International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

Design and Development of Digital-Analog Seismograph

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Abstract— ***The analog Seismograph is a device designed and developed to monitor process and record the field seismic data from remote sites. This data contains the timing information which is usually recorded on paper wrapped around drum. Being generating only the hardcopy, the data however cannot be uploaded on seismic software for analysis purpose along with ease of calculations. Not only this, due to limited memory base, frequent changing of drum rolls is required which often leads to delays. These problems can be removed by digitization of the system which with increased efficiency also provides miniaturization of the system. In this work we have used LattePanda a windows 10 development board to run the system. LattePanda has added advantage of raspberry pie and windows 10 IoT core processor. Accelerometer and seismometer is interfaced with LattePanda to measure seismic vibrations. These motions guide the pen movement of the drum which is further incorporated with stepper motors NEMA 14 and NEMA 17 for quick and robust response. Timing and positioning information of the location along with coordinates of the working satellites and present location of the seismometer is decoded using NEO-6m gps module. The graphical visualization of the entire satellites actively passing data to the module is taken through u-blox u-centre gnss evaluation software tool For sending this data on remote servers, Python based TERA TERM software is utilized. With all these parameters now at our disposal, debugging is enhanced and analysis becomes much more easier. Pre-events calculations with digitization not only become feasible but also allow precautionary measures possible.***

Index Terms— ***LattePanda; Seismograph; Stepper motor; NEO 6m; Accelerometer, NMEA Motors.***

I. INTRODUCTION

The ways in which earthquakes are recorded and the data are analyzed have changed drastically in the past few years. The analog seismograph is a device designed and developed to monitor process and record the field seismic data from remote sites. The electrical signal produced by the short period seismometer due to ground motion is fed directly to the analog recorder. This recorder processes the seismic signal, which is extremely low in amplitude and is highly corrupted with dominant background noise. The whole seismic data is tagged with the internally generated time clock, which can be synchronized with reference ATA Timing Signal transmitted by NPL, New Delhi.

Revised Manuscript Received on February 28, 2020.
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The duly processed data tagged with timing information, is finally recorded on a smoked paper wrapped on a drum. [8] With drum rotation rate of 30,60,120,240 mm/min, it can record data continuously for 10 days.This conventional method of communication uses analog signals for long distance communications which suffers from data loss due to distortion, interference etc. Also they are triggered by a specific threshold of acceleration which means the first motions are often not recorded. Along with these limitations frequent changing of drum rolls is required as the storage capacity is limited, and complex circuitry makes the system very heavy which decreases its portability. Figure 1 depicts the traditional analog seismic recorder.

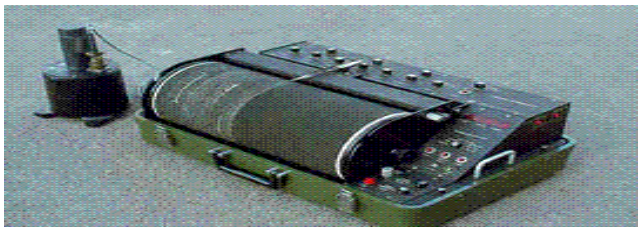


Fig 1 Analog seismic recorder

The digital instruments and the computers have replaced the traditional drum recorders of seismographs. Analog seismometers required daily seismogram paper changes, in contrary to the modern digital seismograph recorders which provide more and better data. In this work we used LattePanda to run the system. LattePanda offers windows 10 iot core and a raspberry pi, giving us a combined development platform and iot device. that's a big win, as we can write code on the LattePanda push it to the arduino. it has much faster response time and can be called combination of both raspberry pi and arduino leonardo. Figure 2 gives the block diagram of working of analog seismic recorder.

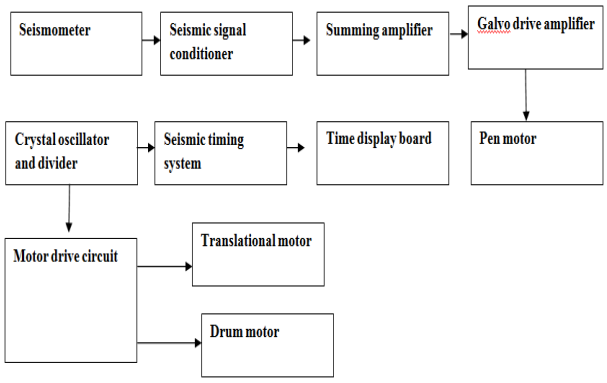


Fig 2 Working of analog seismic recorder

II.WORKING OF HYBRID SEISMOGRAPH

LattePanda as depicted in figure 3 is a mini computer fully installed with windows l0 version. It includes arduino full software version too. It does what a regular pc would do. It supports numerous languages like c++,s javascript, ruby, c#, python etc.[5] Using its existing API we can develop our own software and hardware. This device also supports Ubuntu. LattePanda offers windows l0 Iot core and a Raspberry pi which gives combined development platform and a Iot device. Along with intel cherry trail Z8300 quad core 1.8 GHz processor, it has storage capacity of upto 64 gb. The board comes preinstalled with plug and play sensor connectors and also wi-fi and Bluetooth 4.0.

Fig 3 LattePanda board

The sensors as seismometer are interfaced with LattePanda to measure the ground motion and seismic signals. Acting as input these signals guide the pen motion. Nema 17 and Nema 14 Stepper motor is also incorporated with this board itself and can be operated at desired frequencies in desired direction.

NEO 6m module is also connected with LattePanda for acquiring positioning and timing information and converting NMEA format into understandable form for displaying on LCD graphics or on any desired screen. The graphical and visualization of the entire satellites actively passing data to the module is taken through u-blox u-centre software tool. This not only makes system more compact but also enhances debugging.

The 12 bit ADC data is stored in 3 channel system with 100 sample per channel. this device would be able to store data for 500 days as LattePanda has memory of 64 gb. With this memory including window's software the seismic data can be recorded for 2 years in continuous mode and event mode. This file can be used further for calculating precise event of occurrence of spike due to any hazard with the long term and short term averaging technique.

Finally this event whose text and graphic both are recorded on capacitive type 7 inch hdmi screen. With all parameters of earth quack calculated through software, pre-vents can also be recorded through which taking precautionary measures are feasible. Figure 4 gives the working of hybrid seismic recorder.

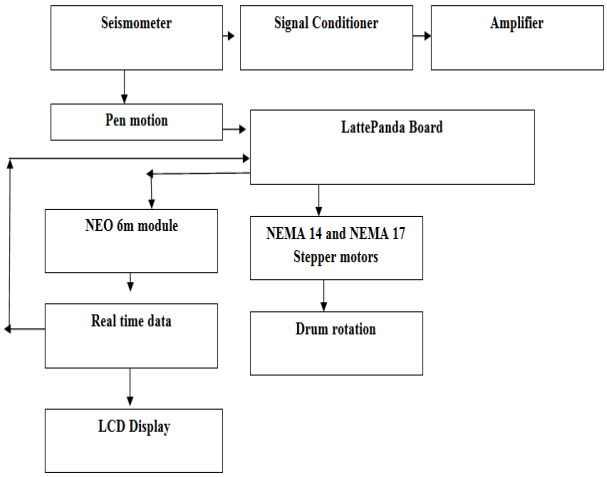


Fig 4 Working of hybrid seismic recorder

III. METHODOLOGY

A. Operating stepper motor Nema 14 and Nema 17 through LattePanda at precise steps.

A stepper motor divides full rotation in equal number of steps and provides high torque at low speed. We need to plot data and graph of vibrations on drums, so for this we have chosen stepper motors as they move in precise repeatable steps.L293d driver ic acts as current amplifier. These signals drive stepper motor.

Nema 14 stepper motor has 0.9° step angle. Which means it has 400 steps per revolution. Its every phase uses 500 mA current at 9 V, which can further allow a holding torque of 1 kg-cm (14 oz-in).The motor has co1or coded wires for making connections easier. B1ack and green are one coil while red and blue makes another one. Nema 17 stepper motor has.8° step angle. Which means it has 200 steps per revolution and its every phase uses 1.7 A current at 3 V, allowing for a holding torque of 3.7 kg-cm.

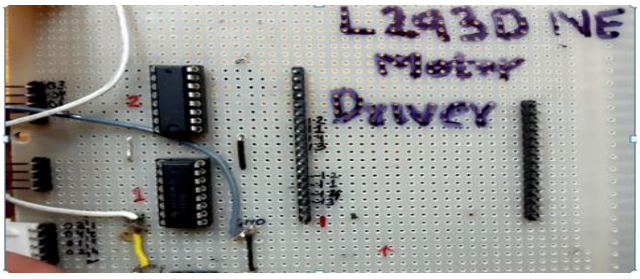


Fig 5 L293D motor driver board

Latte panda has built in arduino Leonardo board so connections are made on pin d1,d2,d9,d10 of latte panda and these are further given to L293d driver ic as given in figure 5, as input and its input pins 1,2,3,4 are used. output of driver ic which acts as current amplifier is directly given to nema motors. And Visual studio is used for running stepper motor on LattePanda. Code is uploaded on arduino side and libraries are imported on the visual studio for smooth working.

Using l293d we found that motor rotates smoothly only if total of set speed function (which sets speed of motor in rpm) and steps per revolution comes out to be minimum of 48000, as l293d was not compatible enough with LattePanda it does not work properly at its rated voltage i.e. 5v but works at higher voltage i.e. 8v. more compatible boards like easy driver 4.0. can be used for precautionary measures as the setup can damage if exceeded rated voltage. Figure 6 gives the setup of stepper motor with LattePanda

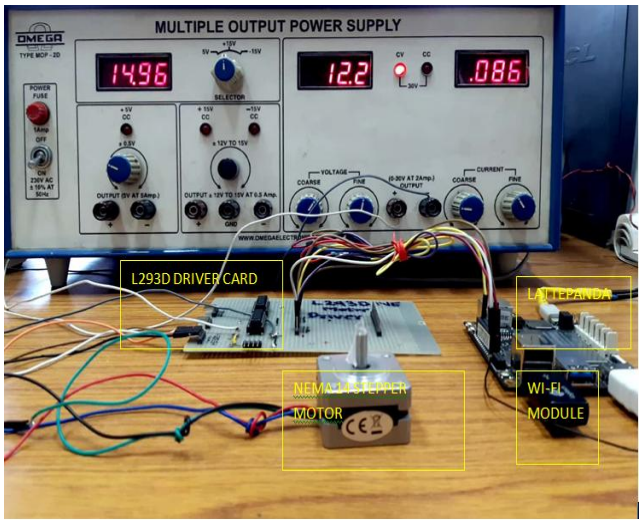


Fig 6 Setup For NEMA motors with LattePanda

B. Interfacing NEO 6m module with LattePanda and generation of data in NMEA format.

In the form of radio signals, satellites transfer their positioning and timing information to the receivers. These receivers then calculate the time signals took to reach them and via this process they determine the distance of satellites. It requires at least information of three satellites on how far they are in space and with this it can pinpoint seismic recorder's position. In this we have used NEO 6m gps module is used to get location of seismograph. NEO-6m belongs to series of GPS receiver fami1y which has features of high performance and are part of U-B1ox positioning engine. It has external antenna with no header pins so we have to solder them and keep outside for better signal quality. It can track upto 22 satellites and can update 5 locations in 2.5 m horizontal position accuracy while consuming only 45mA current.

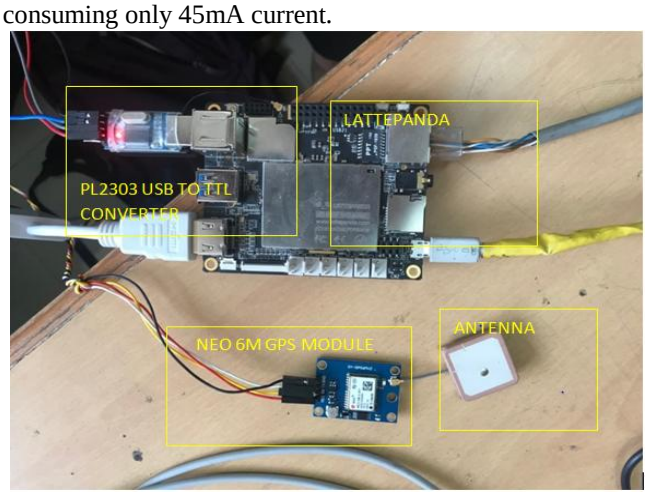


Fig 7 Setup for NEO 6M with LattePanda

As shown in figure 7, the RX pin is connected to D9 and TX pin of NEO 6M is connected to D10 of the LattePanda board respectively. Ground and supply to the module is given through LattePanda itself.

The SPI interface allows for the connection of external devices with a serial interface, e.g. serial flash to save configuration and Assist Now Offline a gps data or to interface to a host cpu.

The interface can be operated in master or slave mode. In master mode, one chip select signal is available to select external slaves. In slave mode a single chip select signal enables communication with the host.

NMEA is short of National Marine E1ectronics Association.

Nmea is a very o1d format and existed before gps invention. It was formed in 1957 for better manufacturing and communication between e1ectronics association. nmea is a standard data format now which is supported by 11 gps manufacturers. there are more than one nmea messages so all kinds of gps receiver supports these messages. nmea can be transmitted via different types of transmitters and communication interfaces 1ike rs-232, b1uetooth, uhf, wi-fi etc [7]. there are different types of nmea sentences. The type of message is indicated by the characters before the first comma. The GP after the $ indicates it is a gps position. [7] The $GPGGA is the basic gps nmea message, that provides 3D location and accuracy data. Below is a example of nmea message

$GPGGA,110617.00,41XX.XXXXX,N,00831.54761,W,1,05,2.68,129.0,M,50.1,M,,*42

110617 – Represents the time at which the fix location was taken, 11:06:17 UTC

41XX.XXXXX,N – latitude 41 deg XX.XXXXX' N

00831.54761,W – Longitude 008 deg 31.54761′ W

1 – fix quality (0 = invalid; 1= GPS fix; 2 = DGPS fix; 3 = PPS fix; 4 = Real Time Kinematic; 5 = Float RTK; 6 = estimated (dead reckoning); 7 = Manual input mode; 8 = Simulation mode)

05 – Number of satellites being tracked

2.68 – Horizontal dilution of position

129.0, M – Altitude, in meters above the sea level

50.1, M – Height of geoid (mean sea level) above WGS84 ellipsoid

Empty field – time in seconds since last DGPS update

Empty field – DGPS station ID number

*42 – the checksum data, always begins with *

The other NMEA sentences provide additional information like

$GPGSA – GPS DOP and active satellites

$GPGSV – Detailed GPS satellite information

$GPGLL – Geographic Latitude and Longitude

$GPRMC – Essential GPS pvt (position, velocity, time) data

$GPVTG – Velocity made good.

Figure 8 depicts various NMEA messages obtained through U- Centre software.

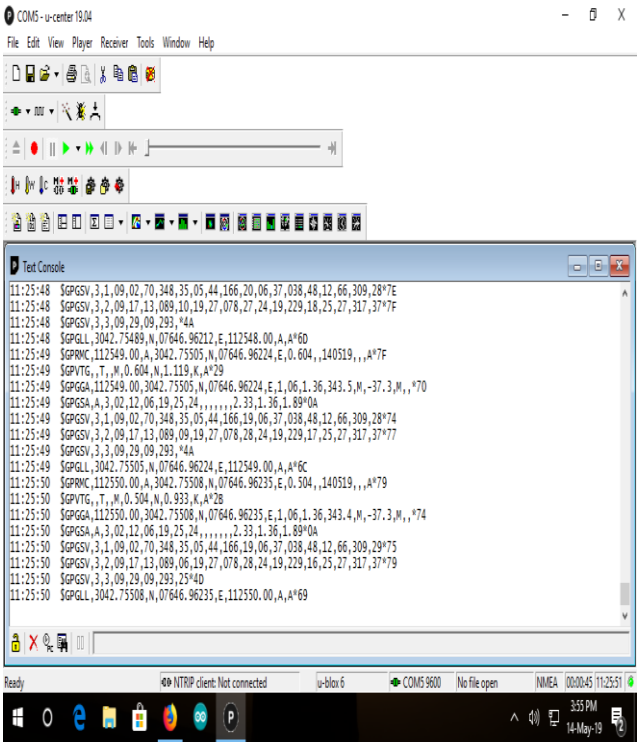


Fig 8 Data received in Nmea format

C. Parsing NMEA sentences with TinyGps++ libraries

To get data in simpler and understandable form in terms of position, data, altitude as shown in figure 9, TinyGps libraries can be used.. Tx and rx pin of gps are connected with pin 10 and 11 on LattePanda board for serial communication and through tinygps++ libraries. we first have to import these libraries from arduino Leonardo to LattePanda. This library has inbuilt code for decoding nmea sentences into longitude, latitude, speed and altitude. With this we can work with the raw data from the GPS, or can convert those NMEA messages into a readable and useful format, by saving the characters sequences into variables [7].

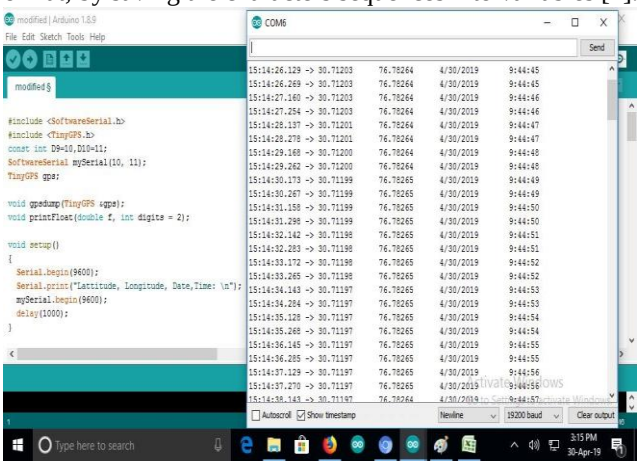


Fig 9 Position information using Tinygps++ libraries

D. Collecting and storing real time data through TERA TERM software.

The data collected needs to be continuously stored somewhere instantaneously for further retrieval or monitoring. For this purpose Term Tera software is implemented. TERA TERM is very popular windows terminal programs, being free and open-source software it are highly used for implementing and communication purposes. This software supports telnet and other serial port connections. We have used it to record and display real time data using NEO 6M and LattePanda. For making a connection follow the below steps.

A. Select the most suitable serial port and then select serial radio button.
B. The default baud rate setting is 9600 bps, if this is needed to be changed then select setup option
C. This will open different baud rates, choose the best suitable baud rate and click ok
D. The title of the window would change
E. A blank window will appear which is used to send and receive data as shown in figure 10.

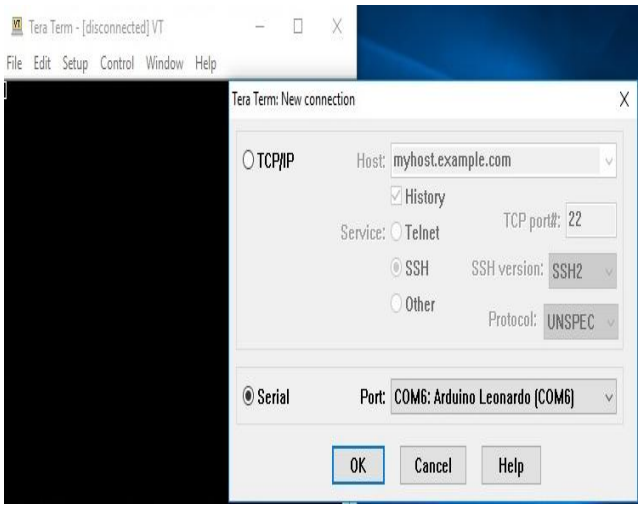


Fig 10 Tera Term opening dialog box

After following these steps TERA TERM will automatically connect to whichever serial port is working for data transfer. And will generate the live data coming from LattePanda as shown in figure 11.

TERA TERM can save data in many formats as per the requirement. We saved the data in excel for more convenience but it can be saved in notepad too. After generation of live data in TERA TERM, open log and save file with .csv extension. This will create a excel file with stored real time data in it.

Fig 11 Generation of live data in TERA TERM software

E. Sending live time data on remote LCD graphics

The live data on remote screen can be obtained using python In this we first made an object called socket to send the data. Below figure 12 is the client side of the program. Enter the password which is given by the server while it asks for it and when the connection is made the monitor shows the message has been sent and sends the data to the remote display. This is how the connection is made between client and server

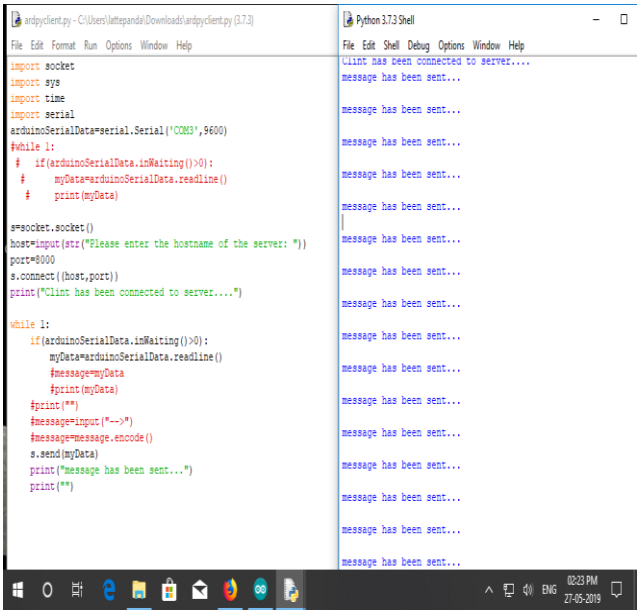


Fig 12 Client side of the display

In the receiver or server side run the program. After no error and successful compilation of the program the screen displays an password which must be entered into the client pc for successful connection. The password need not be changed and is stable but once the connection is interrupted from any external source the program needs to re run. After the connection as given in the below figure, the live data is generated on the screen and prints longitude and latitude information of the affected area.. it can also be obtained in NMEA format or as per the requirement. Figure 13 gives the server side of the program.

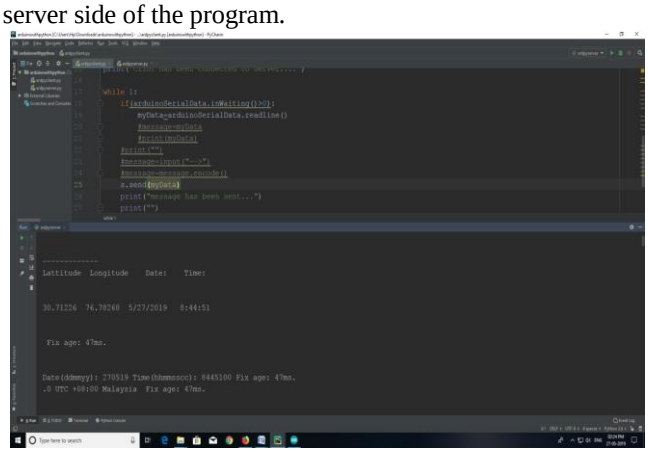


Fig 13 Server side of the display

F. Data visualization and graphical representation using U-Centre software.

The satellites sending data to the receiver module is tracked using U-centre, as shown in figure 14. It is a GNSS evaluation software and a very powerful performance analysis and evaluation tool. It can be used to change the internal configurationally settings of any GNSS receiver module and NEO 6m being part of it its internal settings can also be changed[8].

It can display real time structured and graphical data visualization from any GPS receiver such as

A. Satellite summary view
B. Navigation summary view
C. Compass, speedometer, clock, altimeter
D. Chart view of any two parameters of choice
E. Data recording and playback functionality

PL2303 is a small USB to TTL serial tool ,which can be used to connect some serial device with PC via USBB port. The connections of NEO 6m gps module with pl2303 is vcc to 5v, tx pin to rx pin and vice verse. When pl2303 module is connected to LattePanda, the driver for com port is needed to be installed i.e. prolific 2303 otherwise the software u-centre does not read the data.

Locate the communication toolbar and click on the arrow beside the icon. This will show a list with all available COM ports. Select the corresponding COM port where the receiver is connected. While the com port can change every time the converter is taken out. The green light below the connection indicates if the connection is established or not

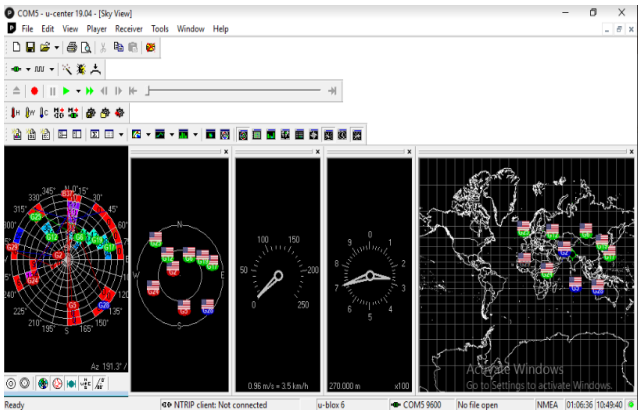


Fig 14 Working satellites visualization through U-centre

IV. ADVANTAGES OF HYBRID SEISMOGRAPH

A. Below are some of the advantages that a hybrid seismograph has over conventional seismograph
B. The high and low gain sensors provide data on scale for both small and large earthquakes.
C. The digital data can be error checked so that line noise won't cause the data to be corrupted
D. The data can be uploaded to seismic analysis software for future reference.

E. We can easily monitor and modify the data according to our easiness
F. LattePanda not only makes the system compact but also enhances the debugging
G. It increases the storage capacity and efficiency of the system while not compromising on accuracy
H. Gives 3-D view of working satellites through u-centre software
I. Easy retention of data using online tools.
J. Gives 3-D view of working satellites through u-centre software
K. Analog instruments are prime source of noise, by digitizing the system this problem is also removed
L. High portability makes this instrument more desirable.

V. RESULTS

Both NEMA 14 and NEMA 17 can operate simultaneously with LattePanda and can be rotated in desired direction with desired speed. Table 1 and table 2 gives working condition of NEMA motors at different voltages, speed and revolutions along with l293driver ic and LattePanda.

Table 1. Working Condition of Nema 14

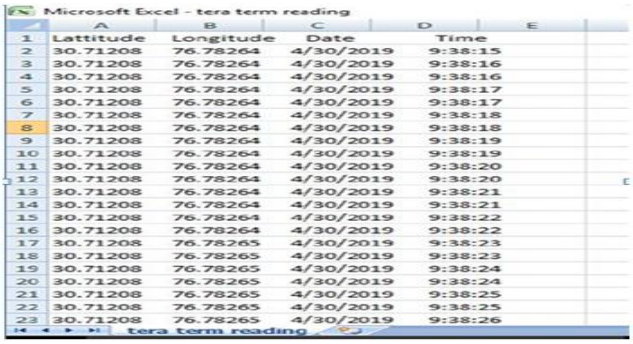
Power supply	Steps per revolution	Set speed	Working conditions
12	800	60	No
12	1000	60	No
12	1200	60	No
14	800	60	yes
14	1000	60	Yes
14	1200	45	Yes

Table 2. Working Condition of Nema 17

Power supply	Steps per revolution	Set speed	Working conditions
5	800	60	No
5	1000	45	No
5	1000	60	No
5	1200	45	No
5	1200	60	Yes
8	800	60	Yes
8	1000	60	Yes
8	1200	60	Yes
8	1000	45	No

NEO 6M gives exact location of the recorder, in NMEA format which can be further decoded into simpler terms by using TinyGps++ libraries.

Live data is stored continuously in TERA TERM software and can be took in excel extension too if needed as shown in fig 15.



Microsoft Excel - tera term reading

	A	B	C	D	E
1	Lattitude	Longitude	Date	Time	
2	30.71208	76.78264	4/30/2019	9:38:15	
3	30.71208	76.78264	4/30/2019	9:38:16	
4	30.71208	76.78264	4/30/2019	9:38:16	
5	30.71208	76.78264	4/30/2019	9:38:17	
6	30.71208	76.78264	4/30/2019	9:38:17	
7	30.71208	76.78264	4/30/2019	9:38:18	
8	30.71208	76.78264	4/30/2019	9:38:18	
9	30.71208	76.78264	4/30/2019	9:38:19	
10	30.71208	76.78264	4/30/2019	9:38:19	
11	30.71208	76.78264	4/30/2019	9:38:20	
12	30.71208	76.78264	4/30/2019	9:38:20	
13	30.71208	76.78264	4/30/2019	9:38:21	
14	30.71208	76.78264	4/30/2019	9:38:21	
15	30.71208	76.78264	4/30/2019	9:38:22	
16	30.71208	76.78264	4/30/2019	9:38:22	
17	30.71208	76.78265	4/30/2019	9:38:23	
18	30.71208	76.78265	4/30/2019	9:38:23	
19	30.71208	76.78265	4/30/2019	9:38:24	
20	30.71208	76.78265	4/30/2019	9:38:24	
21	30.71208	76.78265	4/30/2019	9:38:25	
22	30.71208	76.78265	4/30/2019	9:38:25	
23	30.71208	76.78265	4/30/2019	9:38:26	

tera term reading

Fig 15 Positioning and timing data in excel

Data visualization and evaluation of live satellites with their location is obtained done through u-centre software as shown in figure 16. It is also used for changing configurational setting of NEO 6m module.

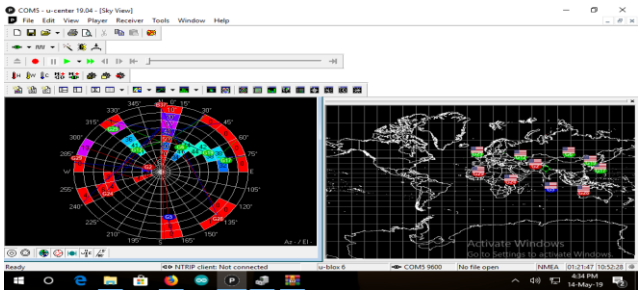


Fig 16 Sky view and satellites visualization through U-centre

Real time data is successfully sent to remote HDMI screen, using client server database. Figure 17 gives the connection of HDMI with LattePanda board.

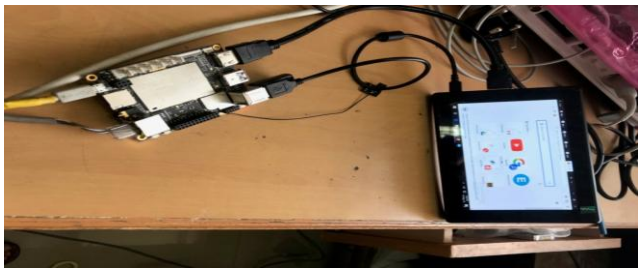


Fig 17 HDMI 7-inch display with LattePanda board

VI. CONCLUSION AND FUTURE SCOPE

Earthquake is one of the most terrifying natural disaster and has consumed countless lives during the course of mankind. The sudden release of energy during earthquake causes the generation of seismic waves. These waves can be recorded and deduced for signaling of danger. The ways in which earthquakes are recorded and the data are analyzed have changed drastically in the past few years. The digital instruments and the computers have replaced the traditional drum recorders of seismographs. Processing of seismic signals is now completely digital.

Keeping this in mind we thought to design a hybrid (analog-digital) seismograph. It has a lot advantages over traditional drum recorders. Along with having accuracy of analog system, it has more storage capacity which makes easy retention of data possible. In this work we interfaced NMEA 14 and NMEA 17 stepper motor with LattePanda board to run the drum at precise steps. The pen motion is guided by seismic vibrations. The timing and location information of the recorder is successfully obtained using NEO 6M gps module. The data is obtained in NMEA format (a standard data format supported by all gps devices) and is further decoded using TinyGps++ libraries. The whole bunch of data is stored continuously in Tera Term software for further retrieval and analysis purpose.

The main challenge was to send this data on remote LCD graphics which is done by client and server modeling using python. The system is password protected. Means the client has to enter the same password as server for monitoring the data. With these steps done and tested. The speed of the system increases manifolds due to fast processing of LattePanda. Through this we can upload data on seismic analysis software which also makes calculation of pre events slightly possible. With increased portability and cost efficiency the seismometer will not only generate more users all over but more detailed information about earthquake source and the earth's interior can be inferred. Which can save countless lives.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to whole mechanical instrumentation department of central scientific instruments organization for providing us the resources to carry out our work smoothly and giving us the opportunity to work on the live project.

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AUTHORS PROFILE

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