flow, etc.) (Adapted from BOMAN et al. 2006).

**Real Time Feedback System**

With this application irrigation is based on actual dynamic demands of the plant itself; the plant root zone is effectively reflecting all environmental factors acting on the plant. Operating within controlled parameters, the plant itself determines the degree of irrigation required. Various sensors, tension-meter, relative humidity sensors, rain sensors, temperature sensors etc. control the irrigation scheduling. These sensors provide feedback to the controller to control its operation (RAJAKUMAR et al. 2008).

**Computer Based Irrigation Control Systems**

![Computer Based Irrigation Control Systems](image)
Control board showing timers, soil moisture sensor-controllers, solenoid valves wiring, and flowmeters-data logger. Source: CARDENAS-LAILHACAR (2006)

A computer-based control system consists of a combination of hardware and software that acts as a supervisor with the purpose of managing irrigation and other related practices such as fertigation and maintenance. Generally, the computer-based control systems used to manage irrigation systems (e.g. drip irrigation systems) can be divided into two categories: interactive systems and fully automatic systems. (RAJAKUMAR et al. (2008)).

Besides these high-tech solutions there are also effective methods without any energy supply. Optimizing a system mechanically with the help of gravity can automate an irrigation process. Examples are the small-scale and self-made drip irrigation systems described here or the systems described below.

### 1.2 Objectives

The objective of this study is to design and develop an automated irrigation system. The work involves:

a. To design and develop a GSM based automated instrumentation system based on microcontroller, flow meter and moisture sensor via wireless system.

b. To design and develop spray irrigation system to be integrated to the proposed instrumentation system.
c. To conduct a comprehensive test of the proposed GSM based automated irrigation system.
This chapter is conducting about the development of irrigation through ages and the modern methods of irrigation. The new technologies, methods and the usage of sensors in the systems. Also the objectives of the study are mentioned below. The previous studies close to the subject of the project.

2.1 Irrigation systems history

   a. 6000 BC

Irrigation began at about the same time in Egypt and Mesopotamia (present day Iraq and Iran) using the water of the flooding Nile or Tigris/Euphrates rivers. The flood waters, which occurred July through December, were diverted to fields for 40 to 60 days. The water was then drained back into the river at the right moment in the growing cycle.

   b. 1700 BC (Shaduf)
Figure 2.1 Irrigation Shaduf

A large pole balanced on a crossbeam, a rope and bucket on one end and a heavy counter weight at the other. By pulling the rope it lowered the bucket into a canal or river. The operator would then raise the full bucket of water by pushing down on the counter weight. The pole could be swung around and the bucket emptied in a field or different canal. This development enabled irrigation when a river wasn’t in flood which meant higher ground could be used for farming.

c. 550-331 BC (Qanat)

Figure 2.2 Qanat System
The development of this technique allowed the use of ground water to become the primary source for crop irrigation. A Qanat was built by first digging a vertical well into sloping ground. Once the well was completed a tunnel was dug nearly horizontal to the lower end of the well. The natural slope would allow well water to travel by gravity down the tunnel and emerge some distance down slope from the well. Construction of Qantas was labor intensive and vertical openings were placed every 20-30 meters to allow the tunnel diggers to breathe and to remove the debris from the tunnel. Once the tunnel was completed, the area had a constant source of water. Qantas are still in use today and at least 20,000 still operate from China to Morocco.

d. 500 BC (Sakia)

Figure 2.3 Persian Water Wheel (Sakia)
The first use of what is now called a pump. This device was an endless series of pots on a rope which ran over two pulleys. The oxen-powered device powered a cogged wheel allowing the pots to enter the water supply, fill and then be raised and emptied. The Sakia was similar to the Noria except that it was powered by an external force rather than the flow of the river’s current.

e. 1800 AD Irrigated Acreage Worldwide

Irrigated acreage worldwide reaches 19,760,000 acres. This compares with an estimated 600,000,000 acres today.

2.2 Modern irrigation

2.2.1 Surface irrigation

Figure 2.4 Typical elements of a surface irrigation system
Surface irrigation stands for a large group of irrigation methods in which water is distributed by gravity over the surface of the field. The three most common methods are basin irrigation, border irrigation and furrow irrigation. Water is typically introduced at the highest point or along the edge of a field, which allows covering the field by overland flow. Historically, surface irrigation has been the most common method of irrigating agricultural land. The defining feature of surface irrigation methods is that the soil is used as the transport medium as opposed to pipeline.

Surface irrigation methods contain two basic categories ponding (surface water pooled in a puddle) and moving water. The moving water methods require some runoff or ponding to guarantee adequate infiltration at the lower end of the field. The soil type controls the length of the run and the depth of infiltrated over time. The better the quality of the soil is the less is the unnecessary runoff and the better the infiltration into the soil and therefore the use for the crops (BURT 2000). Due to ponding however, it is important not to irrigate the crops during the day but in the early morning or at night in order to avoid water loss due to evaporation.

Each surface system has its own unique advantages and disadvantages depending on such factors as initial development costs, size and shape of individual fields, soil characteristics, nature and availability of the water supply, climate, cropping pattern, social preferences and structures, and historical experience (WALKER 2003).

**Basin Irrigation**
Basin irrigation is the most common form of surface irrigation, particularly in regions with layouts of small fields. If a field is level in all directions, is encompassed by a dyke to prevent runoff, and provides an undirected flow of water onto the field, it is herein called a basin.

If the basins are small or if the discharge rate available is relatively large, there are few soils not amenable to basin irrigation. Generally, basin irrigation is favored by moderate to slow intake soils and deep-rooted, closely spaced crops. Crops, which do not tolerate flooding and soils subject to crusting can be basin irrigated by furrowing or using raised bed planting. Basin irrigation is an effective method of leaching salts from the soil profile into the deeper groundwater.

Basin irrigation systems can be automated with relatively simple and inexpensive flow controls at the basin inlet. However, basin irrigation has a number of limitations in association with agriculture in the less developed countries: Accurate land levelling is prerequisite to high uniformities and efficiencies, but this is difficult to accomplish in small areas; the perimeter dikes must be well maintained to eliminate breaching and waste; and it is difficult and often infeasible to incorporate the use of modern farm machinery in small basins, thereby limiting small-scale basin irrigation to hand and animal powered cultivation (WALKER 2003).

**Border Irrigation System**
In many circumstances, border irrigation can be viewed as an expansion of basin irrigation to include long rectangular or contoured field shapes, longitudinal but no lateral slope, and free draining or blocked conditions at the lower end.

In border irrigation, a field is divided into strips separated by border ridges running down the slope of the field. The width of the stripes is usually from 20 to 100 feet (6 to 30 meters). The area between the ridges is flooded during irrigation. Border irrigation is used for tree crops and for crops as alfalfa (Medicago sativa) and small grains (UCCE 2003).

**Furrow Irrigation**

An alternative to flooding the entire field surface is to construct small channels along the primary direction of water movement. Water introduced in these furrows infiltrates through the wetted perimeter and moves vertically and laterally thereafter to refill the soil. Furrows can be used in conjunction with basins and borders to overcome topographical variation and crusting (WALKER 2003). Furrows are well adapted to row crops and orchards or vineyards (BURT 2000).

Furrow systems require more labor than border or basin systems. Some disadvantages are salinity hazards between the furrows, limited machinery mobility across the lateral field direction and an increased erosion potential. On the other hand, topographical conditions can be more severe and variable, and the smaller wetted area can reduce evaporation loss (WALKER 2003).
The three most important hardware items for an efficient furrow irrigation are (BURT 2000):

- A tail water return flow system, which incorporates a reservoir
- Short furrows for an acceptable advanced ratio
- A large variable water supply stream

The Importance of the Soil Type

There is one disadvantage of surface irrigation that confronts every designer and irrigator. The soil, which must be used to convey the water over the field, has properties that are highly varied both spatially and temporally. They become almost indefinable except immediately preceding the watering or during it. This creates an engineering problem in which at least two of the primary design variables, discharge and time of application, must be estimated not only at the field layout stage but also judged by the irrigator prior to the initiation of every surface irrigation event. Thus, while it is possible for the new generation of surface irrigation methods to be attractive alternatives to sprinkler and trickle systems, their associated design and management practices are much more difficult to define and implement (WALKER 1989).

Costs Considerations

Levelling the fields and building the water ditches and reservoirs might be expensive, but once this is done, costs are low and the self-help capacity is very high. Thus, the expected life of the system, fixed costs, and annual operation costs
(energy, water depreciation, land preparation, maintenance, labor, taxes, etc.) should be included in the analysis when selecting an irrigation system (WALKER 2003). The water allocation is done by gravity, therefore no energy is required. On the other hand, a surface irrigation system is labor intensive, which should be considered.

**Operation and Maintenance**

Good operation of any irrigation system includes matching the irrigation duration with the rate of application and the intake rate of the soil to maximize the fraction of water stored in the root zone. Operation of surface irrigation requires being there to “tend” the water, i.e. to move the water to successive application points as it reaches the end of the run. (HILL et al. 2008).

Ditches should be cleaned out at least annually and more often if needed. A shovel can be used to clean smaller ditches. A mechanical ditcher and tractor is very helpful on larger ditches. Often ditch cleaning is an early spring “rite” to be completed prior to the first delivery of water. Many irrigation and canal companies require that shareholders maintain their own head gates and keep them in good operating condition. In areas where rodent damage is a problem, “tromping gopher holes” or otherwise fixing leaks in ditches may be a daily chore. Periodic re-leveling of surface irrigated fields may be needed to compensate for soil settlement or consolidation over time (HILL et al. 2008).

**Applicability**
This system depends on three factors: type of soil, water quality and climate, plant and labors. If the soil is very permeable, it is difficult to transport the water over the surface and may not the entire field will be irrigated. But surface irrigation is not negatively influenced by winds or sediments and debris as are sprinkler systems.

Moreover, salinity is less of a problem under surface irrigation because of less risk of clogging pipes and salts can be leached from the soil profile. Surface irrigation is not a high-automated system, what makes it more simple, but it requires therefore also more labors.

Figure 2.5 Surface Irrigation

2.2.2 Sprinkler Irrigation
Figure 2.6 Example of Sprinkler

Sprinkler irrigation is a method of providing rainfall-like irrigation to the crops. Water is distributed through a system of pipes usually by pumping. Spray heads at the outlets distribute the water over the entire soil surface. Sprinklers provide efficient coverage for small to large areas and are suitable for all types of crops. Furthermore, they can be adapted to nearly all irrigable soils since sprinklers are available with a variety of discharge capacities (FAO 1988). However, sprinkler
systems can easily clog with the presence of sediment or debris and large systems incur high capital costs

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**Sprinkler Heads**

Impact and gear-drive sprinklers are two general types of sprinklers used in lawns, gardens and pastures. They produce moving streams of water and spray nozzles that discharge water on the whole wetted pattern at all times. Impact or gear-drive sprinklers can accommodate only full or part circle application patterns. Since each sprinkler covers a large area (typically 12 m head-to-head spacing), they are used on pastures and larger lawn areas

Figure 2.7 Sprinkler Head
Several sprinkler heads are connected to a lateral pipe, which is supplied by a mainline. These sprinklers may be used in a solid set configuration where sufficient nozzles are installed to cover all parts of the desired area drawing water from a surface or buried mainline and laterals. Or they can be used in a set-move configuration where lateral lines are operated and then moved at intervals of 12 or 24 hours. Solid set systems cost more to install, but have lower labor requirements and may be automated. The equipment and installation cost per acre of set-move systems is less expensive, but their operation requires more labor, as they cannot be completely automated.

**Centre Pivot**

This self-propelled sprinkler system rotates around the pivot point and has the lowest labor requirements of the systems considered here. It is constructed using
pipes attached to moveable towers. The amount of water applied is controlled by the speed of rotation. Centre pivots can be adjusted to any crop height and are particularly suited for lighter soils. With a computerized control system, the operator is able to program many features for the irrigation process. Furthermore, it is possible to install a corner attachment system (also called “end-gun”) that allows irrigation of corner areas missed out by conventional Centre pivot systems.

![Figure 2.9 Demonstration of center pivot movement](image)

**Linear Move**

The linear move (also called lateral move) irrigation system is built the same way as a center pivot; that is moving towers and pipes interconnecting the towers. The main difference is that all the towers move at the same speed and in the same direction. Water is pumped into one of the ends or into the center. Due to the high capital investment, linear moves are used on high-value crops such as potatoes, vegetables and turf.
Figure 2.10 Demonstration of linear move

**Travelling Big Gun**

The travelling big gun system uses a large-capacity nozzle and high pressure to throw water out over the crop as it is pulled through an alley in the field. Travelling big guns come in two main configurations: hard-hose or flexible-hose feed. With the hard-hose system, a hard polyethylene hose is wrapped on a reel mounted on a trailer. The trailer is anchored at the end or Centre of the field. The gun is connected to the end of the hose and is pulled towards the trailer. The gun is pulled across the field by the hose winding up on the reel. With the flexible-hose system, the gun is mounted on a four-wheel cart. Water is supplied to the gun by a flexible hose from the main line. A cable winch pulls the cart through the field towards the cart.
Side Roll

The side roll (also called wheel roll) system consists of a lateral, usually a quarter mile long, mounted on 4 to 10 foot (1 to 3 meters) wheels in diameter and the pipe serving as an axle. When the desired amount of water has been applied to an area, a gasoline engine at the center is used to move the side roll to the next. The sprinklers are generally mounted on weighted, swiveling connectors so that no matter where the side roll is stopped, the sprinklers will always be on top. This type of system is not recommended for gradients greater than 5 per cent and should be used mainly on flat ground. Side roll systems are adapted only to low growing crops, have medium labour requirements and moderate initial investment.
Cost Consideration

The costs of the different systems vary. Except for small sprinkler equipment for gardening, big systems such as linear move or centre pivot irrigation incur high capital costs. It is important to also consider operation and maintenance costs for these technical and sometimes computer controlled systems.

Operation Maintenance

Depending on the system, expert knowledge is necessary to carry out irrigation. It is important to maintain the whole facility. Motors, water supply pipes/hoses and all mechanical components have to be kept in shape to avoid damage and high repair costs. The operation and maintenance of irrigation equipment for gardens, such as sprinkle or spray heads, is not tricky and thus easy to handle for everyone.

Health Aspect
When water quality is very low (e.g. wastewater) and/or solvable fertilizer was added, workers should not stand close to the irrigated field to avoid contact with the water.

**Applicability**

Sprinklers are suited best for sandy soil with high infiltration rates although they are adaptable to most soil types. The average application rate of the sprinklers (in mm/hour) is set lower than the basic infiltration rate of the soil so that surface ponding and runoff can be avoided. Sprinklers are not suitable for soils that easily form a crust or in case of risk of salinization. Moreover, they can easily clog with the presence of sediments or debris. If irrigation is the only method available, then light fine sprays should be used. Sprinklers producing larger water droplets should be avoided (FAO 1988).

### 2.2.3 Drip irrigation
With drip irrigation, water is conveyed under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers which are located close to the plants. Compared to other types of irrigation (sprinkler irrigation or surface irrigation), only the immediate root zone of each plant is wetted. Therefore this can be a very efficient method of irrigation. Drip irrigation is sometimes called trickle irrigation (FAO 1988).

Drip irrigation can be a very technical irrigation system for food or plant production fields. But compared to other technical systems (e.g. sprinkler irrigation) it is a low-technique solution. Furthermore it is possible to combine this system with a water treatment plant (e.g. non-planted filter or constructed wetlands (horizontal flow or vertical flow) and use the treated water as irrigation water).
Drip irrigation requires little water compared to other irrigation methods. About 40-80 liters per day are needed per 100-200 plants (INFONET-BIOVISION 2010). The small amount of water reduces weed growth and limits the leaching of plant nutrients down in the soil. In organic fertilizer or urine tea can be applied efficiently to the plants through the drip system (INFONET-BIOVISION 2010).

**Commercial Drip Irrigation System**

Figure 2.14 Schematic design of a commercial drip irrigation system. This includes technical components such as filters, pumps and hydraulic control valves.

Expensive commercial drip irrigation systems are employed in highly technical and industrial farming. The used systems are very expensive and needs expert design and maintenance (INFONET-BIOVISION 2010).

Most large drip irrigation systems employ some type of filter to prevent clogging of the small emitter flow path by small waterborne particles. New technologies are now being offered that minimize clogging. Some residential systems are installed without additional filters since potable water is already filtered at the water
treatment plant. Virtually all drip irrigation equipment manufacturers recommend that filters be employed and generally will not honor warranties unless this is done. Last line filters just before the final delivery pipe are strongly recommended in addition to any other filtration system due to fine particle settlement and accidental insertion of particles in the intermediate lines. Drip systems often mix liquid fertilizer with the irrigation water. This is called fertigation and chemigation (application of pesticides and other chemicals to periodically clean out the system).

Small Scale and Self-Made Drip Irrigation Systems

For a relatively low initial investment a small-scale farmer can buy and set up a drip-irrigation system. If used to grow crops for market, this investment will pay itself within the first season and lead to increased household food production, especially during extended dry periods (INFONET-BIOVISION 2010). Apply correct design (that might need training of the farmers), very simple drip systems can be built with local available material. Using buckets or barrels as water reservoir and bamboo or PVC tubes as distribution pipes, everyone can construct a very efficient irrigation system. If wastewater is used, a filtration unit after the treatment plant is recommended to avoid clogging of the emitters. Read more about simple manual irrigation methods here.

Design of a Simple Drip Irrigation System
A simple drip can consist of a 20 liter bucket with 30 meters (100 feet) of hose or drip tape connected to the bottom of the tank. The bucket is placed at least 1 meter (3 feet) above the ground so that gravity provides sufficient water pressure to ensure even watering for the entire crop. Clean water is poured into the bucket daily through a filter/strainer. The water in the bucket fills the drip tape and is evenly distributed to 100 watering points. A multi-chambered plastic drip tape is engineered to dispense water through openings spaced at 30cm (12 inches). The bucket kit is the smallest type of drip irrigation technique (Adapted from RCSD 2008). A filter after the control valve can be installed, to prevent blockages (e.g. a screen) or an even more developed filter to improve the water quality.

![Figure 2.15 Schematic design of a low-cost drip irrigation system](image)

**Costs considerations**
As already mentioned, commercial systems for industrial production are very expensive. Small scale farmers can buy a drip irrigation system for relatively low initial costs (US$15 to $85) or construct it with local available material (buckets, bamboo or plastic pips) (INFONET-BIOVISION 2010). In general, it is more costly than manual irrigation, but has improved yields and decreased water/operating costs.

**Operation and Maintenance**

For perennial crops, the drip hose should be lifted periodically if a drip hose system is used on the soil surface, so that leaves, soil, and debris do not cover the hose. If the drip hose is not lifted, roots can grow over the hose, anchor it to the ground, and eventually pinch off the flow of water. Leaks can occur unexpectedly as a result of damage by insects, animals, or farming tools. Systematically monitor the lines for physical damage. It is important to fix holes as soon as possible to prevent uneven irrigation. If the rate of water flow progressively declines during the season, the tubes or tape may be slowly plugging, resulting in severe damage to the crop. Once a month, flush the drip lines by opening the far ends of a portion of the tubes at a time and allowing the higher velocity water to flush out the sediment (INFONET-BIOVISION 2010). If poorly treated wastewater is used, soil quality can be degraded over time (e.g. accumulation of salts) (TILLEY at al. 2008).

**Health Aspects**
If wastewater is used for the irrigation process, there are potential health risks if water is not properly pre-treated (i.e. inadequate pathogen reduction). If poorly treated wastewater is applied. Appropriate pre-treatment should precede any irrigation scheme to limit health risks to those who come in contact with the water. As well, depending on the degree of treatment that the effluent has undergone, it may be contaminated with the different chemicals that are discharged into the system. When effluent is used for irrigation, households and industries connected to the system should be made aware of the products that are and are not appropriate for discharging into the system. Drip irrigation is the only type of irrigation that should be used with edible crops, and even then, care should be taken to prevent workers and harvested crops from coming in contact with the treated effluent. Despite safety concerns, irrigation with effluent is an effective way to recycle nutrients and water (Adapted from TILLEY et al. 2008).

Applicability

Generally, drip irrigation is the most appropriate irrigation method; it is especially good for arid and drought prone areas. Drip and subsurface drip irrigation is used almost exclusively when using recycled municipal wastewater. Regulations typically do not permit spraying water through the air that has not been fully treated to potable water standards. Furthermore, this system can be very technical for industrial crop production but also a simple small-scale irrigation method, which farmers can construct by themselves.
All previous methods depend either fully or partially upon the usage of pumps due to the difference in land elevation in case of surface irrigation or to control the water pressure in case of sprinkler or drip irrigations.

### 2.3 Irrigation technologies and sensors

Precision irrigation is still in its infancy internationally. Despite the widespread promotion and adoption of precision agriculture in dry land cropping systems, the concept of precision irrigation or irrigation as a component of precision agricultural systems has not been widely canvassed nor its potential evaluated.

Sensor-based controllers rely on soil moisture sensors placed below ground in the root zones of lawns and landscapes to determine if and how long to water. Soils may be maintained between lower and upper target moisture levels for optimal plant health. Alternatively, a simpler decision is to schedule the regular irrigation program to run based on the soil moisture.

### 2.4 Instrumentation of automated irrigation systems

The following are some previous studies and projects regarding automation of irrigation.

**International Journal of Advanced Research in Computer Science and Software Engineering. Arduino Based Automatic Plant Watering System**

Watering is the most important cultural practice and most labor intensive task in daily greenhouse operation. Watering systems ease the burden of getting water to
plants when they need it. Knowing when and how much to water is two important aspects of watering process. To make the gardener works easily, the automatic plant watering system is created. There have a various type using automatic watering system that are by using sprinkler system, tube, nozzles and other. This project uses watering sprinkler system because it can water the plants located in the pots.

This project uses Arduino board, which consists of ATmega328 Microcontroller. It is programmed in such a way that it will sense the moisture level of the plants and supply the water if required. This type of system is often used for general plant care, as part of caring for small and large gardens. Normally, the plants need to be watered twice daily, morning and evening. So, the microcontroller has to be coded to water the plants in the greenhouse about two times per day. People enjoy plants, their benefits and the feeling related to nurturing them. However for most people it becomes challenging to keep them healthy and alive. To accommodate this challenge we have developed a prototype, which makes a plant more self-sufficient, watering itself from a large water tank and providing itself with artificial sunlight. The prototype reports status of its current conditions and also reminds the user to refill the water tank.

The system automation is designed to be assistive to the user. We hope that through this prototype people will enjoy having plants without the challenges related to absent or forgetfulness.

**International Journal of Science and Research (IJSR) Android based Automated Irrigation System using Raspberry Pi.**
Nowadays, adopting an optimized irrigation system has become a necessity due to the lack of the world water resource. The system has a distributed wireless network of soil-moisture and temperature sensors. This project focuses on a smart irrigation system which is cost effective. As the technology is growing and changing rapidly, Wireless sensing Network (WSN) helps to upgrade the technology where automation is playing important role in human life. Automation allows us to control various appliances automatically.

DC motor based vehicle is designed for irrigation purpose. The objectives of this paper were to control the water supply to each plant automatically depending on values of temperature and soil moisture sensors. Mechanism is done such that soil moisture sensor electrodes are inserted in front of each soil. It also monitors the plant growth using various parameters like height and width. Android app.

**International Journal of Advanced Research in Computer and Communication Engineering** GSM based Automated Irrigation Control using rain gun Irrigation System.

The green house based modern agriculture industries are the recent requirement in every part of agriculture in India. In this technology, the humidity and temperature of plants are precisely controlled. Due to the variable atmospheric conditions sometimes may vary from place to place in large farmhouse, which makes very difficult to maintain the uniformity at all the places in the farmhouse manually. The proposed system implemented GSM is used to report the detailed about irrigation.
The report from the GSM is send through the android mobile. The keil software is used for simulating the results.

2.5 Components of automation

2.5.1 Microcontroller

A microcontroller is a small and low-cost computer built for the purpose of dealing with specific tasks, such as displaying information in a microwave LED or receiving information from a television’s remote control. Microcontrollers are mainly used in products that require a degree of control to be exerted by the user.

![Microcontroller head](image)

Figure 2.16 Microcontroller head

**Microcontroller v/s microprocessor**

Microprocessors are used to execute big and generic applications, while a microcontroller will only be used to execute a single task within one application. Some of the benefits of microcontrollers include the following:
Cost advantage: The biggest advantage of microcontrollers against larger microprocessors is that the design and hardware costs are much lesser and can be kept to a minimum. A microcontroller is cheap to replace, while microprocessors are ten times more expensive.

Lesser power usage: Microcontrollers are generally built using a technology known as Complementary Metal Oxide Semiconductor (CMOS). This technology is a competent fabrication system that uses less power and is more immune to power spikes than other techniques.

All-in-one: A microcontroller usually comprises of a CPU, ROM, RAM and I/O ports, built within it to execute a single and dedicated task. On the other hand, a microprocessor generally does not have a RAM, ROM or IO pins and generally uses its pins as a bus to interface to peripherals such as RAM, ROM, serial ports, digital and analog IO. Read more about the difference between microcontroller and microprocessor.

**Operation of microcontroller**

Microcontroller has an input device in order to get the input and an output device (such as LED or LCD Display) to exhibit the final process. Let us look into the illustration of how a microcontroller works in a Television.

The Television has a remote control as an Input device and the TV screen as the output device. The signal sent from the remote control is captured by the
microcontroller. The microcontroller controls the channel selection, the amplifier system and picture tube adjustments such as hue, brightness, contrast etc.

**General architecture of a microcontroller**

The architecture of a microcontroller depends on the application it is built for. For example, some designs include usage of more than one RAM, ROM and I/O functionality integrated into the package.

![Schematic diagram for microcontroller components](image)

Figure 2.17 Schematic diagram for microcontroller components

### 2.5.2 Sensors

Sensors play a great role in the daily life of modern people. Thus including these technologies in agriculture was expected to get higher yields and efficiencies.
2.5.2.1 Flow Meter

A flow meter is an instrument used to measure linear, nonlinear, mass or volumetric flow rate of a liquid or a gas. When choosing flow meters, one should consider such intangible factors as familiarity of plant personnel, their experience with calibration and maintenance, spare parts availability, and mean time between failure history, etc., at the particular plant site. It is also recommended that the cost of the installation be computed only after taking these steps. One of the most common flow measurement mistakes is the reversal of this sequence: instead of selecting a sensor which will perform properly, an attempt is made to justify the use of a device because it is less expensive. Those "inexpensive" purchases can be the most costly installations. This page will help you better understand flow meters, but you can also speak to our application engineers at any time if you have any special flow measurement challenges.

![Flow Meter Design](image)

Figure 2.18 Flow meter components
2.5.2.2 Soil moisture sensor

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners.

Soil moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in soils called water potential; these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks.
2.5.3 Communication

GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM supports voice calls and data transfer speeds of up to 9.6 kbps, together with the transmission of SMS (Short Message Service).

GSM operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US. GSM services are also transmitted via 850MHz spectrum in Australia, Canada and many Latin American countries. The use of harmonized spectrum across most of the globe, combined with GSM’s international roaming capability, allows travelers to access the same mobile services at home and abroad. GSM enables individuals to be reached via the same mobile number in up to 219 countries.
Terrestrial GSM networks now cover more than 90% of the world’s population. GSM satellite roaming has also extended service access to areas where terrestrial coverage is not available.

Figure 2.20 GSM
CHAPTER 3

MATERIALS AND METHODS

The objective of this project is to design and develop a GSM based automated instrumentation system to be integrated into a spray irrigation system. The instrumentation system is based on a microcontroller, flow meter, and moisture sensor via a wireless system, while the spray irrigation system consists of spray nozzles, irrigation piping, solenoid valve, and a wooden box as a cultivation field. The wireless control system uses the mobile phone SMS service via a GSM installed in the system.

3.1 System Description

The proposed GSM based automated spray irrigation system prototype consists of two main components: hardware and software. The hardware consists of two components: instrumentation system and spray irrigation system. The instrumentation system is based on a microcontroller, flow meter, moisture sensor, LCD, and GSM. The spray irrigation system consists of spray nozzles, irrigation piping, solenoid valve, and a wooden box to plant inside it. The software consists of a C++ code to link the various components together. Figure (3.1) describes the proposed GSM based automated spray irrigation system.
3.2 Instrumentation system

The proposed GSM based automated instrumentation system is based on microcontroller, moisture sensor, flow meter, LCD and GSM.

3.2.1 Microcontroller

The project uses a microcontroller (Arduino, ATmega 2560, Italy). It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is
compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

Figure 3.2 ATmega 2560 Arduino

3.2.2 The moisture content sensor

The project uses Soil moisture sensor (MH-Sensor, Flying-Fish, China) to measure the water content in soil. Measuring soil moisture is important in agriculture to help farmers manage their irrigation systems more efficiently. Not only are farmers able to generally use less water to grow a crop, but they are also able to increase yields and the quality of the crop by better management of soil moisture during critical plant growth stages.

Besides agriculture, there are many other disciplines using soil moisture sensors. Golf courses are now using sensors to increase the efficiencies of their irrigation systems to prevent over watering and leaching of fertilizers and other chemicals offsite.
The module uses LM393 comparator to compare the soil moisture level with the preset threshold. When the soil moisture deficit module outputs a high level, and vice versa.

Chart 3.1 presents the calibration done on the moisture sensor and the equation formulated from the straight line estimated.

```
y = -12.407x + 1020.3
R^2 = 0.9702
```
3.2.3 Flow meter counter

The project uses (The Water Flow Hall Effect Sensor Switch Flow Meter Counter, China). The principle of operation The main water flow sensor by copper body and plastic forming, water flow rotor components, steady flow components and hall components. It’s used in water dispenser, coffee machine and household appliances the water used for measuring the water flow.

When water flows through the rotor components, magnetic rotor rotating, and speed along with the flow of a linear change. Hall element output corresponding pulse signal feedback to the controller, the size of the flow of water by controller judgment, adjust proportional valve control of electric current.

Water flow sensor fundamentally solve the differential water-gas valve flap type high pressure and start water valve easy disoperation appear dry and shortcomings. It has reflected sensitive, long service life, action quick, safe and reliable, joins
convenient traffic advantages such as the start low, deeply the general user affection.

The main components of turbine rotor flow switch shell, magnetic rotor, brake ring composition. Use water flow switch mode, its performance than the mechanical differential pressure plate structure, and decrease the size. As the water through the turbine switch shell, promote magnetic rotor, different pole near the hall element hall element when conduction, and leave the hall components disconnect. Thus, can measure the rotor speed. According to the measured data of the rotor speed and water flow, the output signal (voltage) curve, can be sure water dispenser, coffee machine and household appliances start water pressure, hydraulic pressure and startup corresponding start the flow of water and rotor the start of the speed.

The flow meter is pre-calibrated with the following equation:

\[
\text{flowrate} = \left(\frac{1000.0}{(\text{millisecond()} - \text{old-time})} \right) \times \text{pulse-Count} / 7.5
\]

Figure 3.4 Water flow hall effect sensor switch flow meter counter
3.2.4 LCD

The system uses a LCD screen (Hitachi-compatible LCDs, Japan) that can be controlled in two modes: 4-bit or 8-bit. The 4-bit mode requires seven I/O pins from the Arduino, while the 8-bit mode requires 11 pins. For displaying text on the screen, you can do most everything in 4-bit mode, so example shows how to control a 2x16 LCD in 4-bit mode.

![Figure 3.5 LCD screen](image)

3.2.5 GSM

The project uses a wireless system (GSM, SIM900A Italy). The GPRS module is a breakout board and minimum system of SIM900 Quad-band/SIM900A Dual-band GSM/GPRS module. It can communicate with controllers via AT commands (GSM 07.07, 07.05 and SIMCOM enhanced AT Commands). This module supports software power on and reset.
Figure 3.6 SMS and GPRS operation

Figure 3.7 SIM900A
3.3 Spray irrigation system prototype

Spray irrigation system prototype consist of spray nozzles, irrigation piping, solenoid valve and wooden box. To simulate the work of the GSM based automated spray irrigation system in a small confined area.

3.3.1 Spray nozzles

A number of 9 nozzles were used in this project, connected on a gardening hose and spaced about 33.3 cm apart from each other so as to provide an adequate distribution of water throughout the area. The area of the experiment is wooden box with dimensions of 120*120*60 cm.
Figure 3.8 Spray nozzles and irrigation piping used in this project

Figure 3.9 wooden box
3.3.2 The Electric Solenoid Valve

Solenoid valves come in a variety of sizes and materials in order to integrate within many fluid management systems. The body of the valve should be made of a material that is compatible with the system media to prevent premature failure of the valve, or contamination of the media. The most important components to consider when selecting a solenoid valve are the seal, coil, and the ports of the valve.

![Electric solenoid valve](image)

Figure 3.10 Electric solenoid valve

3.4 Software

Arduino has a special app which is very simple to use by anyone. A C++ code is written which includes all the orders which operate the system and then uploaded into the Arduino. The code is attached in the appendix.
Chapter 3  [Materials and Methods]
3.5 Required crop data

The project uses purslane to test the efficiency of the system. The selection was based on the fast growth of this crop. Purslane needs little watering just enough to keep a 3 inch layer from the surface from drying out. The optimum moisture content for purslane is between 20-25%.
3.6 Installation and operation

3.6.1 GSM based automated instrumentation system

The processing unit of this system is the Arduino which means all the available sensors and components should be connected to it via an electronic bread board.

The Flying-Fish sensor is connected by inserting the signal wire to the A0 pin in the Arduino and the current wires (VCC and Ground) to the breadboard.

The Hall effect flow meter is connected by inserting the signal wire to pin 2 in the Arduino and the same for the current wires (VCC and Ground).

The solenoid valve is connected to the Arduino via a relay which converts the 5 volts current of the Arduino to meet up with the 220 volts of the solenoid. A wire connects the solenoid to the relay while the other one is connected to the electrical source, also taking a wire from the relay and connect it to the electrical source.
connection becomes between the relay and the Arduino by inserting the signal wire to pin 40 and the current wires (VCC and Ground) to the breadboard.

Text Display Controller Card Serial port has 16 pins connected to the breadboard 6 of them are data pins which are to be connected to the Arduino in pins 48 to pin 53.

The GSM has 2 current wires ground and VCC connected to the breadboard and 2 data wires connected to the Arduino in pins 8 and 9.

**3.6.2 Spray irrigation system**

The nozzles are connected in three parallel lines divided 3 nozzles in each one, those lines are connected from the sides so as complete a closed system, one end is permanently closed while the other is connected to the controlling segment.

This segment starts with a manual valve installed for maintenance if needed, the valve is then connected to the solenoid valve which operates as the main controlling unit of the Automatic system. The Hall effect flow meter then comes directly after the solenoid so as to operate as the counter which provides the needed information to signal the solenoid. The final connection is the link between the controlling segment and the nozzle system.
3.6.3 System Operation

The propose GSM based automated spray irrigation system depends on the Flow meter to control the opening and closing of the solenoid. The flow meter counts the amount of water which passes through it, after the programmed amount passes it gives a signal to the Arduino which transfers this signal to the solenoid. The timing of the irrigation process is pre-set on the code to trigger the opening of the solenoid according to the irrigation interval of the purslane.
The moisture sensor is used to monitor the moisture content of the soil at all times. Recording the readings and notifying the owner in case of emergency to manually open the valve and when the emergency passes to manually close the valve.

The GSM is used to send and receive the messages from and to the Arduino. Providing the information of your field at any given time and to control manually in case of emergency.

The text display screen is used to read the data on site. Providing the moisture content and the flow in the certain moment.
CHAPTER 4

RESULTS AND DISCUSSION

This chapter illustrates the development and evaluation of GSM based automated Irrigation System.

4.1 Development of the GSM automated spray irrigation system

A GSM automated irrigation system was successfully developed and connected. The developed system consists of a microcontroller, a flow meter, a moisture content sensor, an electric solenoid valve, GSM, a text display Controller Card Serial port and spray nozzles. Fixed over the irrigation system prototype. The area of study was 1.44 square meters which was irrigated sufficiently to meet the crop water requirements of purslane. Figure (4.1) show the developed wireless automated instrumentation system circuit while figure (4.2) shows Automated irrigation system prototype. Table (4.1) presents the specification of the materials used.
Figure 4.1 wireless automated instrumentation system circuit

Figure 4.2 Automated irrigation system prototype
Table 4.1 Specifications of GSM based automated spray irrigation system prototype

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino</td>
<td>ATmega 2560, Italy</td>
</tr>
<tr>
<td>Flow meter sensor</td>
<td>POW110D3B, China</td>
</tr>
<tr>
<td>Moisture sensor</td>
<td>MH-Sensor Flying-Fish, China</td>
</tr>
<tr>
<td>LCD screen</td>
<td>Hitachi-compatible LCDs, Japan</td>
</tr>
<tr>
<td>GSM</td>
<td>SIM900A, Italy</td>
</tr>
<tr>
<td>Irrigation piping</td>
<td>13 mm diameter</td>
</tr>
<tr>
<td>Wooden box</td>
<td>120<em>120</em>60 cm</td>
</tr>
<tr>
<td>Solenoid valve</td>
<td>FCD270A, China</td>
</tr>
<tr>
<td>Software</td>
<td>Windows based application running C++ code</td>
</tr>
</tbody>
</table>

4.2 Software development

The Program was tested and found running. Allowing the required amount of water to pass in its specific time. Also the monitoring of soil moisture was tested and found to be efficient.
Figure 4.3 C++ code of the system

4.3 System Evaluation

The GSM based automated spray irrigation system operation begins with the initiation of the irrigation process with a pre-set timer on the microcontroller and ends with the flow meter signal. The moisture sensor monitors the moisture content of the soil if higher than the permissible limit it signals the GSM to call the user to send a specific order r1 to open water or r0 to close water. The system was tested successfully and found to be running smoothly and without any human interference except in the case of an urgent emergency. In this case the system notifies the user
of this emergency and waits for the command of the user, when the emergency is through it notifies the user about the stability of the situation and waits for the users decision.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following conclusions obtained from the last results:

1. A GSM based automated instrumentation system was successfully designed and developed. The developed system consists of a microcontroller, a flow meter, a moisture content sensor, LCD screen and GSM to be utilized in the spray irrigation system (Table 5.1).

2. The spray irrigation system which consists of spray nozzles, irrigation piping, wooden box and solenoid valve was successfully developed and integrated to the wireless automated instrumentation system.

3. The windows based software was successfully developed based on C++ coding language.

4. The evaluation for the wireless automated spray irrigation system was conducted successfully and the system was found to be running correctly.

5. The unit total cost of the system was found to be $200.

6. With the existing system remote agricultural fields could be easily operated and monitored with a relatively low cost.
Table 5.1 Materials GSM based automated spray irrigation prototype specifications

<table>
<thead>
<tr>
<th>Name</th>
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<tr>
<td>Software</td>
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</tbody>
</table>

5.2 Recommendations

The following recommendations should be carried on:

1. In real size fields the control should be done on pumps and solenoid valves could be used to control different water requirements on the same field.

2. This system could be used as a replacement of the hanging system by the addition of wheels to make it mobile.
3. The addition of pH, humidity and other sensors to maximize the precision of the irrigation system.

4. The hydraulic research center in Medani has a project that notifies farmers about the scarcity of water in the field using satellite messages. The addition of the GSM based automated irrigation system can be utilized in the control over these fields.


http://plants.usda.gov/java/profile?symbol=POOL.

Figure 4. Seedling of common purslane.

Credits: D. C. Odero

Figure 5. Branched prostrate common purslane.

Credits: D. C. Odero

Figure 6. Flower of common purslane.

Credits: D. C. Odero


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USU (Editor) (n.y.): Introduction to Surface Irrigation Systems. Logan: Utah State University. URL [Accessed: 20.06.2011]. PDF


http://www.arduino.com
APENDIX

Code 1:

```c
#include <LiquidCrystal.h>
#include <Wire.h>

LiquidCrystal lcd(8, 9, 4, 5, 6, 7);

int lcd_key     = 0;
int adc_key_in  = 0;
int m=10;
#define btnRIGHT  0
#define TotalResetButton 1 // UP button,
#define DailyResetButton 2 // Down Button
#define btnLEFT    3
#define btnSELECT  4
#define btnNONE    5

int read_LCD_buttons()
{
  adc_key_in = analogRead(0);

  if (adc_key_in > 1000) return btnNONE;
  if (adc_key_in < 250)  return TotalResetButton;
  if (adc_key_in < 450)  return DailyResetButton;

  return btnNONE;
}

byte sensorInterrupt = 0;
byte sensorPin = 2;

// The hall-effect flow sensor outputs approximately 4.5 (Closer to 7.5-7.6) pulses per second
// per litre/minute of flow.
float calibrationFactor = 7.55;

volatile byte pulseCount;

float flowRate;
unsigned int flowMilliLitres;
unsigned long totalMilliLitresA;
unsigned long totalMilliLitresB;
```

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float calibrationFactor = 7.55;

volatile byte pulseCount;

float flowRate;
unsigned int flowMilliLitres;
unsigned long totalMilliLitresA;
unsigned long totalMilliLitresB;
unsigned long oldTime;

void setup()
{
    pinMode(m, OUTPUT);
    lcd.begin(16, 2);
    lcd.setCursor(0, 0);
    lcd.print(" ");
    lcd.setCursor(0, 1);
    lcd.print(" ");
    Serial.begin(38400);

    pinMode(sensorPin, INPUT);
    digitalWrite(sensorPin, HIGH);
    pulseCount = 0;
    flowRate = 0.0;
    flowMilliLitres = 0;
    totalMilliLitresA = 0;
    totalMilliLitresB = 0;
    oldTime = 0;

    attachInterrupt(sensorInterrupt, pulseCounter, FALLING);
}

void loop()
{
    digitalWrite(m, HIGH);

    lcd_key = read_LCD_buttons();

    switch (lcd_key)
    {
    case TotalResetButton:
    {
        totalMilliLitresA = 0;
        lcd.setCursor(5, 1);
        lcd.print("AGR11");
        lcd.setCursor(11, 0);
        lcd.print("UOFK ");
        break;
    }
case DailyResetButton:
{
  totalMilliLitresB = 0;
  lcd.setCursor(11, 1);
  lcd.print("AGR11");
  lcd.setCursor(11, 0);
    lcd.print("UOFK ");

}

if((millis() - oldTime) > 1000)
{
  detachInterrupt(sensorInterrupt);

  flowRate = ((1000.0 / (millis() - oldTime)) * pulseCount) / calibrationFactor;
  oldTime = millis();

  flowMilliLitres = (flowRate / 60) * 1000;

  totalMilliLitresA += flowMilliLitres;
  totalMilliLitresB += flowMilliLitres;

  unsigned int frac;

  lcd.setCursor(0, 0);
  lcd.print(" ");
  lcd.setCursor(0, 0);
  lcd.print("Flow");
  lcd.write(255);
  lcd.setCursor(0, 1);
  if(int(flowRate) < 10)
  {
    lcd.print(" ");
  }
  lcd.print((int)flowRate);
  lcd.print('.');
  frac = (flowRate - int(flowRate)) * 10;
  lcd.print(frac, DEC) ;
  lcd.write(255);
lcd.setCursor(5, 0);
lcd.print("Total");
lcd.write(255);
lcd.setCursor(5, 1);
if(int(totalMilliLitresA / 1000) < 10)
{
lcd.print( " ");
}

if(int(totalMilliLitresA / 1000) < 100)
{
lcd.print( " ");
}
if(int(totalMilliLitresA / 1000) < 1000)
{
lcd.print(" ");
}
if((int(totalMilliLitresA / 1000))>2)
{
digitalWrite(m,LOW);
totalMilliLitresA = 0;
delay(50000);
}
lcd.print(int(totalMilliLitresA / 1000));
lcd.setCursor(9, 1);
lcd.print("L");
lcd.write(255);

pulseCount = 0;
attachInterrupt(sensorInterrupt, pulseCounter, FALLING);

void pulseCounter()
{
pulseCount++;
}
Code 2:
#include <SoftwareSerial.h>
SoftwareSerial GPRS(7, 8); // RX, TX
char msg;
char call;
const int s1 = A0;
int slReading;
enum _parseState {
    PS_DETECT_MSG_TYPE,
    PS_IGNORING_COMMAND_ECHO,
    PS_READ_CMTI_STORAGE_TYPE,
    PS_READ_CMTI_ID,
    PS_READ_CMGR_STATUS,
    PS_READ_CMGR_NUMBER,
    PS_READ_CMGR_SOMETHING,
    PS_READ_CMGR_DATE,
    PS_READ_CMGR_CONTENT
};
byte state = PS_DETECT_MSG_TYPE;
char buffer[80];
byte pos = 0;
int lastReceivedSMSId = 0;
boolean validSender = false;

void resetBuffer() {
    memset(buffer, 0, sizeof(buffer));
    pos = 0;
}

void setup() {
    GPRS.begin(9600);
    Serial.begin(9600);
    // Set as appropriate for your case
    pinMode(2, OUTPUT);
    pinMode(4, OUTPUT);
digitalWrite(2, HIGH);
digitalWrite(4, HIGH);

for (int i = 1; i <= 15; i++) {
    GPRS.print("AT+CMGD=");
    GPRS.println(i);
    delay(200);

    // Not really necessary but prevents the serial monitor from dropping any input
    while(GPRS.available())
        Serial.write(GPRS.read());
}

void loop()
{

    while(GPRS.available()) {
        parseATText(GPRS.read());
    }

    slReading = analogRead(s1);
    Serial.print("Analog reading = ");
    Serial.println(slReading);
    if (slReading>900)
        MakeCall();
}

void parseATText(byte b) {

    buffer[pos++] = b;

    if ( pos >= sizeof(buffer) )
        resetBuffer(); // just to be safe

    /*
    // Detailed debugging
    Serial.println();
    Serial.print("state = ");
    Serial.println(state);
    Serial.print("b = ");
    Serial.println(b);
    Serial.print("pos = ");
    Serial.println(pos);
*/
Serial.print("buffer = ");
Serial.println(buffer);

switch (state) {
    case PS_DETECT_MSG_TYPE:
        {
            if ( b == '\n' )
                resetBuffer();
            else {
                if ( pos == 3 && strcmp(buffer, "AT+" ) == 0 ) {
                    state = PS_IGNORING_COMMAND_ECHO;
                }
                else if ( pos == 6 ) {
                    //Serial.print("Checking message type: ");
                    //Serial.println(buffer);
                    if ( strcmp(buffer, "+CMTI:" ) == 0 ) {
                        Serial.println("Received CMTI");
                        state = PS_READ_CMTI_STORAGE_TYPE;
                    }
                    else if ( strcmp(buffer, "+CMGR:" ) == 0 ) {
                        Serial.println("Received CMGR");
                        state = PS_READ_CMGR_STATUS;
                    }
                    resetBuffer();
                }
            }
        }
        break;
    case PS_IGNORING_COMMAND_ECHO:
        {
            if ( b == '\n' ) {
                //Serial.print("Ignoring echo: ");
                //Serial.println(buffer);
                state = PS_DETECT_MSG_TYPE;
                resetBuffer();
            }
        }
        break;
    case PS_READ_CMTI_STORAGE_TYPE:
        {
            if ( b == ',' ) {
                Serial.print("SMS storage is ");
                Serial.println(buffer);
            }
        }
        break;
}
state = PS_READ_CMTI_ID;
resetBuffer();
}
}
break;

case PS_READ_CMTI_ID:
{
    if ( b == 'n' ) {
        lastReceivedSMSId = atoi(buffer);
        Serial.print("SMS id is ");
        Serial.println(lastReceivedSMSId);
        GPRS.print("AT+CMGR=");
        GPRS.println(lastReceivedSMSId);
        //delay(500); don't do this!
        state = PS_DETECT_MSG_TYPE;
        resetBuffer();
    }
}
break;

case PS_READ_CMGR_STATUS:
{
    if ( b == ',' ) {
        Serial.print("CMGR status: ");
        Serial.println(buffer);
        state = PS_READ_CMGR_NUMBER;
        resetBuffer();
    }
}
break;

case PS_READ_CMGR_NUMBER:
{
    if ( b == ',' ) {
        Serial.print("CMGR number: ");
        Serial.println(buffer);
    }
    // Uncomment these two lines to check the sender's cell number
    //validSender = false;
    //if ( strcmp(buffer, "\"+0123456789\",") == 0 )
    validSender = true;
    state = PS_READ_CMGR_SOMETHING;
resetBuffer();
}
break;

case PS_READ_CMGR_SOMETHING:
{
    if ( b == ',' ) {
        Serial.print("CMGR something: ");
        Serial.println(buffer);
        state = PS_READ_CMGR_DATE;
        resetBuffer();
    }
}
break;

case PS_READ_CMGR_DATE:
{
    if ( b == \n ) {
        Serial.print("CMGR date: ");
        Serial.println(buffer);
        state = PS_READ_CMGR_CONTENT;
        resetBuffer();
    }
}
break;

case PS_READ_CMGR_CONTENT:
{
    if ( b == \n ) {
        Serial.print("CMGR content: ");
        Serial.print(buffer);
        parseSMSContent();

        GPRS.print("AT+CMGD=");
        GPRS.println(lastReceivedSMSId);
        //delay(500); don't do this!

        state = PS_DETECT_MSG_TYPE;
        resetBuffer();
    }
}
break;
}
void parseSMSContent() {

    char* ptr = buffer;

    while ( strlen(ptr) >= 2 ) {

        if ( ptr[0] == 'r' ) {
            if ( ptr[1] == '1' )
                digitalWrite(2, HIGH);
            else
                digitalWrite(2, LOW);
        }

        if ( ptr[0] == 'y' ) {
            if ( ptr[1] == '1' )
                digitalWrite(4, HIGH);
            else
                digitalWrite(4, LOW);
        }

        ptr += 2;
    }
}

void MakeCall()
{
    GPRS.println("ATD+249992277120; "); // ATDxxxxxxxxx; -- watch out here for
    Serial.println("Calling "); // print response over serial port
    delay(1000);
}