TELEPHONE LINE SECURITY DEVICE (TLSD)

Zulazri Bin Mohd Ahnuar
Bachelor of Electrical Engineering (Hons)
Faculty of Electrical Engineering
Universiti Teknologi MARA
40450 Shah Alam, Selangor, Malaysia
Supervisor : En. Mohd Faizul Bin Mohd Idrus

Abstract - This paper presents the invention relates to a telephone line security. The device has been developing to preventing unauthorized use of the subscriber's telephone set. Act as an inhibit device to isolate unauthorized make a call. The device has a personal identification number (PIN) storing in the PIC microprocessor, personal identification number (PIN) is a secure number which is used every time when make a call. The device includes circuitry which able to disconnect the transmitting element from the telephone if the personal identification number given are incorrect. TLSD was tested and develops based on public switched telephone network (PSTN) architecture. An emergency service number is obtainable at any time even when other calls are inhibited.

Keywords: security device; telephone line; public switched telephone network (PSTN); personal identification number (PIN); microprocessor; telephone line security device (TLSD)

I. INTRODUCTION

This report has been prepared at the end of the final stage of the project, after all the required part in this project was completed. This project began with the literature review and research from the books, journals and websites on the any topics related to the telephone circuitry and PSTN architecture respectively. A study on the telephone signal transmitting method especially on hook switch and DTMF detector were also studied during this stage. In the next stage, the controller and power management circuitry were studied to make the device more reliable. Then at the final stage of the project, all the necessary circuit was configured and develops to be one final product. Printed circuit board (PCB) design and fabrication were also studied during this stage.

This project is completed based on the objectives below:

1) To study the telephone circuitry, telephone transmitting line and PSTN architecture.
2) To familiarize the PIC Basic programming language, including debugging and coding.
3) To familiarize the electronic circuit design and configuration.
4) To design and fabricate printed circuit board (PCB).
5) To understand product design method.

Various telephone security devices have been proposed which generally comprise an inhibiting circuit and switch, for example a key switch or a switch in a hidden position, for bringing the inhibiting circuit into operation. There are also known devices which, by mechanical means, enable particular telephone number for example to call the operator or to call an emergency services number (999 in the Malaysia), to be obtained free.

A. System Description

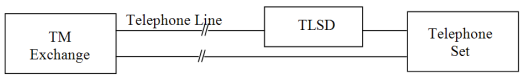

Figure 1: System Architecture of Telephone Line Security Device.

Telephone is connected to the telephone exchange by about three miles or 4.3 km of a twisted pair of No.22 American Wire Gauge (AWG) or 0.5mm copper wires, through Public Switching Telephone Network (PSTN) [1]. Telephone measurements refer to current consumption, not voltage. The length of the wire connecting the subscriber to the telephone exchange affects the total amount of current that can be drawn by anything attached at the subscriber's end of the line. The voltage applied to the line to drive the telephone is 48 VDC [2].

TLSD used that signal line (48VDC) as a power supply and current to operate. Due to telephone measurement refer to current consumption, power control circuit are required. This circuit will help to increase total current required for the device.

The signal from exchange will connected to subscriber telephone set when a correct personal identification number (PIN) are entered. If incorrect PIN numbers are entered the device will terminate the line. But in some reason the device can be programmed to make a several telephone number a command example an emergency number, owner/subscriber phone number etc.

TLSD should place at the secure/hidden area to prevent a fraud on the subscriber telephone line example line tapping. The personal identification numbers (PIN) are set through the dial pulse or tone. Microcontroller detects a correct pulse or tone form telephone keypad before processing a call.

II. METHODOLOGY

Telephone Line Security Device (TLSD) was prepared and characterized according to the procedures shown below:

1) Literature review and background study.
2) Experimental work:
   - Preparation of hook-switch detector circuit, power management circuit, DTMF detector circuit, controller and relay circuit.
   - Configuration of above circuit to become one final product.
   - Layout printed circuit board (PCB) design and fabrication.
   - Analyzation of data and tested a unit.
3) Preparation of technical report and presentation.

A. TLSD Description.

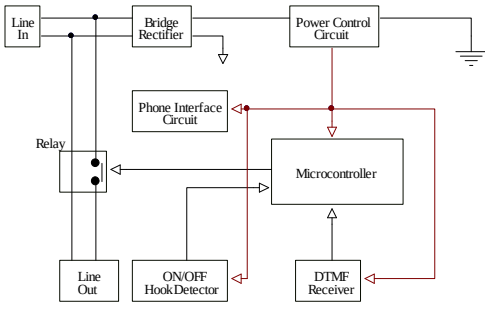

Figure 2: Telephone Line Security Device Block Diagram

TLSD is provided for installation in subscriber telephone line. A block diagram is shown in Figure 2. The device comprises of a DTMF detector, ON/OFF hook detector, microcontroller, power control circuit and relay circuit. It is connected to the line between the telephone and the TM exchange.

B. Telephone Line Interface Circuit

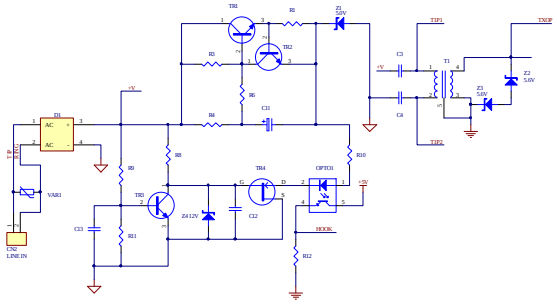

Figure 3: Telephone Line Interface Circuit

Purpose of this circuit to detect a telephone line signal every time user makes a call. Circuit of Telephone Line Interface is shown in Figure 3. The circuit has been tested and simulates using Electronic Workbench 5.1 software; the result has been describe and shown below:

1) During OFF-Hook, transistor, TR3 is OFF. Collector (C) voltage will be more than 2.5V to turn ON the MOSFET, VN2222L, TR4, making Drain (D)- Source (S) resistance drop to 3Ω (switch ON) and current will flow from opto-coupler LED with 10mA ±1mA sufficient to turn ON LED light and ON the opto-coupler relay. When the opto-coupler relay is ON, 5V can go through to the Pin 17 of IC4 (PIC16F628A) to detect the OFF-Hook condition.
2) The function MOSFET, TR4 is to reduce the resistance to 7.5Ω between negative pin of the opto-coupler LED to the virtual ground of Tip-Ring. The Zener diode, Z4 is used to protect voltage between Gate (G) and Source (S) to not more than 12V.
3) If telephone status in ON-Hook, Collector (C) voltage of TR3 will switch to virtual ground making the Ground voltage almost 0V. The transformer, T1 is a one-to-one transformer to isolate the T-Ring signal from network to the circuit. DTMF signal will be captured and sent to IC1 MT8870DE. IC1 will decode DTMF to 4-bit binary and send to IC4, PIC16F628A.

C. Main Controller Circuit

The microcontroller used in this project is PIC microcontroller. This chip is used to implement the security signal. The PIC16F628A is a low-density complementary semiconductor with high-performance. The microcontroller implements the digital algorithm by processing the acquired signals. PIC16F628A microcontroller has 2 ports, namely port A and port B. Each port is an eight-bit register. A program was written on a personal computer, in PIC Basic Pro language, containing the commands required for the control operation of the microcontroller. The main program represents the software part of the system.

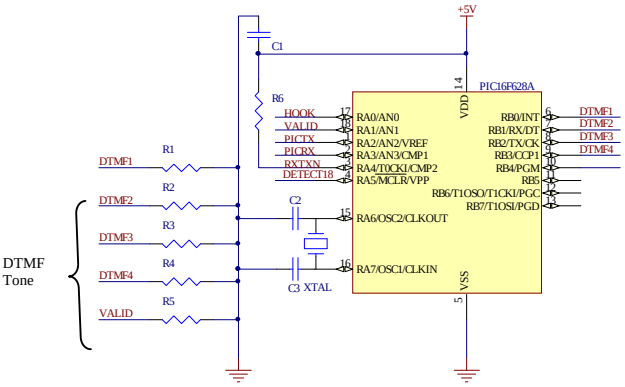

Figure 4:PIC16F628A Pin Configurations for TLSD

An 8-bit controller, PIC16F628A is chosen as a controlling device in this circuit. Referring to Figure 4, Vcc at Pin 14 is connected to power +5V and Vss at Pin 5 is connected to Ground. 4-bit digital input from IC1 are received at Pin 6-9, with a valid input data from IC1 received at Pin 18. Hook status signal is received at Pin 17, where OFF-Hook status of telephone can be detected. Whereas, output PHONECTRL from Pin 10 is sent to Relay. If personal identification numbers (PIN) entered is incorrect, Logic 1 is sent from Pin 10 of IC1 to Relay, to disconnect Tip and Ring from telephone line. As referred to PIC16F628A, an internal clock is controlled by 20MHz Crystal at Pin 15 and Pin 16. In this work the software is used to detect PIN number and send acknowledgement signal from/to TLSD. The software furthermore controls the telephone line from frauds and consequently trip-off to provide protection.

D. DTMF Receiver

This module is a complete DTMF receiver integrating both the band split filter and digital decoder functions. The filter section uses switched capacitor techniques for high and low group filters; the decoder uses digital counting techniques to detect and decode all 16 DTMF tone-pairs into a 4-bit code. External component count is minimized by on chip provision of a differential input amplifier, clock oscillator and latched three-state bus interface.

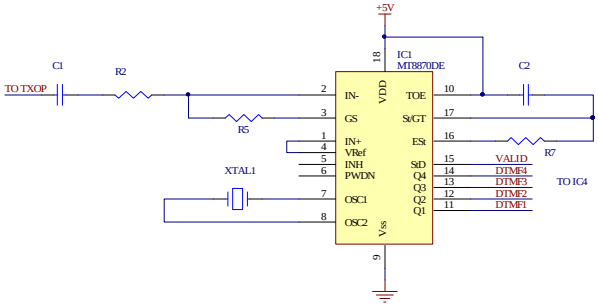

Figure 5: DTMF Detector Pin Configuration for TLSD

Referring figure 5 Low-group and high group DTMF tones is achieved by applying the DTMF signal to the inputs of two sixth-order switched capacitor band pass filters at pin 1 and 2, the bandwidths of which correspond to the low and high group frequencies. The filter section also incorporates notches at 350 and 40 Hz for exceptional dial tone rejection. A 3.579545 MHz crystal is connected between pins OSC1, at pin 7 and OSC2 at pin 8 to complete the internal oscillator circuit. When a voltage greater than V_{TSt} detected at St causes the device to register the detected tone pair and update the output latch. A voltage less than V_{TSt} free the device to accept a new tone pair. The GT output acts to reset the external steering time-constant; its state is a function of E_{St} and the voltage on St. When TOE is enabled, Q1-Q4 provide the code corresponding to the last valid tone-pair received. The output from Q1-Q4 goes to pin 6-9 of Controller. When TOE is logic low, the data outputs are high impedance.

E. Relay Circuit for TLSD

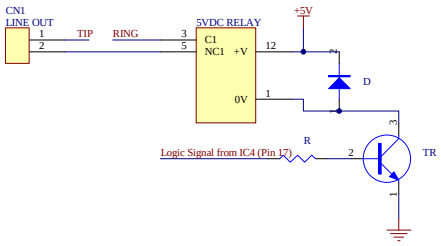

Figure 6: Relay circuit diagram

Figure 6 shows a relay circuit diagram for TLSD. When a logic signal from IC4 pin 17 is high, transistor, TR5 junction will ON and Emitter (E) and Collector(C) almost short. At that condition, relay will be energized, Ring signal will be opened. If signal is low, transistor, TR5 junction will OFF, Collector pin will be almost 5V making relay coil not energized, and the TIP-RING is stay connected.

F. TLSD Flow Chart

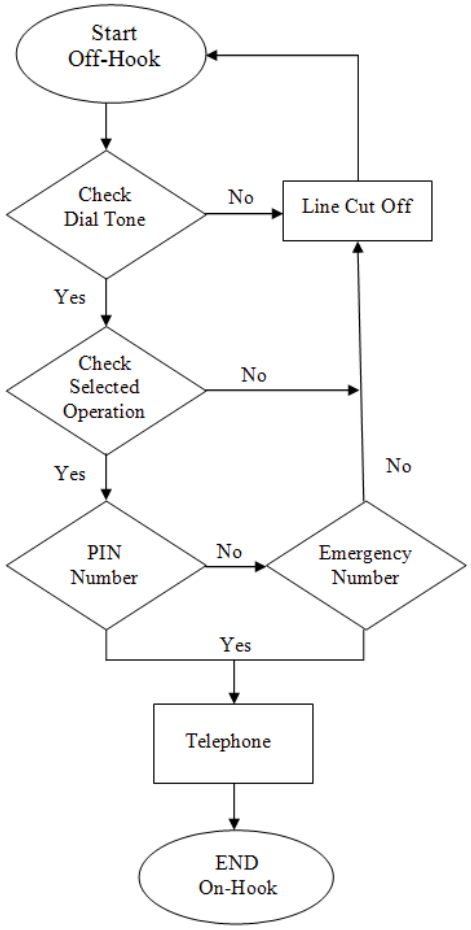

Figure 7: TLSD Flow Chart

1) Flow Chart Description

The on-hook detector circuit detects the signal on the line when the status of the telephone is OFF-Hook or ON-Hook and signals the line status to the main controller. When the line status is OFF-Hook the main controller checks whether PIN number is received from the keypad module in the telephone set.

If the PIN number is not entered, this indicates a fraud and the main controller activate the relay switch to disconnect the connection to the telephone exchange, thus preventing any call being made. The main controller can be programmed to either disconnect the line to prevent the call if the data information is not received, assuming fraud has occurred at the telephone. Alternatively the main controller can check whether a number which does not require payment, such as a call to an emergency number, is being made by checking the dialed number using the DTMF receiver, the depending on the dialed number the call may be allowed or disconnected

III. RESULT AND DISCUSSTION

The Telephone Line Security Device has been successfully implemented and tested in the laboratory. The performance of the hardware and software showed that the development of the device is capable of detecting and eliminating common fraud at telephone line.

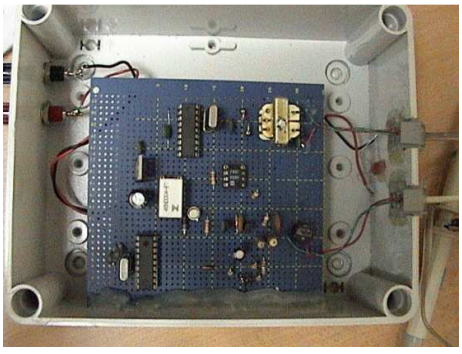

Figure 8: TLSD Circuit Board

A. Testing Setup

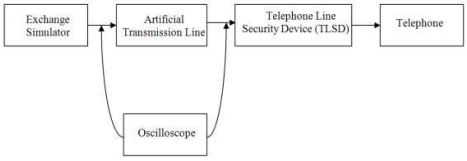

Figure 9: Block diagram of testing Setup

The device is placed between subscriber telephones and Artificial Transmission Line. Exchange Simulator simulates a TM exchange and the Artificial Transmission Line simulates the length of the wire connecting the subscriber to the TM exchange. It is able to simulate the distance from telephone to TM exchange up to 12.5 km. The phone set as shown in the figure is used to simulate ON-HOOK and OFF-HOOK of subscriber telephone set.

B. DC Voltage Of Telephone Line Before and after Off-Hook

Channel one oscilloscope is connected to tip wire of telephone line whereas the Channel two oscilloscopes are connected to ring wire of the same telephone line. These two lines are measured in DC and are differentiated to get the DC voltage of the telephone line. The differentiated signal is saved as Math1. This testing is required to investigate and study regarding the telephone line data. From Figure 4.4 shows the telephone line voltage is 52.27 V (A), when the handset is lifted or OFF-HOOK, the voltage drops to 7.55 V (B). At this time TLSD circuit starts operating. Oscilloscope ground and telephone ground is difference therefore to get the exact result Math1 signal are required.

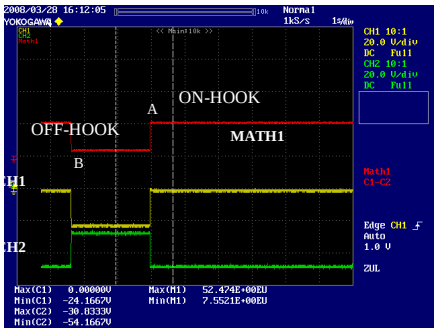

Figure 9: DC Voltage of Telephone Line before and after Off-Hook

C. Testing Telephone Line Without the Security Device

The purpose of this testing to investigate and record the DC voltage data without any additional equipment attach at telephone line. The data use to compare with DC voltage data when TLSD are installed at telephone line, it's important to make sure not have any looses with or without install the TLSD. Without TLSD subscriber or any user able to make a call as usual. Figure 4.5 shown that telephone number are entered during the off-hook, the voltage drops to 6.64 V when conversation in progress. Channel 3 (purple) oscilloscopes is connected to microcontroller pin 10, whereas enable the relay. There shown no any signal form microcontroller (0V).

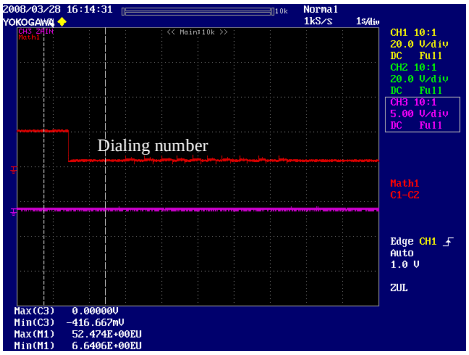

Figure 10: DC Voltage of Telephone Line without TLSD security device.

D. Testing Telephone Line With Correct PIN Number

Referring to figure 11, Math1 showed the DC voltage of telephone line whereas channel 3 oscilloscope is selected to measure signal from microcontroller pin 10, to analyze and transfer the signal to relay. At beginning when handset is lifted (off-hook), PIN numbers are entered through the telephone keypad, and microprocessors analyze every number are entered. 5V voltage form last number will enable the relay. Telephone line will ON and OFF hook for a while because of time taken to trigger the relay. Telephone line remains on OFF-Hook and allowing make a call. During the OFF-Hook voltage drop to 4.17 V, that shows the voltage during OFF-Hook without TLSD is slightly higher compare when install a TLSD. The voltage is enough for conversation progress.

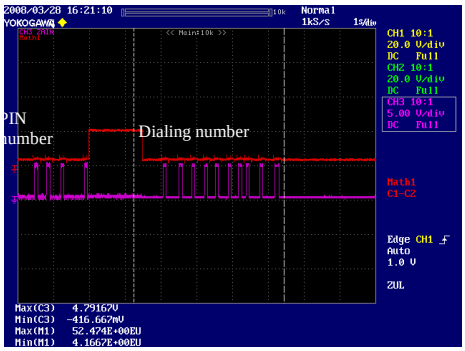

Figure 11: DC Voltage of Telephone Line with correct PIN number

E. Testing Telephone Line With Incorrect PIN Number

Referring to figure 12, three incorrect PIN number are entered. First PIN number are entered with true three first digit and last digit are wrong, second and third PIN number are entered with true two first digit and third digit are wrong. It shown that microprocessor will terminate a telephone line at the wrong digits are entered. Telephone line remains on ON-Hook and not allowing make a call. The DC voltage still at 4.17 V, that mean the voltage does not change with correct or incorrect PIN number.

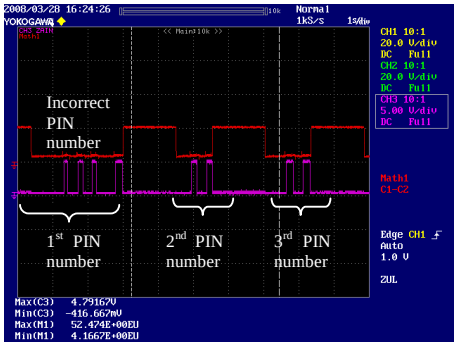

Figure 12: DC Voltage of Telephone Line with incorrect PIN number

F. Testing Telephone Line With an Emergency Number

Emergency numbers are setting as a special number. The TLSD will allow the number pass through. Three digit emergency numbers are entered, the number are set in microprocessor during the software development. Microprocessor detects the last number and allows the call pass through. The security device not allows any phone numbers are entered after the last digit as shown in figure 13.

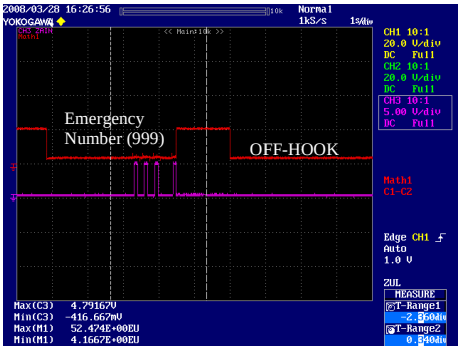

Figure 13: DC Voltage of Telephone Line with an Emergency Number

IV. CONCLUSION

Telephone line security device have been successfully design, construct and develop for a telephone line installed in Malaysia. The design of the device was accomplished using available data and hardware found form the literature review and research from the books, journals and websites on the any topics related to the project.

Testing of the device has been carried out in the laboratory and the results were noted. Necessary graphs have been obtained. This is to show the response of the device to the different tests conducted to ascertain its viability.

Judging from the experiments conducted, the objectives of the project have been achieved, as the device is able to protect telephone line form the unauthorized use of the telephone subscriber's set, and terminate the calls immediately. In addition, the system does not deteriote voice quality of telephone or introduces significant delay during dialing, conversation and metering signal.

V. FUTURE DEVELOPMENT

After going through this project work and successfully completing it, some recommendation might be suggested as follows:

1) The present device caters only one-to-one communication between a subscriber telephone line and the device, installed at subscriber home. Future works should be tried to design the device installed at TM Exchange that able to cater others problem/fraud like line tapping, line cutting, shorting etc.
2) Adding more user PIN number, then each PIN number has their own billing and record. Whereas every user easily monitor their own record and able to prevent over usage.
3) Enhance the device with transmitter and receiver therefore user can extract any data from the device. Extracting data to personal computer or laptop to view the fraud, charge, call number etc.
4) Fabricate and design a PCB using a SMD component therefore the size of overall device can be reduce, size is important to make product are marketable[5].
5) Enhance the power consumption and EMC level of the circuit. Do a proper circuit design and component selection [5].

VI. ACKNOWLEDGEMENTS

I would like to convey my deepest gratitude and appreciation to my project supervisor, En. Mohd Faizul Bin Mohd Idrus invaluable suggestion, guidance, and advice and discussions for the completion and success of this project.

I would like to take this opportunity to express my appreciation to my family and friends for give a lot of support until finish my study. May ALLAH SWT bless all of you and thank you so much.

VII. REFERENCES

[1] J.M Griffiths, Peter Peregrinus, Local Telecommunication 2 (1998) 220–227.
[2] E. Storer, Telephone AIEE Trans, (1997), 464 – 475.
[3] Lillian Goleniewski, Kitty Wilson Jarrett, Telecommunications Essentials, Second Edition: The Complete Global Source (2nd Edition) (2007) 150-173.
[4] Yoshihiro Konishi, Electronic Circuit Technology (1998), 123-230
[5] Karl Ulrich , Steven Eppinger, Product Design and Development (2007), 372-375
[6] Chris Schroeder, PCB Design (Edn Series for Design Engineers) (1999), 120-430