Remote Monitor and Control based Access Control System using PIC Microcontroller

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Summary
This paper describes the development of access control system (ACS) remote monitor and control for fiber to the home (FTTH) passive optical network (PON), and uses PIC microcontroller integrated Ethernet technologies in its implementation. The device works on a standard local area network (LAN) thus enabling the deployment of flexible and low cost for monitoring purposes. It was successfully identified without affecting communication signal transmission, with the specification available a complete system can be made with 24 man-hours. Finally, the benefits of such a system are considered, using some initial result obtained in an experimental implementation.

Key words:
PIC microcontroller, ACS, FTTH, remote monitor and control.

1. Introduction

A microcontroller is a type of microprocessor furnished in a single integrated circuit and needing a minimum of support chips. Its principal nature is self-sufficiency and low cost. Microcontrollers are embedded in many control, monitoring, and processing systems. Some are general-purpose devices but most microcontrollers are used in specialized systems such as communication systems [1].

The PIC microcontroller is manufactured by Microchip. Currently they are one of the most popular microcontrollers, used in many applications. It is a self-contained computer-on-a-chip that integrates a microprocessor, input and output ports, memory for program and data storage, an internal clock, and one or more peripheral devices such as timers, counters, analog-to-digital converters, communication facilities, watchdog circuits and special hardware features. Among all the PIC microcontroller families, especially the PIC18F97J60 of devices feature an embedded Ethernet controller module. It was integrated MAC and 10Base-T PHY, making Ethernet communication possible. The 8-bit microcontroller has enjoyed a tremendous growth in embedded systems applications. It is a fine chip that is easy to program by means of a simple device attached to the parallel or serial port or Ethernet port. With the 128Kb of code space available on the PIC18F97J60, a TCP/IP stack can easily be accommodated while leaving plenty of program memory for the application. The available EEPROM memory offers the possibility of reprogramming fast and easy. It also features an integrated 16-channel 10-bit A/D converter. Peripherals included five timers, four external interrupt pins, and dual analog comparators with input multiplexing. PIC18F97J60 has a maximum operating speed of 25 MHz with low power consumption. [2].

As technology advances, monitoring FTTH network without human intervention can prove quite effective in terms of cost and efficiency in optic communication scenarios. In this letter, we proposed an ACS scheme to monitor the status of signals flow and provide the restoration against failure by using optical switch. It is expected to be a key component which provides survivability through optical protection by switching to alternative routes in the optical layer and access network. The switching performed within the access node will be able to achieved high speed restoration against the failure/degradation of cables, fibers & also optical amplifiers [3]. During our research work, we developed an ACS based on PIC microcontroller integrated Ethernet. Our work included design and implementation of the hardware and the software for monitoring the status of ONU device, transmitting its status to the CO, and controlling it from remote locations having access to same LAN or internet.

2. Hardware Design

The proposed hardware consists of two basic parts:

- Access Control System.
- Ethernet Module System.

2.1 Access Control System

Access Control System (ACS) is control the status of any optical switch device connected to it and transmits its status to the PIC18F97J60. Its then arranges the information in the form of a packet and transmits it over the LAN using the embedded Ethernet system. The architecture of ACS is shown in Fig. 1 below. It consists of three major parts, PIC18F97J60 microcontroller, In-

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Line Monitoring (ILM) and Restoration Scheme Activate (RSA). Generally, ACS is integrated in a single system, which also includes optical switch, splitter, OTDR and personal computer (PC). Tapping 3% of the downstream and upstream signal by using coupler can recognize the status of feeder section and drop section. If breakdown occurs in feeder section, ACS will send a signal to activate the dedicated protection scheme. But if the breakdown is the detected in drop section, ACS will recognize the related access line by the 3% tapped signal that is connected to every access line. The activation signal is then sent to active the dedicated protection scheme. But if fault is still not restored, the shared protection scheme will be activated. The monitoring signal section is responsible for sensing fault and its location whereas generation of activation of signal is sent by activation section in ACS.

ACS is focusing on providing survivability through the RSA against failure by means of dedicated and shared protection that is applied in PON. ACS is used to monitor the status of the working and restoration fibers. ACS recognized the types of failure and sent the activation signal to the related optical switch according to the activated protection mechanisms. Each ONU is connected to splitter output terminal by two fibers; working line and protection line through optical switch that is controlled by ACS. The function of optical switch is to switch the signal to the protection line when failure occurs in the working line. The route depends on the restoration mechanism that is activated according to the types of failure. When the failure occurs in the working line, the first ACS will switch the signal to the local protection line and the second ACS will be activated simultaneously to switch the signal back to the transmission line.

To locate a failure without affecting the transmission services to other customers, it is essential to use a wavelength different from the triple-play services operating wavelengths for failure detection. ACS integrated Ethernet is using the operating wavelength 1625 nm for failure detection control and in-service troubleshooting. The triple-play services operating wavelengths (1310 nm, 1490 nm and 1550 nm) are multiplexed with a testing signal (1625 nm) from OTDR. The OTDR is installed in the OLT and will be connected to a PC to display the troubleshooting result.

When four kinds of signals are distributed, the testing signal will be split up by the Wavelength Selective Coupler (WSC) which is installed before the splitter. The WSC only allow the testing signal at 1625 nm to enter into the taper circuit and reject all unwanted signals (1310 nm, 1490 nm and 1550 nm) that contaminate the OTDR measurement. The downstream signal will go through the WSC which in turn connected to splitter before it reaches the ONUs. The distance between the OLT and ONU is about 20 km. On the other hand, the testing signal which is demultiplexed by WSC will be split up again in power ratio 99:1 by using directional coupler to activate the ACS. The 99% 1625 nm signal will then be configured by using optical splitter which each output is connected to single line of ONU. The operational of optical switch is controlled by ACS system that is activated by 1% of 1625 nm signal.

2.2. Ethernet Module System

The Ethernet Module System is designed to transmit the status of optical switch device connected to our system over the LAN or internet connectivity applications through Ethernet connection. In considering Ethernet, it is important to discuss data packet traffic speed. The first speed that gained momentum in the PC industry was 10Base-T or 10Mbps. Other speeds that are more common today are 100Base-T and gigabit Ethernet. However, 10Base-T is more than sufficient for the applications that would be served in the embedded market. The typical requirements communication requirements for remote monitoring and control require only small bursts of data sent infrequently.

The PIC18F97J60 microcontroller with integrated Ethernet is a complete connectivity solution, including full implementations of both Media Access Control (MAC) and Physical Layer transceiver (PHY) modules. Two pulse transformers and a few passive components are all that are required to connect the microcontroller directly to an Ethernet network.

A simple block diagram of the module is shown in figure 2. The Ethernet module consists of the five major functional blocks:

- The PHY transceiver module that encodes and decodes the analog data that is present on the twisted-pair interface and sends or receives it over the network
- The MAC module that implements IEEE 802.3 compliant MAC logic and provides Media Independent Interface Management (MIIM) to control the PHY.
- An independent, 8-Kbyte RAM buffer for storing packets that have been received and packets that are to be transmitted.
- An arbiter to control access to the RAM buffer when requests are made from the microcontroller core, DMA, transmit and receive blocks.
- The register interface that functions as an interpreter of commands and internal status signals between the module and the microcontroller's SFRs.

To complete the Ethernet interface, the Ethernet module requires several standard components to be installed externally. These components should be connected as shown in Figure 3. The internal analog circuitry in the

PHY module requires that an external resistor (2.26 kΩ) be attached from RBIAS to ground. The resistor influences the TPOUT+/- signal amplitude. It should be placed as close as possible to the chip with no immediately adjacent signal traces to prevent noise capacitively coupling into the pin and affecting the transmit behavior. It is recommended that the resistor be a surface mount type.

The Ethernet module is designed to operate at 25MHz. This is provided by the primary microcontroller clock either with a 25MHz crystal connected to the OSC1 and OSC2 pins or an external clock source connected to the OSC1 pin. Its uses three independent memory spaces for its operations:

- An Ethernet RAM buffer which stores packet data as it is received and being prepared for transmission.
- A set of 8-bit Special Function Registers (SFRs), used to control the module and pass data back and forth between the module and microcontroller core.
- A separate set of 16-bit PHY registers used specifically for PHY control and status reporting.

Now at this point it must be mentioned that the connection to Ethernet through the RJ-45 connector requires the standard twisted pair for transmission or the TX+/TX- and also the twisted pair for RX+ and RX-.

3. Experimental Result

Fig. 1 shows the experimental setup to demonstrate the proposed remote monitor and control in a FTTH-PON.

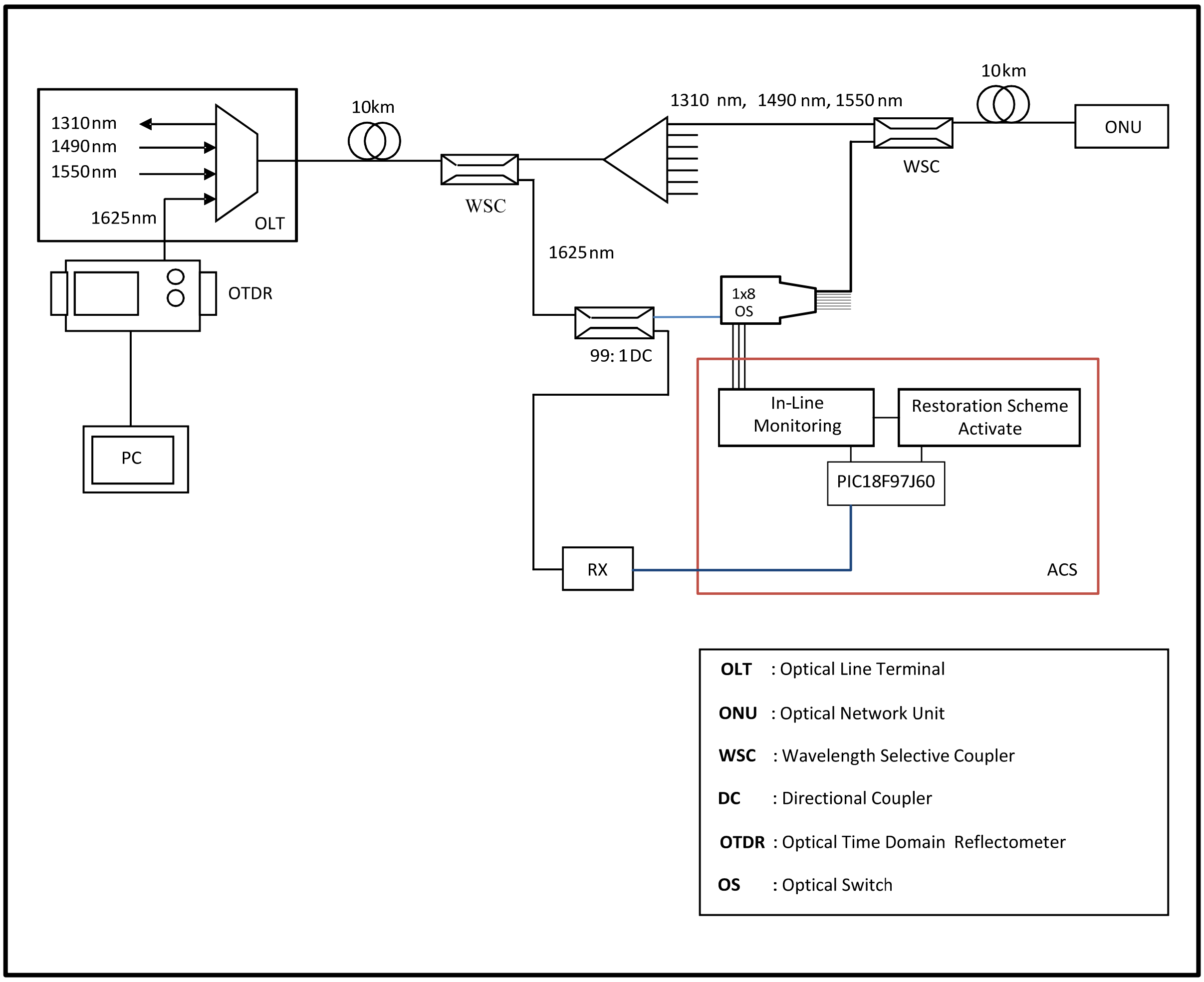

Fig. 1 Access Control System (ACS) in FTTH-PON network.

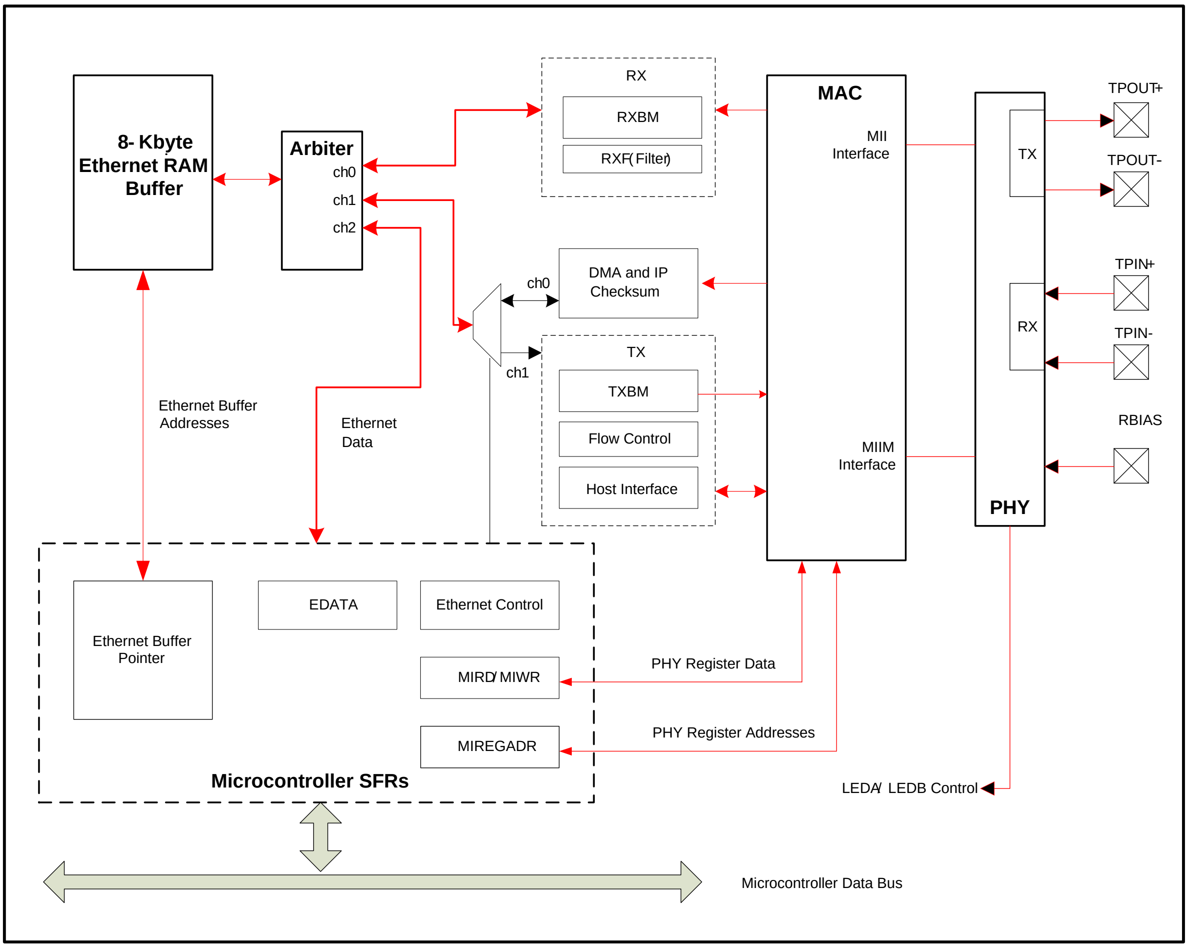

Fig. 2 Block diagram for Ethernet module system.

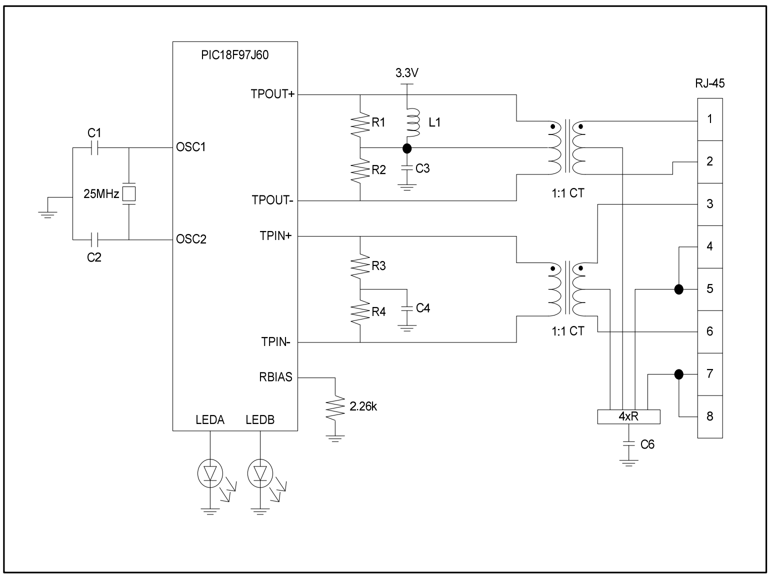

Fig. 3 External components for Ethernet operation.

ACS send 3 bits signal to activated optical switch to chosen fiber line for monitoring and control. And the OTDR pulse takes energy from different part of the traffic signal (1625 nm) so the effect on the traffic will be much less severe but it can be neglected. The function of optical switch is to switch the signal to the protection line when failure occurs in the working line. The route depends on the restoration mechanism that is activated according to the types of failure. When the failure occurs in the working line, the first ACS will switch the signal to the local protection line and the second ACS will be activated simultaneously to switch the signal back to the transmission line.

To show the performance of the proposed optical switch, table 1 shows the optical switch input/output of the proposed live fiber monitoring. Therefore, by monitoring of the optical switch route of the proposed ACS scheme can be detected the line faults.

Table 1: I/O Optical Switch

Route Optical Switch	***Output Pin***			***Input***
	D0	*D1*	*D2*	
Line 1	0	0	0	000
Line 2	0	0	1	001
Line 3	0	1	0	010
Line 4	0	1	1	011
Line 5	1	0	0	100
Line 6	1	0	1	101
Line 7	1	1	0	110
Line 8	1	1	1	111

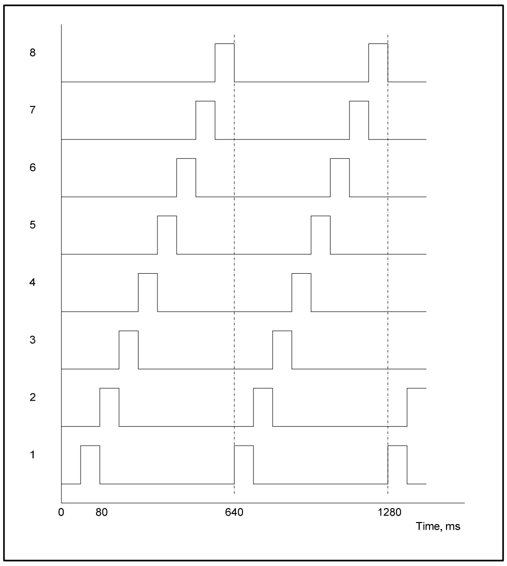

Fig. 4 Curve of optical power at eight switch output

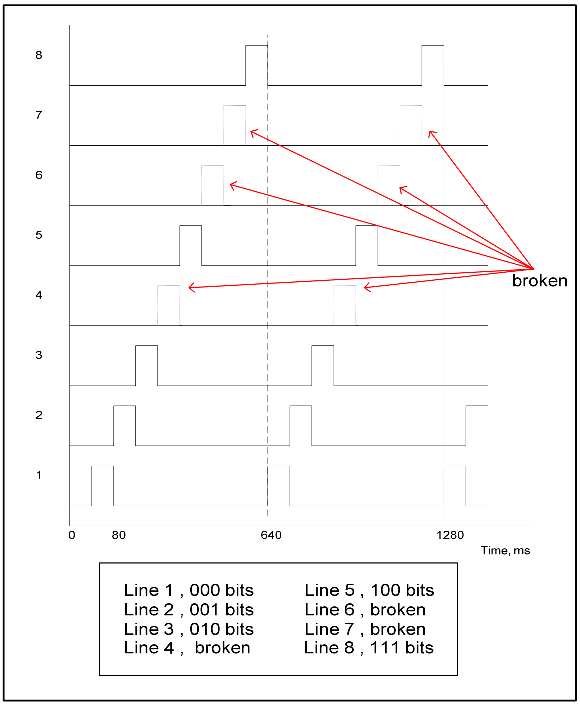

Fig. 5 The optical power output of the proposed monitoring when the fiber line 4, 6-7 are broken by external force applied.

As shown in Figure 4, the switching of fiber lines between the eight wavelengths can be clearly observed. And to simulate the fault identification process, Figure 5 shows the optical power output of the proposed fiber line monitoring when the fiber line 4 and 6-7 are broken by the external force application.

The solid line indicates the normally operation from fiber line 1-3, 5, 8, and the dotted line shows the fiber fault behavior when the fiber line 4, 6-7 are disconnected, as seen in Fig. 5. The experimental results show that our proposed scheme is very feasible.

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Aswir Premadi was become Lecturer at Institut Teknologi Padang, Indonesia, before working toward the M.Sc. degree in Electrical, Electronics, and Systems Engineering at Universiti Kebangsaan Malaysia, until 2008. Currently he is Research Engineer of Computer and Network Security Research Group Universiti Kebangsaan Malaysia. His fields of interest are access control system for fiber to the home network.

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