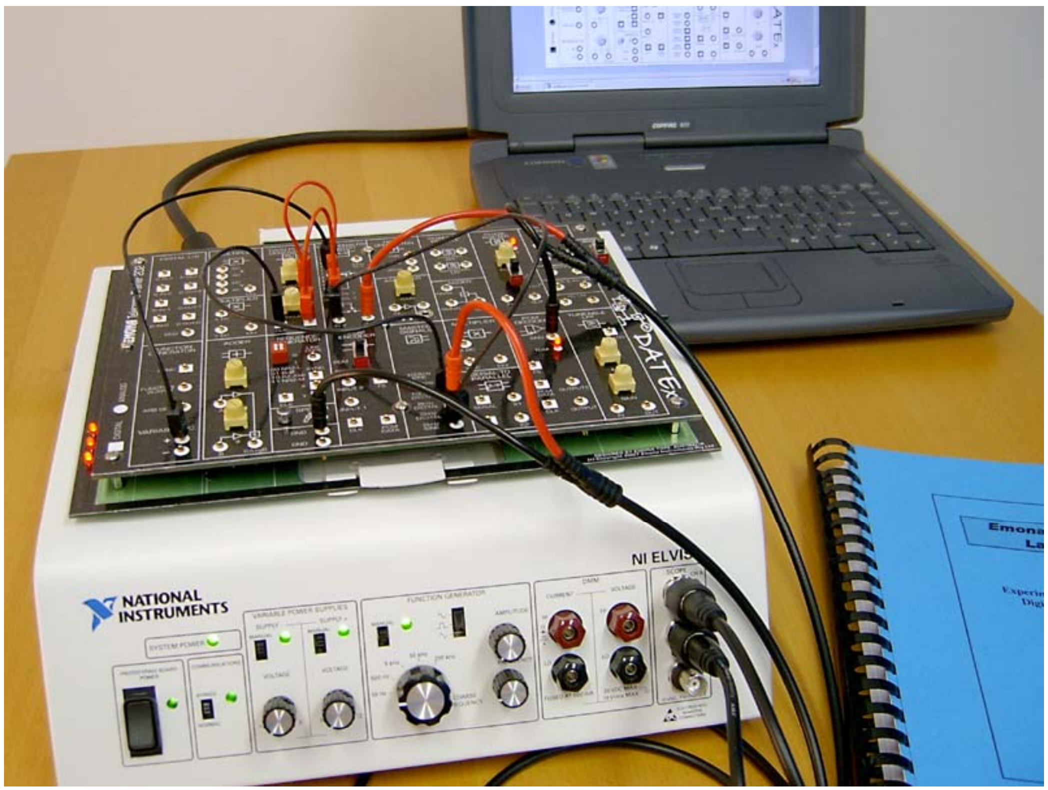
Developing Digital/Analog Telecommunication Laboratory Courses

Introduction and Motivation

- Engineering technology programs specify that theory courses should be accompanied by coordinated laboratory experiences
- Hands-on laboratory has been an essential part of undergraduate engineering programs
- The well prepared laboratory courses make the students be able to reinforce the theory they see in textbooks with in-class demonstrations and laboratory exercises.

Introduction of Emona DATEx

The Digital Anolog Telecommunication EXperimenter unit (DATex) is an add-on board for the NI ELVIS used for teaching analog and digital Telecommunications theory to university students[6]. Figure 1 shows DATex unit with NI ELVIS



Introduction of Emona DATEx (continue….)

With Emona DATEx, over 29 analog and digital telecom's experiments can be implemented on one board, plugged into the NI ELVIS platform. These experiments include :

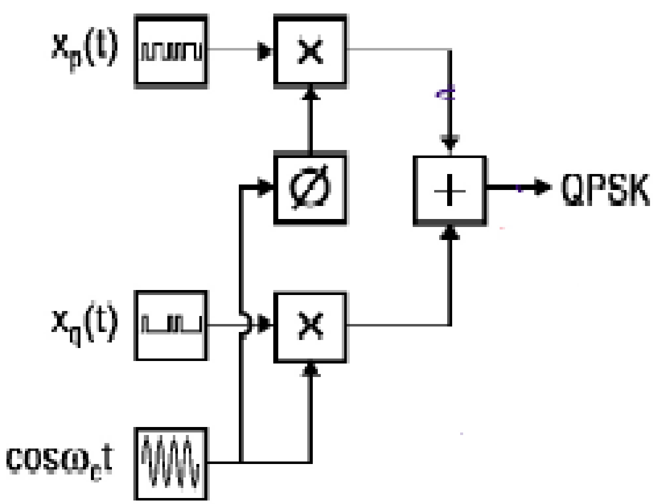
- Basic analog communication experiments:
  - amplitude modulation (AM)
  - frequency modulation (FM)
  - phase modulation (PM)

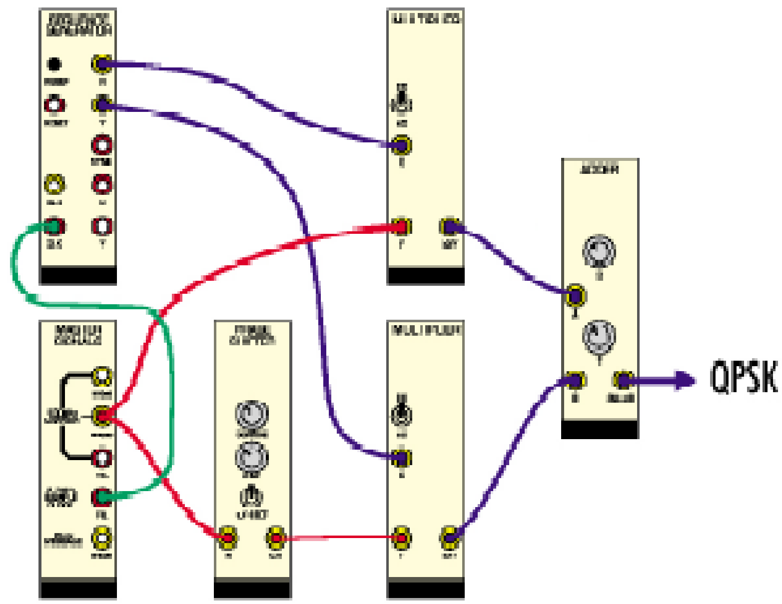
- Digital communication experiments:
  - sampling,
  - pulse-code modulation (PCM)
  - amplitude-shift keying (ASK)
  - quadrature phase shift keying (QPSK),
  - frequency-shift keying (FSK)

Introduction of Emona DATEx continue….

DATEx has a unique "block diagram approach" to modeling telecommunications experiments. It provides a selection of individual circuit blocks.

$$x_q(t)\cos(\omega_c t) + x_p(t)\sin(\omega_c t) = QPSK$$





Introduction of Emona DATEx continue....

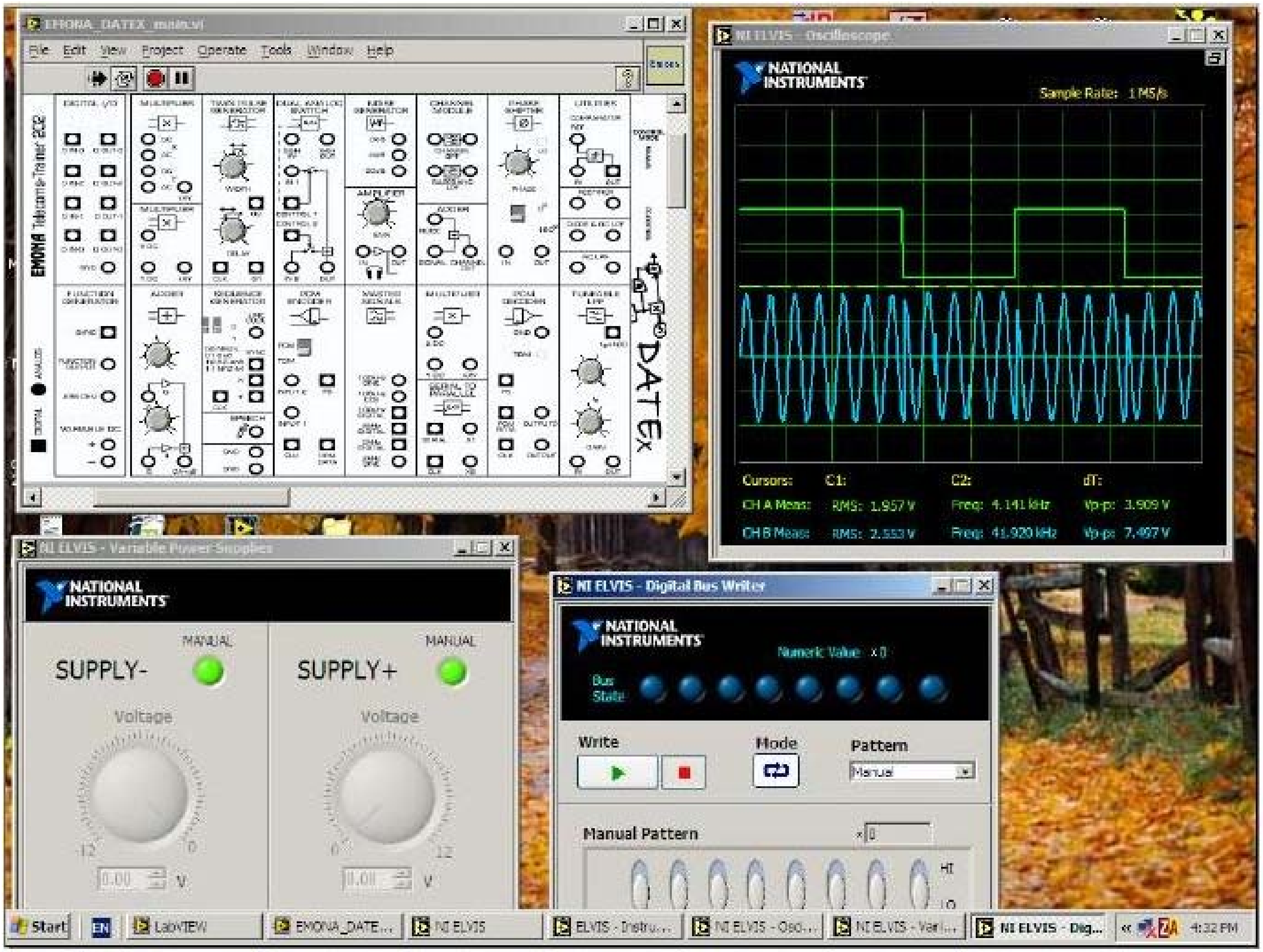


Figure 4: DATEx SFP functions alongside ELVIS SFP functions

Case Study

Our students did many experiments :

- AM, AM demodulation,
- FM, FM demodulation,
- Sampling and reconstruction,
- PCM encoding/decoding,
- ASK, FSK and QPSK.

- Course project
  - ➢students recorded their own speech signals, applied various modulation techniques they learned in classroom to process and transmit these signals and finally obtained the recovered speech signal from the receiver.

  - ➢These kinds of experiments not only stimulated students' interest but also enhanced their understanding of the principle of communication systems.

Experiment: Amplitude modulation

In the classroom's telecommunication theory, the students learned that the mathematical model that defines the AM signal is:

AM = (DC + message) × the carrier.

When the message is a simple sine wave , the AM signal consists of three sine waves:

1) carrier frequency
2) a frequency equal to the sum of the carrier and message frequencies
3) a frequency equal to the difference between the carrier and message frequencies.

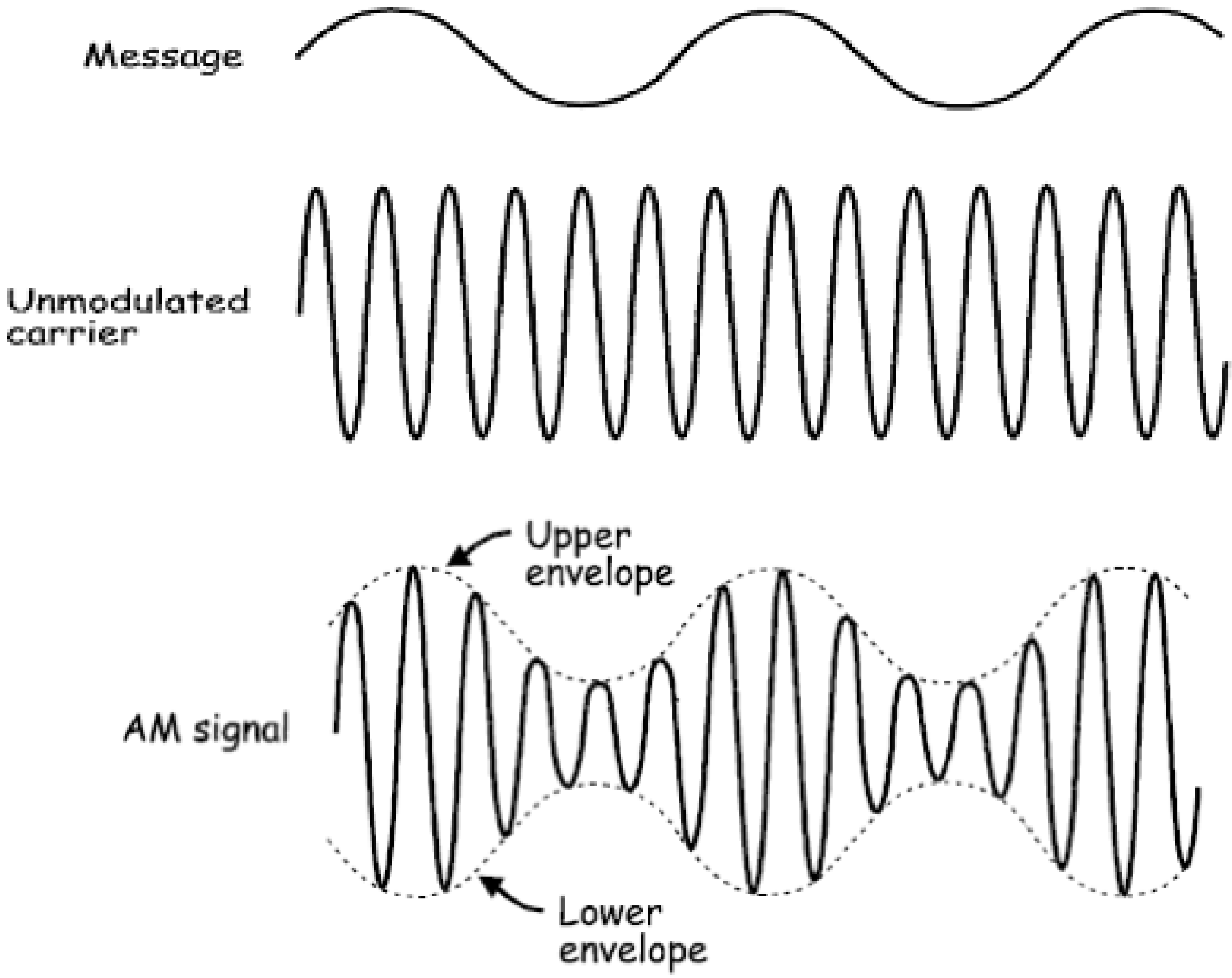
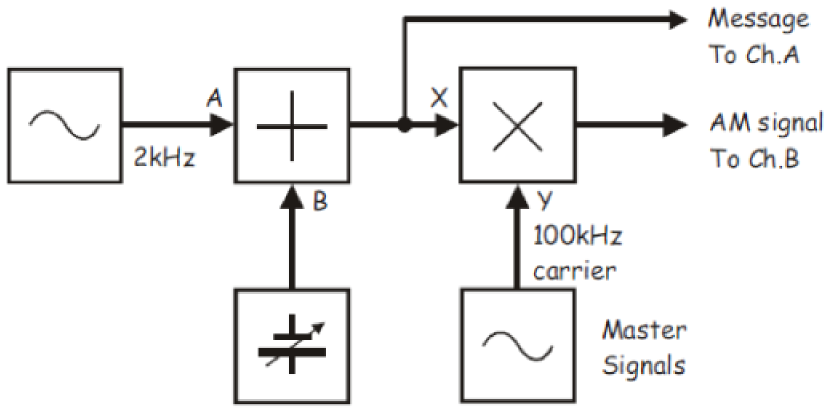


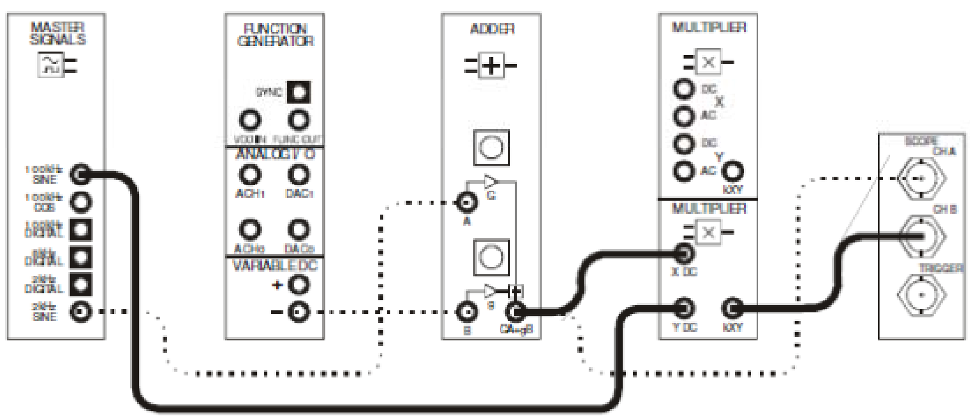
Figure 5: Original message and high frequency carrier wave form

Amplitude modulation continue…

The set-up in Figure 7 can be represented by the block diagram in Figure 8 below. With values, the equation becomes:

AM = (1VDC + 1Vp-p 2kHz sine) × 4Vp-p 100kHz sine.





Amplitude modulation continue…

Students obtained the AM signal and showed in the scope in Figure 9. The experiment enhanced students' understanding of amplitude modulation. Specially, they observed what the under modulation and over modulation look like.

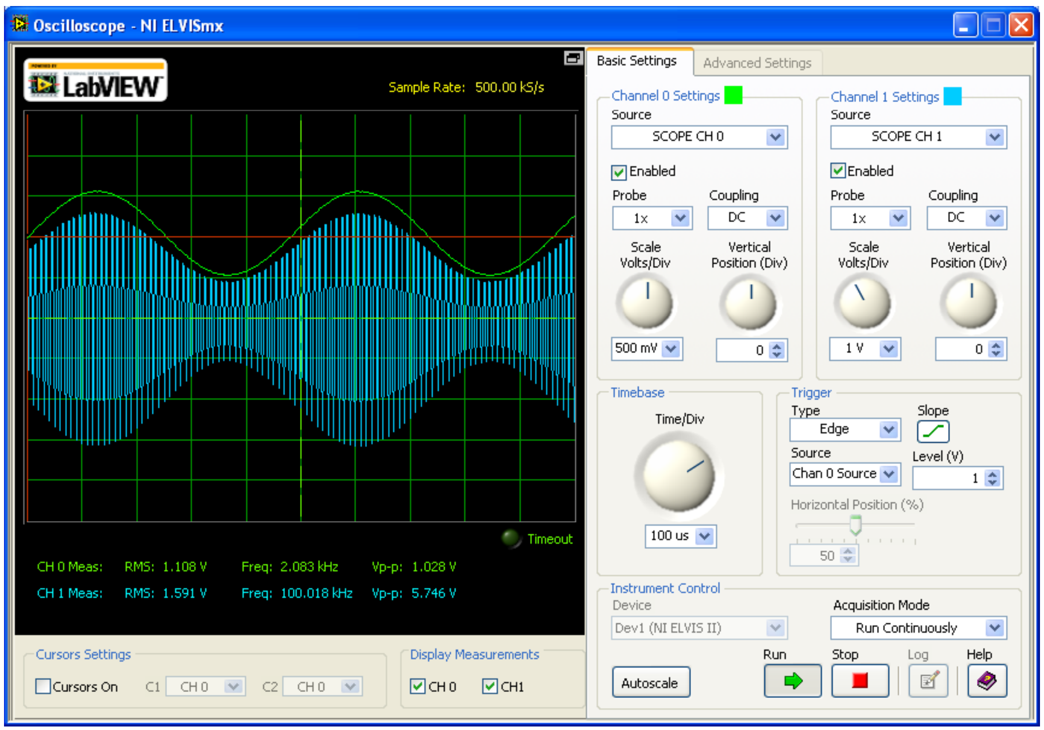


Figure 9: Original sine wave and the AM wave form

Experiment – Amplitude Shift Keying

Figure 10 below shows what an ASK signal looks like. Notice that the ASK signal's upper and lower limits (the envelopes) are the same shape as the data stream (though the lower envelope is inverted).

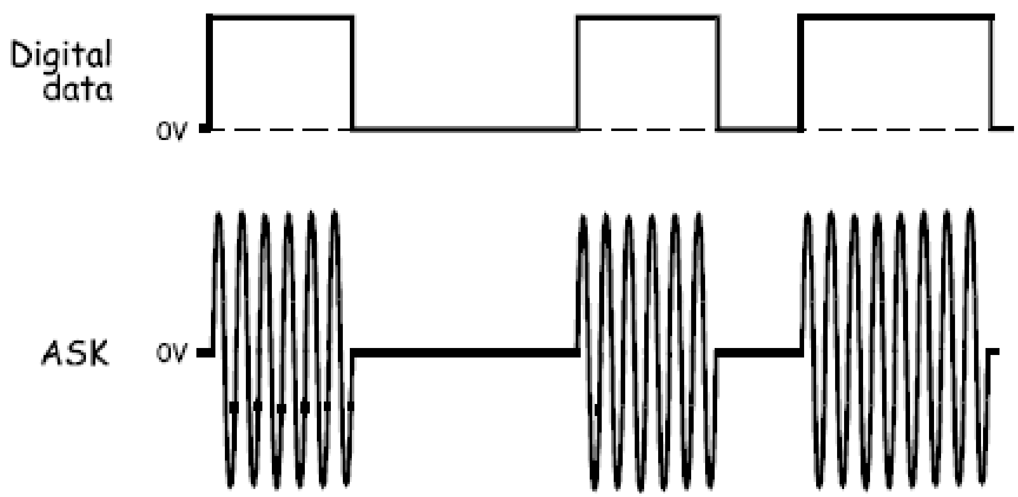
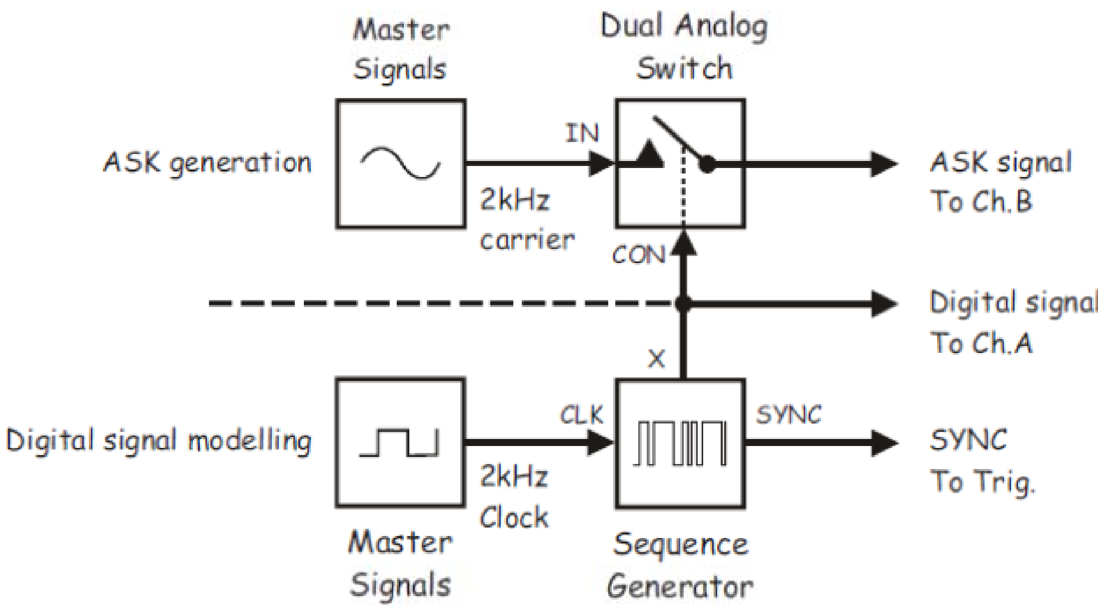
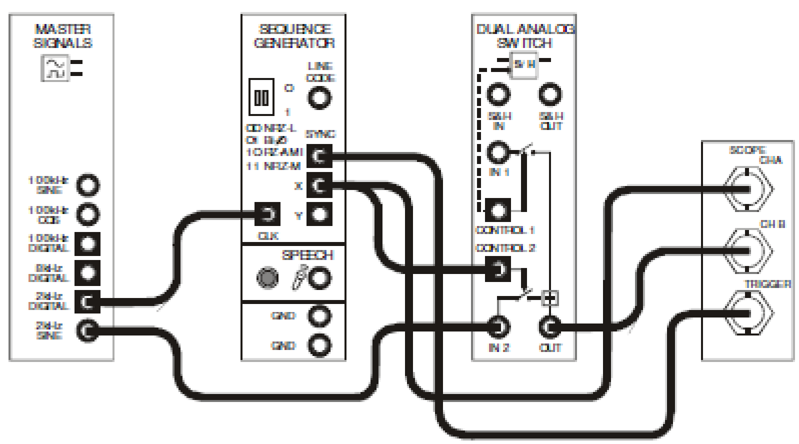


Figure 10: The original digital signal and its corresponding ASK signal

Amplitude Shift Keying continue…





Amplitude Shift Keying continue…

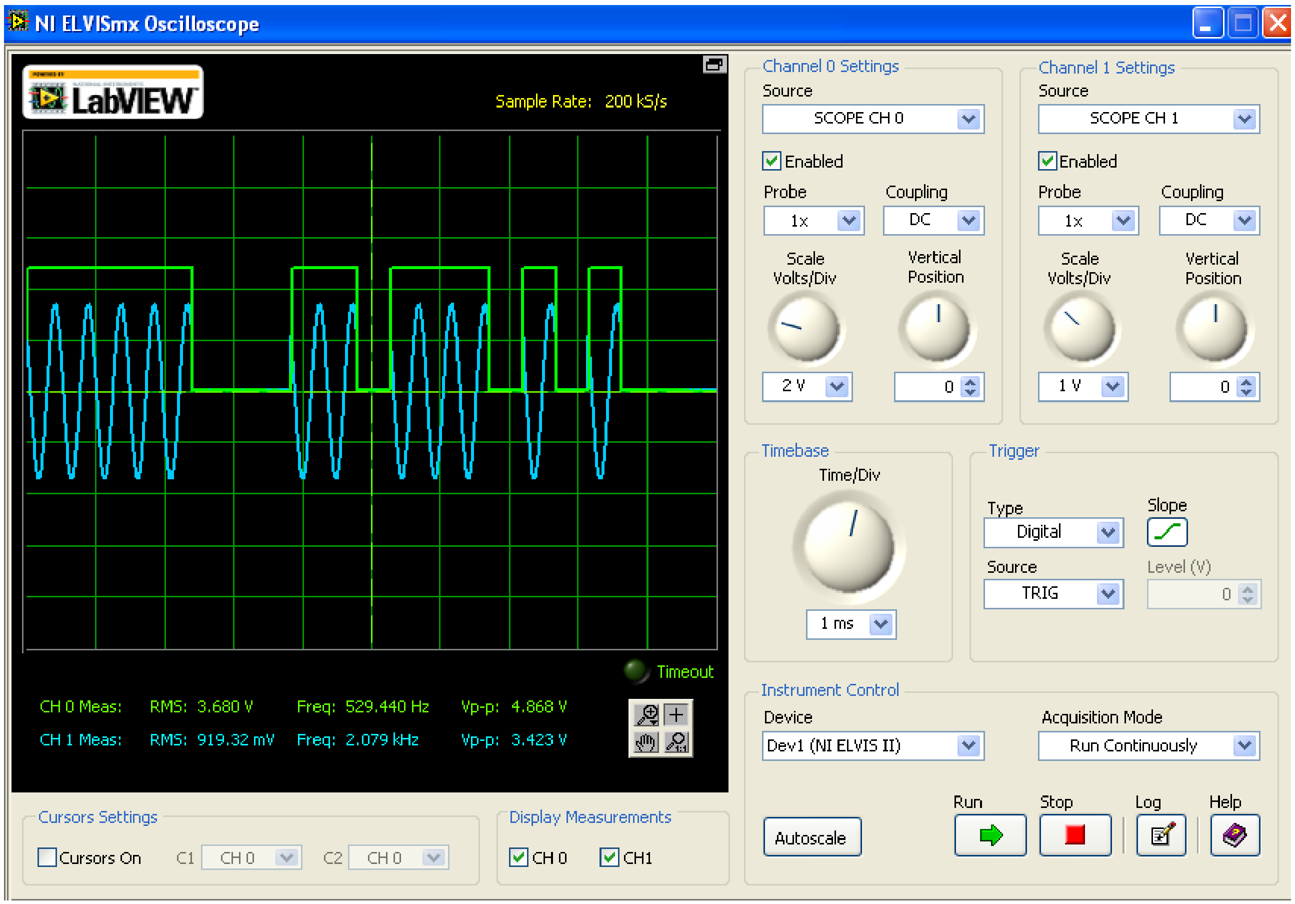


Figure 13: ASK signal wave form

Conclusions

- With NI ELVIS and its extensions, a completely consistent laboratory course framework can be established that covers material from the first year's DC, AC circuit design, second year's analog/digital electronics design, to the third or fourth year's telecommunication systems lab, data communication method lab, control system lab and digital signal processing lab.

- By taking advantage of these consistent Labs, our students are able to reinforce the theory they see in textbooks with in-class demonstrations and laboratory exercises. This kind of state-of-art laboratory and technology will help our engineering technology education better prepare students for careers in industry.