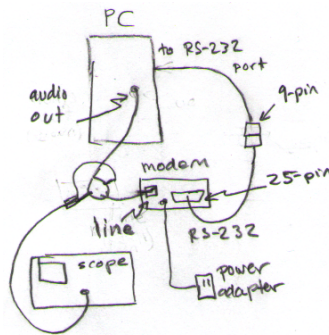


Lab 4 - V.21 FSK Modulator

Introduction

In this lab you will modify your program from Lab 2 so that instead of an RS-232 waveform it generates an FSK waveform that complies with the ITU-T V.21 standard.

To test your program you will output the generated FSK waveform to a telephone-line modem that is hooked up to the PC via a serial port. The modem will demodulate the FSK signal and, if you did everything right, display your name on a terminal emulator running on the PC.



V.21

A copy of the V.21 standard is available on the course web site or from <http://www.itu.int/rec/T-REC-V/en/>.

Signal Levels

The V.21 modem specification requires a maximum of 0 dBm and says that typical connections have attenuations of from 5 to 30 dB. You should set the level at the modem input to -6 dBm.

Frequencies

V.21 uses FDD with a different pair of frequencies in each direction. Use the frequencies for the station placing (“originating”) the call: 980 Hz for a mark (‘1’) and 1180 Hz for a space (‘0’).

Software Changes

Modify the C program you wrote for Lab 2 so that:

- it computes and outputs 8-bit signed samples of a modulated V.21 FSK signal instead of 8-bit signed samples of an (inverted) RS-232 waveform.
- the data rate is 300 bps instead of 1200 bps (the sample rate should be left at 9600 Hz)
- your waveform should begin with one second (300 bits) of mark (‘1’s) to allow the modem to detect the carrier

There are various algorithms you can use to compute the sample values for an FSK waveform. Here is the pseudo-code for one method:

1. initialize a phase variable to zero
2. for every output sample:
 - (a) increment the phase by the appropriate amount. This phase increment will depend on whether you are trying to output the mark or space frequency.
 - (b) compute the cosine of the phase variable and scale the value to the range +/- 127
 - (c) write the value to the output file (“waveform.txt”)

The hardware implementation of this algorithm is known as a Numerically Controlled Oscillator (NCO).

You will have to determine the appropriate phase increment per sample. (Hints: Frequency is defined as phase difference per time increment. The time increment in this case is the time between samples.)

You can use a float value to keep track of the phase and use the function `cos()` to compute the cosine of the phase. Include `math.h` to get the prototype for `cos()`. You will have to convert the value from float to signed char before writing it to the file. The phase variable’s value needs to be retained across calls to `writeword()` so the phase variable must either be declared *static* or outside of a function.

The `lab2.c` example should be modified to open the output file in binary mode. Otherwise a carriage

return character (0x0d) will be inserted after very line-feed character (0x0a). Use the following syntax for the open: `f = fopen ("waveform.txt", "wb") ;`

An incomplete version of the code is available in the file `lab4incomplete.c` on the course share-out folder under folder Lab4.

Procedure

Follow the instructions given in Lab 2 to install the lcc compiler, Audacity audio editor and Teraterm terminal emulator if necessary.

Compile and run your program to generate the `waveform.txt` file containing the FSK signal. To avoid losing your work, work on your network (H) drive. When you create a new project the `.exe` and `waveform.txt` files may be placed in sub-folders `lcc2`, `lcc3`, etc.

Plug the audio cable into the audio output port on the front of the PC. Connect the scope probe ground clip to the yellow lead and the probe to the violet lead.

Load the waveform into Audacity as in Lab 2 and start continuous playback. Look at the waveform on the scope and adjust Audacity's volume control (beside the speaker icon) for a signal level of about -6 dBm.

Connect the PC's audio output to the modem's *line* port. You will need a cable that has an RJ-11 jack on one side and bare wires on the other. Polarity does not matter. You can use the scope probe's clips to hold the wires together.

Connect the 9-pin RS-232 cable from the back of the PC to the 9-to-25 pin cable that is normally hooked up to the back of the Lab-Volt power supply. Connect the 25-pin end of that cable to the RS-232 port on the modem.

Connect the modem's power adapter to the modem and 120VAC power (unplug the Lab-Volt unit if necessary).

Run Teraterm in the same way as for Lab 2 *except* that the baud rate must be set to 300 bps.

Type the following commands in the Teraterm window. These commands will be sent to the modem and configure it for V.21 modulation and then have it "pick up" the phone line and begin receiving data:

- type ATZ (followed by Enter) to reset the modem. If the modem understands the command it will respond with "OK".
- type ATLOB15N0 (0 is a zero) to: reduce the modem's speaker volume (L0), enable V.21 modulation (B15), and disable speed negotiation (N0)

- type ATA to have the modem go "off-hook" and connect to the phone line input

After a few seconds the modem should detect carrier, print CONNECT and start demodulating the FSK-modulated data and sending the data to the PC over the RS-232 line. You should see your name displayed on the terminal. Take a screen capture for your report.

If you don't get the expected results, check the frequency and level of your waveforms using the scope. If you trigger on the positive zero crossing you should be able to measure the two periods and compute the frequencies. A known-good test waveform is available in the file `lab4testwaveform.txt` on the course share-out folder under Lab4. You can use this waveform to confirm whether the problem is with your waveform or somewhere else.

Restore the RS-232 and power connections to the Lab-Volt power supply when you are finished.

Pre-Lab

What is the power of a sine wave of amplitude A ? What amplitude corresponds to a power of -6 dBm if the modem's input impedance is 600 ohms?

What phase increments per sample will result in the V.21 originate mark and space frequencies for a sample rate of 9600 Hz?

How many samples per bit are required for a 300 bps waveform sampled at 9600 Hz?

Modify your Lab 2 code as described above to generate an FSK signal with the appropriate frequencies and baud rate.

Hand in the answers to the above questions and a printout of your code *before the start of the lab*.

You should try to complete the pre-lab before the lab because you will probably not have enough time to figure out how to modify the code *and* complete the procedure given above during the lab period.

Lab Report

Hand in: (1) a copy of your modified code with any additional changes you made in the lab and (2) a screen capture showing the Teraterm window with your name displayed (you can use the Windows Snipping Tool or PrtScr and paste into an editor).