Surigao City Campus

Bachelor of Science in Electrical Engineering

SURIGAO STATE COLLEGE OF TECHNOLOGY

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I.4.4. development of software for electrical circuit analysis;

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APPROVAL SHEET

This Project Study entitled **"AUTOMATED DUAL-SOURCE SQUID DRYER WITH IMAGE PROCESSING MONITORING"** prepared by **BRAINGELOURSE L. RIVAS, DHEVIN TRIZ G. JAMERA, DILMAR E. MERCADO, JAYMAR P. LABONG, PATRICK G. CORTES** in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical Engineering** has been examined and is recommended for acceptance and approval for ORAL EXAMINATION.

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1.4.4

LOCATING UTILITY PIPES USING IMPULSE RADAR: A CASE STUDY IN SURIGAO CITY

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Abstract - Impulse radar is used for below ground imaging of shallow buried objects, this paper presents an experimental study in Surigao City for locating pipe from the water distribution agency Surigao Metropolitan Water District (SMWD).[1] This distribution system (underground) is used to collectively describe facilities used to supply water from the source to the point of use.[2] As a result, a leak in the groundwater distribution piping increases the likelihood of safe water, leaving a treatment source to become contaminated prior to reaching the consumer.[3] The purpose of this study is to evaluate the radar in locating leaking pipes by field test on some different kinds of underground utility pipes.[4] The experimental results show that the impulse radar has greater capability of detecting steel pipe compare to PVC pipe, steel pipes are very obvious due to strong signal reflection, the hyperbola curve is clearly visible compared to the curve of PVC pipe.[5] Results also showed that the effectiveness of the impulse radar in detecting pipe leakage from both metal and PVC pipes, both showed clear curves but the change in appearance like the cut out feature in the middle part because of water leaks.[6]

Keywords: Impulse Radar, Jetson Nano, Ultra-wideband, Pipe positioning,

1. INTRODUCTION

An impulse radar is a technique that uses high-frequency radio waves to image the subsurface of the Earth. It provides a substantially higher resolution internal image of the ground than any other conventional geophysical method since high-frequency radar waves are used.[1] A significant factor to look from is the homogeneity of the land. In effect, an underground radar system sees changes in the medium's dielectric properties; it will respond to a rock, a change in soil type, or a pocket of moisture, just as well as to a pipe or cable. Furthermore, the underground environment is itself very complex. Unlike the radar above ground, where the medium between the antenna and the target is transparent except for rare weather conditions, the land is very inhomogeneous. Soil types vary greatly; there may be natural stratification or isolated rocks.[2]

This technology has been widely accepted and is routinely used for various applications such as mapping utilities, bedrock, cavities/sinkholes, archaeological artifacts, and groundwater levels. Impulse radar has been widely applied in Asia not only on its excellent quality of the soil but also for the changing rainfall and other natural events. Scientists use this technique extensively to study the sedimentology related to Southeast Asia's coastal hazards, such as the trace of the unusual typhoon events and the deposits from the tsunami waves. They also use impulse radar in Nepal to sense the giant fault's location at the root of the Himalayan mountain range. This giant fault ruptured in 1934 and caused great destruction to the Nepal area.[3]

In the Philippines, impulse radar is applied to investigating erosion and recovery in a volcaniclastic barrier dune system in the country's central area. The study of large cyclones' erosional and depositional effects is a first step in developing long-term history of damaging tropical cyclones along a volcaniclastic coastline in the Philippines. Records can assist government agencies in understanding the dynamics and recurrence of storm surges. In Japan, impulse radar is also applied for detecting underground cavities in one of the caves in Japan. Underground cavities or voids detection is essential, especially when it comes to building construction. By knowing the presence of opening lying underground, one could consider whether the subsidence is likely to be prevented or not. Impulse radar is a high-frequency electromagnetic-sounding technique that has been developed to investigate the shallow subsurface using the contrast of dielectric properties.[4]

This study's primary purpose is to determine if the impulse radar method is applicable in locating underground pipes by field tests on some different kinds of underground pipe such as metal or plastics pipes. In Surigao City, the water distributor agency, Surigao Metropolitan Water District (SMWD), had encountered problems in locating their leaking pipes. Also, in many situations, the agency responsible for the underground pipes is unaware of the pipes' exact position. By doing the experiments and performing series of trials, the researchers can determine if the impulse radar applies to this type of problem. With signal processing, the radar can locate or determine leakage in metal pipes or plastic pipes.

Water leakage from underground utility pipes is a concern in Surigao City because changing rainfall patterns and earthquakes may also damage the distribution system. Doing this research has many benefits in the city, like the addition of knowledge for the agency's maintenance when it comes to pipe management. Since this paper discusses using the impulse radar method in positing utility pipes' location, a brief overview of the impulse radar is presented. Some field test results on positioning different utility pipes are also discussed to evaluate the impulse radar method's applicability in probing underground objects.

1.1 Related Literature

Nowadays, UWB has become a research hotpot in the field of radar, owing to its advantages of high range resolution and intense penetration. UWB radar transmits a wideband signal to the ground, and the received echo will contain information on the target with rich transitory response content. Here, we can see that an antenna is one of the essential components in this type of radar system. The antennas should be able to transmit and receive the ultra-band spectrum with no distortion.[5]

In this past work, a simulation-based technique has been introduced to develop a traveling-wave antenna for GPR systems. This technique has been applied to a V-shaped dipole antenna with loading resistance and a parabola-shaped reflector antenna. In this paper, a cylindrical reflector antenna is proposed which is fed by a resistively loaded V-shaped dipole. A numerical model of this cylindrical reflector antenna is constructed, and some characteristics of this antenna are analyzed by the RWG moment method.[6]

Many traditional methods employed for positioning pipes are negatively affected by the surrounding noise and time-consuming factor. So, the development of an efficient, rapid, high-resolution and non-destructive technique to locate the underground pipes is important. The concept of utilizing the reflections of electromagnetic waves for investigating subsurface structure was first introduced by Melton (1937) and Donaldson (1953). This method was widely applied during the 1960s in probing underground structure of snow and ice in polar regions (Cook, 1960). Many non-ice explorations by using ground penetrating radar (GPR) were being attempted by the 1970's. GPR has been proved in many applications (Davis and Annan, 1989; Cook, 1975) to be a very useful tool in the soil rock explorations.[1]

As an alternative to pulsed radar, correlating m-sequence or pseudo noise (PN) radar has proven to have significant advantages, namely the large achievable bandwidth, its low peak power, excellent stability and the possibility to be implemented mostly using digital circuits. These solutions either rely on the radar being stationary, using the stability of the m- sequence to allow for very efficient background subtraction and thus increasing the dynamic range, or they are optimized for low penetration depths and high resolution.[7]

Other methods of leak detection which have been used with varying degrees of success are tracer gas. thermography, flow and pressure modelling, and ground penetrating radar. The potential of several non-acoustic technologies has been evaluated by Hunaidi et al. In leak detection surveys using acoustic methods, the most widely used approach involves the cross-correlation of the measured acoustic signals. This has proved to be reasonably effective in detecting and locating metal pipes, but has been problematic when used on plastic pipes.[8]

In the last decade, the next generation of technology for mapping infrastructure has emerged with the development of compact, broadband sensors combined with modern positioning systems in mobile sensor arrays. These new array systems can move quickly over large areas and could, in principle, produce 3D digital maps of a regional utility network within a relatively short period.[9]

One of the technologies to be incorporated in the device is low-frequency vibro-acoustics; the application of this technology for detecting buried infrastructure, in particular pipes, is currently being investigated. Here, a shear wave ground vibration technique for detecting buried pipes is described. For this technique, shear waves are generated at the ground surface, and the resulting ground surface vibrations measured. Time-extended signals are employed to generate the illuminating wave.[10]

Other projects have different techniques in locating underground pipes like using shear wave ground vibration technique, developing high-frequency antennas, or just locating pipes with a very time-consuming map. With impulse radar, finding the pipes has been very easy, and this technique is not destructive and especially not time-consuming.

Previous work also discusses impulse radar to locate utility pipes, but the information gathered is not sufficient. Other projects are only focused on the location of the underground pipes. What differs from this study to others is that it provides more comprehensive knowledge and information on the application of impulse radar in detecting utility pipes. This paper discusses an experimental study using impulse radar to gather data on the detection of metallic pipes with or without leaks and plastic pipes with or without leaks.

1.2 Theoretical Framework

Theory 1: Magnetic permeability (μ) describes how intrinsic atomic and molecular magnetic moments respond to the magnetic field. Therefore, it represents the degree of magnetization a material obtained in response to the magnetic field. Electrical conductivity (σ) is related to an electric field (E) and conduction currents created as electrical conductivity applied to the electric field.

$$J = \sigma E \text{ (A/}m^2\text{)} \quad [1]$$

$$E = \rho J \text{ (N/C)} \quad [2]$$

J is the current density in unit Ampere per meter square (A/m^2)

σ is the electrical conductivity in unit siemens per meter (S/m)

ρ is the electrical permeability in unit newtons per ampere squared (N/A^2)

Theory 2: Electrical conductivity of soils and sediments can influence the effectiveness of impulse radar. Soils with high electrical conductivity quickly weaken the radar signals, reduce the depth penetration, and limit impulse radar performance broadly. The amount and type of salts in the solution and the clay content affect the electrical conductivity of soils and sediments.[11]

Electrical conductivity measures water-soluble salt concentration in soils and is directly related to dissolved salts' concentration in a particular solution.

$$k = \varepsilon/\varepsilon_0 \text{ (F/m)} \quad [3]$$

K is the ratio of dielectric permittivity of material to free space or dielectric constant with unit in Farad per meter (F/m).

ε is dielectric permittivity with unit in Farad per meter (F/m).

ε_0 is in vacuum, a finite value of 8.85 x1012 F/m (Farads per meter)

Theory 3: When electric field (E) is applied, a dipole moment is created as bound charges move to another static configuration. The dipole moment density (D) is given by:

$$D = E\varepsilon \text{ Coulomb-meter (C. m)} \quad [4]$$

Dielectric properties in rocks and sediments depend on mineralogy, porosity, and rock lithology. In general, the changes in dielectric properties of rocks, variations in water content, and changes in bulk density at stratigraphic interfaces generated the reflected EM waves from the subsurface.[11]

Theory 4: When a propagating electromagnetic wave encounters a discontinuity in electric, magnetic or conductive properties, part of the electromagnetic energy is reflected, and the reflection strength is proportional to the magnitude of change. For a perpendicular incident wave, the power of impulse radar reflection is a function of the contrast in relative dielectric constants across the reflecting boundary, and the reflection coefficient RC can be expressed as[12]:

$$RC = \frac{\sqrt{\varepsilon_{r2}} - \sqrt{\varepsilon_{r1}}}{\sqrt{\varepsilon_{r2}} + \sqrt{\varepsilon_{r1}}} \quad [5]$$

Where ε_{r2} represents a relative dielectric constant of upper soil horizon and ε_{r1} represents the relative dielectric constant of the lower soil horizon.

1.3 Conceptual Framework

The basic concept of an impulse radar is that it produces high-frequency electromagnetic waves to map structures and utilities under the subsurface. The radar depends on the physical characteristics of the subsurface to generate a signal return. A typical impulse radar has three main components; Transmitter and receiver that are directly connected to an antenna and a control unit, as shown in the figure. The transmitting antenna radiates a short high-frequency Electromagnetic pulse into the ground. It is refracted, diffracted, and reflected primarily as it encounters dielectric permittivity and electric conductivity changes.

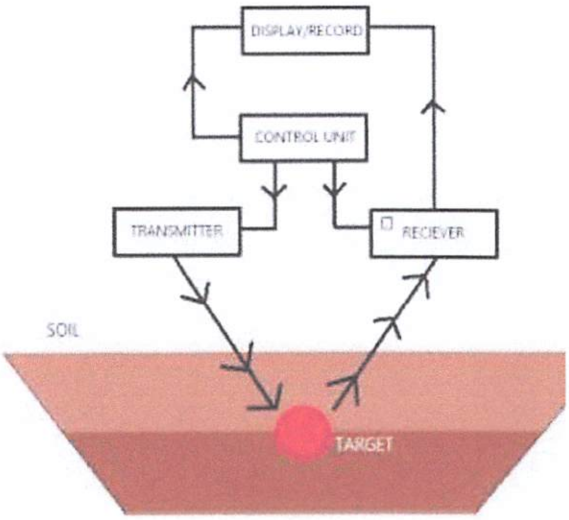


Figure 1: ***Flow Chart for a typical GPR system***

Material	Dielectric Constant	Conductivity (m mho/m)	Velocity (m/ns)
Air	[illegible]	[illegible]	0.3
Distilled water	[illegible]	[illegible]	0.033
Fresh water	80	0.5	0.033
Sea water	80	3000	0.01
Dry sand	3-5	0.01	0.15

Table 1: ***Tabl... conductivity and velocity for common material***

1.4 Objectives

In this study, the general objective is to develop and implement a reliable system to locate leaking pipes of Surigao Metropolitan Water District (SMWD) using impulse radar.

Specifically, it aimed to:

1. To document the system design.
2. To simulate of buried pipes to be detected by radar.
3. To compare each results given by the detected pipes.

2. METHODS

2.1 Research Design

The type of research design applied in this study is an experimental design. The purpose of this study is to determine if the impulse radar method is applicable in locating underground pipes and pipe leakage detection by field tests on some different kinds of underground pipe such as metal and plastic. By doing the experiments and performing series of trials, the researchers can determine if the impulse radar is applicable.

2.2 Project Design

The system's block diagram consists of 5 parts: the impulse radar, Antenna 1(*Transmit Signal*), Detection of target, Antenna 2(*Receiving Signal*) and the Display Records.

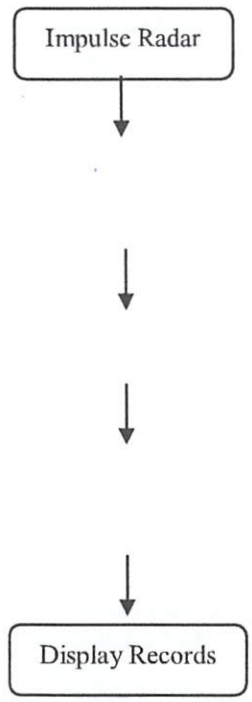


Figure 2: ***Block Diagram of the system***

2.3 Project Development

Figure 3 shows the block diagram on how the researcher develop the study. It starts with the project consultation and background check of the study, including the online and offline research related to the project. Researchers proceed to transceiver and software investigation of what type of material will be use, including the availability of the material. After that, the component gathering is now applied. Researcher gather all the component that will be used. Throughout these, researcher now already to conduct the design and development of the transceiver and software and after that the researcher can then conduct the analysis of the data that will gather from the device. Lastly, the researcher proceeds to the evaluation of results base on the data analysis.

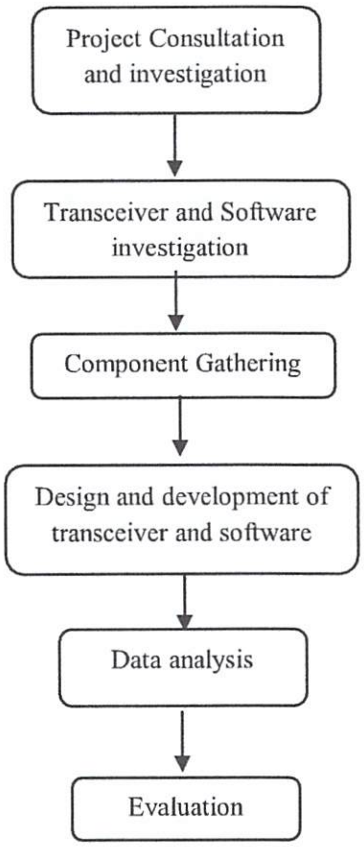


Figure 3: ***Project Development Flow Chart of the Project***

2.4 Project Implementation

To accomplish this goal, an experimental cart has been designed and constructed. The prototype model is made with PVC pipe and then it is assembled to form a cart. Both PVC and metal pipe has the same dimension which 4.5 inches' diameter and 22 inches as its length. The cart is pushed through a plastic railing to provide smoothness and avoid shaking of the antenna. The experiment was divided into three parts: 1. Detecting/locating pipe 2. Detecting/ locating underground pipe with water, 3. Detecting leakage of underground water pipe. Each material and condition is tested in 3 trials.

In parts 1and 2, detecting underground pipes with and without water, two different material pipes were used (steel and PVC). The pipes are buried under 0.25 meters below the sand, as the researchers consulted to an expert plumber saying that mostly smaller pipes are just buried 0.25 to 0.5 below the ground. The experiment was done using the impulse radar 1GHz antenna, where the first experiment uses empty steel pipe and PVC pipe. Using the same pipe, each material is filled with water and covered with a plastic garbage bag both sides and sealed tightly with a rubber.

In the third part of the experiment, detecting leakage of the underground water pipe, both steel and PVC pipe were buried in the same depth under 0.25 meters below the surface. Each pipe is drilled in the middle and with a small hole it is enough for the water to leak. The movement of the cart is perfectly perpendicular to position of the buried pipe.

2.5 Project Setting

Figure 4 shows the location that the project will be implemented. The experiment will be conducted by the sea shore at Sabang, Surigao City.

Figure 4: ***Location map***

2.6 Instruments

In this study, the following components are used as an instrument for the fulfillment of this experimental study:

1. PicoR software
2. Computer
3. Transmitting and receiving antennas
4. Push cart
5. Metering stick

First instrument is the software called PicoR. This program reads the data for the radar and it will show the depth and curves for the buried objects. Next is the computer, laptop is used in this experiment for portable usage during testing. Then the antennas as its load for the radar transceiver module. Next is the assemble push cart for testing and accurate data reading. Lastly is metering stick to measure precisely how deep the pipe is buried in the sand

2.7 Data Collection Procedure

Figure 5 shows the flow of the data collection procedure. First of all is the analysis of the problem for precise collecting of data. Followed by the consultation of the co-author. Asking questions and advises to the one who has wider experience about the project to gain knowledge about it. After that, surveying follows to meet the recommended quality and condition of the soil for the experimenting process. Then assembling the project with its cart which can operate to the surveyed location. Next is the collecting of data by doing series of trials then lastly is the analyzing of the data recorded.

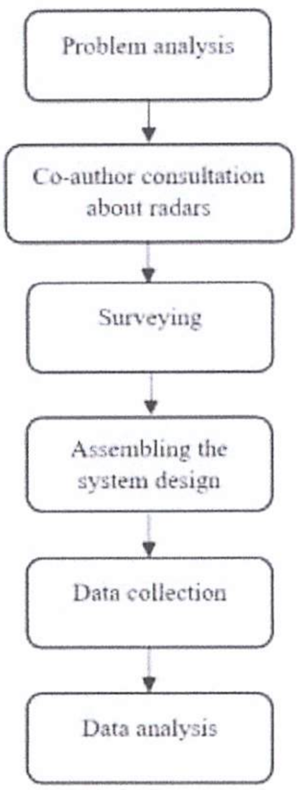


Figure 5: ***The flow of data collection***

3. RESULTS AND DISCUSSIONS

3.1 Documentation of the system design

Figure 6 shows the transceiver module of the impulse radar which is the main part of the system. It is like the brain of the radar it controls everything. With its application, both the transmitting and receiving antennas are connected to the side of the module and on the other end, is the mini-USB connector for power and data transmission connected to the laptop.

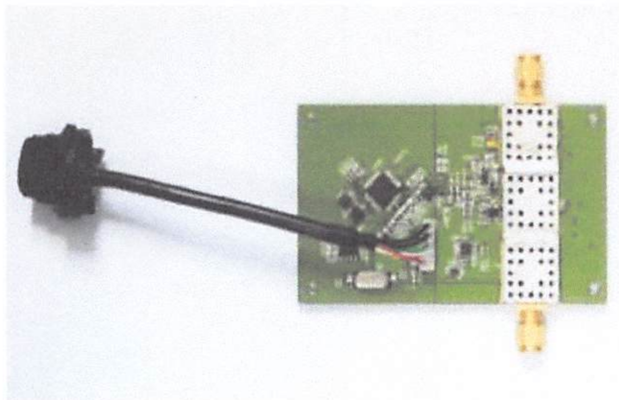


Figure 6: ***Transceiver module***

Figure 7 shows the transmitting and receiving antennas called antrad-3 are connected to the transceiver module. Antrad-3 antennas are main antennas for 1600 MHz band. The radiation is directed along the long side towards the opening of the metallized part of the antenna. There is also a connector for the antennas if longer length is needed.

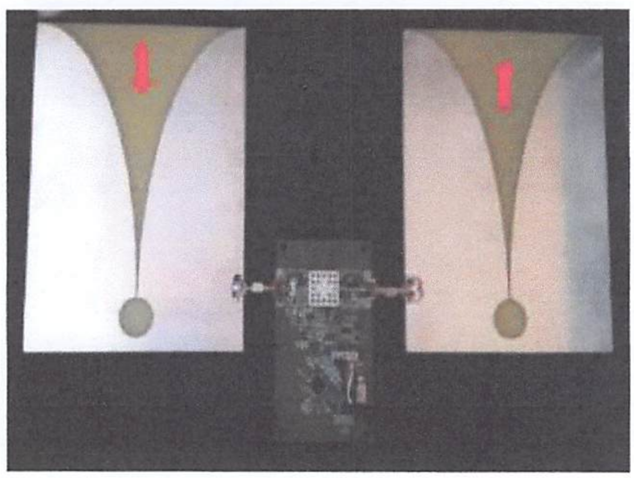


Figure 7: Transmitting and receiving antennas

Figure 8 shows the design of the push cart. It just works like a trolley with a 1-meter-wide with 0.25 meter as the height from the ground to the module. The handle is 1 meter away from the module to reduce noise and interference.

Figure 8: ***Push cart design***

Figure 9 shows the graphical user interface (GUI) of the software used to gather and record data. This type of program is also called radar gram. The depth is shown on the left side with numbers measured in meters. The window on the far left side shows the graph of amplitude. Based on retrieved data the device allows to calculate the thickness of the layers inside environments or to detect and calculate the distance to the in homogeneities inside environments. Another possible application of PicoR is detection of moving objects behind obstacles. PicoR 5.0 software created specifically for the GPR, but it allows to implement all the main features of PicoR 2k.

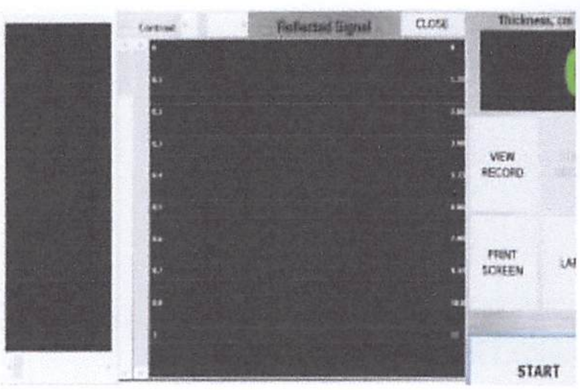


Figure 9: ***PicoR software GUI***

3.2 Simulation of buried pipes

Experiment was conducted using sandy soil without buried pipes as shown in the figure 10, buried metal pipes as shown in the figure 11, and buried plastic pipes as shown in the figure 12.

Dry sand is used in this experiment, located near the shore as shown in the figure 10.

Figure 10: ***Sand used for the experiment***

Figure 11 shows the buried metal pipe. The cart pushed through a plastic railing to provide smooth movement to the cart and eliminate unnecessary bumping. The buried object should be perpendicular or at an angle to the movement of the cart to produce a data with hyperbolic curve.

Figure 11: ***Buried metal pipe***

Figure 12 shows the plastic pipe buried in the sand under 0.25 meter below the surface. The pipe is 4.5 inches' diameter with 22 inches as its length same with plastic. Same procedure is done.

Figure 12: ***Buried plastic pipe***

Figure 13 shows the buried plastic pipe filled with water. The pipe is sealed with plastic bag both sides and tightened with rubber band.

Figure 13: ***Buried plastic pipe with water***

Figure 14 shows the buried metal pipe filled with water. Same with the plastic pipe, it is sealed with plastic bag both sides and tightened with rubber band.

Figure 14: ***Buried metal pipe with water***

Figure 15 shows the leaking metal pipe. The pipe is drilled to have a small hole on the side in order to leak and both sides are sealed with plastic bag again. Same procedure is done to leaking plastic pipe.

Figure 15: ***Metal pipe with leaking***

3.3 Analysis of Radargram

Analysis of Radargram: Pipes without water

Test was conducted using the result of radargram without buried metal and plastic pipes as shown in figure 16.

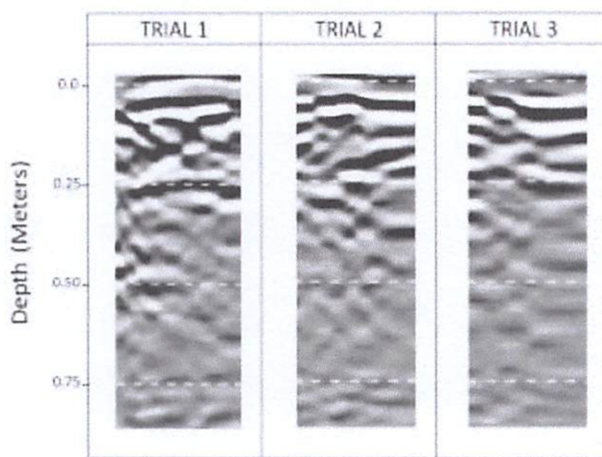


Figure 16: ***Without buried object data***

Figure 16 shows which the data without a buried object. Clearly the radar gram doesn't read any curve or something like bold hyperbolic curve.

This means the radar did not process any material signal.

Test was conducted using the result of radargram with buried metal pipes as shown in figure 17.

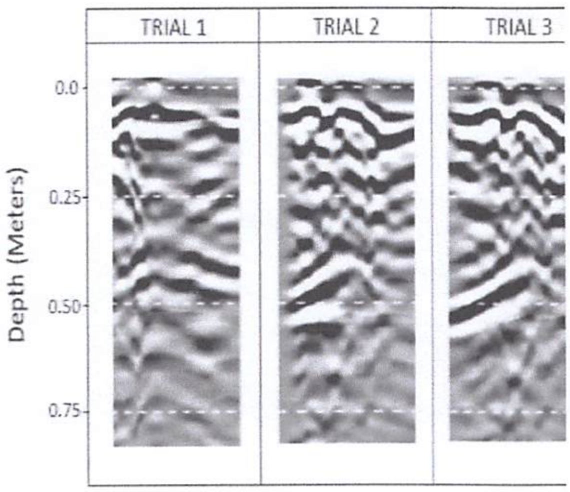


Figure 17: ***With buried Metal Pipe at 25cm depth***

Figure 17 shows the data for the metal pipe using the impulse radar. The pipe is buried to sand under 25 centimeter below the surface. Metal pipe is very visible to the radargram its because of its high dielectric constant, the reflection of the pipe gives a visible hyperbola curve.

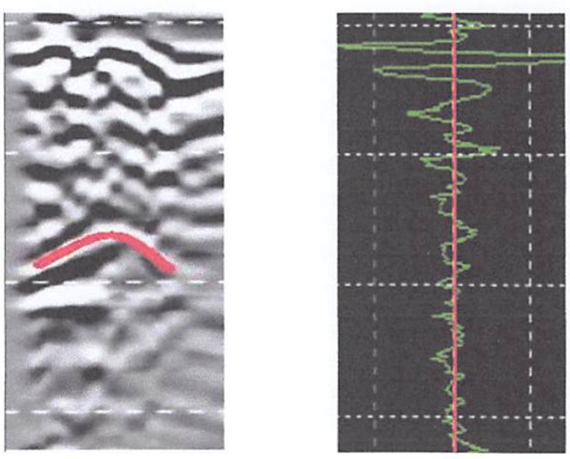


Figure 18: ***Location of the metal pipe***

Test was conducted using the result of radargram with buried plastic pipes as shown in figure 19.

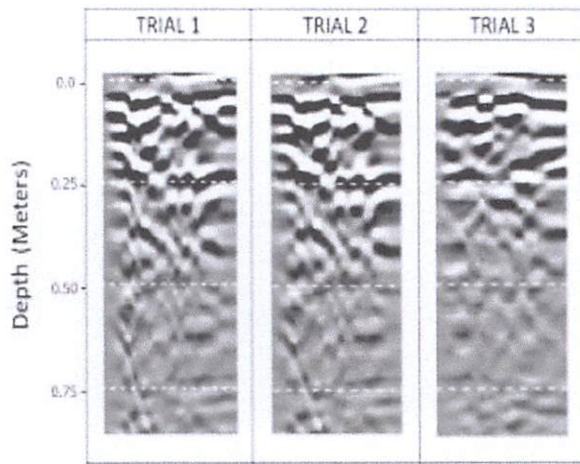


Figure 19: ***With buried Plastic Pipe at 25cm depth***

Figure 19 shows the data for the plastic or PVC pipe. The reflection of the curve of the plastic pipe is not clearly visible compared to the metal pipe. It is also found that the curve is smaller than the steel pipe curve. As expected, their readings are different because of their different dielectric constant.

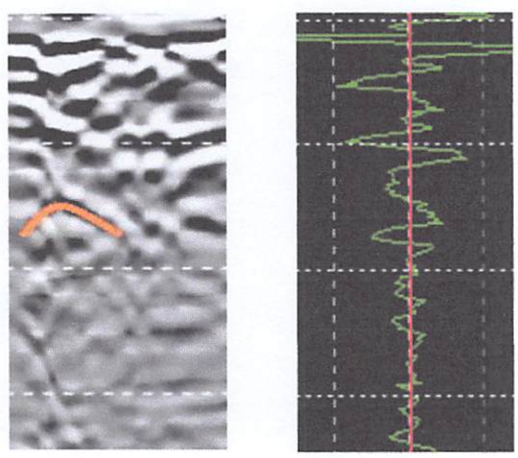
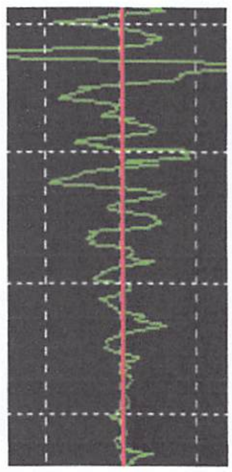


Figure 20: ***Location of the plastic pipe***

Comparison of the results in radargram of soil without buried pipes, with buried metal pipe and with buried plastic pipe is shown in figure 21.



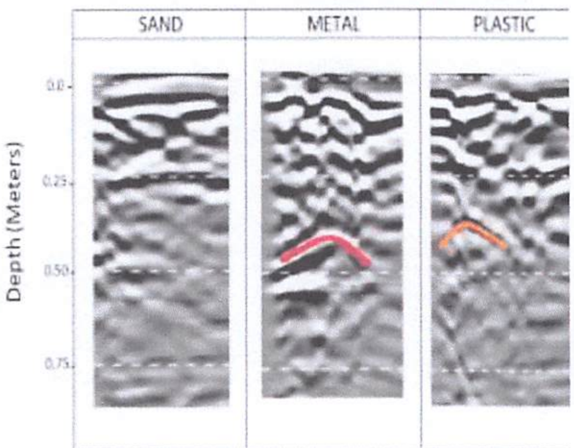


Figure 21: ***Data comparison between sand, metal and plastic pipe***

Figure 21 shows the data comparison as the radar process sand without buried object and with plastic and metal buried. First, the data from the sand without buried object clearly shows no hyperbolic curve while on the metal pipe part, the curve is sharp and visible and compared to plastic pipe the curve is less sharp and less visible.

Analysis of Radargram: Pipes with water

Test was constructed using the result of radargram of buried metal pipes as shown in figure 22.

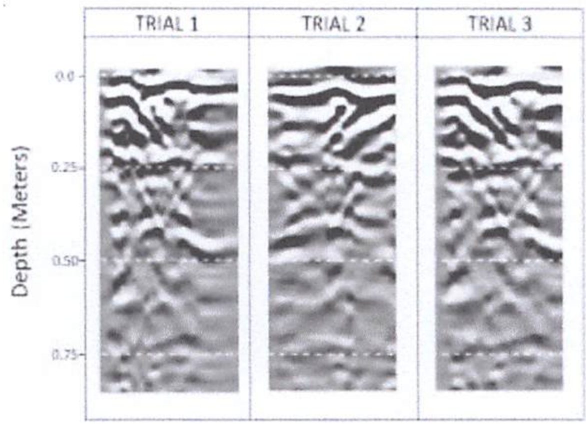


Figure 22: ***Data for buried metal pipe with water at 25cm depth***

Figure 22 shows the data for metal pipe water. In this case the pipe is still buried under 25centimeters below the surface. The curve is slightly similar; it simply differs from the clearness of hyperbola curve. As predicted, the water significantly altered the dielectric constant of the steel pipe. The amplitude graph indicates that the wave began to decrease when water was placed inside the steel pipe. This is due to the loss of energy when the electromagnetic wave traveled sand through the water.

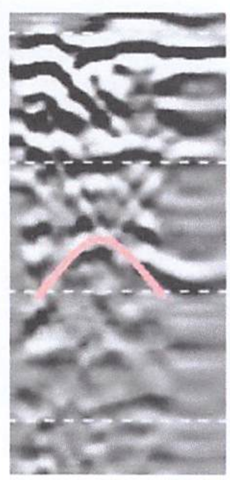
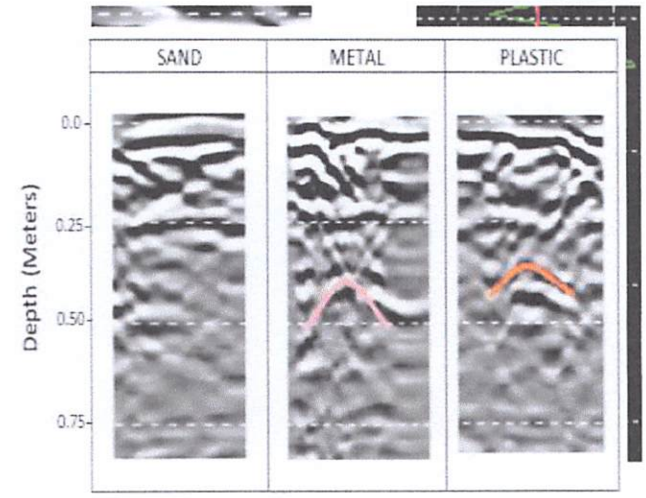


Figure 23: ***Location of the metal pipe with water***

Test was constructed using the result of radargram of buried plastic pipe as shown in figure 24.



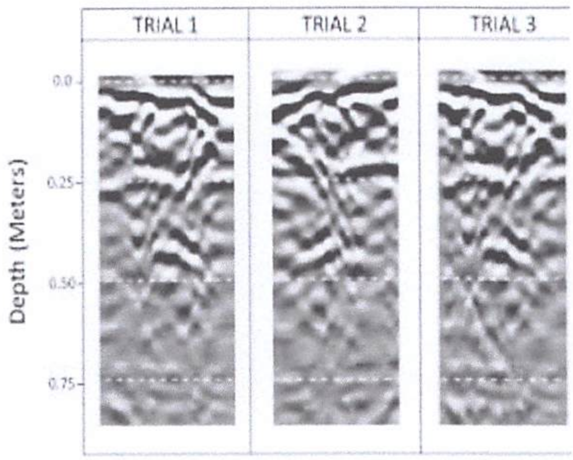


Figure 24: ***Data for buried plastic pipe with water at 25cm depth***

Figure 24 shows the data for plastic pipe with water. The pipe is still buried under 25centimeters from the surface. Similar to the metal pipe with water, the clarity or sharpness of the curve is greatly reduced due to the water inside. In this case, the curve is almost invisible as a result of its plastic material. The amplitude graph also shows that the wavelength is decreased.

Figure 25: ***Location of the plastic pipe with water***

Comparison between soil, buried metal pipe with water and buried plastic pipe with water is shown in figure 26.

Figure 26: ***Data comparison between sand, metal and plastic pipe with water***

Figure 26 shows the data comparison between the sand and the pipes filled with water. A huge difference is still visible between the sand without buried object and with buried object. Both curve from plastic and metal is slightly similar; it simply differs from the clearness of hyperbola curve. This is due to the loss of energy when the electromagnetic wave traveled sand through the water.

Analysis of Radargram: Pipes with leaking

Test was constructed using the result of radargram of buried metal pipes with leak as shown in figure 27.

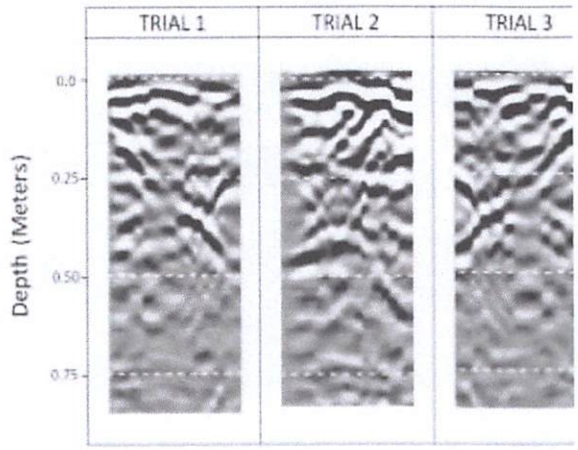


Figure 27: ***Data for buried metal pipe with leaking at 25cm depth***

Figure 27 shows a leaking pipe is buried within 25centimeters below the surface and the recorded data after 3 minutes, the pipe is buried. As illustrated in Figure 8, the curve is still visible on radar, but the appearance of the hyperbole curve changes. The curve is as if cut in the middle of its because of water leakage. The water quickly migrated up to the upper surface of the pipe that causes the cutting curve feature.

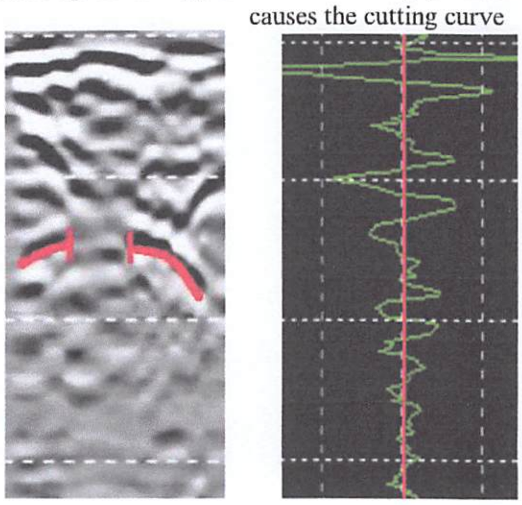


Figure 28: ***Location of the leaking metal pipe***

Test was constructed using the result of radargram of buried plastic pipes with leak as shown in figure 29.

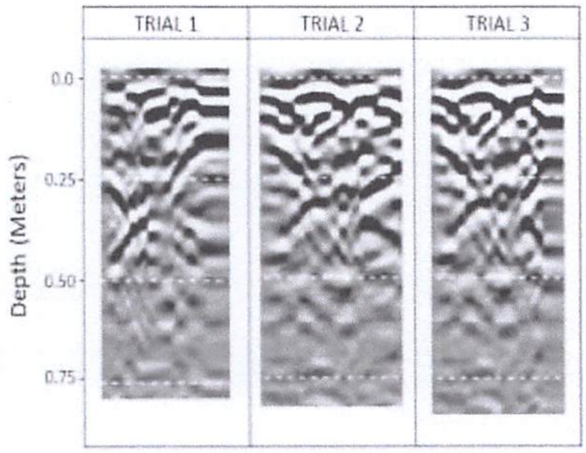


Figure 29: ***Data for buried plastic pipe with leaking at 25cm depth***

Figure 29 shows the data for leaking plastic pipe. This data is similar to leaking metal pipe, the curve is visible but it has the feature of cut out in the middle this due to the water leaking and rapidly migrated upward to the surface. This experiment shows how effective impulse radar is at detecting leaks of PVC and metal pipes.

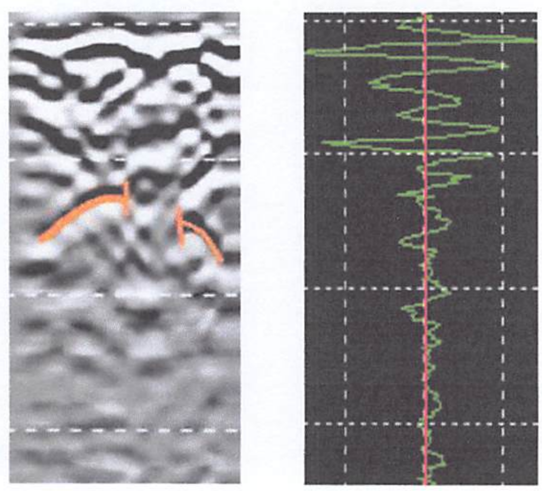


Figure 30: ***Location of the leaking plastic pipe***

Comparison between soil, buried metal pipe with water and buried plastic pipe with leaking is shown in figure 31.

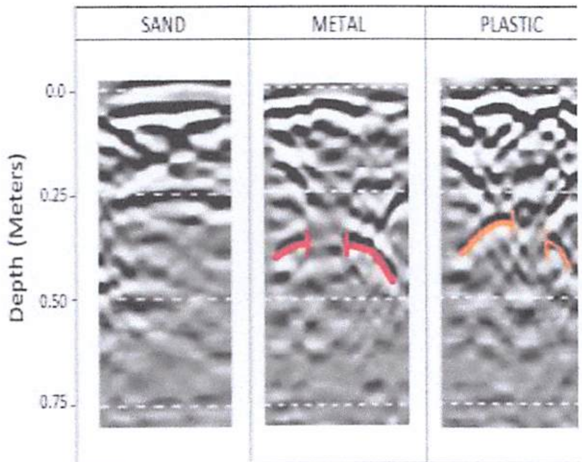


Figure 31: ***Data comparison between sand, metal and plastic pipe with leaking***

Figure 31 shows the data comparison between the sand without buried object and with buried pipes with leaking. Still the difference from the sand without the pipes and with the leaking pipes is the presence of the hyperbolic curve. The curve from metal and plastic pipe is still visible on radar, but the appearance of the hyperbole curve changes. The curve is as if cut in the middle of its because of water leakage. The water quickly migrated up to the upper surface of the pipe that causes the cutting curve feature. The data on the plastic pipe is similar to leaking metal pipe, the curve is visible but it has the feature of cut out in the middle. This experiment shows how effective impulse radar is at detecting leaks of PVC and metal pipes.

4. CONCLUSIONS

The documentation if the system design is easy. The user interface of the software is easy to operate. Both transmitting and receiving antennas are easy to attach to its transceiver module. The push cart is also documented properly with all its eco-friendly materials, also easy to assemble.

In the simulation process, dry sand is applicable to the project since it is just an experimental study. During simulation, data readings from the impulse radar is detected easily with smooth pushing motion. Each type of pipes is detected with hyperbolic curve but different appearances.

The experimental results show that the impulse radar has greater capability of detecting steel pipe compare to PVC pipe, steel pipes are very obvious due to strong signal reflection, the hyperbola curve is clearly visible compared to the curve of PVC pipe. In addition, impulse radar also has the ability to distinguish between pipes that is either empty or full with water. The sharpness and clarity of the water-filled pipe curve is slightly reduced in comparison with empty pipes. The experimental results also showed that the effectiveness of the impulse radar in detecting pipe leakage from both metal and PVC pipes, both showed clear curves but the change in appearance like the cut out feature in the middle part because of water leaks.

RECOMMENDATIONS

The following recommendations:

1. It is recommended to do the testing and trials with a smooth railing to reduce interference to the radar gram so that the reading is more clear and also reduce noise of the processing of signal.
2. It is better to use signal filtering software if the data has a lot of interference or noises.
3. It is recommended not to use wires for the antennas to produce precise depth from the radargram, this is due to signal loss.

5. ACKNOWLEDGEMENTS

The researchers would like to express the deepest gratitude to those who provided and gave their encouragement and full support to make this study a reality. They are grateful to the Heavenly Father, for the strength, wisdom, and guidance bestowed when the proponent needs it the most towards those encountered problems. To our adviser, Engr. Vrian Jay Ylaya, for his undying support to make this study realized. Also, the dean Engr. Robert R Bacarro, for extending his effort and giving time to enhance our thinking on making a very detailed and concise research study. To our classmates for sharing their valuable time and knowledge. This research would not be possible without their help.

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SURIGAO STATE COLLEGE OF TECHNOLOGY

"For Nation's Greater Heights"

COLLEGE OF ENGINEERING AND INFORMATION TECHNOLOGY
1st Semester, Academic Year 2019-2020

COURSE SYLLABUS in EE 101 – CIRCUIT 1

Institutional Vision, Mission, and Goals

SSCT Vision:

An innovative, technologically-advanced State College in Caraga.

SSCT Mission:
To provide relevant, high quality and sustainable instruction, research, production and extension programs and services within a culture of credible and responsive institutional governance.

SSCT Goals:

1. Foster application of the discipline and provide its learner with industry-based training and education particularly in engineering, technology and fisheries.
2. Conduct and utilize studies for the development of new products, systems and services relevant to Philippine life and of the global village.
3. Promote transfer of technology and spread useful technical skills, thus empowering its learners and their activities.

Institutional Intended Learning Outcomes : SSCT graduates are expected to:

1. Innovation and technical skills;
2. Exhibit critical thinking collaboration, and communication;
3. Manifest leadership, adaptability and responsibility.

Programs Goals:

The Electrical Engineering program aims to design and apply the generation, transmission, and distribution of electrical energy to produce competent engineers that exhibit positive work ethics and flexibility in work conditions for the development of Caraga.

Programs Educational Objectives:

The BS Electrical Engineering program is geared towards producing graduates who have the following attributes within three to five years from graduation:

1. Graduates demonstrate technical expertise and practical skills in the field of electrical engineering.
2. Graduates demonstrate flexibility in working with multidisciplinary teams and apply professional and ethical responsibility in the practice of electrical engineering.
3. Graduates are engaged in lifelong learning and knowledgeable in contemporary issues relevant to the field of electrical engineering.

Program Outcome(s)

Upon the completion of the course, the students must able to:

a. Apply knowledge of mathematics and sciences to solve complex engineering problems; - **enabling**
b. Develop and conduct appropriate experimentation, analyze and interpret data; - **demonstrate**
c. Function effectively on multi-disciplinary and multi-cultural teams that establish goals, plan tasks, and meet deadlines; - **enabling**
d. Communicate effectively with a range of audiences; - **demonstrate**
e. Apply techniques, skills, and modern engineering tools necessary for electrical engineering practice; - **enabling**
f. Demonstrate knowledge and understanding of engineering and management principles as a member and/or leader in a team to manage projects in multi-disciplinary environment. - **demonstrate**

Course Code	EE 101
Course Title	CIRCUIT 1
Course Credit	3 units lecture, 1 unit laboratory
Pre-requisites/Co-requisites	Physics 102, MATH 107

Course Description: This is a 3-unit course covers the basic concepts and fundamental laws of electrical circuit theory; analysis and application of series, parallel and series-parallel resistive circuits; mesh and nodal analysis theorems; characteristics of inductors and capacitors; analysis of RL, RC, and RLC circuits with excitation.

Course Intended Learning Outcomes

At the end of the course, the students should be able to:

Detailed Course Syllabus

Intended Learning Outcome	Topics	Time Frame	Teaching and Learning Activities	Assessment Tasks	Resources	Values Integration	References	Remarks
Express understanding of the Vision and Mission statements of SSCT, including its Goals and Objectives; Analyze the syllabus by looking into the ILOs, Subject Matter, TLAs, Assessment Strategies, Values and References; and Design strategies that will help meet the requirements and obtain desired grades/marks for the course	**ORIENTATION ON THE COURSE** **VMGO** **Syllabus** **Grading System**	1 hr	*Big Group Discussion* on VMGO *Documentary Analysis* of Syllabus and Grading System *Concept Mapping (Sunflower Map/Fishbone Map)* on strategies to meet course requirements		Computer/ Projector for Power point presentation of the VMGO Syllabus	Obedience, Punctuality, Diligence	Student Handbook	
Identify basic electrical quantities, electrical units,	**1. BASIC ELECTRICAL QUANTITIES SYSTEM OF**	4 hrs.	*Small Group Discuss* on electrical quantities, electrical units and	*Problem set Compilation* on the Basic Electrical	Whiteboard Marker Handouts	Appreciating the complex of the lesson	Alexander C. & Sadiku M. 4th Edition	

and electrical components Identify and solve Ohm's Law and Kirchhoff's Law	**UNITS; CIRCUIT COMPONENTS** **2. OHM'S LAW AND KIRCHHOFF'S LAWS**	 4 hrs.	components *Small Group Discuss* on the Ohm's Law and Kirchhoff's Law	Quantities system of units; Circuit components as well as Ohm's Law and Krchhoff's Laws			(2009) Charles Alexander, Matthew Sadiku-Fundamentals of Electric Circuits (2012, McGraw-Hill Science-Engineering Math)	
Identify and Analyze Series-Parallel Circuits Solve complex Series-Parallel Circuits Problems Learn the application of different types of circuits	**3. ANALYSIS OF SERIES, PARALLEL, SERIES-PARALLEL CIRCUITS** **4. APPLICATIONS OF RESISTIVE CIRCUITS-RESISTANCE BRIDGE CIRCUITS; BIASING CIRCUITS VOLTAGE DIVIDER CIRCUITS; ANALOG METERS**	4 hrs. 4 hrs. 2 hrs.	*Small group discussion and Brainstorming:* Analyze Series-Parallel Circuits and problems *Hands-on Laboratory Activity* on Applications of resistive circuits-resistance bridge circuits.	*Problem set Compilation* on the Analysis of resistive circuits with controlled sources and network theorems Rubrics: Accuracy: 40 Timeliness 30 Attitude/teamwork 30 TOTAL 100	Whiteboard Marker Handouts	Self-confidence in understanding and appreciating the lesson	Alexander C. & Sadiku M. 4th Edition (2009) Charles Alexander, Matthew Sadiku-Fundamentals of Electric Circuits (2012, McGraw-Hill Science-Engineering Math)	
Analyze and Solve complex	**5. ANALYSIS OF RESISTIVE**	4 hrs.	*Small group discussion and*	*Problem set Compilation*	Whiteboard Marker	Awareness in dealing	Alexander C. & Sadiku M.	

Series-Parallel Circuits problems with controlled sources Analyze and Solve Complex Series-Parallel Circuits problems with controlled sources using circuit analysis techniques and network theorems such as Thevenin and Norton Theorems	**CIRCUITS WITH CONTROLLED SOURCES** **6. CIRCUIT ANALYSIS TECHNIQUES AND NETWORK THEOREMS**	4 hrs. 2 hrs.	*Brainstorming:* on Series-Parallel Circuits problems and network theorems of Thevenin and Norton Laws *Hands-on Laboratory Activity* on Circuit analysis techniques and network theorems	on the Analysis of resistive circuits with controlled sources and network theorems Rubrics: Accuracy: 40 Timeliness 30 Attitude/teamwork 30 TOTAL 100	Handouts	with the difficulties in lesson	4th Edition (2009) Charles Alexander, Matthew Sadiku- Fundamentals of Electric Circuits (2012, McGraw-Hill Science-Engineering Math)	
MIDTERM EXAMINATION (3 hours)								
Identify inductors and Capacitors Analyze the DC response of inductors and capacitors	**7. FUNDAMENTALS OF INDUCTORS AND CAPACITORS**	8 hrs. 2 hrs.	*Small group discussion and Brainstorming:* on characteristics of internal forces in rigid bodies, proper plotting and labelling of structural members *Hands-on Laboratory Activity* on inductors and	*Problem set Compilation* on the Internal Forces Rubrics: Accuracy: 40 Timeliness 30	Whiteboard Marker Handouts	Self-confidence in understanding and appreciating the lesson	Alexander C. & Sadiku M. 4th Edition (2009) Charles Alexander, Matthew Sadiku- Fundamentals of Electric Circuits (2012,	

			capacitors	Attitude/teamwork 30 TOTAL 100			McGraw-Hill Science-Engineering Math)	
Identify and Analyze first order dynamic circuits Solve complex problems	**8. ANALYSIS OF FIRST ORDER DYNAMIC CIRCUITS WITH DC EXCITATION**	8 hrs 2 hrs.	*Small group discussion and Brainstorming:* on First order dynamic circuits and complex problems *Hands-on Laboratory Activity* on first order dynamic circuit with DC excitation	*Problem set Compilation* on the Analysis of first order dynamic circuits with DC excitation Rubrics: Accuracy: 40 Timeliness 30 Attitude/teamwork 30 TOTAL 100	Whiteboard Marker Handouts	Self-confidence in understanding and appreciating the lesson	Alexander C. & Sadiku M. 4th Edition (2009) Charles Alexander, Matthew Sadiku-Fundamentals of Electric Circuits (2012, McGraw-Hill Science-Engineering Math)	
Analysis and solve complex second order dynamic circuits	**9. ANALYSIS OF SECOND-ORDER DYNAMIC CIRCUITS WITH DC EXCITATION**	8 hrs. 2 hrs.	*Small group discussion and Brainstorming:* on the Analysis and complex second order dynamic circuits *Hands-on Laboratory Activity* on second order dynamic circuit with	*Problem set Compilation* on the Analysis of Second-order Dynamic Circuits with DC Excitation Rubrics: Accuracy: 40 Timeliness 30 Attitude/teamwork 30	Whiteboard Marker Handouts	Self-confidence in understanding and appreciating the lesson	Alexander C. & Sadiku M. 4th Edition (2009) Charles Alexander, Matthew Sadiku-Fundamentals of Electric Circuits (2012, McGraw-Hill Science-	

			DC excitation	TOTAL 100			Engineering Math)	
FINAL EXAMINATION (3 hours)								

Course Requirements:

- Individual Reports
- Graphic Organizers
- Group Project
- Midterm & Final Examination

Grading System:

Criteria: Academic Subjects	Lecture Grade	Laboratory Grade
Quizzes/ Problem Sets	20%	
Project	30%	
Laboratory Exercises		50%
Laboratory Reports		50%
Major Examination	50%	____
TOTAL	100%	100%

Grade Point	Description
1.0	Excellent
1.5 – 1.1	Very Good
2.0 – 1.6	Highly Satisfactory
2.5 – 2.1	Good
2.9 – 2.6	Satisfactory
3.0	Passing
5.0	Failed due to poor performance, absences, withdrawal without notice
DRP	Dropped with approved dropping slip
INC	Incomplete requirements but w/ passing class standing. INC is for non-graduating students only

Source: *SSCT Student Handbook*

Course Policies:

1. Attendance sheet will be passed around and the student is responsible to sign to prove his/her presence for that sessions. This is to monitor whether absences incurred by the student is still within the allowed number of absences for a course stipulated in the Student Handbook.
2. Excuse from the class will only be honored if a Memo from the school is issued before the absence or valid excuse letter from parents/guardians is presented after the absence. No other excuses will be entertained.
3. It is a part of your education to learn responsibility and self-discipline, particularly with regards to academic honesty. Cheating is defined to include an attempt to defraud, deceive, or mislead the instructor in arriving at honest grade assessment. Plagiarism is a form of cheating that involves presenting as one's own work the ideas or work of another. Therefore, all portions of any test, project, or major examination submitted by you for a grade must be your own work, unless you are instructed to work collaboratively. Cheating in a major course examination by a student will entail a failing mark for the given course. Plagiarism in papers and other works will entail zero score for the said requirement.
4. The use of multiple choice questionnaires is used during the exams. However, detailed solution to the problem should be written legibly in a clean long size bond paper.
5. Unsatisfactory project will not be accepted. However, the student/group will be given a chance to improve their project. Non-submission of the project on the set deadline means an automatic final grade of 5.
6. Exemptions from taking the final examination are as follows: (1) No exam below 60%, (2) No missed quizzes/exams, (3) Laboratory reports are submitted on the specified date, (4) The project is submitted on the specified deadline, and (5) Absences do not exceed the maximum allowed.
7. This class policy serves as our written agreement for the whole semester.

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Republic of the Philippines
SURIGAO STATE COLLEGE OF TECHNOLOGY
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"For Nation's Greater Heights"

COLLEGE OF ENGINEERING AND INFORMATION TECHNOLOGY
City Campus
Second Semester, Academic Year 2021-2022

Outcomes Based-Education (OBE) Syllabus in EE 202
ELECTRICAL CIRCUITS 2
Course Credit: 4.0unitslec.(108hrs)

Institutional Vision, Mission, and Goals

Vision:
An innovative and technologically-advanced State College in Caraga.

Mission:
To provide relevant,

a. high quality and sustainable instruction,
b. research, production and extension programs and
c. services within a culture of credible and responsive institutional governance.

Goals:

1. Foster application of the discipline and provide its learner with industry-based training and education particularly in engineering, technology and fisheries.
2. Conduct and utilize studies for the development of new products, systems and services relevant to Philippine life and of the global village.
3. Promote transfer of technology and spread useful technical skills, thus empowering its learners and their activities.

SSCT Core Values

Service-Oriented   Socially Responsive   Committed   Transformational

SSCT Quality Policy

Surigao State College of Technology provides quality instruction, research, extension programs and production services to satisfy its customers by responding to their needs and expectations and continually improving its quality management system.

Institutional Graduate Attributes (IGA) :

- Visionary Leader
- Effective Communicator
- Competent Technologist
- Self-Directed Lifelong Learner

Program Goals

The Electrical Engineering program aims to design and apply the generation, transmission, and distribution of electrical energy to produce competent engineers that exhibit positive work ethics and flexibility in work conditions for the development of Caraga.

ProgramEducational Objectives (PEO) and Relationship to Institutional Mission

Program Educational Objectives (PEO)	Mission		
	a	b	c
EE-PEO1. Demonstrate professionalism in electrical engineering and apply professional ethics thru communication and collaboration.	/	/	/
EE-PEO2. Use appropriate techniques, resources, and modern tools necessary for analysis, design, and modelling of complex electrical systems	/	/	/
EE-PEO3. Plan, lead, and implement designated tasks, interact with other engineering professionals, and take leadership roles in electrical engineering organization.	/	/	/
EE-PEO4. Engage in lifelong learning able to discover new opportunities for continuing personal and professional development in electrical engineering	/	/	/

Program Outcomes (PO) and Relationship to Program Educational Objectives (PEO)

Program Outcomes (PO)	Program Educational Objectives (PEO)			
	1	2	3	4
EE-POa.Apply knowledge of mathematics and sciences to solve complex engineering problems				
EE-POb.Develop and conduct appropriate experimentation, analyze and interpret data	/	/	/	/
EE-POc.Design a system, component, or process to meet desired needs within				

realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards				
EE-POd.Function effectively on multi-disciplinary and multi-cultural teams that establish goals, plan tasks, and meet deadlines				
EE-POe.Identify, formulate, and solve complex problems in electrical engineering	/	/	/	/
EE-POf.Recognize ethical and professional responsibilities in engineering practice				
EE-POg.Communicate effectively with a range of audiences	/	/	/	/
EE-POh.Understand the impact of engineering solutions in a global, economic, environmental, and societal context				
EE-POi.Recognize the need for additional knowledge and engage in lifelong learning				
EE-POj.Articulate and discuss the latest developments in the field of electrical engineering				
EE-POk.Apply techniques, skills, and modern engineering tools necessary for electrical engineering practice				
EE-POl.Demonstrate knowledge and understanding of engineering and management principles as a member and/or leader in a team to manage projects in multidisciplinary environments				

Course Description

The course deals with sinusoidal steady-state analysis in the frequency domain; AC circuit power analysis; analysis of polyphase circuits and magnetically-coupled circuits; frequency response; per unit system and symmetrical components; and two-port networks

DACUM Main Duties (DMD)

EE-DMD1. Diagnose electrical problems using the electrical diagrams or blue print (as built electrical plans)
EE-DMD2. Install, repair, and maintenance electrical power systems(building wiring, controls, electrical machines and transformers)
EE-DMD3. Facilities Manager
EE-DMD4. Power Plant Manager
EE-DMD5. Electrical Researchers, Professor and Faculty

Course Outcomes (CO) and Relationship to Program Outcomes (PO)

Program Outcome (PO) / Level	Course Outcomes (CO)	Assessment Task (CO-AT)	DACUM Links				
			1	2	3	4	5
EE-POb(Enabling).Develop and conduct appropriate experimentation, analyze and interpret data	*EE201-CO1*: Develop and conduct electrical engineering experimentations and then analyze and interpret the data.	Students conduct electrical engineering experiments. These experiments serve as a group activity where they will analyze and interpret data. Criteria – Functionality and lab report Total Points: 100 points	/	/			/
EE-POe(Enabling). Identify, formulate, and solve complex problems in electrical engineering.	*EE201-CO2*: Calculate complex electrical engineering problems related to electric circuit theory.	Students calculate sets of electrical engineering problems using the electric circuit theory concepts. Criteria – 70% correct answers and solutions Total Points: 100 points	/				/
EE-POg(Enabling).Communicate effectively with a range of audiences	*EE201-CO3*: Communicate effectively with the team, group or other range of audiences when conducting experiments and solving problems in electrical engineering.	Students create a group project and present them in the class. Criteria – creativity, functionality, delivery Total Points: 100 points			/	/	/

Course Outcomes (CO) and Relationship to Intended Learning Outcomes (ILO)

Course Outcomes (CO)	Intended Learning Outcomes (ILO)
EE201-CO1: Develop and conduct electrical engineering experimentations and then analyze	*EE202-ILO1*: Apply the circuit theorems and techniques used in DC to analyse AC circuits.(EE201-CO2)

and interpret the data. *EE201-CO2*: Calculate complex electrical engineering problems related to electric circuit theory. *EE201-CO3*: Communicate effectively with the team, group or other range of audiences when conducting experiments and solving problems in electrical engineering.	*EE202-ILO2*: Recognize the essential concepts used in AC power analysis. (EE201-CO1) *EE202-ILO3*: Calculate electrical engineering problems related to AC power analysis. (EE201-CO2) *EE202-ILO4*: Analyse balanced and unbalanced three-phase circuits. (EE201-CO1) *EE202-ILO5*: Analyse magnetically coupled circuits. (EE201-CO1) *EE202-ILO6*: Analyse the concepts of transfer function, series and parallel resonance, and basic filter design. (EE201-CO1) *EE202-ILO7*: Recognize the concept of per-unit and understand its significance in power system analysis. (EE201-CO2) *EE202-ILO8*: Recognize the concept of symmetrical components in the analysis of unbalanced three-phase power system. (EE201-CO2) *EE202-ILO9*: Recognize the various two-port parameters to analyse electrical/electronic circuits. (EE201-CO3)

Detailed Course Content

Intended Learning Outcomes (ILO)	Topics	Time Frame	Teaching and Learning Activities(TLA)	Assessment Tasks (ILO-AT)	Target	Resources	Values Integration	Remarks
EE202-ILO1: Apply the circuit theorems and techniques used in DC	1. **SINUSOIDAL STEADY-STATE ANALYSIS**	10 hrs.	Learning Module 1 *Asynchronous*	Problem analysis quiz and assignment	70% of the students shall have	Learning module and videos on	Core Value: *Transformational*	

to analyse AC circuits.(EE201-CO2)	*1.1. Nodal and Mesh Analysis* *1.1.1 Nodal Analysis* *1.1.2 Mesh Analysis* *1.2. Superposition Theorem* *1.3. Source Transformation* *1.4. Thevenin's and Norton's Theorems*			on sinusoidal steady-state analysis.	a rating of at least 3.0	sinusoidal steady-state analysis Multisim	Sub-Value: *Adaptive application of circuit techniques and theorems to analyse ac circuits*	
EE202-ILO2: Recognize the essential concepts used in AC power analysis.(EE201-CO1) *EE202-ILO3*: Calculate electrical engineering problems related to AC power analysis.(EE201-CO2)	**2. AC POWER ANALYSIS** *2.1. Instantaneous and Average Power* *2.2. Maximum Average Power Transfer* *2.3. Effective or RMS Value* *2.4. Apparent Power and Power Factor* *2.5. Complex Power* *2.6. Conservation of AC Power* *2.7. Power Factor Correction*	14 hrs.	Learning Module 2 *Asynchronous*	Problem analysis quiz and assignment on ac power analysis.	70% of the students shall have a rating of at least 3.0	Learning module and videos on ac power analysis Multisim	Core Value: *Committed* Sub-Value: *Dedicated analysis of ac power*	
EE202-ILO4: Analyse	**3. ANALYSIS OF**	14 hrs.	Learning Module 3	Problem	70% of the	Learning	Core Value:	

balanced and unbalanced three-phase circuits.(EE201-CO1)	**POLYPHASE CIRCUITS** 3.1. *Balanced Three-Phase Voltages* 3.2. *Balanced Wye-Wye Connection* 3.3. *Balanced Wye-Delta Connection* 3.4. *Balanced Delta-Delta Connection* 3.5. *Balanced Delta-Wye Connection* 3.6. *Power in a Balanced System* 3.7. *Unbalanced Three-Phase Systems* 3.8. *Three-Phase Power Measurement*		*Asynchronous*	analysis quiz and assignment on three-phase circuits	students shall have a rating of at least 3.0	module and videos on the analysis of polyphase circuits Multisim	*Committed* Sub-Value: *Perseverant in the analysis of polyphase circuits*	
EE202-ILO5: Analyse magnetically coupled circuits.(EE201-CO1)	**4. ANALYSIS OF MAGNETICALLY-COUPLED CIRCUITS** 4.1. *Mutual Inductance* 4.2. *Energy in a Coupled Circuit* 4.3. *Linear Transformers* 4.4. *Ideal*	12 hrs.	Learning Module 4 *Asynchronous*	Problem analysis quiz and assignment on magnetically-coupled circuits	70% of the students shall have a rating of at least 3.0	Learning module and videos on the analysis of magnetically-coupled circuits. Multisim	Core Value: *Transformational* Sub-Value: *Adaptive application of mutual inductance in the analysis of magnetically-coupled circuits*	

	Transformers 4.5. *Ideal Autotransformers*							
MIDTERM EXAMINATION– 2.0 Hrs.								
EE202-ILO6: Analyse the concepts of transfer function, series and parallel resonance, and basic filter design.(EE201-CO1)	**5. FREQUENCY RESPONSE** 5.1. *Transfer Function* 5.2. *Series Resonance* 5.3. *Parallel Resonance* 5.4. *Basic Filter Design*	10 hrs.	Learning Module 5 *Asynchronous*	Problem analysis quiz on frequency response	70% of the students shall have a rating of at least 3.0	Learning module and videos on frequency response	Core Value: *Committed* Sub-Value: *Determined analysis of the frequency response of electrical circuits*	
EE202-ILO7: Recognize the concept of per-unit and understand its significance in power system analysis.(EE201-CO2)	**6. PER UNIT SYSTEM** 6.1. *Single-Phase Systems* 6.2. *Change of Base* 6.3. *Three-Phase Systems*	14 hrs.	Learning Module 6 *Asynchronous*	Problem analysis quiz and assignment on per-unit system	70% of the students shall have a rating of at least 3.0	Learning module and videos on per-unit system	Core Value: *Transformational* Sub-Value: *Optimistic application of per unit system in the analysis of power systems*	
EE202-ILO8: Recognize the concept of symmetrical components in the analysis of unbalanced three-phase power system.(EE201-CO2)	**7. SYMMETRICAL COMPONENTS OF UNBALANCED 3-PHASE VOLTAGES AND CURRENTS**	14 hrs.	Learning Module 7 *Asynchronous*	Problem analysis quiz and assignment on symmetrical components	70% of the students shall have a rating of at least 3.0	Learning module and videos symmetrical components.	Core Value: *Transformational* Sub-Value: *Adaptive analysis of unbalanced 3-phase voltages*	

							and currents	
EE202-ILO9: Recognize the various two-port parameters to analyse electrical/electronic circuits.(EE201-CO3)	**8. ANALYSIS OF TWO-PORT NETWORKS** *8.1. Impedance Parameters* *8.2. Admittance Parameters* *8.3. Hybrid Parameters* *8.4. Transmission Parameters* *8.5. Relationships Between Parameters* *8.6. Network Interconnection*	12 hrs.	Learning Module 8 *Asynchronous*	Problem analysis quiz on two-port networks	70% of the students shall have a rating of at least 3.0	Learning module and videos on analysis of two-port networks.	Core Value: *Committed* Sub-Value: *Determined application of two-port networks to analyse electrical circuits*	
FINAL EXAMINATION – 2.0 Hrs.								

References:

Charles Alexander & Matthew Sadiku (2016).*Fundamentals of Electric Circuits*.6th ed. McGraw-Hill Education
HemchandraMadhusudanShertukde (2019). *Power System Analysis Illustrated with MATLAB and ETAP*. CRC Press Taylor and Francis Group
J. Duncan Glover, Thomas J. Overbye, &Mulukutla S. Sarma (2017).*Power System Analysis & Design*. 6th ed. Cengage Learning
Turan Gönen (2014).*Electric Power Distribution Engineering*. 3rd ed. CRC Press, Taylor & Francis Group
MahmoodNahvi, PhD. & Joseph A. Edminister (2017).*Schaum's Outlines of Electric Circuits*. 7thed. McGraw-Hill Education

Course Requirements:

- Laboratory Reports(CO-AT1)
- Portfolio of solved Problems(CO-AT2)
- Group Project(CO-AT3)
- Quizzes and Assignments

- Midterm and Final exams

Course Evaluation:

Criteria	Lecture Grade
➢ Quizzesand online outputs/interaction (ILO-AT)	20%
➢ Performance Tasks (CO-AT)	40%
➢ Major Exams (Midterm and Final)	40%
TOTAL	**100%**

Grade Computation: $\frac{Midterm\ Grade + Final\ Grade}{2} = Average\ Grade$

Grade Point	Description
1.0	Excellent
1.5 – 1.1	Very Good
2.0 – 1.6	Highly Satisfactory
2.5 – 2.1	Good
2.9 – 2.6	Satisfactory
3.0	Passing
5.0	Failed due to poor performance, absences, withdrawal without notice
DRP	Dropped with approved dropping slip
INC	Incomplete requirements but w/ passing class standing. INC is for non-graduating students only
NG	No Grade

Source: *SSCT Student Handbook*

Course Policies:

1. Attendance shall be checked in every class session in the Google Meet. This is to monitor the absences incurred by the students in terms of the allowable number of absences for a course as stipulated in the Student Handbook.
2. During online classes, video camera shall be turned on all the time and microphone shall be turned off. The microphone shall be unmuted only if the student's name is called to participate in class discussion.
3. Major examinations in multiple-choice type shall be done online. For problem solving type, detailed solutions shall be written legibly in separate sheets of paper

and shall be converted to pdf form prior to submission.

4. Cheating in major examinations which include attempts to defraud, deceive, or mislead the instructor in arriving at an honest assessment shall entail zero score.
5. Plagiarism which is a form of cheating that involves presenting the ideas or work of another as one's own work shall entail zero score.
6. Projects shall be submitted on or before the deadline. Students who submit unsatisfactory projects shall be given the chance to improve their works on the condition that they resubmit the revised outputs on the date set by the instructor. Non-submission of a project on the deadline shall entail zero score.
7. An INC grade shall be given to students who fail to submit the course requirements of at least 95% of the projects and quizzes or failure to take the major examinations.

Revision History:

Revision No.	Revised by	Date of Revision	Date of Implementation	Highlight of Revision
1	Engr. Vernon V. Liza	July 19, 2021	August 23, 2021	Followed OBTL Format as per CMO #101 S. 2017
2	Engr. Vernon V. Liza	January 25, 2021	February 7, 2021	DACUM Workshop vis-à-vis CMO No. 101 S. 2017

Prepared by:

ENGR. VERNON V. LIZA
Guest Lecturer

Date: 1-25-2022

Checked and reviewed by:

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Program Chair, BSEE

Date: 1-28-2022

Noted by:

ENGR. ROBERT R. BACARRO, MECE, MBA
Dean, CEIT

Date: 1-28-2022

Recommended by:

RONITA E. TALINGTING, PhD
Campus Director

Date: 1-31-2022

Approved by:

EMMYLOU A. BORJA, EdD
VP for Academic Affairs

Date: 1-31-2022