MULTIPLE OUTPUTS QUEUED SWITCHING FOR DETECTION OF FAULTY OF PILOT CABLE BY USING PULSED TECHNIQUE.

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ABSTACT

This paper develops the implementation of technique to control the inspection wires in pilot cable by using multiple output queued switch. This MOQ switching has a selector that sorts the multiple outputs switching to connect the specific input to the single output. This project used a pulsed signal as the signal source where it is used to transmit in the pilot cable wires which mostly placed underground and the oscilloscope used as a waveform monitor. This idealized switching is available to modified input voltage of TDR at any value and easy to carry out any where. A computer program is developed so that it can transfer all the data that appeared on the oscilloscope and straightly save in computer. As a result, the analysis of the data which is reflected waveform can easily be performed. The software called Labview was chosen to apply for this programming. This MOQ switching is implemented to use as tester switch for low-voltage and high-voltage circuit.

Keywords:
Multiple Output Queued (MOQ) Switching, Multiplexer (MUX), Time-Domain Reflectometers (TDR), Polyethylene Vinyl-Chloride (PVC), Pulse Signal Generator (PSG), Pulse Signal Detection (PSD), Pilot Cable Wires (PCW)

Scope of Work
The purpose of this project is to study, design and construct the multiple switching testers for detection of fault wires using pulsed technique. This work involves on the technique for detection of fault cable wires in pilot cable using pulsed signal. The multiple switching for pulsed technique is applicable for pilot wires cable.

1.0 INTRODUCTION

The pilot cable normally using for controlling, signaling, telecommunication, protection and data transmission purposed associated with power distribution and transmission system. In a pilot cable, there are bundles of wires enclosed with wires armor and covered by PVC insulation.
This bundle of wires is assembling by parallel to each other. Due to it characteristic, the new problem is encounter and that is a maintenance work. To sort out this matter, the technique of time-domain reflection was chosen based on it capability along with signal of pulsed as indicator. From the previous paper [1] the best signal of pulse had been introduced. This pulse signal was applied for detection the fault in the pilot cable wires and proven already that it working as desired.
The limitation to detect the faults at one time when applying pulsed technique on the pilot wires cable. In second previous paper [2] to overcome this matter, multiplexer switching is employed. There are limitations when used multiplexer switching where the problem is:
1. After combined of both circuit, the pulse signal generator circuit is failed to supply the right input to the multiplexer switching circuit. That mean the output signal from pulse generator cannot drives the multiplexer switching circuit.
2. The second problem is limitation of switching to allow the increasing voltage in pulse signal generator, where mux will destroy when high voltage flow through them.

In new design circuit, often desirable or essential to isolate one circuit electrically from another, while stills allowing the first circuit to control the second. To control a high-voltage circuit from pulse generator, and would probably not want to connect it directly to a low-voltage port on the back of the relay port circuit in case something went wrong and the mains electricity ended up destroying the components inside timer and decade counter circuit.

One simple method of providing electrical isolation between two circuits is to place a relay between them, as shown in the circuit diagram of figure 1.0. A relay consists of a coil which may be energized by the low-voltage circuit and one or more sets of switch contacts which may be connected to the high-voltage circuit.

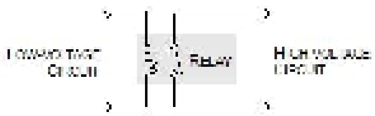

Figure 1.0: A relay providing isolation between two circuits.

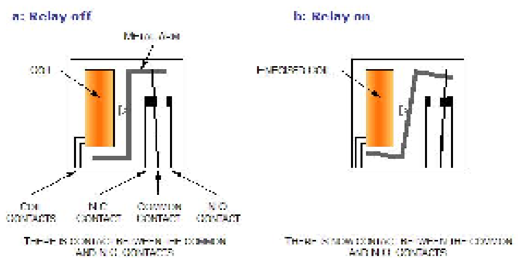

Figure 1.1: The mechanical operation of a relay

In figure 1.1(a) the relay is off. The metal arm is at its rest position and so there is contact between the Normally Closed (N.C.) switch contact and the 'common' switch contact.

If a current is passed through the coil, the resulting magnetic field attracts the metal arm and there is now contact between the Normally Open (N.O.) switch contact and the common switch contact, as shown in figure 1.1(b).

The multiple outputs queued switching is a very flexible controlling instrument and the most useful tools in switching equipment. Their basic capability is to conduct and control multiple outputs to be tested at any voltage value; at the same time with proper timing setting depends on the user desired. It is a special type of electronic switch and it has three important part of circuit. That part is astable (pulsed generator) circuit, decade counter circuit, and parallel port relay board. The astable circuit is function to setup timer for decade counter circuit to selected port of relays to switch on the tester of TDR. The space-mark ratio is function to control time for selected relay to be turn on by sequence, and time to transmitted pulse signal with monitor waveform reflection pulse signal.

2.0 METHODOLOGY

The propose of employing the multiple switching techniques is for controlling the signal of pulsed generated by circuit based on time-domain reflection (TDR) method designed by previous worker [1]. The multiple switching is able to monitor the waveform signal from which the wire is being tester according to the input that the user desired. The waveform signal appear on the oscilloscope is resulting of reflection waveform when the signal arrived at one end of the cable. As a result, the output signal or reflected waveform on oscilloscope can analyzed and determined the type of faults and the location of fault on the pilot cable.

Figure 2.1 show the process on detection faults wires in the pilot cable develop by previous people [1]. By the way it needs some improvement in term of switching to select the wires to be tested for save time and maintenance cost.

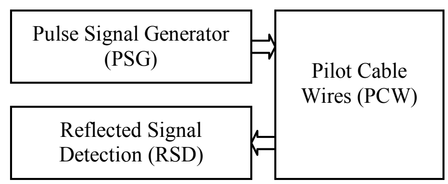

Figure 2.1: The operation block diagram

The second paper [2] is propose of employing the multiplexer switching technique to controlling the signal of pulse generated by circuit based on time-domain reflection (TDR) method design by previous paper [1]. This technique is basically located between the pulsed signal generation and pilot cable wires. Figure 2.2 shows the improvement of the way pilot cable wires to be tested.

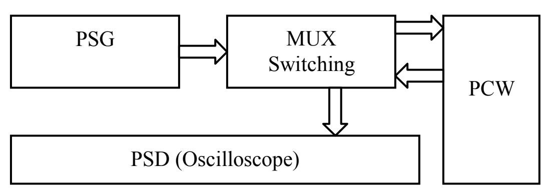

Figure 2.2: The second previous block operation diagram.

The main task is to develop the multi-tasking switching that can combine with the available pulsed signal generation circuit then applying the same detection method on pilot cable. The multiplexer switching shall be able to allow the signal of pulsed to go through and reached the under checking wires. The pulse signal passing shall be able transmit into the wire as a result, the reflected signal then will display on the specific equipment which is oscilloscope through the same multiplexer switching through output channel addressed early.

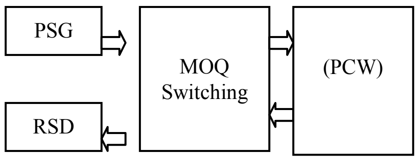

Figure 2.3: The new block operation diagram.

The newly developed switching technique is basically located between the pulsed signal generation and pilot cable. Figure 2.3 show the improvement to smooth process of tested the pilot cable.

In this project, a pilot wires cable was tested. Since the pilot cable contains bundle of wires, therefore the main task is to develop the multi-tasking switching that can combine with the available pulsed signal generation circuit then applying the same detection method on the pilot cable. The multiple switching shall be able to allow the signal of pulsed to go through and reached the under checking wire. The pulse is passing shall be able to transmitted into wire, as a result, the reflected signal then will display on the oscilloscope through the same multiple switching.

The pulse width available may be adjusted or varied subject to the length of cable under inspection. For wider pulse width, more energy is transmitted and thus the distance of the signal can travel is much further. Unfortunately, larger pulse width has larger blind spots.

There are two designs that may generate pulse signal that can used to test for this project. The first design circuit is created by previous worked [1] where it has three different channel for monitoring the transmit pulse, monitor the reflected pulse of fault wire and monitoring the un-fault wire for comparison.

The both design circuit is capable to generate pulse continuously with different pulse width. The widths of pulse are controlled by the capacitor with different values. The capacitances starting from 47 pF until 22 nF will respectively produce the pulses with varying widths from 10 nS until 3 uS. The first design circuit can also be used to test the pilot cable but with some limitation.

In this project, some modifications were made on the previous circuit. The three resistors with the value of 27Ω each used by the previous design is removed. The resistor at mark-space ratio in pulse signal generator circuit was modified to get better pulse waveform. Figure 2.4 shows the resultant circuit after modification done.

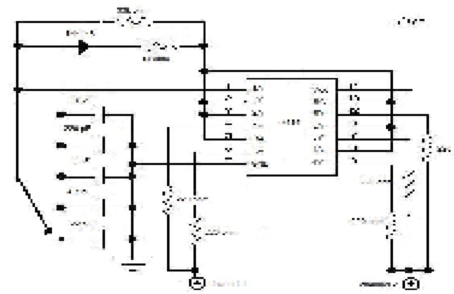

Figure 2.4: The modification circuit pulse signal generator.

The improvement circuit shown in Figure 2.5 is expected to function as required when implemented to pilot cable together with multiple switching. The two end point of resistor (220 ohm) is isolate for reference and injected signal for MOQ switch as figure below.

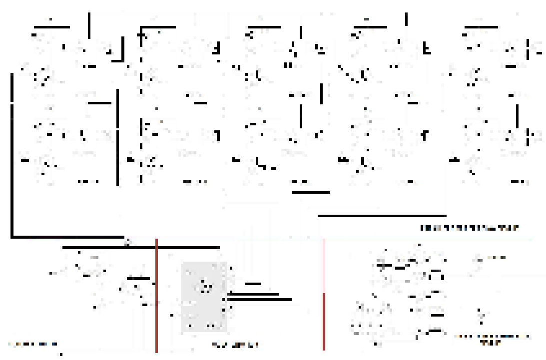

Figure 2.5: The purposed circuit for combine with multiple output queued switching circuit.

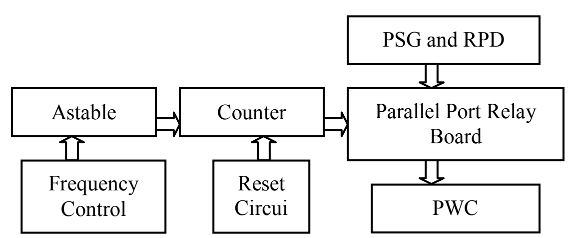

Figure 2.6: Block of multiple output queued switching diagrams.

2.0.1 Astables Circuit (pulse Generators)

The figure 2.6 shows the block of MOQ switching diagrams which is consist three main parts. The first part is astable or pulse generator act as frequency controls. In an astable circuit, the output continually switches between the high and low states without any intervention from the user, producing a 'square' wave. An astable has no stable state- hence the name "astable". This type circuit could be used to give a mechanism intermittent motion by switching a relay on and off at regular intervals. It can also useful as a 'clock' pulse for other digital ICs and circuits. An astable circuit a constructed by using a 555 timer IC and few other components as shown in figure 2.5.

The figure 2.5 shows the circuit diagram of the 555 astable circuit. The values of the components (R1, R2 and C) determine the frequency and duty cycle of the astable, and they may be calculated using the equations below:

$$T_{mark} = 0.7\,(R1 + R2)C$$
$$T_{space} = 0.7R2C$$
$$F = 1.44 / ((R1 + 2R2)C)$$

Where T_{mark} and T_{space} are the mark and space periods in seconds, F is the frequency in Hertz, and R1, R2 and C are the component values in Ohms (Ω) and Farads (F). The third equation is in fact derived from the first two, but we will only consider using the first two equations.

Figure 2.7 shows the square wave output of an astable circuit. There is one 'cycle' (one high period and one low period) every 1/10th second, so the wave has a 'period' of 0.1 seconds. The time period is directly related to the 'frequency' of the wave by equation …

$$F = 1/T$$

Where F is the frequency of the wave in Hertz (Hz)) and T is the time period of the wave in seconds. Therefore, the wave in figure 11a has a frequency of 10Hz…

$$F = 1/T = 1/0.1s = 10Hz$$

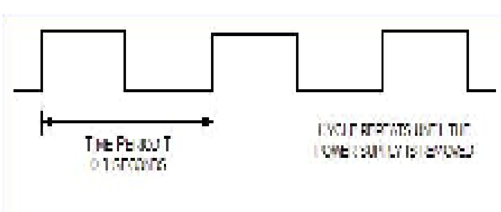

Figure 2.7: A square wave

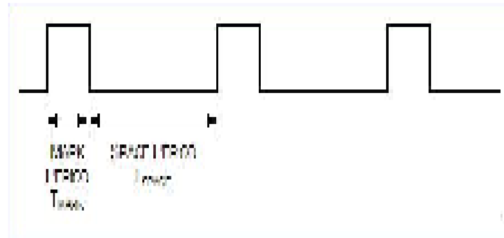

Figure 2.8: Another square wave

Figure 2.8 shows another square wave output from an astable circuit. As the wave in figure 2.7, it also has a frequency of 10 Hz, but this time the high and low periods are unequal. The high period, also known as the 'mark' period, is 0.025 seconds long. The low period, also known as the 'space' period, is 0.075 seconds long. The ratio of these periods is known as the 'mark-to-space ratio'. In this case it is 1:3, but it is usually expressed as a percentage called the 'duty cycle', which in this case is 25%. This simply means that the output is high for 25% of each cycle and low for 75% of each cycle. The duty cycle of the square wave in figure 2.7 would be 50%.

To adjust the frequency of the astable circuit in use, we need used a linear variable resistor for R1, as shown in figure 2.5. Because the resistance of a variable resistor goes down to around 0Ω at one end of its range, a 1kΩ resistor is placed in series with it so that the value of R1 will never fall below 1kΩ. If R2 is much larger than 1kΩ, this means that at the lowest shaft setting of the variable resistor T_{space} and T_{mark} will be approximately equal. As the shaft is turned, T_{space} will become longer. With varying the frequency we will get the proper timing to switching the parallel port of relay in sequence to test the pilot wires cable.

2.0.2 Decade Counter

As shown in figure 2.5, the 4017 is divide-by-10, or decade counter with 10 individual outputs which go HIGH in turn when pulses are fed to its CLOCK input. To make the 4017 work, the power supply is connect to pin 16. In addition, the ENABLE and RESET input are connected to 0V. With these connections in place, the pulses from the 555 astable can be connected to the CLOCK input, pin 14.

Provided the 4017 circuit and astable circuit are connected correctly, each of the 10 individuals output of the 4017 should be pulsing. The astable circuit will be control the pulsing and each output is HIGH for proper timing setting. In fact, each output goes HIGH for one tenth of the time

and goes LOW at the same moment that the next output in the sequence becomes HIGH.
The v/t graphs in the diagram below show how the outputs change following the rising edges of the pulses at the CLOCK input. As shown in figure 2.9, each of the individual outputs goes HIGH in turn. The divide-by-10 output is HIGH for output 0 to 4 and goes LOW for output 5 to 9.

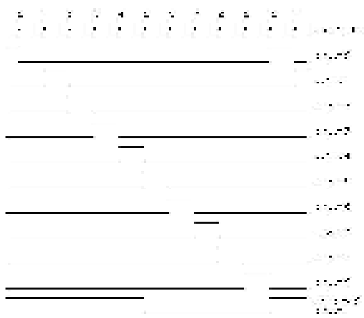

Figure 2.9: Voltage versus time graphs for 4017 counter.

The output of the 4017 can be multiple at same supply voltage with connect the devide-by-10 at pin 12 at first 4017 to the second 4017 at CLOCK input (pin 14). Each of the output the 4017 will connect to port ‘a’ at single port relay circuit to complete the MOQ switch.

2.0.3 Parallel Port of Relay Switching

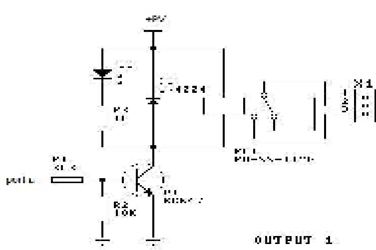

Figure 2.10: Single Port of Relay switching.

The basic design of parallel port of relay boards come from single port of relay circuit as shown in figure 2.10, where it will arrange with parallel or multiple. This PCB contains 10 identical switched relay positions, power input positions to the relays (+9V) and input at ‘port a’ connected to the parallel port of output at counter circuit as shown in figure 2.5. To keep this switch simple no input latches have been put on it. If the board is accidentally disconnected from the parallel port then the 10kΩ pulldown resistors will turn the relay off. The diodes protect the transistors from the back-emf which is occurs when the relay is turned off and its magnetic field collapses.
The relays are under direct control of the output byte (10 bits) from the parallel port. When a pin is high a nominal 5V is present to the base resistor R1 (3.3kΩ). Since there is a fixed 0.6V drop across the BE junction of Q1 there is 4.4V across R1 (5V-0.6V). So by the Ohms Law 1.33mA current flows through the 3.3kΩ resistor. There is also 0.6V across the 10kΩ pulldown resistor which draws 0.06mA. If we assume an hFE of 100 for Q1 then 127mA flows through the CE leads of Q1 when it is turned on (IC = IB.hFE). Since the 9V relay turns on at around 30mA this current is more then enough to turn on the relay. The relay has a coil resistance of around 400 ohms and a coil power consumption of 30mW. The LED is function to indicate where the relay was activated (or switched on). When the relay is on then the voltage should be around 0.1V. If it is 3V-4V then the transistor is not fully on.

2.1 MEASUREMENT PROCEDURE

The previous measurement setup equipment of testing cable will be modified with new measurement setup as shows in figure 2.11.

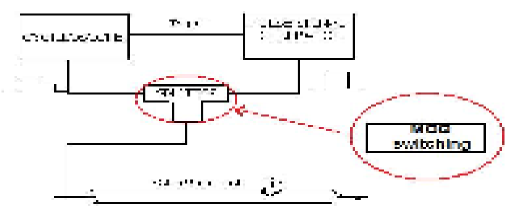

Figure 2.11: The previous setup equipment of testing cable and the new MOQ switch setup of inspection cable.

The pulse generator circuit was supply with a 5V DC power supply or battery. The oscilloscope is setting at 2V/div and the time is depending on the pulse width. The trigger channel is required to ensure that the pulsed can be monitor in oscilloscope. Hence the generated pulsed must be monitor in oscilloscope until the pulse is constant.
The generated pulse is applied to the cable under test and the reflected pulsed will display on the oscilloscope. These procedures are similar to the improvement switching circuit. The difference is that the additional channel is no longer required.
The advantages on the developing multiple outputs queued switching are the capability to test the number of parallel wires up at the one

time is increased and also it is able to choose which wire to be checked. Thus all the observations will appear on the oscilloscope at one output channel only.

3. RESULT

The aim of this project was achieved where the MOQ switch is available to use at pilot wires cable for detection of faulty wires. The time to monitor reflected pulse can be setting with proper timing as what user desired. This MOQ switch is available to modify the voltage amplitude of TDR for injected pulsed signal at the actual long for pilot cable (above 500 meter). The MOQ switching was tested and produces a pulse signal that required transmitting into the cable.

There are several testing has been done by using MOQ switching. This test considered to the open circuit, short circuit, increased of the length of the pilot cable wires and amplifying the voltage amplitude at pulse signal generator.

The reflection occurs when generated signal inject into the cable. Figure 3.0, shown the output pulse when switching is activated. The waveform shows the reference or generated signal and the reflection signal from the cable. This is healthy cable without any defect. In generated waveform, the wiring problem as splice or joint cable between circuits and wires under tested will created some effect at the starting and the end of pulse waveform. For the reflected waveform the transmitted and reflected signals will occur until energy generated by circuit loose.

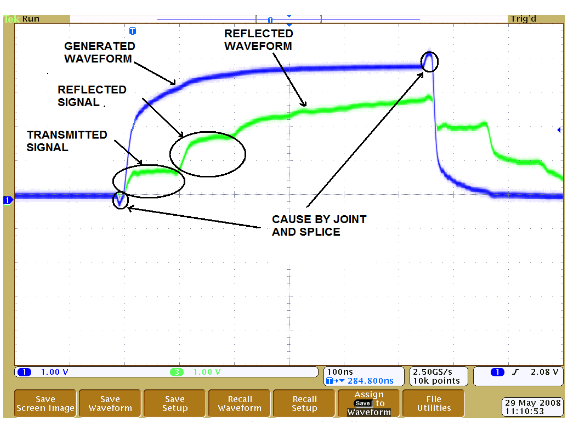

Figure 3.0: Generated waveform and reflection waveform

Short Circuit Test

Short circuit test is consider as a test with the end of the cable is shorted to the ground or short together. This test will show the result of the cable in the actual conditions if the cable is shorted to the ground or the conductor leakage to other conductor. Figure 3.1 show the waveform of reflected pulse of the short to the ground. It shows the reflected pulse opposite polarity to the transmitted pulse.

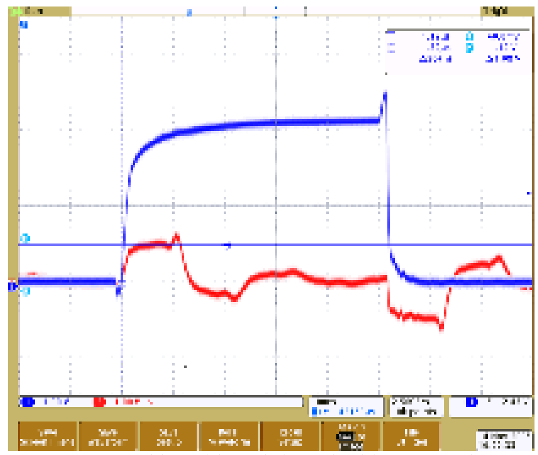

Figure 3.1: Healthy cable and shorted cable to ground.

Another short test is cable shorted with other cable. This show that at shorted spot the signal are reverse polarity with transmitted signal after the short the signal continue travel until end of the cable. It was shown in Figure 3.2.

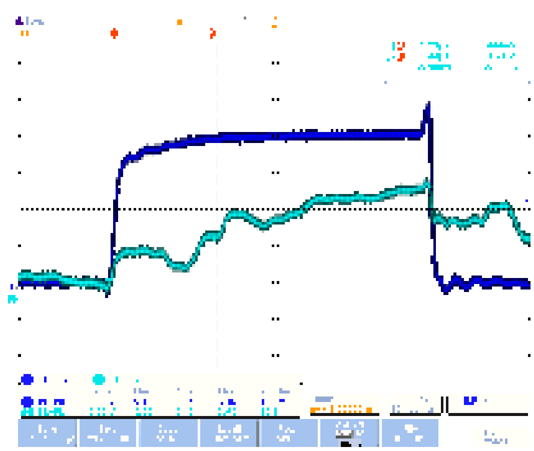

Figure 3.3: Output from cable shorted with other cable

The velocity of propagation can be determined from an experiment on a known length of the same type of cable. The time required from the incident wave to travel down and the reflected wave to travel back from an open circuit termination at the end of a 10 meter pilot cable is 201ns giving $v_\rho = 0.995 \times 10^{-1}$ m/ns. Knowing v_ρ and reading T from the oscilloscope determines D (for healthy cable at 10 m length). From information display in oscilloscope as Figure 3.1 and 3.2, we can calculate the actual locations of fault cable occur. It will shows in the following:

At Figure 3.1, delay time of transmitting to reflecting signal is 204ns so the length of pilot cable, D is;

$$D = v_\rho T/2 = (0.995 \times 10^{-1})\ 204/2$$
$$= 10.149 \text{ meter}$$

(Actual value is 10 meter)

At Figure 3.2, delay time of transmitting to reflecting signal is 74ns so the length of pilot cable, D is;

$$D = v_\rho T/2 = (0.995 \times 10^{-1})\ 208/2$$
$$= 10.348 \text{ meter}$$

(Actual value is 10 meter)

Open Circuit test

Open circuit test is considered as a test with the end of the cable is not connected. This test is used to observation of the actual cable when we cut the cable at the middle. It's also shown that travel signal more shorter compare with healthy cable. Figure 3.3, show the waveform of the open circuit test cable. This will repeat until all the pulse is absorbed by the cable. From the theoretical, the reflected pulse will be in a same polarity to the transmitted pulsed.

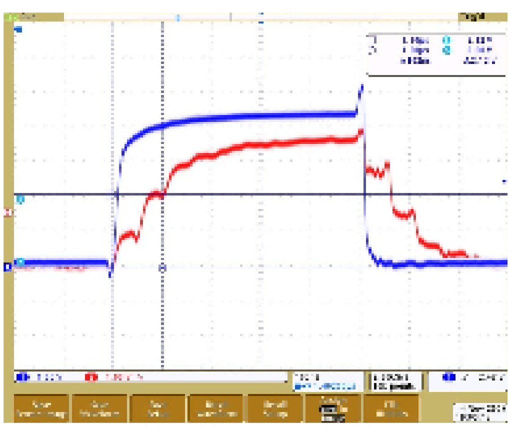

Figure 3.3: Healthy cable and opened cable

From information display in oscilloscope as Figure 3.3, we can calculate the actual locations of fault cable occur. It will shows in the following:

At Figure 3.3, delay time of transmitting to reflecting signal is 204ns so the length of pilot cable, D is;

$$D = v_\rho T/2 = (0.995 \times 10^{-1})\ 102/2$$
$$= 5.0745 \text{ meter}$$

(Actual value is 5 meter)

Increased length of pilot wires cable

For all the cable it will effect by losses of the cable. Long cable will cause higher losses that why the transmitted signal need to amplify to ensure its will return back and present the faulty of the cable. This will be discussed in next stage of the analysis. In Figure 3.5 clearly that can be seen the signal 1 are weak compare signal 2 at normal healthy cable use as reference. These cables (at signal 2) are connected with four time reference cable.

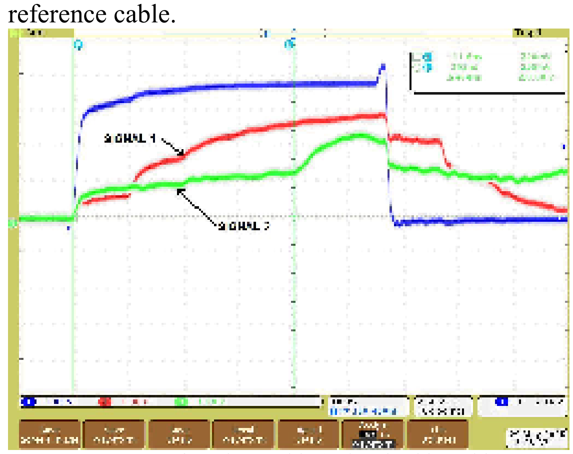

Figure 3.5: Output from long cable (4 time healthy cable)

Amplify voltage amplitude of pulse signal generator.

To avoid the signal as in figure 3.5 happening, the signal that transmitted should be strong enough to make sure this signal will be reflected back. The signal should be amplify firstly, before transmit into the cable. Figure 3.6 show the output amplify with 8 volt before injected into cable.

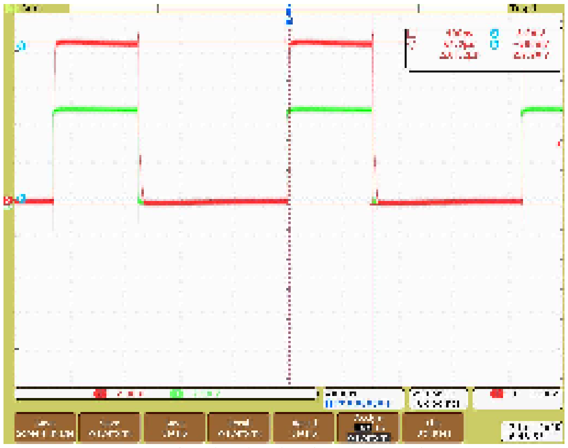

Figure 3.6: Output for circuit 1 in phase at 8 volt

It only shows the signal travel in cable and not the reflected signal that is needed.

4. DISCUSSION

There are more points to be emphasized in order to correct unwanted error to complete this project. The supplied voltage at the circuit must be constant to ensure that switching circuit functions as user desired. It is because the supply voltage will effected to the pulse width on injected pulse waveform.

In addition, the design circuit of pulse signal generator requires a long pilot cable to be test to ensure these circuits operate properly. The existing pilot cable provided for test long cable above 500 meter.

The relay switch is working only when the MOQ switch activated. The relay switch is totally rely on the combination of pulsed signal with detection waveform and MOQ switching were only selected the particular relay and current is passed through the coil, the resulting magnetic field attract the metal arm and there is now contact between the Normally Open (N.O) switch contact, as shown in figure 1.1(b). That means the pulse transmitted straightly to the addressed wires of pilot cable.

5. CONCLUSSION

The aim of this project is to improved the way to testing the pilot cable using signal of pulsed based on time domain reflection theory. This multiple output queued switching will sort the pilot wire cable by sequence and proper timing setting to be testing fault wires.

This switching is convenient to carry out, with pulse signal detection (oscilloscope), because it small and little weight. Method to used this switch is very simple, just plug in the oscilloscope and multiple wires in MOQ switch. After that turn on switch and setting timing as desired, so the process to monitoring the waveform will be done.

This developed technique surely capable to detect the faulty of pilot wire cable with efficient, low consumption costs and accurate. With additional suitable programming, it is anticipated that the equipment will able to indicated the type of fault and most importantly could addressed the location of fault occur.

The MOQ switching is suitable to act as multi-tasking switch for testing low-voltage and high-voltage circuit.

6. FUTURE DEVELOPMENT

The current result of multi-tasking switching is success goes according to planned. For more improvement the parallel port relay boards at MOQ switch must capable to work synchronously with a computer programming run via computer before continue to further improvement. This circuit will be plugs in directly to the parallel port of computer and some software need to builds.

It is the goal of this work to improve the present available technique, so that it becomes more reliable equipment. Through the employed software run via computer, all the important data appeared on the oscilloscope will be directly recorded and keeping it in hard disk of computer. The present data should be able to be analyzed directly in addition to the determination of the type and location of fault.

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