



Degree Program in Information Technology

Telecommunication Engineering

## **Bachelor's Thesis**

Shock Sensor Detection and Transmission of a Forklift

Le Ma

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# ABSTRACT

## SAVONIA UNIVERSITY OF APPLIED SCIENCES

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Abstract

Nowadays, In the highly developed modern industry, based on the development of IC electronic and computer technology, the sensing technology has made big development and brought so much convenient for our lives.

The aim of this thesis was to create a remote mobile monitoring device for a forklift shock situation for AP-TRUKIT OY using an EZ-10 device .The main objectives were to find a suitable shock sensor, and to create a workable python code. The program uses a SMS message to inform the shock time to the service person.

Different kinds of shock sensors were looked for. Their operating principle were studied, to understand how they work. A suitable one was chosen for the thesis. Knowledge and technologies related to GSM, python language and AT commands were studied in detail.

The remote test was done in Savonia's wireless lab at Technopolis Kuopio. The result of the thesis is a working shock sensor.

Keywords

EZ-10, python shock sensor, AT command, GSM

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Tiivistelmä

Nykyisin, kehittyneessä modernissa teollisuudessa, joka perustuu IC-piirien ja tietokoneiden kehittymiselle, sensoritekniikassa on tehty suuria edistysaskeleita ja se on tuonut mukavuuksia elämään.

Tämän työn tarkoituksena oli toteuttaa mobiili shokkisensorointi AP-trukit Oy:n toimittamiin trukkeihin käyttäen GSM modeemia. Pääavoitteina oli löytää sopiva shokkisensori ja tehdä Python koodilla sopiva ohjelma. Ohjelma käyttää tekstiviestiä sensoritiedon lähetykseen huoltomiehen puhelimeen.

Työssä vertailtiin erilaisia shokkisensoreita. Niiden toimintaperiaatteet tutkittiin ja testattiin. Eräs shokkisensori valittiin lopulta toteutukseen. GSM tekniikat, Python kieli ja AT-komennot tutkittiin ja opeteltiin yksityiskohtaisesti.

Shokkisensorin testit ja kehitys tehtiin Savonian Wireless laboratoriossa. Tuloksena saatiin mobiili shokkisensorin prototyyppi.

Avainsanat

EZ-10, python shock sensor, AT command, GSM

Julkinen

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Le Ma  
March 18, 2011  
Kuopio, Finland

## **ABBREVIATIONS**

IC	Integrated circuit
IP	Internet protocol
PZT	piezoelectric zirconate titanate
GSM	global system mobile communication
SMS	short message service
AT	Attention
SIM	Subscriber Identity module
MO	mobile originated
MT	mobile terminated
CPU	central process unit
PDU	protocol data unit
GPRS	general packet radio service
ADC	analog to digital converter
MEMS	micro electrical mechanical system
CDMA	code division multiple access
HSDPA	high speed downlink packet access
UMTS	universal mobile telecommunication system
GPS	general position system
PDN	packet data network

PDP	packet data protocol
EDGE	enhanced data for GSM evolution
TCP	transport control protocol

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## **1. INTRODUCTION**

Nowadays, with the development of sensing technology, the shock sensor as one kind of sensors can be found in a wide variety of applications. Such as alarm and security systems, remote control, object traceability and so on. There are different types of shock sensor like electric, mechanical, wireless and piezoelectric.

The AP-Trukit company needs to remote monitor the forklift shock situations, it is possible to use the shock sensing technology and mobile communication technology to achieve the remote control.

The aim of this thesis is to create a remote mobile monitoring device for a forklift shock situation. Firstly, different possible shock sensors are looked for and understand how they work. Then a suitable one will be selected for this thesis. Secondly, software for Telit (python language) will be created to read the sensor (digital input) and send the SMS message through the GSM mobile communication technology.

## **2. SHOCK SENSOR AND APPLICATION**

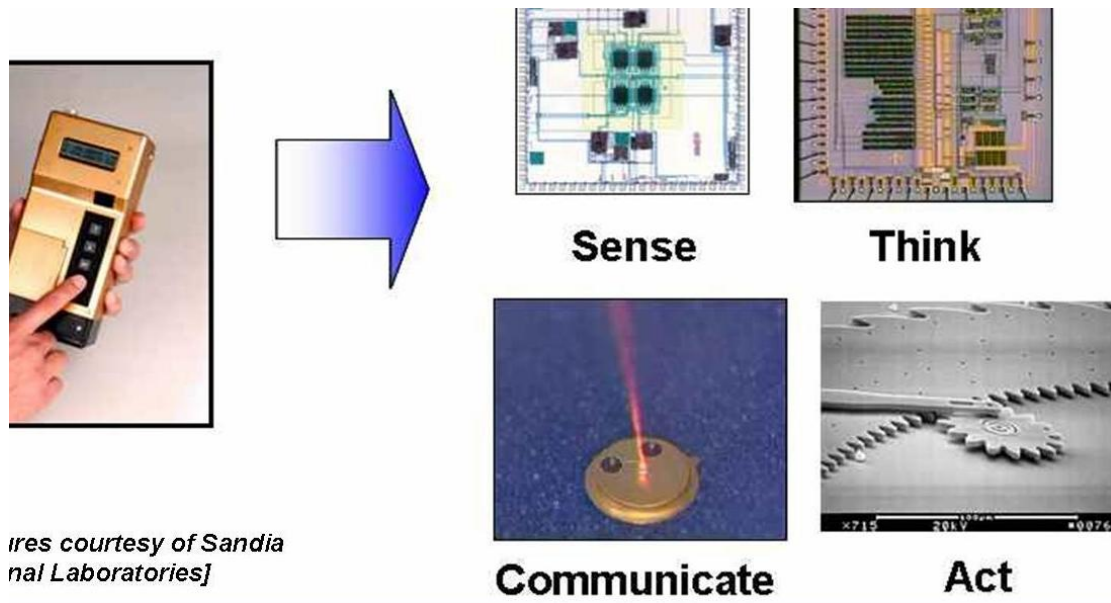
### **2.1 What is Sensor Technology?**

A sensor is a detection device, it could feel the information to be measured and converted to a available signal which can be read by an observer or by an instrument. During the past two decades, there has been an unprecedented growth in the number of products and services, which utilize information gained by monitoring and measuring using different types of sensors. [1] Sensor technology was seen as an integral element in the overall development of products and services. In fact it emerged as the key technology to support a wide variety of research and industrial applications.

Sensors are normally components of some larger electronic system such as a computer control and measurement system. Analog sensors most often produce a voltage proportional to the measured quantity. The signal must be converted to digital form with a ADC before the CPU can process it. Digital sensors most often use serial communication to return information directly to the controller or computer through a serial port.

#### **2.1.1 MEMS Based Sensor Technology**

Micro electromechanical systems (MEMS) are devices that can sense, think, act and communicate. Fig.1 shows the MEMS based technology. MEMS redirect light, pump and mix fluids, and detect the presence of molecules, heat, pressure or motion (all of which have been done for years in a macro scale). Through the miniaturization of these macro-sized devices and the ability to fabricate micro-sized devices in large numbers, the costs of manufacturing have decreased. [2]



**Figure 1** MEMS based technology [2]

A MEMS's small size allows it to be incorporated into a vast array of products. It can be included as a component of an integrated circuit or embedded into materials during manufacturing. Such characteristics permit the construction of more complicated systems and expand the potential applications of MEMS.

### 2.1.2 MEMS Applications

Freescale's MEMS-based sensors are a class of devices that builds very small electrical and mechanical components on a single chip. MEMS-based sensors are a crucial component in automotive electronics, medical equipment, hard disk drives, computer peripherals, wireless devices and smart portable electronics such as cell phones and PDAs. These sensors began in the automotive industry especially for crash detection in airbag systems. Throughout the 1990s to today, the airbag sensor market has proved to be a huge success using MEMS technology. MEMS-based sensors are now becoming pervasive in everything from inkjet cartridges to cell phones. Every major market has now embraced the technology. The benefits of MEMS include: low Cost, low Power, miniaturization, high Performance and Integration.[3]

Applications for MEMS are being realized every day. MEMS are built as sub millimeter devices as needed for medical applications and in the millimeter range for miniature robots. Single MEMS can

consist of a few components to millions of components. Because of this versatility, MEMS applications are practically unlimited.









There are still challenges in the fabrication of MEMS for applications such as RF (radio frequency) devices, optical and chemical devices, and fluidics. However, due to the development of new processes, materials, and equipment, these challenges are being addressed.

## **2.2 Application Field of Sensor**

Sensors are used in everyday objects such as touch-sensitive elevator buttons and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware of. Application field include cars, machines, aerospace, medicine, manufacturing and robotics. [1]

In professional words, sensor applications involve machinery manufacturing, industrial process control, automotive electronics, telecommunication electronics, consumer electronics and special equipment. Nowadays, the fastest-growing sensors market demand for the car industry market, good prospects for the telecommunications market.

As we seen from Fig. 2, there are various sensors, like shock sensors, humidity sensors, alcohol sensors, temperature sensor, air pressure sensors, humidity module, ultrasonic transducers, gas sensors, atmospheric pressure sensors.

Item	Picture	Name	Applications
		<a href="#"><u>Shock sensor</u></a>	Alarm, Electric Lock & other shock detector
		<a href="#"><u>Tilt sensor</u></a>	Nun Mercury type For tilt switch, angle switch, others.
		<a href="#"><u>Close type Ultrasonic Transducer</u></a>	Distance measurement, Back meter, others...
		<a href="#"><u>Gas sensor</u></a>	For detecting: Smoke, Gas, Alcohol, CO, Air pollution...etc
		<a href="#"><u>Atmospheric pressure sensor</u></a>	For air pressure detecting.
		<a href="#"><u>Humidity sensor</u></a>	Humidity (30-90%RH) Stable quality
		<a href="#"><u>Shock sensor for window</u></a>	Alarm, security and other shock detecting
		<a href="#"><u>Password shock detector</u></a>	Alarm, security and shock detecting.

**Figure 2** Some example sensor products. [4]

For example, in a modern Luxury Car, the key of the electronic control system is the number and level of use of sensors, Today an ordinary family cars are about to install only tens to hundreds of sensors, while the number sensors in luxury cars on the sensor up to two hundred only, species is usually more than 30 species, as many as over 100 kinds. Nowadays, new MEMS sensor technology not only to achieve miniaturization, but also have the functions like detection and control ,can be intelligent.[5] Fig.3 shows an MEMS sensor's application to Auto key parts.

<b>MEMS Sensors</b>	<b>Auto Parts</b>	<b>Application</b>
Pressure sensor	Engine assembly	To reflect the air-intake volume and control the fuel injection
Pressure sensor	Engine assembly	To measure the internal pressure of cylinder
Oxygen sensor	Engine assembly	To reflect the concentration of the engine's combustible gas
Crankshaft position sensor	Engine assembly	To reflect the engine crankshaft speed and angle and the top-dead-center piston position
Throttle position sensor	Engine assembly	To reflect the engine load
Speed sensor	Engine assembly	To reflect the auto speed and control the fuel injection
Water temperature sensor	Engine assembly	To measure and control the engine coolant temperature as well as the fuel injection
Acceleration sensor	Air bag	To test and control the airbag popping-up time
Pressure sensor	Air bag	To test and control the inflation pressure
Pressure sensor	Braking system	To control the oil pressure of the braking system
Pressure sensor	Suspension system	To test and control the suspension hydraulic pressure
Pressure sensor	Tire	To test the tire pressure
Wheel speed sensor	ABS/TCS/ESP	Traction control
Tilt sensor	Chassis systems	To measure and control the vehicle seat angle
Gyro	Navigation equipment	To measure and control the angular velocity

**Figure 3.**MEMS sensor's application to Auto key parts. [5]

### 2.3 Application Field of Shock Sensor

A shock sensor is designed to trigger an alarm on light or heavy impacts and vibrations (standard sensor included with most alarms) the shock sensors are used very often. Applications can be found in various fields.

As we seen from Fig.4, car alarm system with electronic shock sensor. Besides, collision sensing system in vehicles, a remote tire pressure monitoring system (a tire monitor for mounting to a vehicle as part of a remote tire monitoring system includes a tire condition sensor to produce a tire

condition signal, a controller coupled to the tire condition sensor to control operation of the tire monitor, and a radio circuit coupled to the controller).

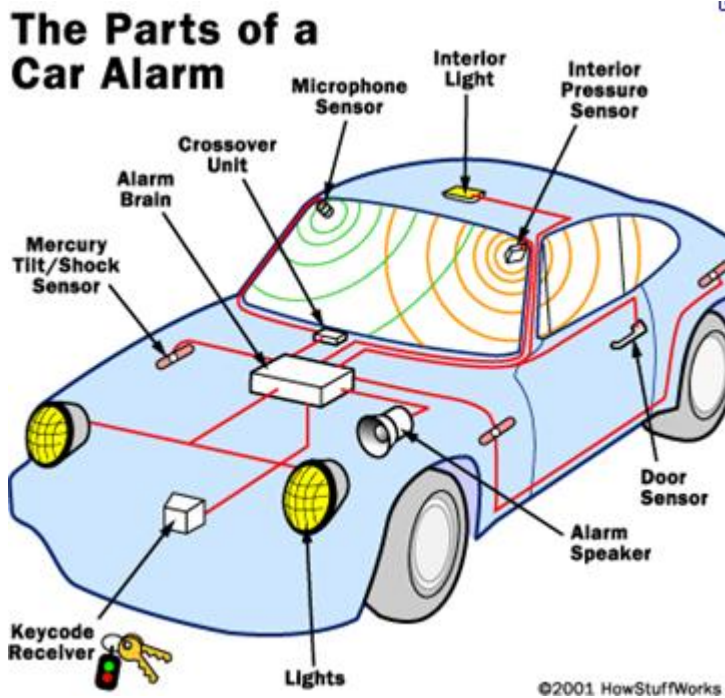


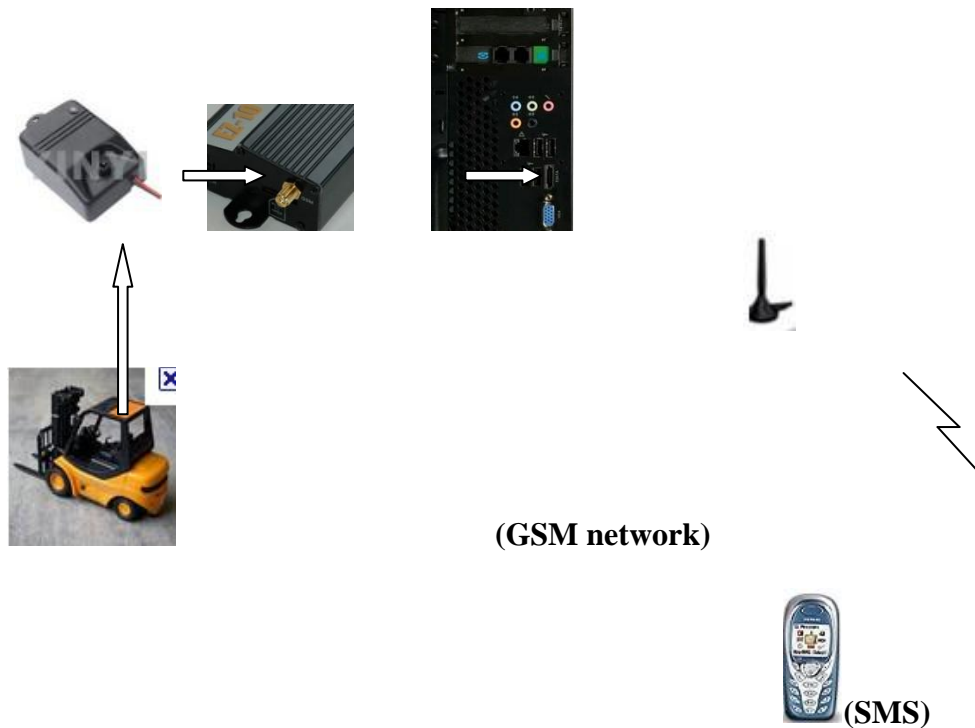
Figure 4. The shock sensor in car alarm system [6]

It is also possible to find shock sensor in laptop. It is used to protect the hard disk in case of sudden impact to the laptop. The shock sensor is designed to decrease the risk of damage to the computer's hard disk drive in the event of excessive impact or vibration. [7]

Additionally, the shock sensor utility can also be used to improve the security of the computer by automatically locking the computer with a password when it is carried. Acceleration shock sensor is also popular.

### 2.3.1 Remote Control via SMS on Shock situation for a forklift

In the final project, shock sensor, one mini PC with Windows 7 operating system with GSM modem and a mobile phone are used in the laboratory work as shown in Fig.5.



**Figure 5** The components in the implementation of this thesis.

## 2.4 Different kinds of Shock Sensor

Nowadays, it is possible to find different types of shock sensor like electric, mechanical, wireless and piezoelectric (mechanical-to-electrical transducers).

### 2.4.1 Piezoelectric Ceramic Characteristics

Piezoelectric ceramics have the property of developing an electric charge when mechanical stress is exerted on them. In these materials, an applied electric field produces a proportional strain. The electrical response to mechanical stimulation is called the direct piezoelectric effect, and the mechanical response to electrical stimulation is called the converse piezoelectric effect. [8]



The most commonly produced piezoelectric ceramics are lead zirconate titanate (PZT). Ceramic materials have several advantages over single crystals, especially the ease of fabrication into a variety of shapes and sizes. In contrast, single crystals must be cut along certain crystallographic directions, limiting the possible geometric shapes. [8]

Piezoelectric ceramics may be used to produce e.g.:

- Actuators
- Sensors
- Generators
- Transducers

## 2.4.2 Piezoelectric Ceramic Shock Sensor

The piezoelectric effect causes a crystal to produce an electrical potential. It has the advantage of high electromechanical transformation efficiency and high machinability. [9]

Piezoelectric ceramic chip as a vibration detection device. Because of the high resonant frequency of PZT, so some gravity springs were welded. Not only reduced the resonant frequency, but also enhanced the effect of vibration.

In this final thesis, the ZD-1 high sensitivity vibration sensor (piezoelectric ceramic shock sensor shown in Fig 6) will be used. The internal components are shown in Fig 7.

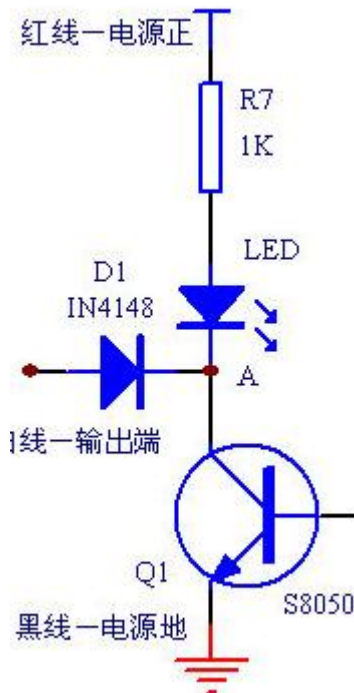


**Figure 6.** ZD-1 high sensitivity vibration sensor



**Figure 7.** The internal components in a shock sensor.

Fig. 8 shows that this kind of sensor is an open collector output transistor drive mode. D1 is the single chip system interface. When the sensor detects vibration signal Q1 turns on, the voltage in point will be down to 0.1V and D1 line will also be down to 0.8V. Then the output could detect changes and get the shock signal.



**Figure 8.** The internal circuit in the shock sensor

### 2.4.3 Specifications

The following list presents some advantages and specifications in this ZD-1 high sensitivity piezoelectric ceramic shock sensor.

1. Green line: 5 to 12V power supply
2. Black line: earth
3. Red line: signal output (output 1 second low power signal after detecting one shock) single chip interface.
4. Size: 50×30×20mm
5. Work temperature: -10°C ~ +50°C
6. Work current: 10mA
7. Advantages: omni-directional detection, sensitivity adjustable, the structure simple, low

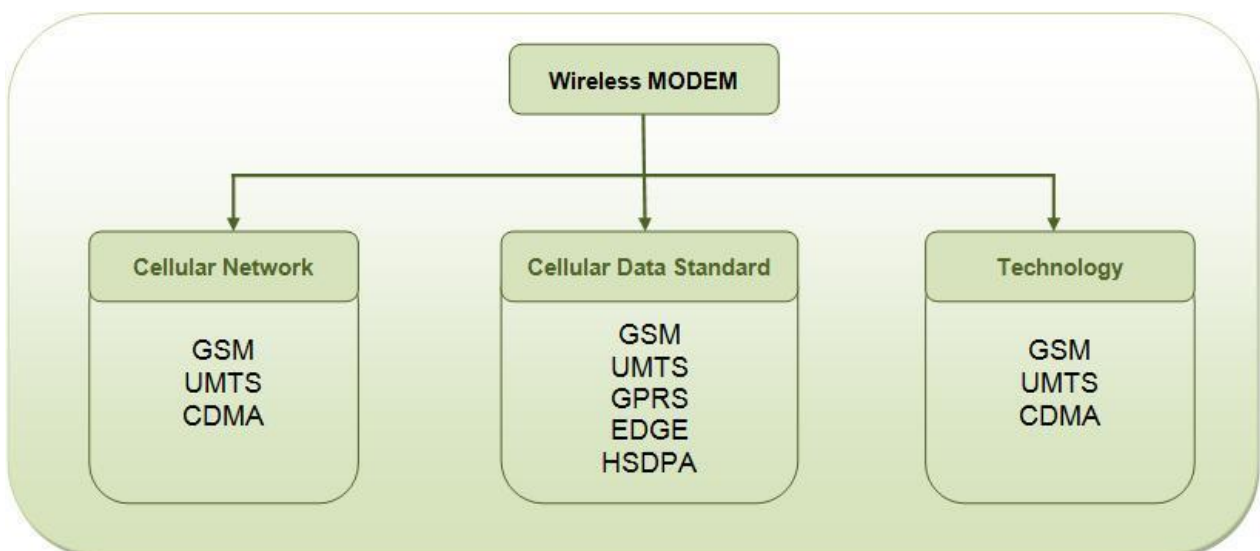
cost, high sensitivity, and continuously adjustable.

8. Sensitivity: there is a adjustment button, clockwise to increase sensitivity, anticlockwise to decrease sensitivity. When the detected vibration is greater than a certain level, the red indicator lights ON.

### **3 GSM Modem**

### 3.1 Wireless Modem

Wireless Modems are the Modem devices that generate, transmit or decode data from a cellular network, for establishing communication between the cellular network and the computer. These are manufactured for specific cellular network (GSM/UMTS/CDMA) or specific cellular data standard (GSM/UMTS/GPRS/EDGE/HSDPA) or technology (GPS/SIM). Wireless Modems like other Modem devices use serial communication to interface with and need Hayes compatible AT commands for communication with the computer (any microprocessor or microcontroller system). [20] .Fig 9 shows the wireless network, data standard and technology.



**Figure 9** The wireless network, data standard and technology

### 3.2 What is a GSM Modem?

The information is composed of digital signals by using "0" and "1" in the computer, but there are only analog signal in the telephone line. Thus when data is transmission through the telephone line, it needs a device for the digital-analog conversion (DAC). The DAC is called the Modem.

A GSM modem is a wireless modem that makes it possible to connect a computer to a GSM network. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in

order to operate. An external GSM modem is connected to a computer through a serial cable or a USB cable. It is possible to make and receive phone calls and send text messages. The main difference is that instead of a cell phone keypad and display, a computer keyboard and monitor are used. A GSM modem is connected to the computer. Communicate with the modem by typing AT commands in the command prompt of the software that came with the modem. [10]

### **3.3 What is a GPRS Modem?**

A GPRS modem is a GSM modem that additionally supports the GPRS technology for data transmission. GPRS stands for General Packet Radio Service. It is a packet-switched technology that is an extension of GSM. (GSM is a circuit-switched technology.) A key advantage of GPRS over GSM is that GPRS has a higher data transmission speed.

GPRS can be used as the bearer of SMS. If SMS over GPRS is used, an SMS transmission speed of about 30 SMS messages per minute may be achieved. This is much faster than using the ordinary SMS over GSM, whose SMS transmission speed is about 6 to 10 SMS messages per minute. A GPRS modem is needed to send and receive SMS over GPRS. Note that some wireless carriers do not support the sending and receiving of SMS over GPRS. [11]

If you need to send or receive MMS messages, a GPRS modem is typically needed.

### **3.4 EZ10 GPS**

The EZ10 GPS is the GSM modem device used in this final year project. EZ10 GPS is based on GM862 GPS module. The Telit EZ10-GPS GSM terminal is the complete GPS capable GSM modem solution for wireless m2m and mobile applications.

Based on Telit's impressive GM-862-GPS module it inherits the reliability and large feature set of this module including quad band GSM 850/900/1800/1900 reception, 20 channel SiRFStarIII GPS and integrated Python scripts interpreter.

The integrated Python interpreter offers the ability for the customer to run custom programs inside the modem, making it a complete self-contained unit for a variety of applications. Programmable GPIO ports and the IIC-Bus can be used to detect external signals, connect sensors, and to switch external devices. [12]

The EZ10-GPS can also be used as a standard GSM modem connected to a PC via RS-232 serial.

Key Features of the EZ10 GPS PY Terminal are shown in Table 1. and Fig.10.

**Table 1.** Key Features of the EZ10 GPS PY Terminal [12]

Feature	implementation
General	
Incorporates GM862 GPS module	The Telit GM862 GPS PY module handles all processing for audio, signal and data within the EZ10 GPS PY Terminal
Frequency bands	Quad band: GSM 850/900/1800/1900MHz
Power supply	Single supply voltage 5V to 30V
Operating temperature	-20 °C to +70 °C ambient temperature
Physical	Dimensions: 107mm x 64m x 33m Weight: 160g



**Figure 10** EZ10 GPS PY Terminal Telit Cellular GPS Engine [12].

The GSM feature is used in this final year project. The implementation on SMS has following

points.

- Point-to-point MT and MO
- Text and PDU mode
- Storage: SIM card plus 20 SMS locations in mobile equipment
- Transmission of SMS alternatively over CSD or GPRS.

Preferred mode can be user defined.

Table 2 shows some software in EZ10 GPS PY Terminal.

**Table 2.** Software in EZ10 GPS PY Terminal [12].

Feature	implementation
software	
AT commands	AT-Hayes GSM 07.05 and 07.07
TCP/IP Stack	TCP/IP stack Access by AT commands
Firmware update	Upgradeable via serial interface
PYTHON platform	<p>Major benefits: seamless integration into PYTHON applications, no need for application microcontroller, extremely cost-efficient hardware and software design – ideal platform for industrial GSM applications.</p> <p>The memory space available for PYTHON programs is 3.0 MB flash file system and 1.5 MB RAM. Application code and data share the space in the flash file system and in RAM.</p>

### 3.4.1 Interface Description



EZ10 GPS PY Terminal provides the following lists are connectors for power supply, interface and antennas, see the Fig. 11 [12]

1. SMA connector (female) for GSM antenna.
2. Led's GSM and Power indicators.
3. 9-pole (female) SUB-D plug for RS-232 serial interface.
4. SMA connector (female) for GPS antenna.
5. 4-pole 3mm Micro Mate-N-LOK connector for power supply and GPIO3.
6. SIM card holder.
7. 6-pole RJ11 plug (female) for 4 GPIOs or option audio, such as a Microphone and Speaker.  
Optional Audio Hand free card 3w, optional Relay card for GPIO5.



**Figure 11** EZ10 GPS PY Terminal side A and B view.[12]

### 3.4.2 Power Supply

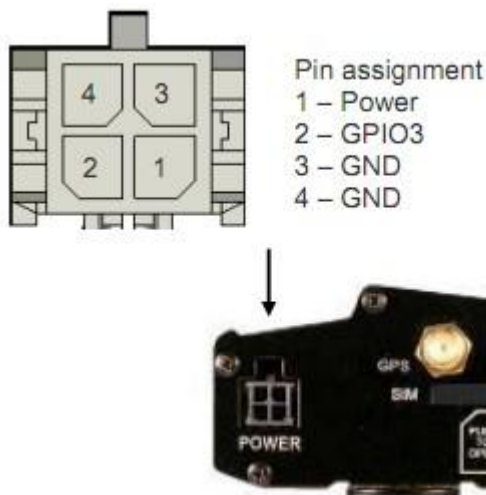
In Fig.12, that is the pin assignment for power supply. The DC power supply must be connected to the POWER input:

- Input voltage range: 12 - 24V DC
- Nominal Voltage 12V DC

Pin description:

- GND = Ground reference (1x POWER, 1x Signal)
- Input Power = 12 - 24VDC
- GPIO3 input CMOS 2.8 (voltage range allowed on)

this pin: 0-3,6VDC vs. GND)



**Figure 12** Male 4-pole plug for power supply [13]

### 3.4.3 Supply voltage requirements

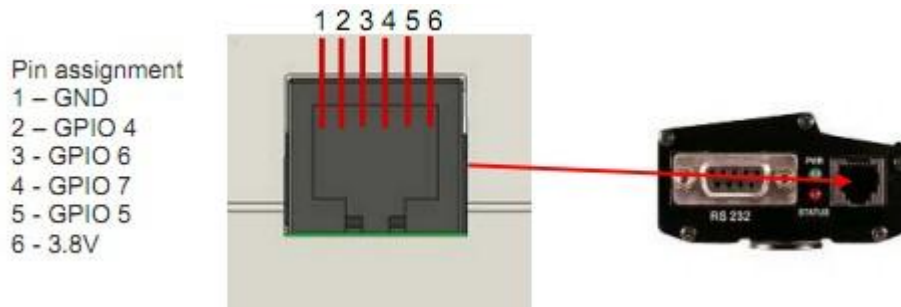
The DC power supply must be connected to the POWER input:

- Input voltage range 5 - 30V DC
- Nominal Voltage 12V DC
- Power Supply current rating: min. 1,2A @12V
- Power Supply ripple: max. 120mV
- Input current in idle mode: 20mA @ 12V
- Input average current in communication mode: 100mA @ 12V

### 3.4.4 GPIO Interface for RJ11 (AUX) connector

The EZ10 GPS PY Terminal provides four GPIO pins at the 6 pins interface connector.

Each GPIO line is ESD protected and a serial resistor of 100 Ohm is added. This avoids short circuits. The signal direction (input/output) of the GPIO lines is selectable with AT commands. We could see the GPIO number for RJ11 (AUX) connector in Fig.13 [13]



**Figure 13** Audio RJ11 plug (6/4-pole female)[13]

Table 3 shows the position of the GPIO pins on the IO interface connector. When the EZ10 GPS PY Terminal starts up.

**Table 3** Input / output Lines on the RJ11 GPIO interface [13]

pin	Signal	I/O	Function	Internal Pull UP	Type
1	GND	-	Power Ground (negative)/ Signal Ground		POWER/GND
2	GPIO4	I/O	Configurable general purpose I/O pin /		CMOS 2.8V
3	GPIO6 / ALARM	I/O	Configurable general purpose I/O pin / ALARM		CMOS 2.8V
4	GPIO7 / BUZZER	I/O	Configurable general purpose I/O pin / BUZZER		CMOS 2.8V
5	GPIO5	I/O	Configurable general purpose I/O pin		CMOS 2.8V
6	VMOD	O	Low power supply output (typically +3.8V DC)		POWER OUT

### 3.4.5 GPIO Interface Specification

All General Purpose input / output lines on the RJ11 GPIO interface have a 100 pF bypass capacitor to ground and are connected to the related pins of the Telit module over a 100 Ohms series resistor.

Table 4 shows the logic level specifications in the Telit EZ10-QUAD-PY terminal interface circuits.

**Table 4** Logic level specifications in the Telit EZ10-QUAD-PY terminal interface

<b>LEVEL</b>	<b>MIN</b>	<b>MAX</b>
Input high level	2.1 V	3.6V
Input low level	0 V	0.5 V
Output high level	2.2 V	3.0 V
Output low level	0 V	0.35 V

### 3.5 Telit GM862-GPS Modem

The Telit GM862 module is a small, lightweight and low power consumption device that allows digital communication services wherever there is a GSM 900 and DCS 1800 network. [14]

Telit GM862-GPS provides all the features of the GM862-QUAD version such as voice, circuit switched, Data transfer, phonebook, SMS four bands GSM capability. Moreover, the GM862-GPS integrate the “EASY SCRIPT” functionality. With the EASY SCRIPT feature the GM862-GPS become a finite product, they just need your script to be run. We could see the picture Telit GM62-GPS Modem in Fig.14. [14]



**Figure 14** Telit GM862-GPS module [14]

In Telit GM862-GPS modem, the core Engine is the GM862-QUAD.

Telit GM862-GPS main characteristics are as follow:

Core engine GM862-PY.

MMCX connectors for GSM.

GPS antenna connection.

Indoor tracking capability.

EASY SCRIPT python Interpreter.

Footprint compatible to GM862-Family.

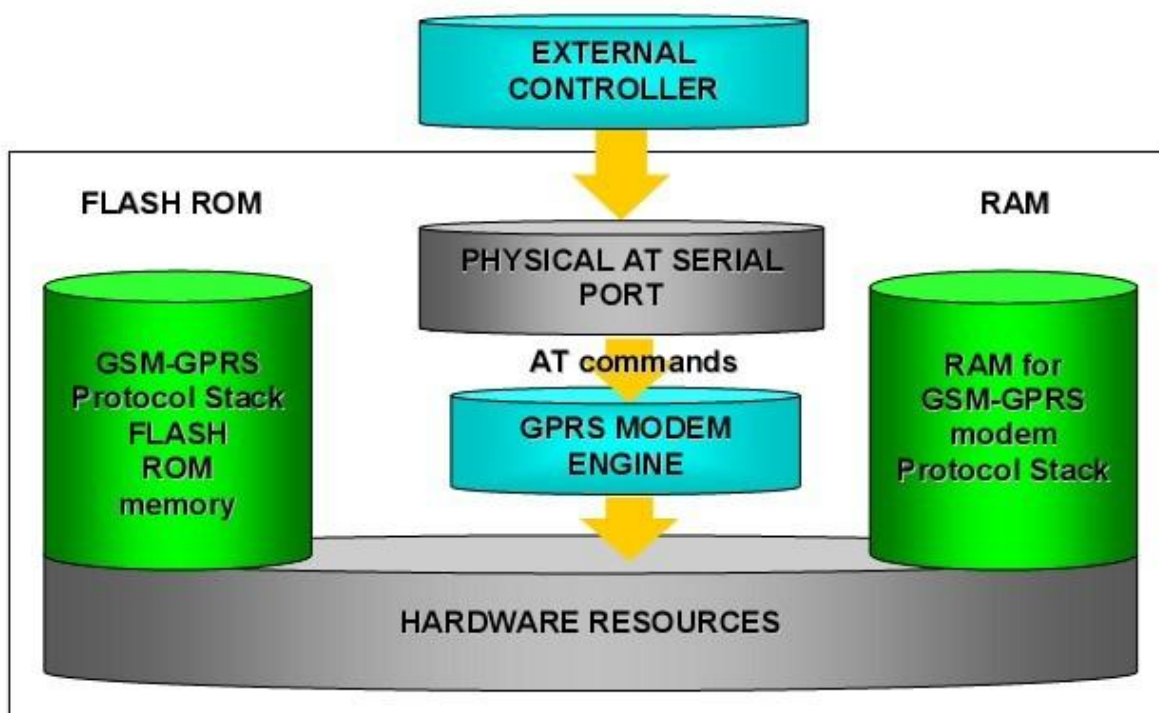
## 4. Python interpreter

### 4.1 Introduction to python

In this final year project, PYTHON program runs on the Telit GM862-GPS quad-band modem. Setup is done by AT command.

It was possible to use the Python programming language to read the shock digital signal and send SMS messages.

Python is a dynamic object oriented programming language that can be used for many kinds of software development. The python interpreter is aimed for the application usually done by a small microcontroller that managed some I/O pins and the module through the AT command interface. [13] Fig 15 shows the schematic of such configuration.

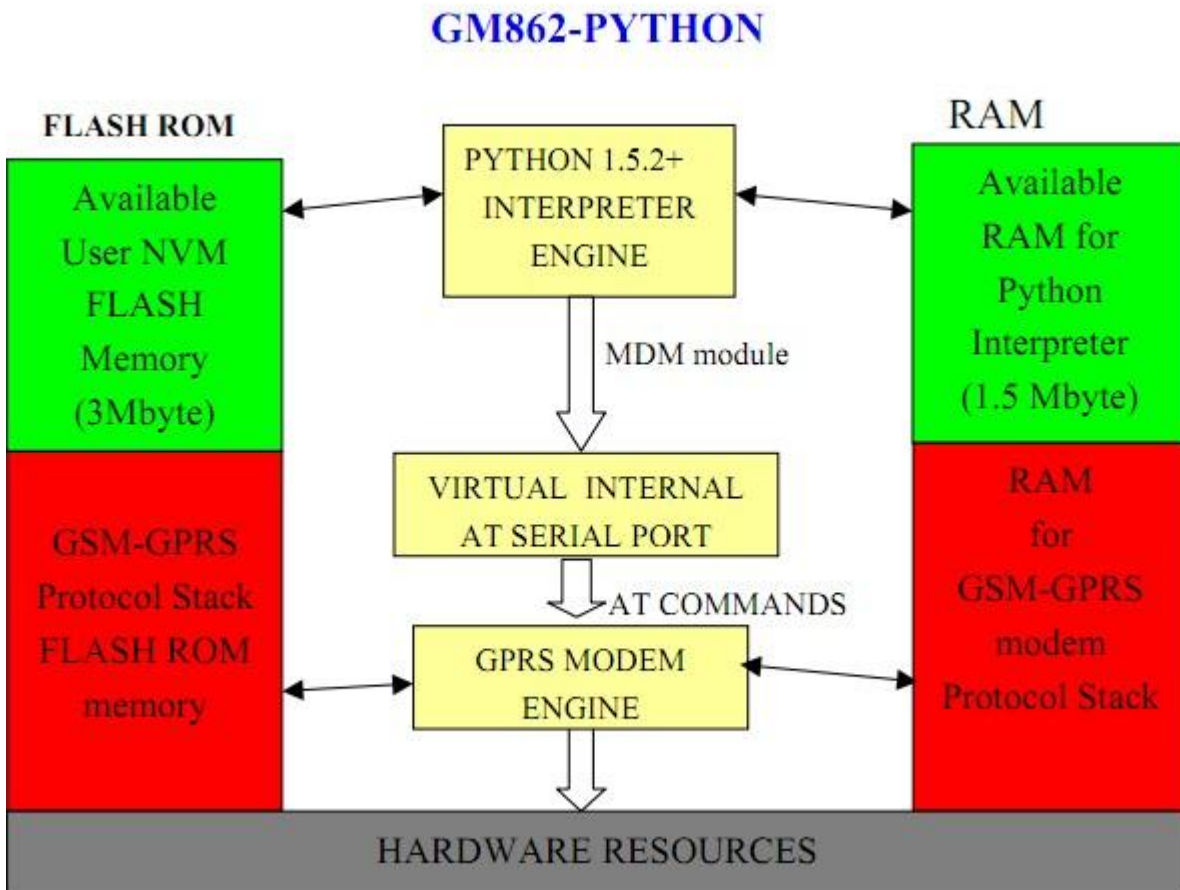


**Figure 15** The schematic of Easy script extension.[15]

In order to eliminate this external controller, and further simplify the programming of the sequence of operations, inside the GM862-PYTHON it is included:

- Python script interpreter engine v. 1.5.2+
- Around 3MB of Non Volatile Memory room for the user scripts and data
- 1.5 MB RAM reserved for Python engine usage.

A schematic of this approach is in Fig. 16.



**Figure 16** A schematic of this approach [16]

The MDM built-in module is the interface between python and the module AT command parser engine. It was used to send AT commands and data from python script to the network and receive responses and data from the network during connections.

The SER built-in module is the interface that allows python script to read from and write to the real physical serial port ASCO that is usually used to send the AT commands to the module.

The MOD built-in module is the interface between python and module miscellaneous functions. You need to use MOD built-in module if there is a need to generate timers in Python script, stop python execution, manage the power saving mode from your python script, etc. It is a collection of useful functions.

If the purpose is to use the MOD built-in module you need to import first:

Import MOD, then you could use MOD method like MOD.sleep(15) this blocks python script execution for 1.5s.

The GPIO built-in module is the interface between the python core and module internal general purpose input output direct handling. If you want to set GPIO values from python script and to read GPIO values from python script. You need the GPIO built-in module.

For example:

```
MDM.send("AT+CREG?\r")      <--- that gives the command
res = MDM.receive(20)      <--- that reads the response.
SER = for serial traffic (rs223, the connection to the PC)
    ... to send text to PC: SER.send("hi there\r")
```

The following are examples about the send SMS in python code.

```
import MDM
import SER
import MOD

file = open('log.txt', 'wb')
file.write('sendSMS.py LOKI AUKI\r\n')

SER.set_speed('115200')
SER.send('sendSMS.py\r\n\r\n')

num = "" # enter the phone number (+358466440535)
message = "" # enter the message

SER.send('phone number: ' + num + '\r\n')
SER.send('message: ' + message + '\r\n\r\n')
file.write('phone number: ' + num + '\r\n')
```



```

file.write('message: ' + message + '\r\n\r\n')

timer = MOD.secCounter() + 200

SER.send('Searching for operator...\r\n\r\n')
file.write('Searching for operator...\r\n\r\n')
res = MDM.send('AT+CREG?\r',0)
res = MDM.receive(5)

while ((res.find('+CREG: 0,1') == -1) and (res.find('+CREG: 0,5') == -1) and
MOD.secCounter() < timer):
    res = MDM.send('AT+CREG?\r',0)
    res = MDM.receive(5)

SER.send('AT+CREG: OK\r\n\r\n')
file.write('AT+CREG: OK\r\n\r\n')

SER.send('Changing the SMS format to text\r\n\r\n')
file.write('Changing the SMS format to text\r\n\r\n')
res = MDM.send('AT+CMGF=1\r',0)
res = MDM.receive(20)

while(res.find('OK') == -1 and res.find('ERROR') == -1):
    res = MDM.receive(5)

if(res.find('ERROR') != -1):
    SER.send('ERROR')
    file.write('ERROR setting message format')
else:
    SER.send('Sending the message...\r\n\r\n')
    file.write('Sending the message...\r\n\r\n')
    # initialize the message
    res = MDM.send('AT+CMGS=' + num + ';\r', 0)
    # wait for answer
    res = MDM.receive(5)

    # if the > character is found, the module is ready to receive the
message
    if (res.find('>') != -1):
        # enter the message
        res = MDM.send(message, 0)

```

```

# end the message
ret = MDM.sendbyte(0x1A, 0)

ok = MDM.receive(5)

while(ok.find('+CMGS:') == -1 and ok.find('ERROR') == -1):
    res = MDM.receive(5)
    ok = ok+ res

if(ok.find('+CMGS:') != -1):
    SER.send('Message sent\r\n\r\n')
    file.write('Message sent\r\n\r\n')
if(ok.find('ERROR') != -1):
    SER.send('ERROR\r\n\r\n')
    file.write('ERROR sending message\r\n\r\n')
else:
    if(res.find('ERROR') != -1):
        SER.send('ERROR\r\n\r\n')
        file.write('ERROR initializing message\r\n\r\n')
    else:
        SER.send('The module is not responding\r\n\r\n')
        file.write('The module is not responding\r\n\r\n')

```

Telit has several custom libraries that make things a lot easier:

- MDM
- MDM2
- SER
- SER2
- GPIO
- MOD
- SPI
- IIC
- GPS

The most used libraries are the MDM interfaces. These are used to send commands to and from the module. MDM and MDM2 use different AT instances. The device can be controlled from either one. For my project, it came in handy to multitask a bit by using MDM to send Telnet packets directly to the SER interface while reading the connection status on the MDM2 interface.

## 4.2 Execution of Python Script

When we run the python project, two steps are needed, this is shown in Fig.16

First



Second



**Figure 17** the steps when we run the python. [16]

At the first switch on, all the scripts are compiled. This operation could take time depending on scripts complexity. Other times only the main is compiled-----quicker.

After the complete “compiling operation”, the compiled scripts will have the extension .pyo. The “functions” source files (.py) could be deleted from NVM if compiled scripts (.pyo) are present. [16]

Fig.18 shows the steps need to update a python script.



**Figure 18** the steps need to update the python. [16]

The following are automatic run code:

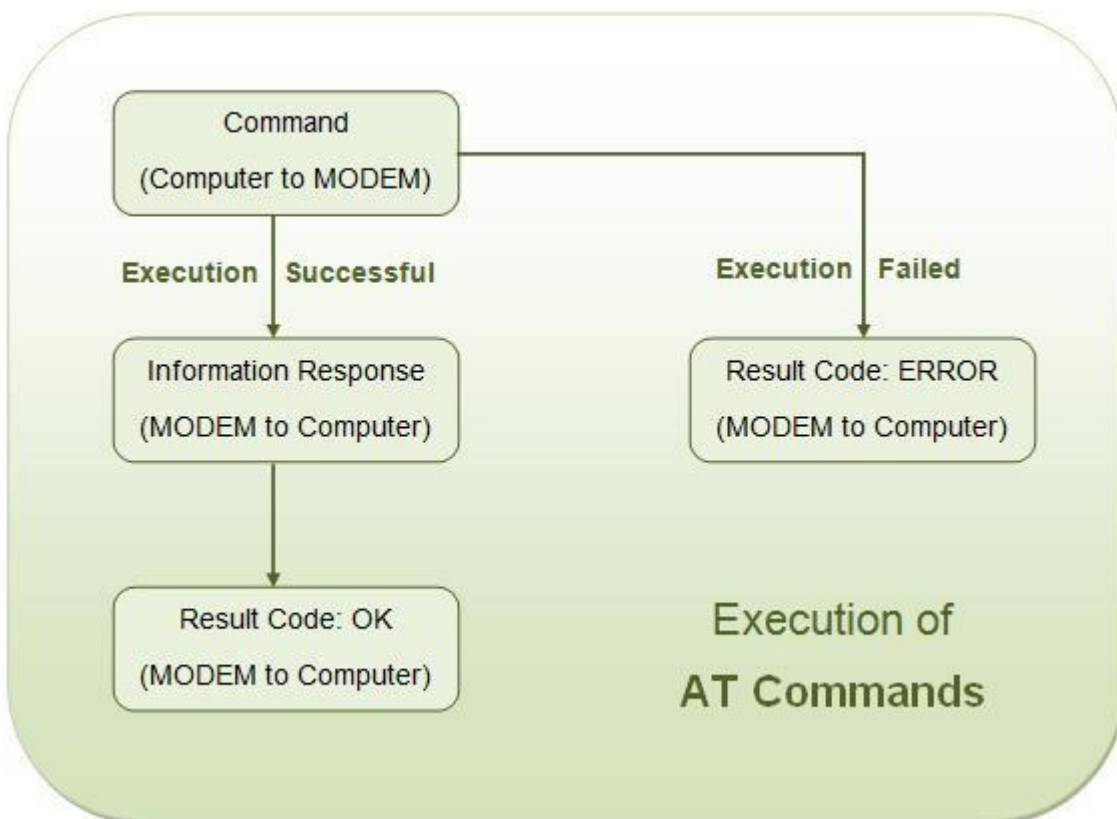
```
import shocksens
```

```
if __name__ == '__main__':  
    shocksens.main()
```

## 5. AT Command

### 5.1 A Brief Description about AT Commands

AT is the abbreviation for Attention. AT commands are instructions used to control a modem, it is an essential part of this work. Because that's the way how to communicate with the modem from code (python program). The Telit wireless module family can be driven via the serial interface using the standard AT command. Fig 19 shows the execution of AT commands.



**Figure 19** the execution of AT commands. [16]

There are two types of AT **commands**:

1. Basic commands are AT commands that do not start with a "+". For example, D (Dial), A (Answer), H (Hook control), and O (Return to online data state) are the basic commands.
2. Extended commands are AT commands that start with a "+". All GSM AT commands are extended commands. For example, +CMGS (Send SMS message), +CMGL (List SMS messages), and +CMGR (Read SMS messages) are extended commands. [17]

When starting to work with AT commands to setup and check the status of the GSM modem, it can be done like this:

AT	Returns a "OK" to confirm that modem is working
AT+CPIN="xxxx"	To enter the PIN for your SIM ( if enabled )
AT+CREG?	A "0,1" reply confirms your modem is connected to GSM network
AT+CSQ	Indicates the signal strength, 31.99 is maximum.

## 5.2 the AT Commands be used

The following are some AT commands that were used in my experiments.

AT+CGMR // returns the software version information

AT+CGMM// returns the Telit module identification.

### Examples

#### Checking the software version

```
AT+CGMR
```

```
07.02.604-A014
```

```
OK
```

Checking the module identification

```
AT+CGMM
```

```
GM862-QUAD
```

AT+CMGF//Check if your GSM modem supports SMS text mode.

**AT+CMGF=1 <ENTER>**

**If the modem reponds with "OK" this mode is supported.**

AT+CREG// mobile network registration status.

AT+CPIN// put PIN code to register with the GSM network.

AT+CMGS// Send SMS message

AT#CGMI// Request manufacturer identification.

AT#/CGMM //Request model identification.

AT#CGMR //Request revision identification.

AT#CGSN //Request product serial number identification.

AT#CIMI //Request international mobile subscriber identity (IMSI)

AT #WSCRIPT// download the script in the module.

AT#DSCRIPT // this deletes file from module.

AT#EXECSCR//Starts to run program.

AT #LSCRIPT //list the scripts on the modem.

AT#ESCRIPRT // this chooses the script to run at startup.

AT#SELINT // read command reports the current interface style.

AT #GPIO// Genreal purpost input/output pin control.

The following AT commands can be used to send SMS via hyper terminal.

AT

OK

AT+CMGF=1

OK

```
AT+CSCA="number of message centre"  
OK
```

```
AT+CMGW="Mobile number"
```

```
> A simple demo of SMS text messaging. (When finished, press Ctrl+z of  
the keyboard.)
```

```
+CMGW: 1 (note this number)
```

```
OK
```

```
AT+CMSS=1 (the number is from returned value of CMGW)
```

```
+CMSS: 20
```

```
OK
```

If an OK is received then the SMS was sent successfully.

The default behavior is to always send SMS using the CS domain but it is possible to send SMS over PS domain. This is sometimes used by data cards that have not implemented the complete functionality of CS domain. To send SMS over PS domain, the following AT command is required.

```
AT+cgsms=0
```

where

0 = PS Domain

1 = CS Domain

2 = PS Domain preferred (else use CS Domain if GPRS not available)

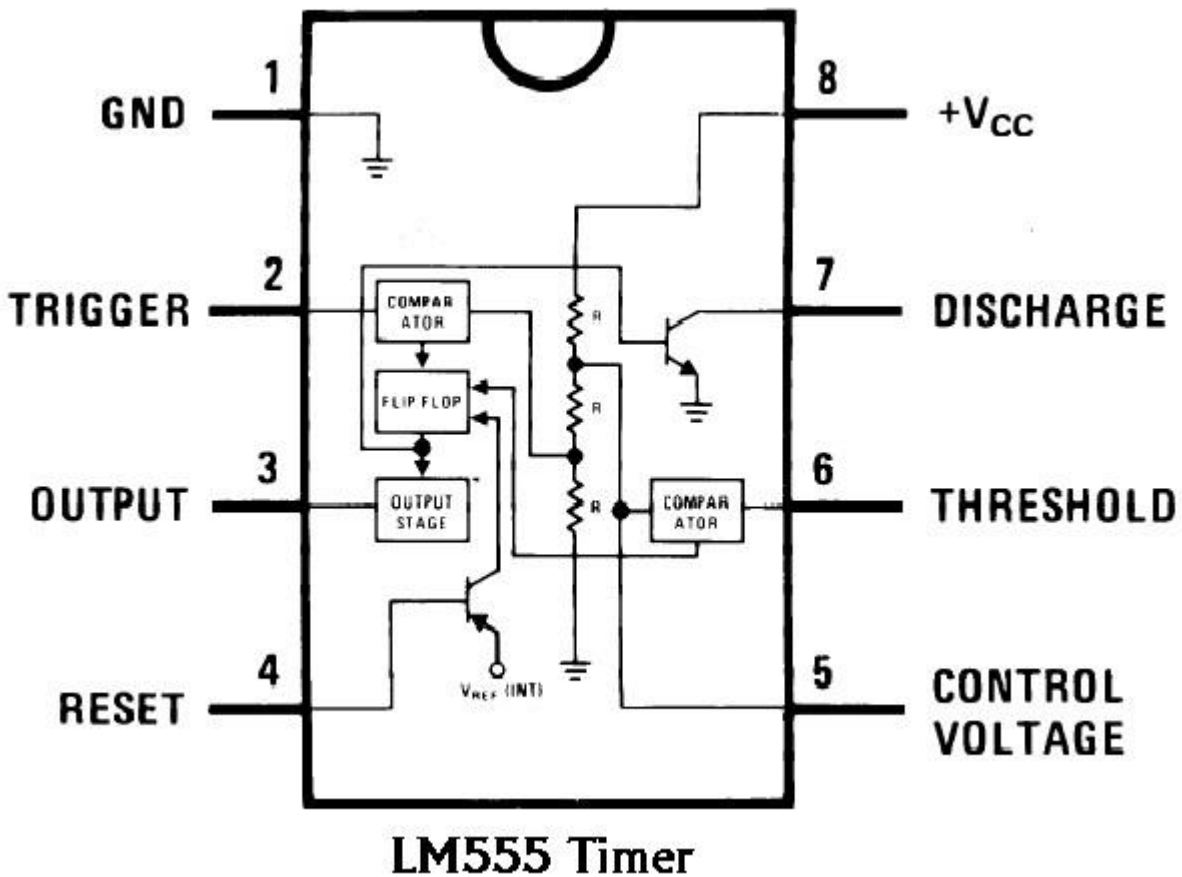
3 = CS Domain preferred (else use PS Domain if CS is not available)

If you use AT+cgsms=0 and if the SGSN is not configured for SMS then the sending of SMS will fail and the UE will resend the SMS automatically using CS Domain.



## 6. LM555 Monostable Circuits

In the actual experiments, a LM555 monostable timer circuit and Schmitt trigger were needed. LM555 produces one pulse of a set length (time period  $T$ ). Fig 20 shows the LM555 Timer Internal circuit block diagram.



**Figure 20** LM555 Timer Internal Circuit Block Diagram

In order to get the time period  $T=10S$ , It is essential to design a circuit. The circuit diagram of 555 monostable circuit is given in Fig 21. The resistor value  $R$  and the capacitor value  $C$  are unspecified. The values of these components determine the length of time.

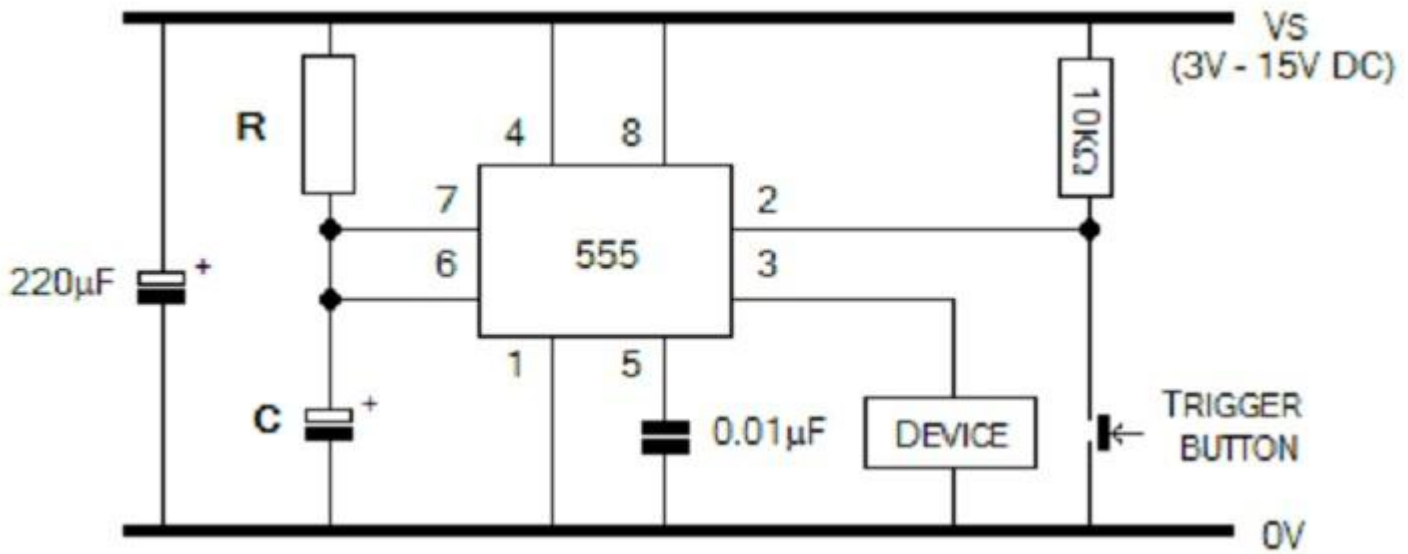
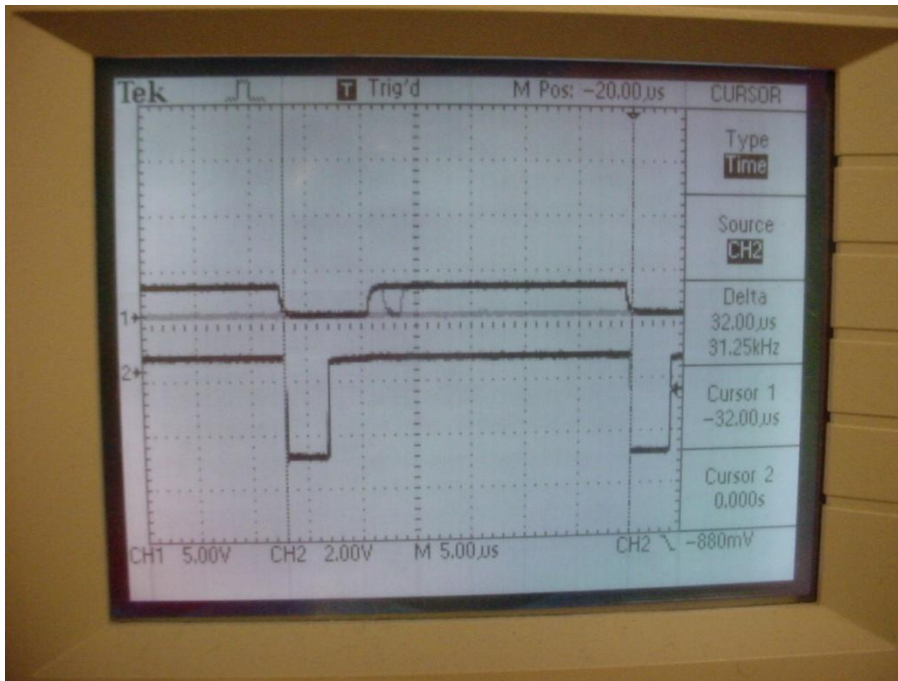


Figure 21. 555 monostable Circuit given in my experiment

## 7. Test and Analysis

### 7.1 Test for Shock Sensor

When shock has happened, after connected with LM555 Monostable circuit and Schmitt trigger circuit, it is possible to read the signal in oscilloscope (shows in Fig 22).



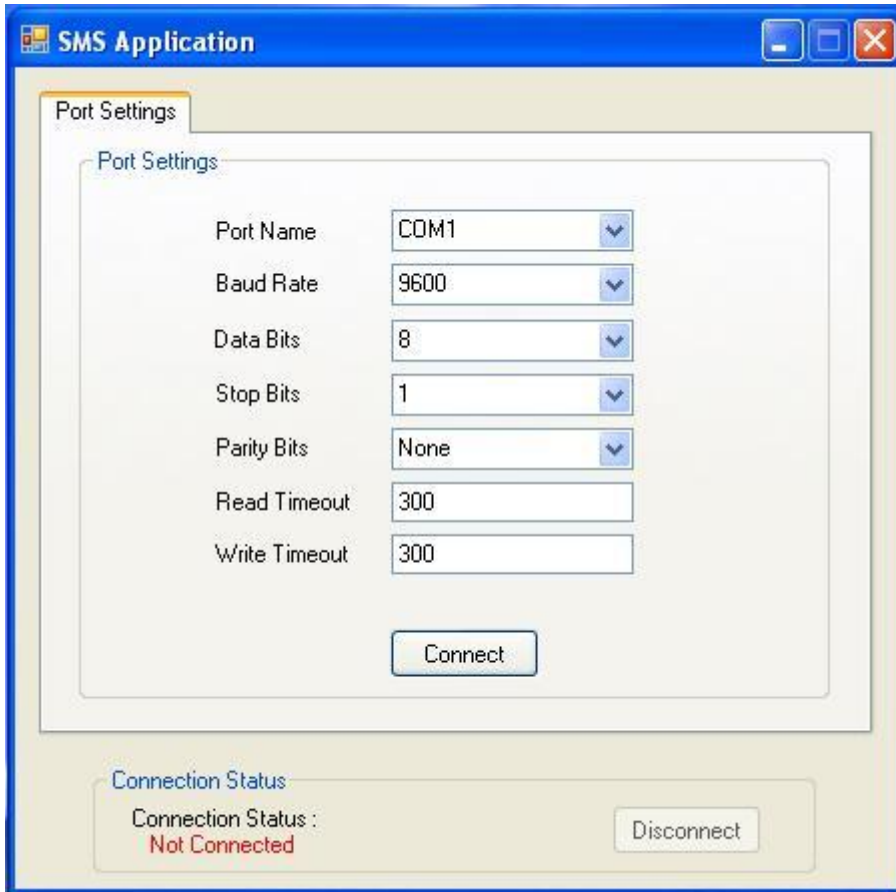
**Figure 22.** Shock signal in oscilloscope

### 7.2 Test for Sending SMS through GSM modem

In general, there are two ways to send SMS messages from a computer to a mobile phone:

1. Connect a mobile phone or GSM/GPRS modem to a computer. Then use the computer and AT commands to instruct GSM/GPRS modem to send SMS messages.
2. Connect the computer to the SMS center (SMSC) or SMS gateway of a wireless carrier or SMS service provider. Then send SMS messages using a protocol / interface supported by the SMSC or SMS gateway.

As we seen in Fig 23, it possible to do port settings which will be the same as you did in the hyper terminal and then click the OK button. If the modem is connected successfully, a message box will appear with the message “**Modem** is connected”.

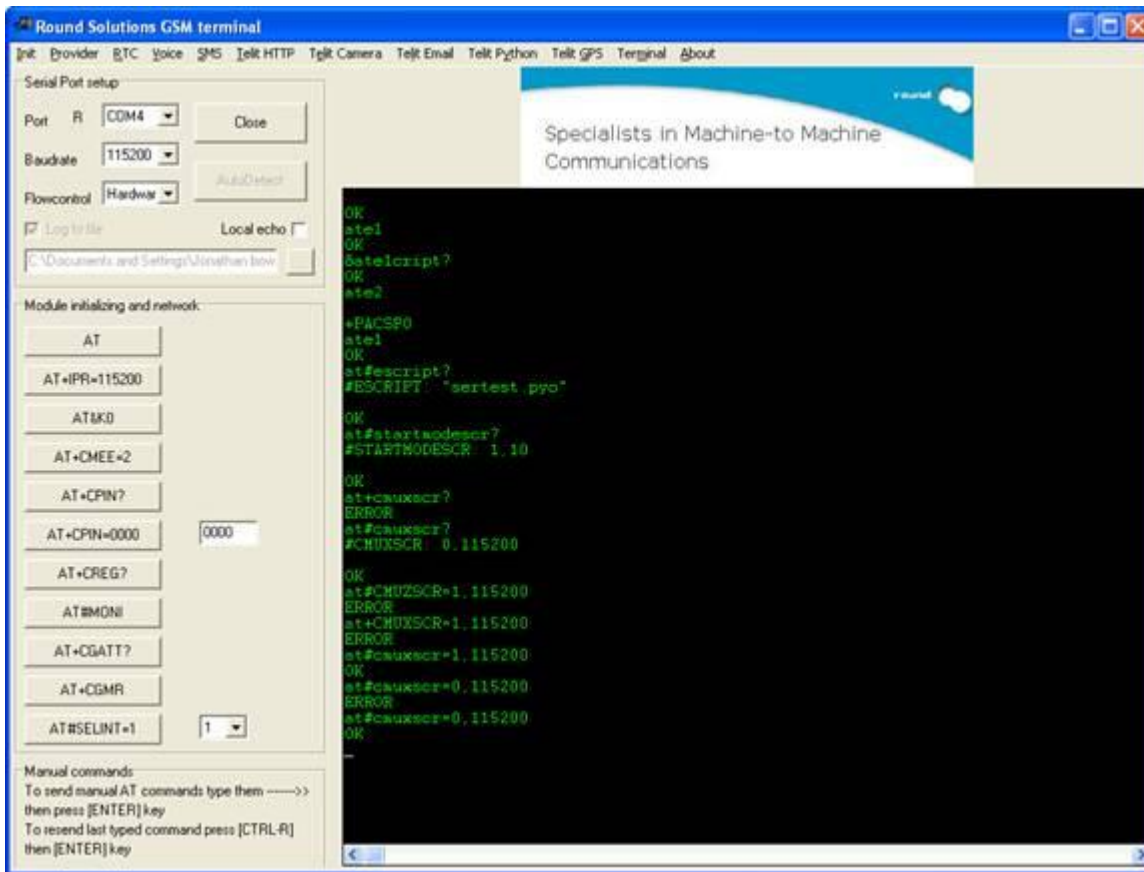


**Figure 23.** port setting in SMS application

- Type "AT" in the main window. A response "OK" should be returned from the GSM modem.
- If “OK” returns, it means your modem is connected successfully.

After successful connection with PC, It could run this application. Download the attached project and run the application. Table 5 lists the AT commands that are related to the receiving and reading of SMS messages.

Now comes the hard part. When connecting to the device that is running Python code, it is possible to see in Fig 24. It is also needed to give it time to startup and begin running.



**Figure 24.** GSM modem is running python code

**Table 5** commands that are related to the receiving and reading of SMS

AT command	Meaning
+CNMI	New message indications
+CMGL	List messages
+CMGR	Read messages
+CNMA	New message acknowledgement

Below shows a simple example that demonstrates how to use AT commands and the HyperTerminal program of Microsoft Windows to read SMS text messages received by a GSM modem. The lines in bold type are the command lines that should be entered in HyperTerminal. The other lines are responses returned from the GSM modem.

**AT**

OK

**AT+CMGF=1**

OK

**AT+CMGL="ALL"**

+CMGL: 1, "REC READ", " +358466440535 ", , "10/1/11,00:30:29+32"

+CMGL: 2, "REC READ", " +358466440535 ", , "10/1/11,00:32:20+32"

OK

Line 3: The AT command +CMGF is used to instruct the GSM modem to operate in SMS text mode. The result code "OK" indicates the command line "AT+CMGF=1" has been executed successfully. If the result code "ERROR" is returned, it is likely that the GSM modem does not support the SMS text mode. To confirm, type "AT+CMGF=?" in the HyperTerminal program. If the response is "+CMGF: (0,1)" (0=PDU mode and 1=text mode), then SMS text mode is supported. If the response is "+CMGF: (0)", then SMS text mode is not supported.

### 7.3 Analysis

In this actual experiment, a lot of actual practice difficulties were solved. Like interfaces between EZ10 and Shock sensor, power supply for different devices, sensitivity of the python language, designing the timer circuit and so on.

Firstly, I choose some possible shock sensors and understand how they work. And then, choose piezoelectric ceramic one for this experiment. The shock signal is too short so the EZ10 modem cannot read the digital signal. It is essential to design a timer circuit. I connected with LM555 Monostable circuit and Schmitt trigger circuit, then it is possible to get the suitable shock signal. The shock sensor is working.

Secondly, it is the software python code. The python code for this final year project has two parts, the first part is to read the signal and the other part is to send SMS, there are some errors in python code of the reading part, the sending SMS part is working. Due to the actual practice ability and time, this experiment is half finished. This experiment still needs some modifications to be done in

the python code. If this experiments continue to be done some deep research. This remote shock monitoring device could be put into use in the future. Besides, the remote control together with GPS is very popular.

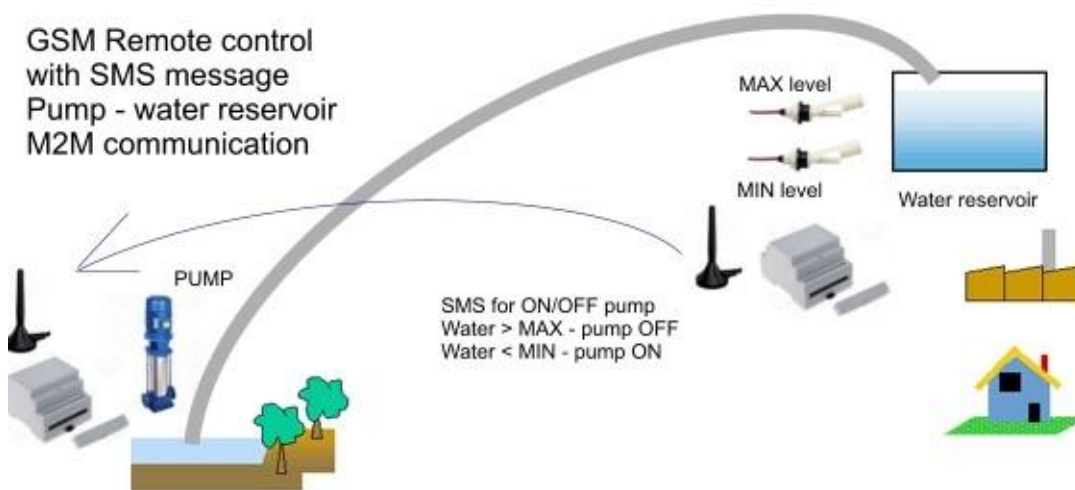
During the last few months, I read materials and the knowledge related on sensor technology, shock sensor, piezoelectric ceramic characterics and applications, GSM modem and so on. This will be very helpful for my future study.

## 8. Various applications on Remote Control over GSM via SMS

Based on m2m communication technology. Remote Control over GSM channel via SMS message. It was used very often and has a big development place in the future.

Like GSM Alarm systems, GSM Remote control (You can transmit command messages and switch remote equipment ), GSM Monitoring and GSM Telemetry.

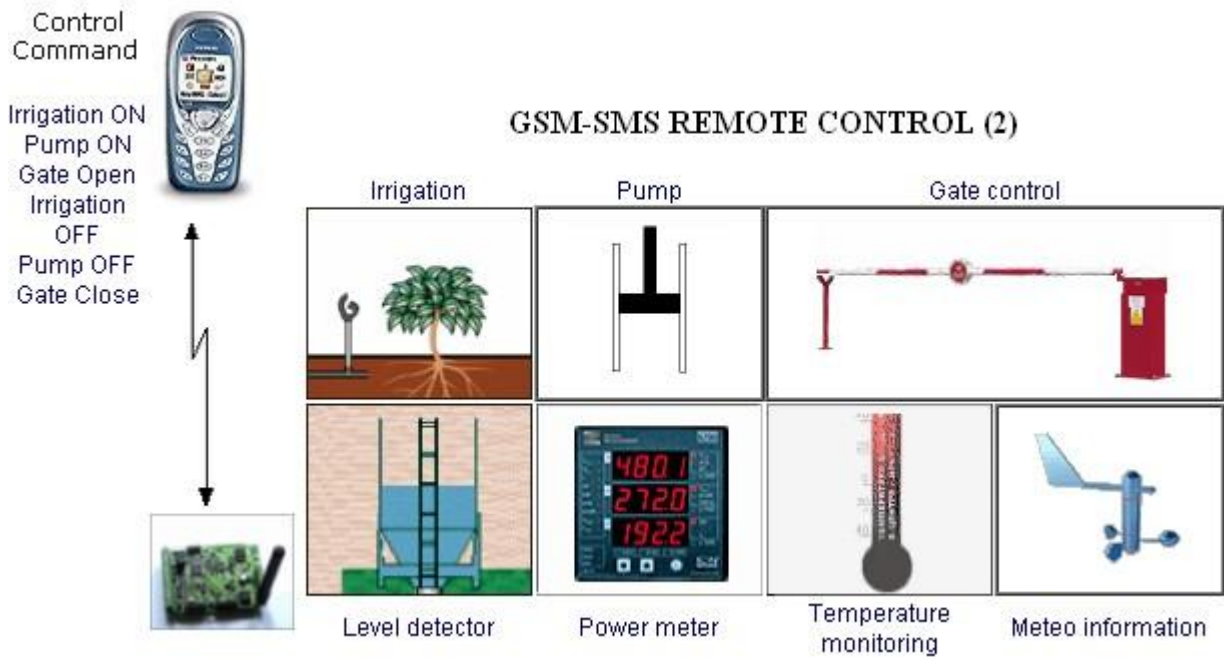
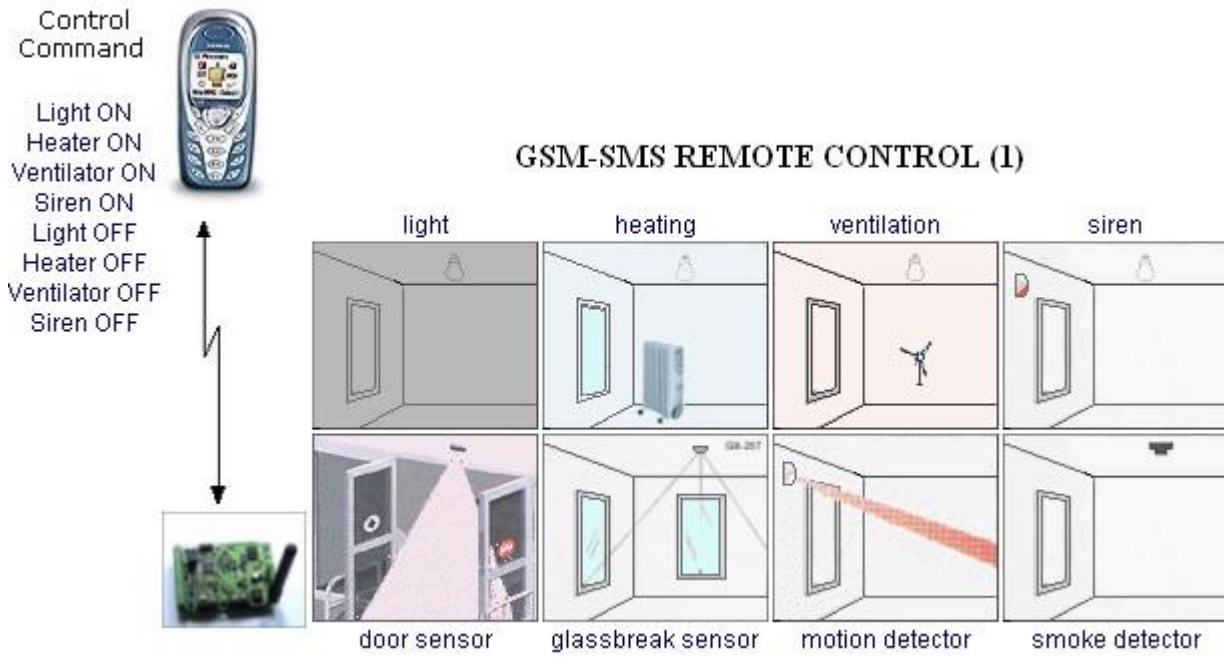
Fig 25 shows an example about remote control with SMS on pumping station.



**Figure 25.** Remote control with SMS on pump-water reservoir.

It is possible for us to receive SMS messages at occurrence of the certain events - operation of entrance sensors. We could also transmit command messages and switch the output - switch on/off remote equipment. In Fig.26 shows some various applications using the GSM-SMS remote control.





**Figure 26.** Some various applications about GSM-SMS remote control.

## **9. Conclusion**

I spent several months on this final year work, a lot of knowledge and skills to understand. I studied things about different kinds of shock sensor technologies, piezoelectric ceramic characteristics, python programming and AT commands. I made a half-finished python code for reading the sensor (digital input) and sending the SMS message through GSM mobile communication technology. The code needs some modifications and if that is done, it could be put into use in the future. If have a chance, I will continue to study in this field.

Being an undergraduate of Information Technology, this project provided me a good opportunity to study and improve my professional knowledge. It made me understand more about remote alarm, remote monitor system and know more ways about mobile technology applications. This will be very helpful for my future study and job career.

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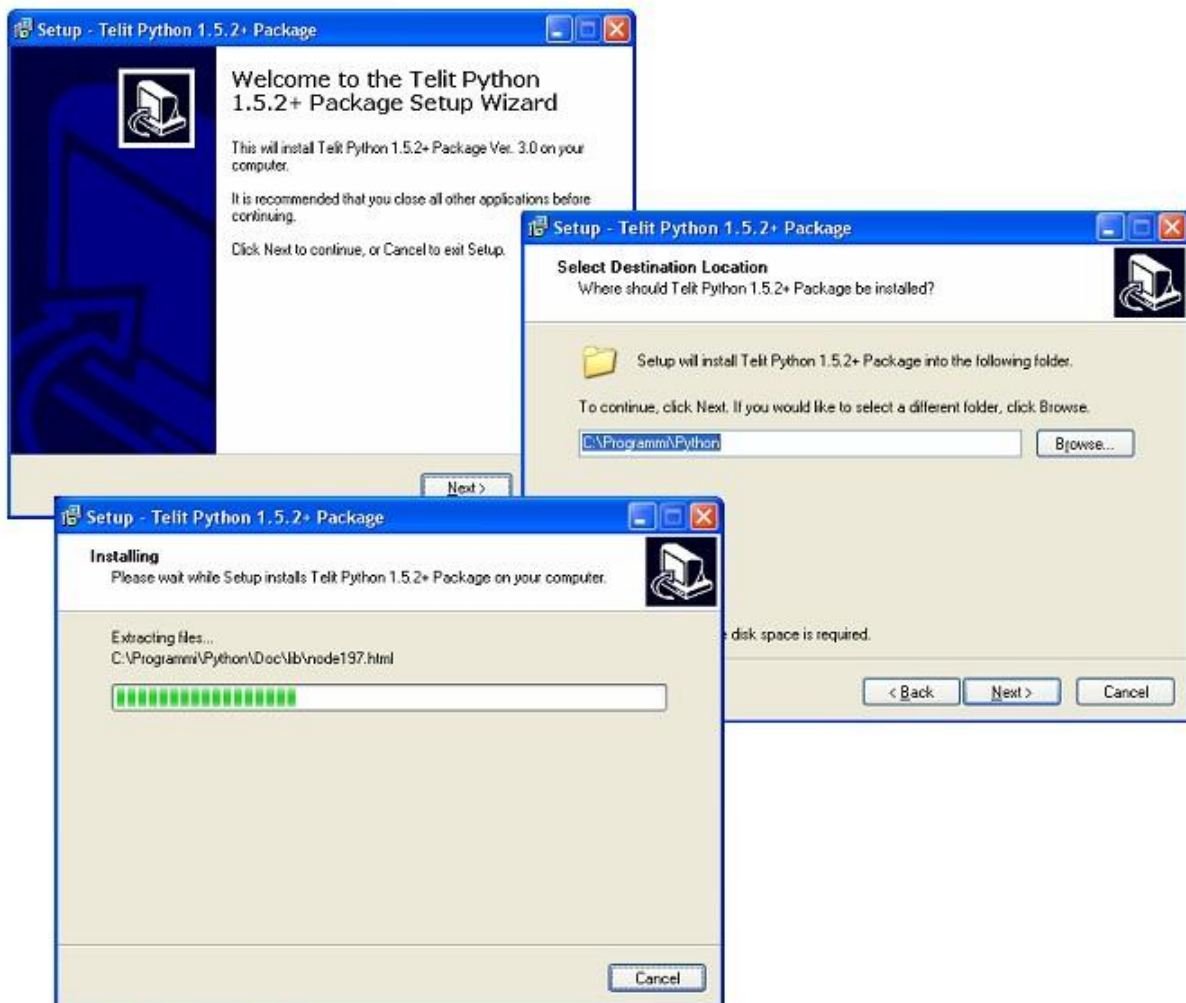
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## APPENDICES

### A.1 Installing of python

Download and get the python Win package 1.5.2+ with the latest version Telit PY 1.5.2+\_V3.0.exe. The installation conditions the Python compiler package. The Telit Python package is placed in the folder C:\programme files\python\. The correct path in the windows Environmental variables will be set up automatically.

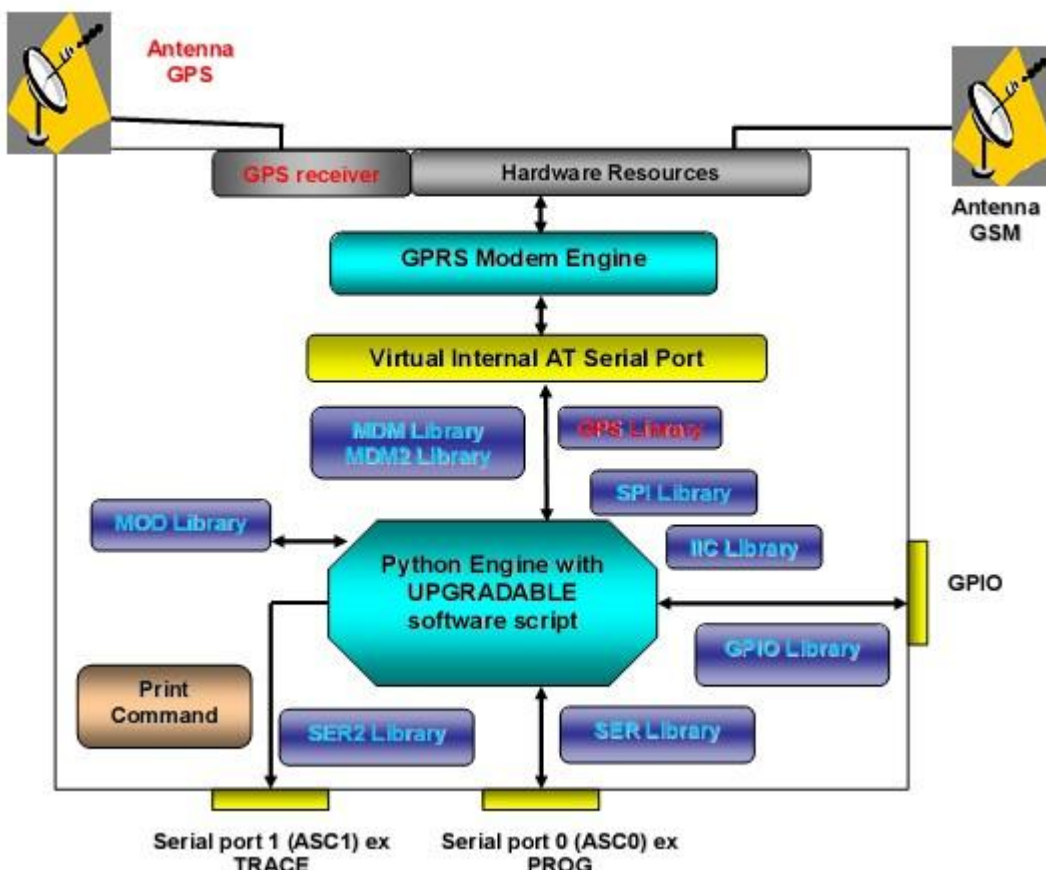


## A.2 python implementation description

Python scripts are text files stored in NVM inside the Telit module. There is a file system inside the module that allows writing and reading files with different names on one single level.

It is possible to run only one python script at the time. The python script is executed in a task inside the Telit module at the lowest priority, making sure this does not interfere with GSM/GPRS normal operations. This allows serial ports, protocol stack, etc. to run independently from the python script.

The python script interacts with the Telit module functionality through four build-in interfaces



Note: Antenna GPS, GPS receiver and GPS library are available exclusively for GPS modules GM862-GPS and GM863-GPS. Moreover SER2 library cannot be used by the GPS modules since their TRACE port is not available.

### A.3 software python code in my final work.

The appendices A.2 is to show the software program that it is developed to be implemented.

```

import MDM
import MOD
import GPIO
import SER

TRUE = 1
FALSE = 0

def SendSMS(message,number):
    SER.send(res)
    etimer=MOD.secCounter()+100
    SER.send('\r\nSendSMS: Start')
    res = MDM.send('AT+CREG?\r',20)
    SER.send(res)
    SER.send('\r\nSendSMS: connection check ok')
    res = res + MDM.send('AT+CMGF=1\r',20)
    SER.send(res)
    SER.send('\r\nSendSMS: textmode ok')
    if(res.find('ERROR') == 1):
        SER.send('\r\nSendSMS: Error')
        return FALSE
    else:
        res = MDM.send('AT+CMGS=' + number + ';\r', 0)
        res = MDM.receive(20)
        if(res.find('>') != -1):
            SER.send('\r\n#')
            res = MDM.send(message, 0)
            res = MDM.sendbyte(0x1A, 0)
            ok = MDM.receive(5)

```

```

while((ok.find('+CMGS:') == -1 and ok.find('ERROR') ==
-1) and (MOD.secCounter() < etimer)):
    res = MDM.receive(5)
    ok = ok + res
    SER.send('#')
    if(ok.find('+CMGS:') != -1):
        SER.send("\r\nSendSMS: OK')
        return TRUE
    elif(ok.find('ERROR') != -1):
        SER.send("\r\nSendSMS: Error 2')
        return FALSE
    else:
        SER.send("\r\nSendSMS: Error?')
        return FALSE
else:
    SER.send("\r\nSendSMS: Error 3')
    return FALSE
return FALSE

def main():
    SER.set_speed('115200')
    SSstate = FALSE;
    ShockAlarm = FALSE;
    ShockAlarmSent = FALSE;
    SER.send("\r\nSER connection initialized!\r\n')
    while 1 == 1:
        SER.send("\r\nMAIN-LOOP!')
        SER.send("\r\nBEFORE SLEEP!')
        MOD.sleep(100)
        #sleep for 10s
        SER.send("\r\nafter SLEEP!')
        #SSstate = GPIO.getIOvalue(5) # read state of
GPIO 5
        SSstate = TRUE
        SER.send("\r\nafter gpio getvalue')

```



```

SSstate = int(SSstate) #
convert to integer
SER.send('\r\nafter gpio value conversion to int')
if ((SSstate == TRUE) | (ShockAlarm == TRUE)): #i
(shockSensorState OR ShockAlarm)
ShockAlarm == TRUE #
sets ShockAlarm to true
SER.send('\r\nSHOCK\r\n') #
prints text SHOCK to terminal
ShockAlarmSent=SendSMS('my message is
something...','0466440535') #sends text message to masternumber
if ShockAlarmSent == TRUE: # if ShockAlarm
was sent..
ShockAlarm == FALSE # reset
ShockAlarm to false

```

