Development of New Terminal Node Controller to Improve Packet Radio Transmission for Field Data Acquisition.

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Abstract- **The existing terminal node controller (TNC) has problem during transmit and receive packet of data as a result of noise interference during the transmission of packet data. Implementation of packet radio network in field data acquisition should have a good performance of TNC. This project will improve the performance of existing TNC in packet radio transmission for field data acquisition. The modem integrated circuit, MX614 (Bell 202 Compatible Modem) is applied in the circuit to minimize the noise interference and improve the performance of TNC in data transmission. The modem integrated circuit of MX614 has the capability to filter and equalize the input signal as well as filter and buffer the output signal. This modem integrated circuit converts the data received from microcontroller into 1200 bps audio tones. The features of this modem integrated circuit will improve the performance of TNC in packet data transmission.**

Keywords — TNC, MX614, microcontroller, audio tones

I. INTRODUCTION

In packet radio network, TNC is used as a device for transmission of packet data. The applications of TNC in packet data transmission enabled the data acquisition for example to acquire data in certain area that does not have Global System for Mobile communication (GSM) coverage. For system of the packet radio network, TNC will be placed between amateur radio transceiver and computer or data logger. The main function of TNC in transmission of packet data in packet radio network is to encode and decode the packet data that has been framed according to the AX.25 data link layer protocol [1]. Generally, TNC is applied in the research field and data acquisition purposes [2]. The TNC also influence the performance of data transmission in packet radio network [3].

At the physical level, TNC implement the Bell 202 Modem standard to send and receive data to or from an amateur radio transceiver. The radio itself is responsible for transforming the audio input and output into radio frequency signals. The Bell 202 Modem standard is simply Audio Frequency Shift Keying (AFSK) at 1200 baud with continuous phase using the audio tones frequency of 1200 Hz and 2200 Hz. In amateur radio application, non-return to zero inverted (NRZI) encoding is implemented. A zero (‘0’) is encoded as a change in frequency while one (‘1’) is encoded as no change in frequency.

Research in [1] stated that the packet radio is devise by a protocol called AX.25 in data link layer. The function of the protocol is to enable the transmission of the packet data. The project in [4] has stated that the TNC is programmed to participate in AX.25 protocol. In the transmitting part, the TNC assembles a packet received (digital) from computer and convert it to audio tones (analog) to be transmit over the amateur radio transceiver. As for the receiving part, it reverses the process by converting the audio tones into packet data that can be read by user using computer.

II. SYSTEM DESIGN AND OPERATION

The system of packet radio network was designed as in Figure 1. The system consist of transmitting and receiving part. In the transmitting part, the computer or data logger is connected to the TNC that will convert the digital signal from computer to audio tones through the amateur radio transceiver. At the receiving part, amateur radio transceiver will receive the audio sent by transmitter and handed it to another TNC. The TNC that is attached to the computer will convert the audio tones to the data readable by using serial monitor.

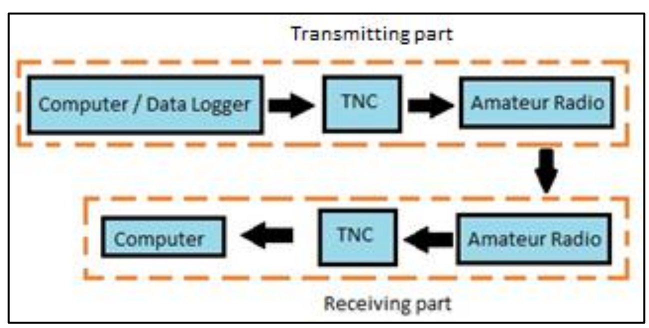

Figure 1: System Block Diagram

As shown in Figure 2, the existing TNC block diagram consists of microcontroller, radio module and universal asynchronous receiver or transmitter (UART) module. The microcontroller is implemented to form packet frame that used in packet radio network. The packet data is framed based on AX.25 data link layer protocol. The function of the microcontroller in TNC is to encode and decode the packet data. In the existing TNC circuit, the input and output signal will flow directly to and from microcontroller. The UART is used as the serial communicator between the TNC and computer.

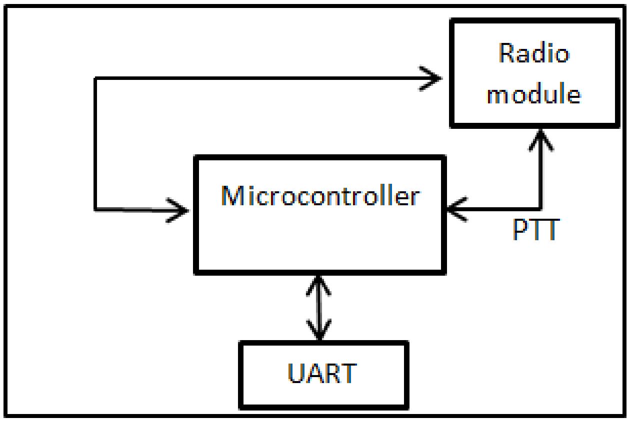

Figure 2: The existing TNC block diagram

The block diagram of proposed TNC is in *Figure 3*. The TNC consists of microcontroller, MX614 modem integrated circuit, radio module and UART module. Compared to existing circuit, the proposed one has MX614 modem integrated circuit that handles the input and output of the signal. In receive mode, the MX614 filter and equalize the input signal. This features minimizes the interference of the signal before it is decoded by microcontroller as a packet data. In transmit mode, the microcontroller frames the packet data and sends it to the modem integrated circuit. The modem integrated circuit converts the data, into 1200 bps audio tones. Before the signal is transmitted using amateur radio transceiver, the modem integrated circuit filters the signal.

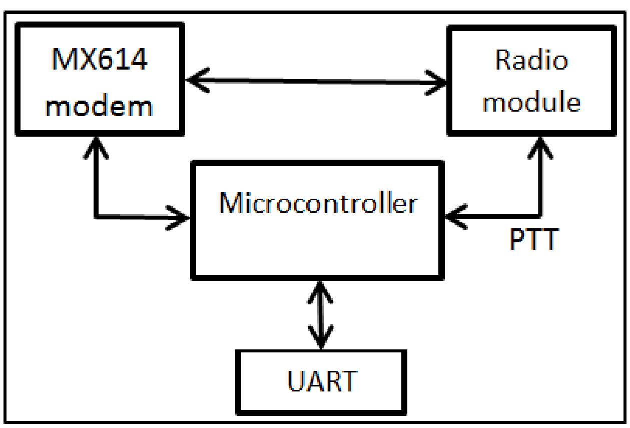

Figure 3: The proposed TNC block diagram

A. *Circuit of existing TNC*

Figure 4 shows the circuit of existing TNC. The circuit consists of voltage regulator. The voltage regulator was designed in the circuit to give a fixed 5V to the circuit. The LM 7805 was used. So, if 12V direct current (DC) power supply connected to the circuit, it does not give any damage to the circuit that only need 5V DC power supply to operate. In this circuit, the PIC 16F88 was used as a microcontroller. The microcontroller control all of the process in receiving or transmit mode. The microcontroller also controls the push-to-talk (PTT) line. When there has a packet of data to send, the microcontroller trigger the PTT line and allowed the amateur radio to transmit the data. The incoming audio tones directly to the microcontroller during the receiving mode. It does not have any filter that can filter the interference in the audio tones. While in transmit mode, after the packet has been framed, the microcontroller need to generate audio tones before send it to the amateur radio transceiver for transmission process.

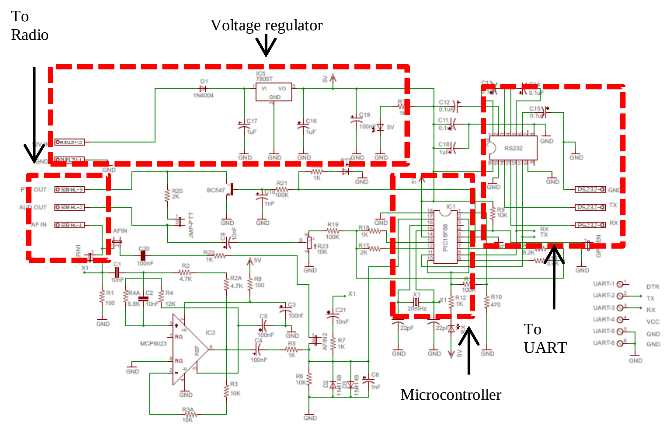

Figure 4: Circuit of existing TNC

B. *Proposed terminal node controller*

The proposed TNC consists of modem integrated circuit that can handle modulation and demodulation between Audio Frequency Shift Keying (AFSK) and serial logic data. This modem integrated circuit called MX614. The modem integrated circuit is linked in parallel with microcontroller, PIC 16F628A which is the transmit (Tx) pin of MX614 connected to the Tx pin of microcontroller and receive (Rx) pin of MX614 connected to the Rx pin of microcontroller. The microcontroller act as encoder and decoder of packet data that has been framed according to the AX.25 data link layer protocol.

In transmit mode, the computer or data logger act as the input of the signal. The serial communication has been done by using UART module. The input was in form of words, which is each one of the character (e.g. A,B 1,5,2) included in ACSII table has their binary form. The microcontroller read the binary form for each one of the character and encode it into the AX.25 data link layer protocol. The packet data in digital signal handed through the MX614 and the audio tones has been created by the modem integrated circuit before the transmission of packet data using the amateur radio transceiver.

In receive mode, the TNC get the input from amateur radio transceiver's speaker jack. The input is in AFSK-modulated analog signal. At the first stage, the signal handed through the filter that consisted in the modem integrated circuit. The filter reduce the unwanted signal called noise that interfere the transmitted signal. After the signal has been filtered, the AFSK demodulator of the modem integrated circuit demodulate the signal to become the digital signal that contains the packet data. The microcontroller take the next step of the process by decode the digital signal based on the AX.25 data link layer protocol. The microcontroller execute a command to display contains of packet data in serial monitor through the UART module.

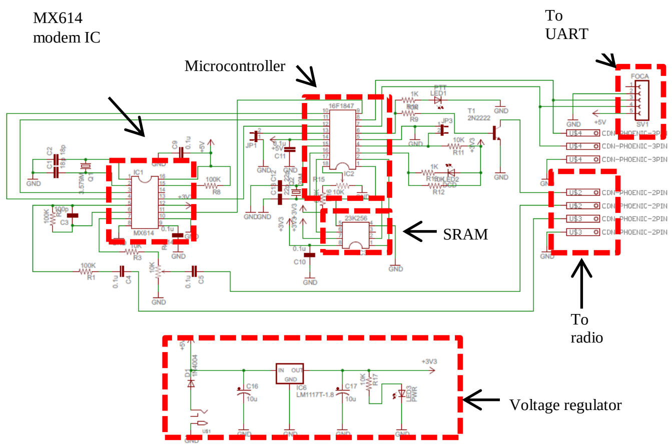

Figure 5: Circuit of proposed TNC

i.MX614- Bell 202 compatible modem integrated circuit

In this project, MX614, Audio Frequency Shift Keying (AFSK) modem integrated circuit was used to convert binary data to audio tones for transmission and audio tones to binary data for receiving.[5] This integrated circuit has capability to act as filter and equalizer for the transmitted signal so that the actual waveform of signal can be preserved. [6] It can detect and decode the small amplitude signals which means it make the system of TNC more sensitive. The modem integrated circuit can be operated with voltage of 3.3V-5V which is low. [7] It has 16 pins out. The M0 and M1 pins are used for switching the modem either receive or transmit mode. [2]

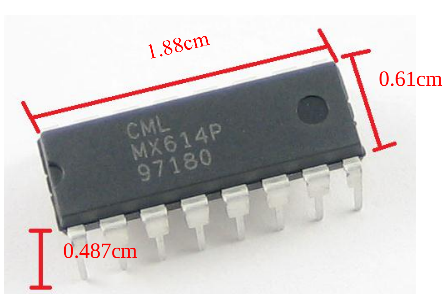

Figure 6: MX614 – modem integrated circuit

ii.23k256-SRAM memory

23k256 is a 256Kbit serial SRAM integrated circuit. The function of the SRAM integrated circuit in this project is to give the extra memory for the process of AX.25 data link layer protocol. It has the capability to read and write byte. The SRAM integrated circuit can be powered by power supply 2.7V-3.6V which is suitable to use in the proposed TNC circuit.

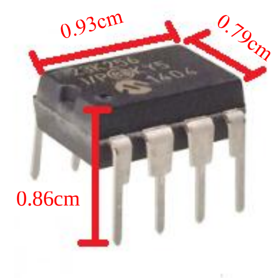

Figure 7: 23k256-SRAM memory

III. METHODOLOGY

A. Project Development

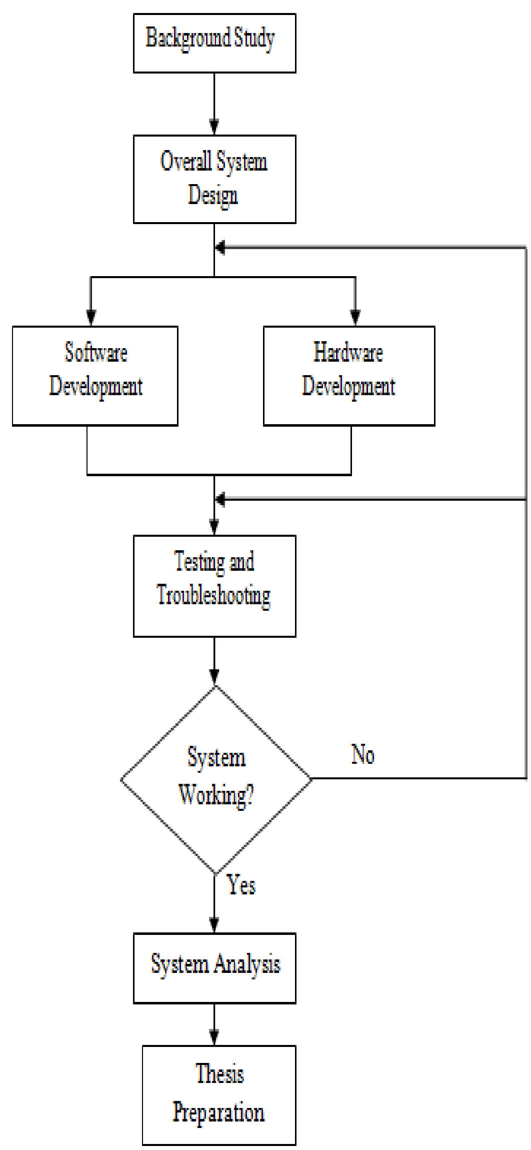

Figure 8: Project Development Flow Chart

At the first stage of this project, the background of the related field has been studied for TNC and also to generate idea that related to the project. The existing of the TNC that used in packet radio network has been studied. Based on the studied, the existing TNC can transmit and receive the data but sometimes, the data that has been sent cannot be received properly by the receiver due to the noise interference. The result of the research generate an idea that can be implemented to increase the performance of the TNC. The idea is to redesign and implement modem integrated circuit in TNC and the idea is proposed. Once the proposal has been proved, the next step is to design the overall system including the system functionality and specification. At this stage, the type of modem integrated circuit, microcontroller that will be used were decided. A few of component was studied and choose according to the specification, cost, and flexibility.

The next step that has been taken is more challenging. The step was to work on hardware and software. During this stage, a lot of problems have been faced. The software was developed using assembly language by using Atmel Studio Version 6.2. The hardware design consisted of PIC 16F628A, MX614 modem integrated circuit and 23k256 SRAM. It took about 3 months to develop the hardware and software.

It took 1 month to solve the problems occurred on the system. The developed TNC is then tested whether it is properly functioning to meet the objective. The analysis of the system is done to obtain the result for technical paper writing. The analysis is divided to 2 parts which is analysis for existing TNC and the proposed TNC. The result of two TNC has been compared to conclude the performance of the proposed TNC.

B. Testing and Troubleshooting

The testing of the existing TNC and proposed TNC has been done to compare the value of signal-to-noise (SNR) ratio. The SNR was measured by using PC soundcard oscilloscope. Both TNC has been set up to transmit the data and PC soundcard oscilloscope detect the transmission signal. Other parameters also has been taken to make comparisons between the existing and proposed TNC.

IV. RESULTS AND DISCUSSION

A. Testing and Measurement

Figure 9(a) shows the digital signal that consist of binary ‘1’ and ‘0’. The digital signal show a set of packet data that has been transmit based on the AX.25 data link layer protocol. In Figure 9(b) shows that the AFSK modulation of the digital signal. The change in digital signal has changed the frequency of the signal. The binary ‘0’ change the frequency to become high in frequency. This graph shows that, in the AFSK modulation, the frequency has changed but not the amplitude or phase of the signal. The AFSK signal has been used in radio transmission.

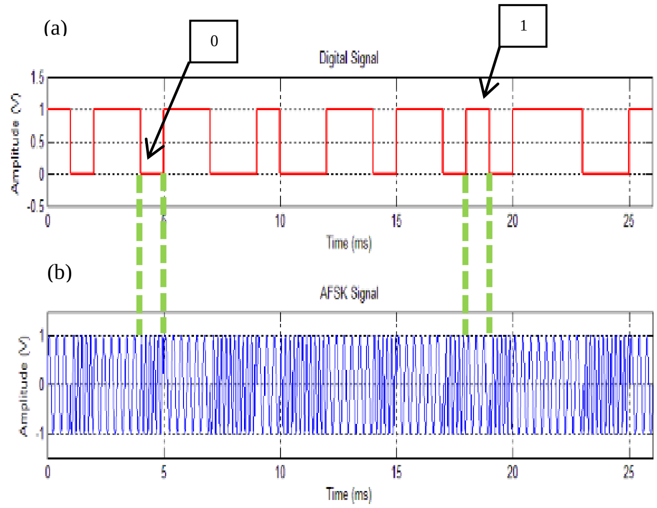

Figure 9: (a) Digital signal and (b) AFSK signal during transmission

Figure 10 (a) and (b) shows the amplitude of the modulation during the transmission of the packet data in decibels relative to full scale (dBFS) of the existing and proposed TNC. In Figure 10(a), during the maximum amplitude of the modulated AFSK signal which is -33.5dBFS, the measured SNR was -9.58dB.

In Figure 10(b), at the maximum amplitude of modulated AFSK signal, which is -26.4 dBFS, the measured SNR was -2.35dB.

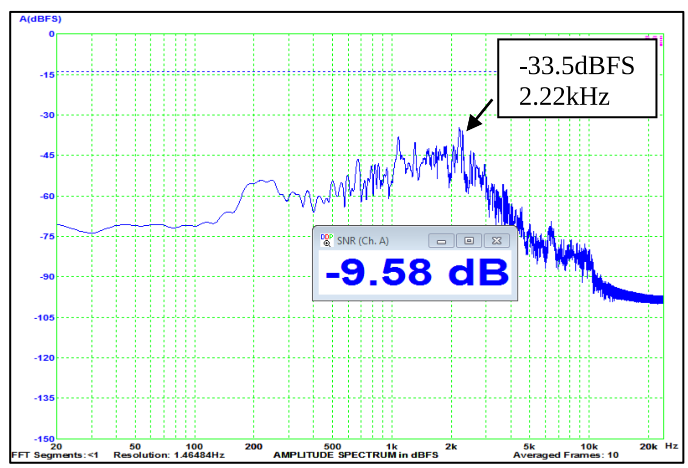

Figure 10 (a): Amplitude spectrum (dBFS) and SNR (dB) of existing TNC

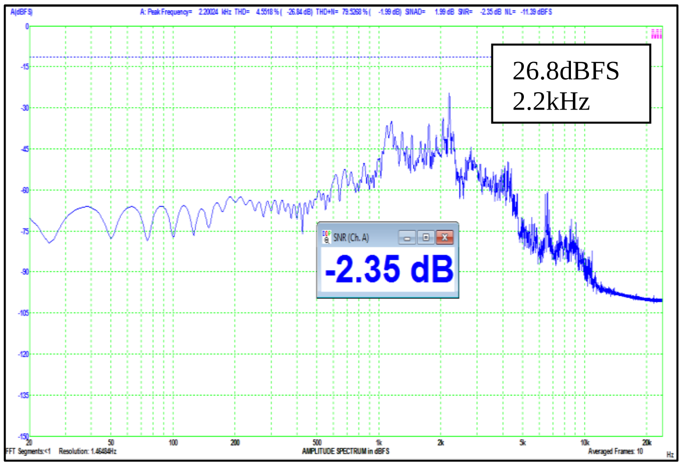

Figure 10(b): Amplitude spectrum (dBFS) and SNR (dB) of proposed TNC

Table 1: Parameters Comparison between Existing TNC and Proposed TNC

Parameters	Existing TNC	Proposed TNC
Signal-to-noise ratio (SNR)	-9.58dB	-2.25dB
Modulator/Demodulator	Microcontroller	MX614 modem integrated circuit
Filter in circuit	No	Yes

From Table 1, the proposed TNC has decrease the noise in signal by 23.4%. The capability of modem integrated circuit to filter the input and output of the signal decrease the interference in the signal.

B. Overall System Set Up

Figure 11 shows the overall system used during the measurement and experimentation. The performance of TNC has been measured by placed apart the transmitter part and receiver part in several distances.

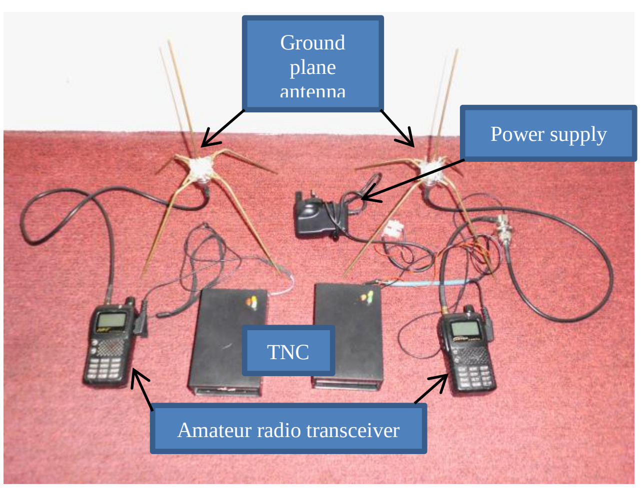

Figure 11: Overall system in measurement and experimentation

V. Future Development

A lot of modifications and improvement can be done to this packet radio system to make it more efficient. A PIC microcontroller can be replaced by Arduino microcontroller for TNC. It will make easier to assemble components and simplified the circuits of TNC. This project just showed how to improve TNC performance by implementing modem integrated circuit. It can be improved by applying it by attached the transmit part of the packet radio system with data logger or sensor. This will show the real application of packet radio system in acquiring data. Several sensors that can be added such as humidity sensor and water level sensor which are practical to use for field measurement and data collection.

VI. Conclusion

As the conclusion for this project, the modem integrated circuit, MX614 increase the performance of TNC in packet radio transmission for field data acquisition by reduce noise in the signal.. It can detect small amplitude of signal that make the TNC more sensitive. However, the noise still can be detected at the higher frequency. Further investigated has to be determined to improve the quality of data received by the TNC.

VII. Acknowledgment

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VIII. References

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