EXPERIMENT CM11: MODULATION AND DEMODULATION FOR ASK AND FSK

Related course: KIE2008 (Communication System)

OBJECTIVES:
To investigate the modulation and demodulation for ASK and FSK implemented in MATLAB

EQUIPMENT:
PC with CommLab-T module console and MATLAB, CommLab-T device by Benchmark

REFERENCE(S):
J.G. Proakis, M. Salehi, “Fundamental of Communication Systems”, 2nd Ed., Pearson, 2014

TEST:
TEST 1: Amplitude Shift Keying (ASK) modulation and demodulation
TEST 2: Frequency Shift Keying (FSK) modulation and demodulation

TEST 1: Amplitude Shift Keying (ASK)

Amplitude-shift keying (ASK) is a form of modulation that represents digital data as variations in the amplitude of a carrier wave. The process involved in ASK modulation is similar to the type of modulation done in the Amplitude Modulation (analog) case except that the message signal is a digital signal.

PRINCIPLE OF OPERATION

i. ASK Modulation
The generated analog message signal is first converted to a digital signal. The digital signal generated is then multiplied by a carrier to generate the amplitude modulated signal (Double-sideband suppressed-carrier (DSB-SC) signal).

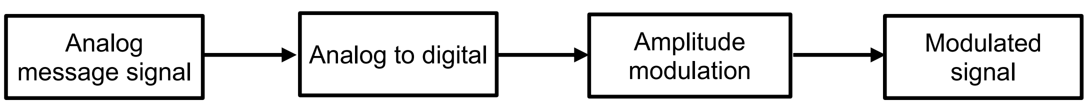

Figure 1: Block Diagram of ASK Modulator

ii. ASK Demodulation
Synchronous Detection is used to demodulate the signal. For this, the carrier needs to be generated in the receiver side. The process is similar to Amplitude Modulation.

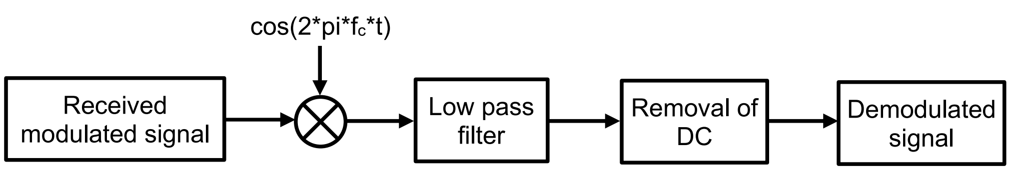

Figure 2: Block diagram of an ASK demodulator

iii. MATLAB implementation of ASK
At the transmitter, a digital signal (Fig. 3) is generated and then multiplexed with the sinusoidal wave to generate the modulated signal (Fig. 4). The generated signal is given to the CommLAB-T Tx block and is sent through the kit as shown in Fig. 5. At the receiver, samples from the kit are passed through CommLAB-T Rx interface blocks to obtain blocks of data. The signal is then amplitude demodulated using the synchronous detection method to detect the message signal.

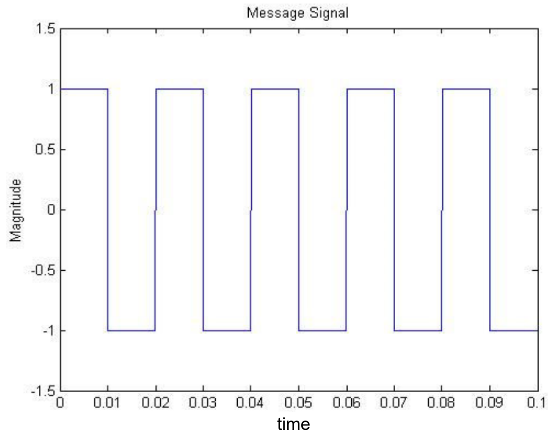

Figure 3: Digital signal

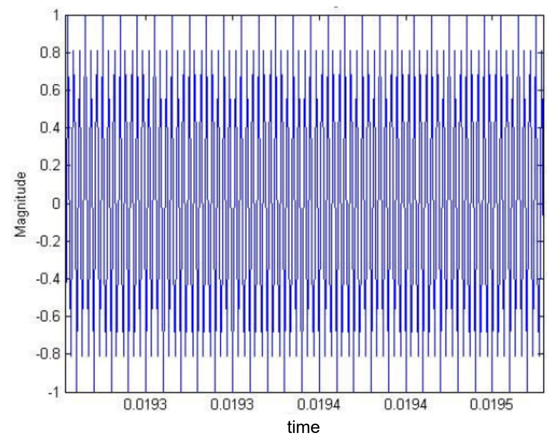

Figure 4: Modulated signal

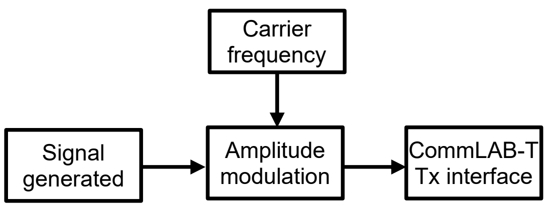

Figure 5: Transmitter block diagram of ASK in MATLAB

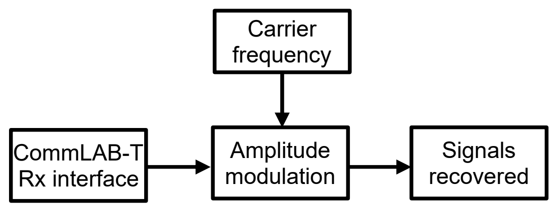

Figure 6: Receiver block diagram of ASK in MATLAB

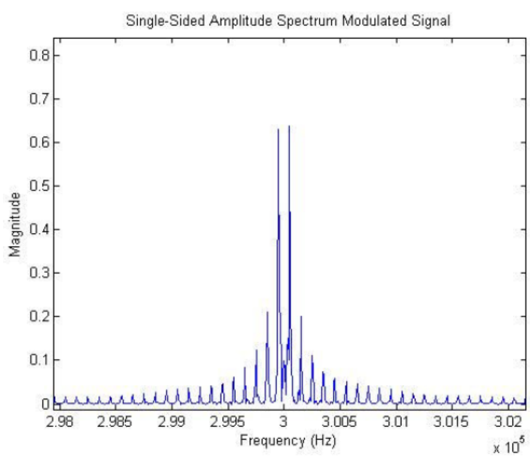

Figure 7: Spectrum of the signal

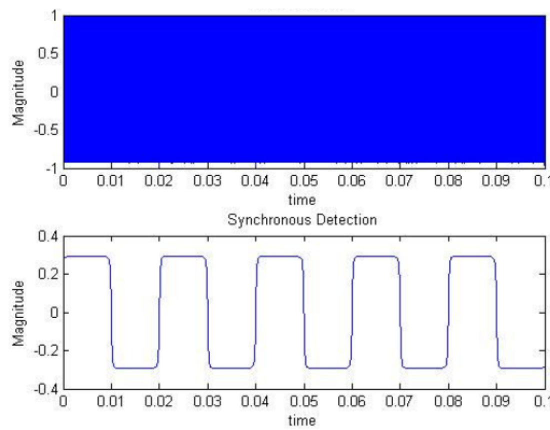

Figure 8: Receiver received signal and demodulated signal

PROCEDURES:

1. Set up CommLAB-T. Refer to Part I of Appendix on how to set up CommLAB-T.
2. Generate the transmitter modem samples. Refer to Part II of Appendix on how to generate the modem samples. Choose Amplitude Shift Keying (ASK) Experiment in selecting your experiment (in Step 2, Part II).
3. Transmit the modem samples through CommLAB-T. Refer to Part III of Appendix on how to transmit and receive the samples through CommLAB-T.
4. Analyze and observe various plots generated by MATLAB.

QUESTIONS:

1. Describe all the output figures obtained from the experiment.
2. What are the advantages and disadvantages of ASK?

TEST 2: Frequency Shift Keying (FSK) Modulation

The digital signals generated by PAM, PPM, etc. are called baseband signals as their bandwidth is concentrated around the zero frequency. These signals can be transmitted via a wired medium. However, to transmit these signals via a band pass channel, a mechanism to shift the signal to that band is required. For this purpose, Frequency Modulation is one of the choices and this frequency modulation is called Frequency Shift Keying (FSK).

PRINCIPLE OF OPERATION

i. Modulation
Frequency shift keying (FSK) is a form of modulation that represents digital data as variations in the frequency of a carrier wave. The process involved in this type of modulation is similar to the type of modulation done in the Frequency Modulation (analog) case, except that the message signal is a digital Signal.

1. The generated analog message signal is first converted to a digital signal.
2. The digital signal generated is modulated using the narrow band frequency modulation technique to generate the FSK signal.

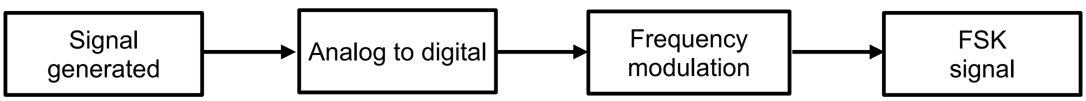

Figure 9: Block diagram of FSK modulator

ii. Demodulation
Improved zero crossing detection is used to demodulate the signal. The process is similar to the one done in Frequency Modulation.

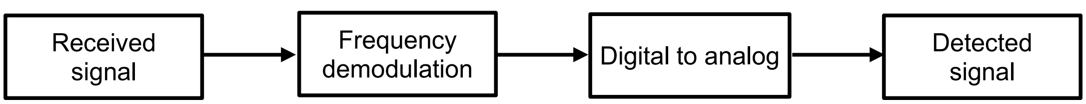

Figure 10: Block diagram of FSK demodulator

iii. MATLAB implementation of FSK
For the transmitter, a digital signal is generated and then frequency modulated before sending it to the CommLAB-T Tx block and to the kit. Fig. 11 shows the transmitter block diagram implemented in MATLAB. For the receiver, samples from the kit are passed through CommLAB-T Rx interface blocks to obtain blocks of data. The signal is then frequency demodulated using the improved zero crossing method to detect the message signal.

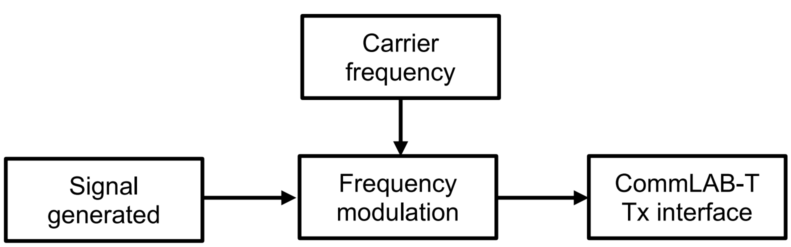

Figure 11: Transmitter block diagram of FSK in MATLAB

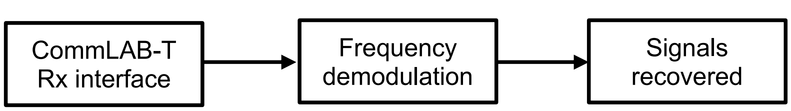

Figure 12: Receiver block diagram of FSK in MATLAB

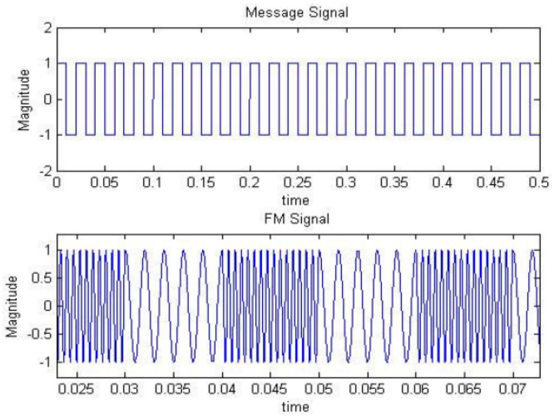

Figure 13: Message signal and FM signal

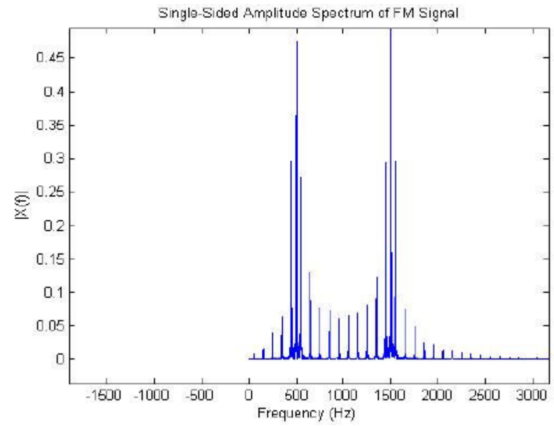

Figure 14: Spectrum of the modulated signal

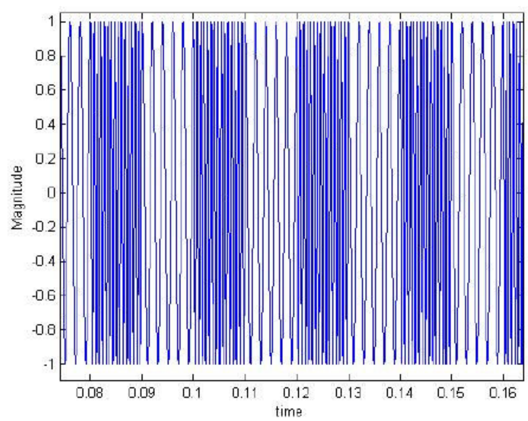

Figure 15: Received signal

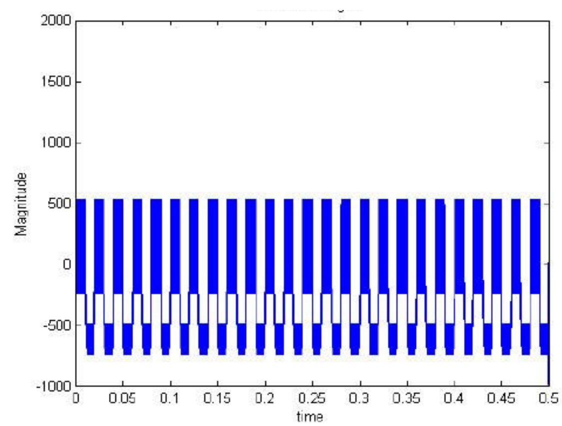

Figure 16: Unfiltered signal

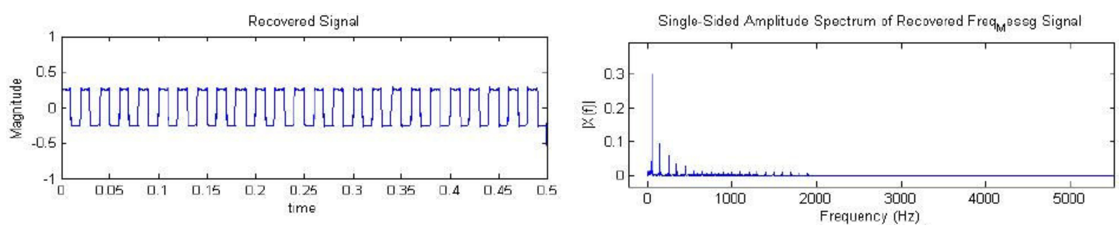

Figure 17: Demodulated signal and its spectrum

PROCEDURES:

1. Setup CommLAB-T Refer Part I of Appendix on how to setup CommLAB-T
2. Generate the transmitter modem samples. Refer Part II of Appendix on how to generate the modem samples. Choose Frequency Shift Keying (FSK) Experiment in selecting your experiment (in Step 2, Part II)
3. Transmit the modem samples through CommLAB-T. Refer Part III of Appendix on how to transmit and receive the samples through CommLAB-T
4. Analyze and observe the various plots generated by MATLAB.

QUESTIONS:

1. Describe all the output figures obtained from the experiment.
2. What are the advantages and disadvantages of FSK?

APPENDIX

Part I: Setup CommLAB-T

1. Double click on the CommLab-T icon on the desktop to activate the software. Wait until the CommLab-T Console appears. Leave this window active and do not close it. Also make sure that the CommLab-T device is switched ON.
2. On this Comm:LAB-T console (Fig. 18), click the 'INITIALIZE' button to initialize CommLAB-T. Press the RESET button once on the CommLab-T device (Fig. 19).
3. On the new window as shown in Fig.20, select Options and then EZ-USB Interface. The CommLab-T initialization window will appear, as shown in Fig. 21. Click download and choose WBU.hex file (Fig. 22).
4. After downloading is completed, you can exit the EZ-USB interface window. In the Cypress USB Console window, select 'Alt setting' as '2' in the 'Configuration Interfaces field' as highlighted in Fig. 23. You can then close this window (Fig. 23).
5. Press 'RUN' button from the CommLAB-T console (refer Fig. 18). This will open the WBU console as shown in Fig. 24. WBU console is used to transmit and receive modem samples through CommLAB-T. Choose the 2MBPS sampling rate using the sampling rate pull down menu as shown, press icon label 1 and make sure that the "Tx & Rx" is selected under 'Direction' and click 'OK' (Refer Fig. 25). Now CommLAB-T is ready to transmit and receive the samples.

   Notes: Do not change any other fields or configuration options. Changing them will result in improper functioning of the system. Results obtained for CommLAB-T may not be correct if sampling rate is chosen as any other value except 2MBPS.

Figure 18: CommLab-T Console

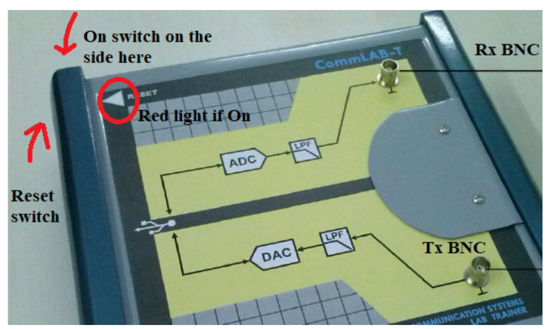

Figure 19: CommLab-T device

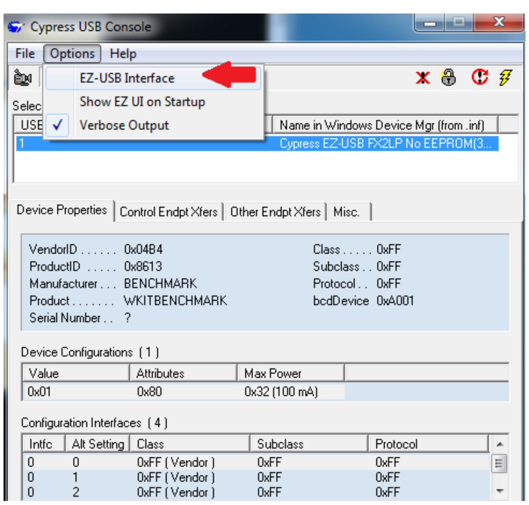

Figure 20: Cyprus USB console

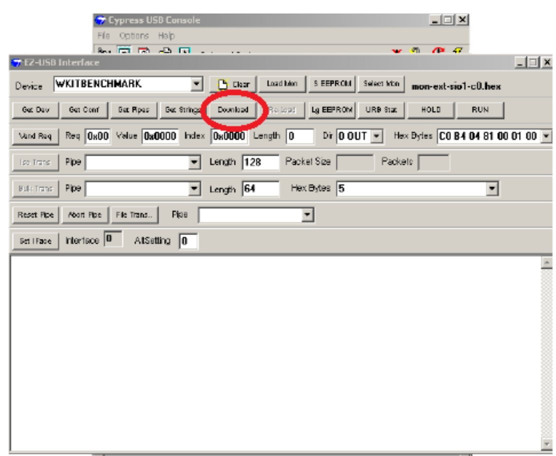

Figure 21: CommLAB-T Initialisation window, EZ– USB Interface

6. Click icon labelled “2” in Fig. 24 which will open the statistics window (Fig. 26)
7. Click ‘EXPERIMENT’ button in CommLAB-T console (Fig. 18) to activate the CommLABT_EXPERIMENT Console (Fig. 27).

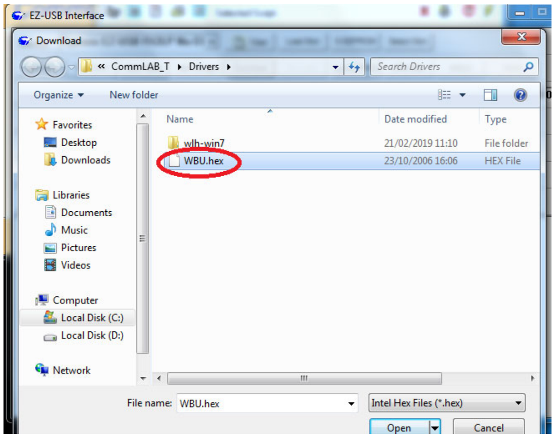

Figure 22: Select WBU.hex file

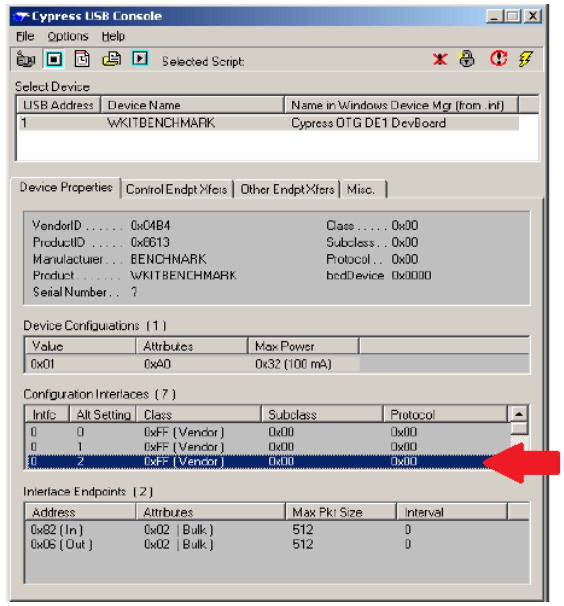

Figure 23: Select in arrow

Figure 24: WBU Console

Figure 25: WBU console – select 2MBPS

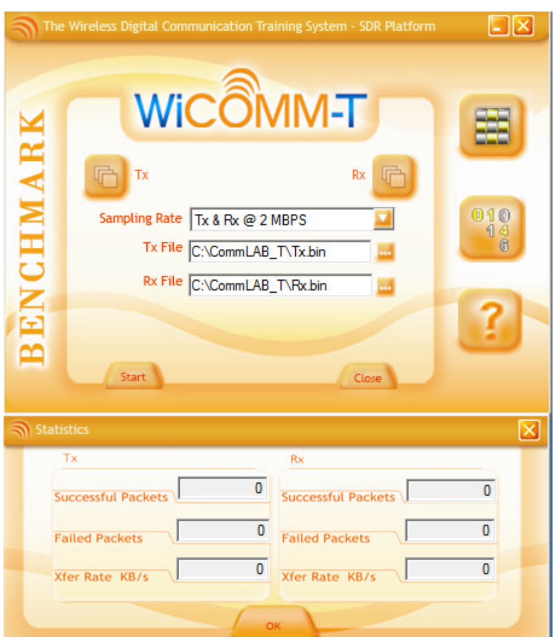

Figure 26: The statistics window

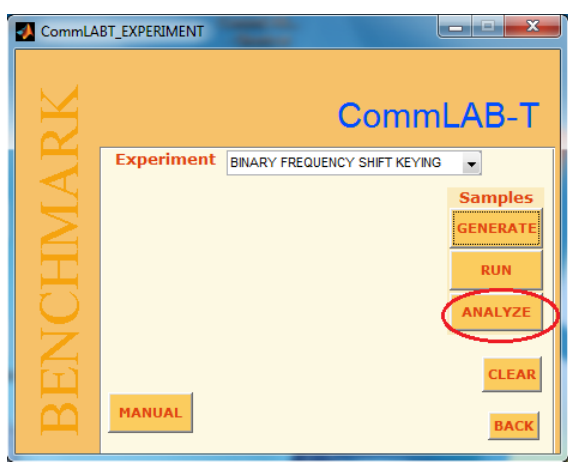

Figure 27: CommLab-T Experiment console

Part II: Generating the Samples

1. In experiment console (Fig. 27) select the Experiment to be run from the EXPERIMENT pull down menu. Upon selecting the experiment, the parameters that can be changed for transmitter and receiver will appear below the experiment as a pull down menu. If any parameters related to that experiment are to be changed, choose the available required value from the pull down menu.
2. Choose the type of experiment.
3. Click the 'GENERATE' button, which will generate the modem samples to be transmitted for the chosen experiment. This generated modem samples have to be transmitted and received through CommLAB-T using WBU console. Save all the figures that are output during this step.

Part III: Transmit and Receive the Samples

1. Press START button in WBU console (Fig. 26) to start transmitting and receiving the modem samples through CommLAB-T. The Tx icon and the Rx icon in the WBU console will start blinking to indicate that CommLAB-T is transmitting and receiving properly. This can be ensured by looking at the statistics window (Fig. 26). If the transmission and reception are successful, then this field will keep incrementing and the Failed Packets field shows zero.
2. After around 50,000 packets are successfully received, press the STOP button to stop transmitting and receiving the samples. Exceeding too far beyond 50,000 may cause insufficient memory problems.
3. Whenever there is a link failure between Tx and Rx, the 'Failed Packets' field for Tx and Rx show non-zero values and the Tx and Rx icons will start blinking in Red. The 'Xfer Rate KB/s' field shows the sampling rate of the modem samples for Tx and Rx.
4. Click the ANALYZE button on the CommLab-T console (Fig. 27). Save the figures generated from the experiment.

END OF EXPERIMENT