

# 14

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## Demonstration of Amplitude Modulation

In this lecture, we demonstrate many of the concepts and properties discussed and developed in several of the previous lectures. The demonstration centers around a number of signals displayed in both the time domain and the frequency domain using a signal generator, an oscilloscope to view the signal in the time domain, and a spectrum analyzer to view the signal in the frequency domain. The spectrum analyzer computes the spectrum digitally using a microprocessor. A segment of the time waveform is captured, digitized, and stored in a digital memory. A microprocessor then computes the Fourier transform for this segment. As the signal evolves in time, successive segments are captured and processed in this way. Consequently, the spectrum analyzer displays the Fourier transform of successive segments of the signal, so as the signal changes its characteristics and spectral content, these changes are reflected in the spectrum analyzer output. For example, with a sinusoidal signal the spectrum analyzer displays a narrow line at the frequency of the sinusoid. If this frequency is slowly changed, the location of the spectral line on the analyzer display shifts position accordingly.

Simultaneously looking at the signal and the spectrum analyzer output helps us to visually correlate properties and characteristics in the time domain and frequency domain. As one example of this, we return in this demonstration lecture to the Fourier transform property of time and frequency scaling. In a previous lecture we demonstrated this property with the glockenspiel, illustrating in particular that if we recorded a note and replayed it at half speed, it would sound an octave lower in frequency. With the equipment that we have available to us in this demonstration lecture, we can visually illustrate time and frequency scaling of the glockenspiel note.

One of the principal demonstrations in this lecture illustrates amplitude modulation with a modulator box. This box has an external input for the modulating signal and a choice of three carrier signals: sinusoidal, triangular, and square wave. By looking at the modulated signal in both the time domain and the frequency domain, we can observe in both domains the effect of changing the percent modulation, or equivalently the amount of carrier injected, and

the effects of changing the input frequency, the carrier frequency, and the carrier wave shape. In demonstrating amplitude modulation, we first use simple modulating waveforms from the signal generator. As a final demonstration, we examine the modulated and demodulated waveforms characteristic of an AM radio.

### **Suggested Reading**

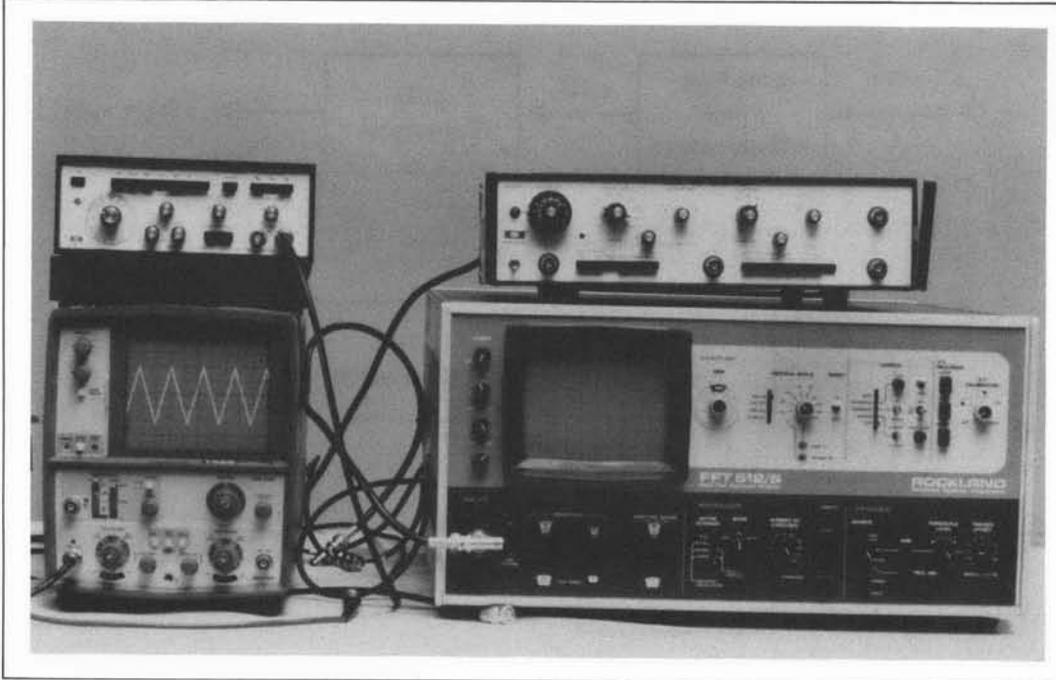
Review:

Section 4.6.5, Time and Frequency Scaling, pages 207–208

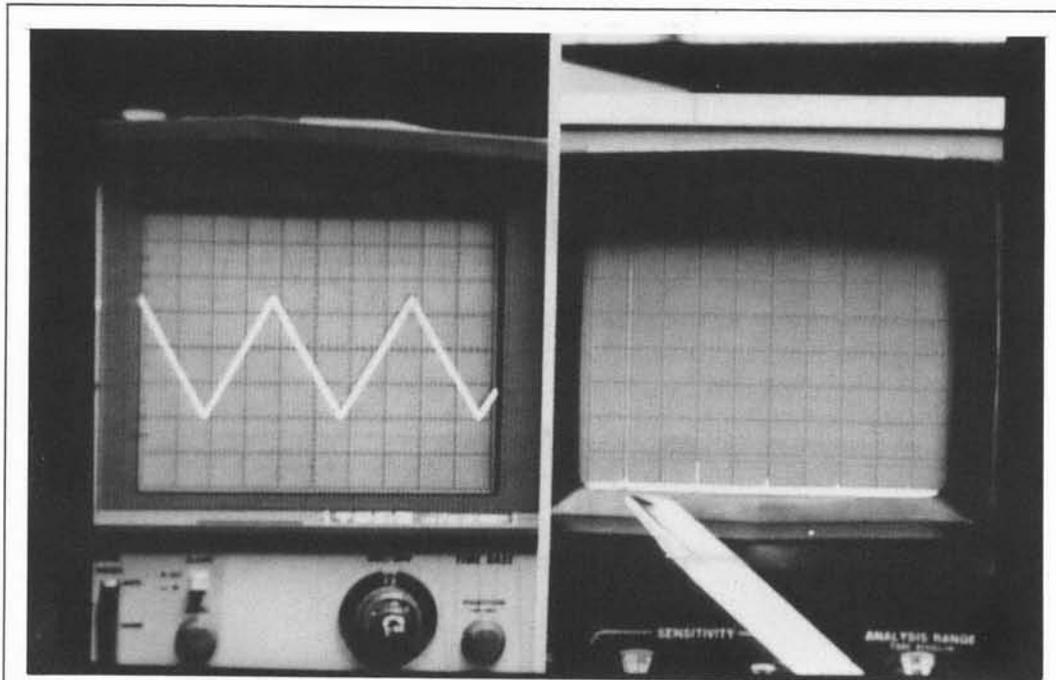
Section 7.1, Continuous-Time Sinusoidal Amplitude Modulation, pages 449–459

Section 7.2.2, Sinusoidal Amplitude Modulation for Communications: Frequency-Division Multiplexing, pages 461–464

Section 7.6, Continuous-Time Frequency Modulation, pages 479–487



**DEMONSTRATION 14.1**  
 Overall equipment configuration. Left: the signal generator and the oscilloscope for the display of time waveforms. Right: the modulator (top) and the Rockland Systems spectrum analyzer.

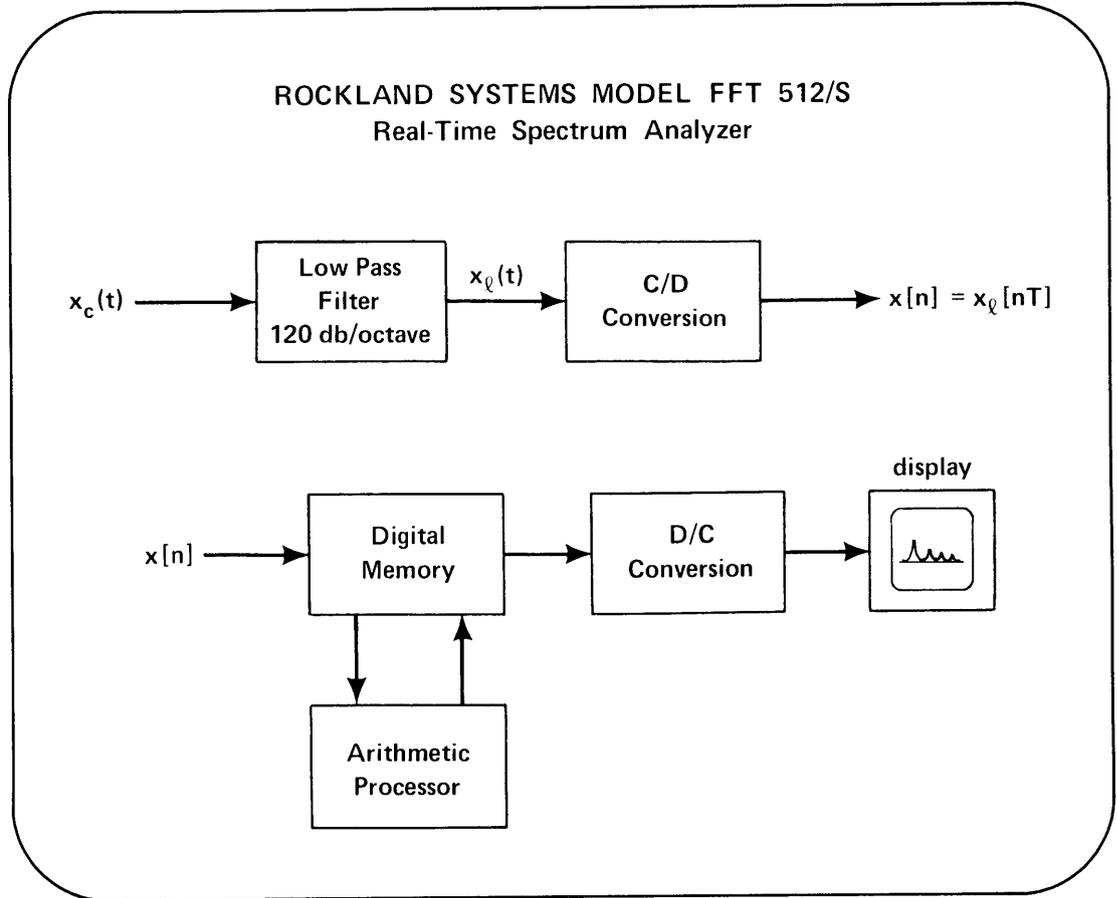


**DEMONSTRATION 14.2**  
 A triangular wave displayed in the time domain (left) and frequency domain (right).

**TRANSPARENCY**

**14.1**

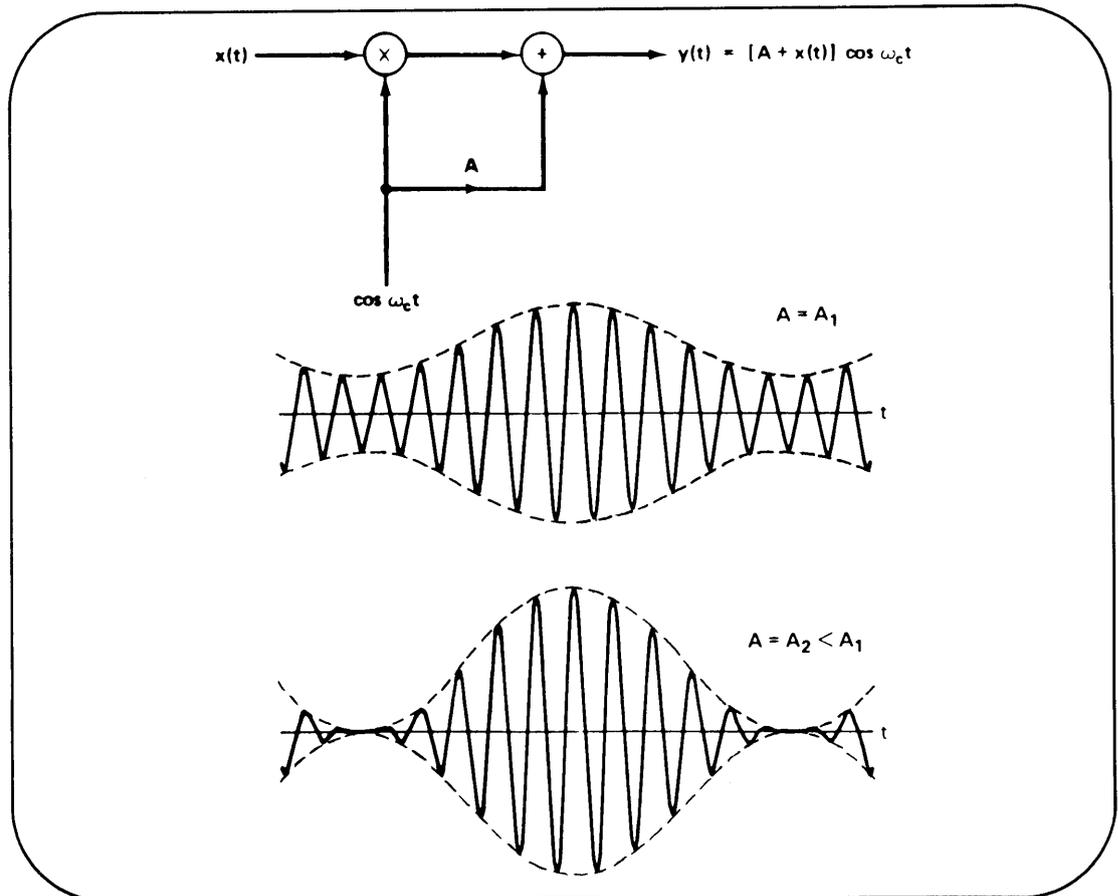
Block diagram of Rockland Systems Model FFT 512/S spectrum analyzer.

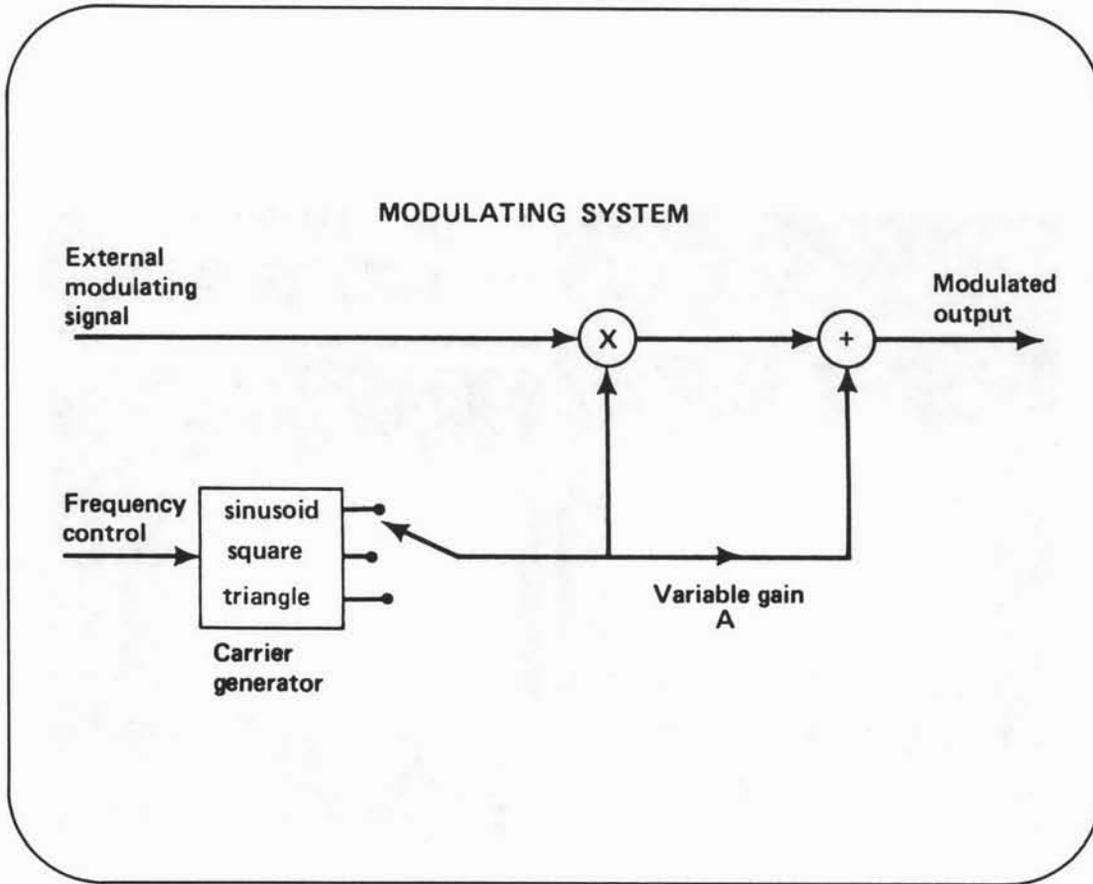


**TRANSPARENCY**

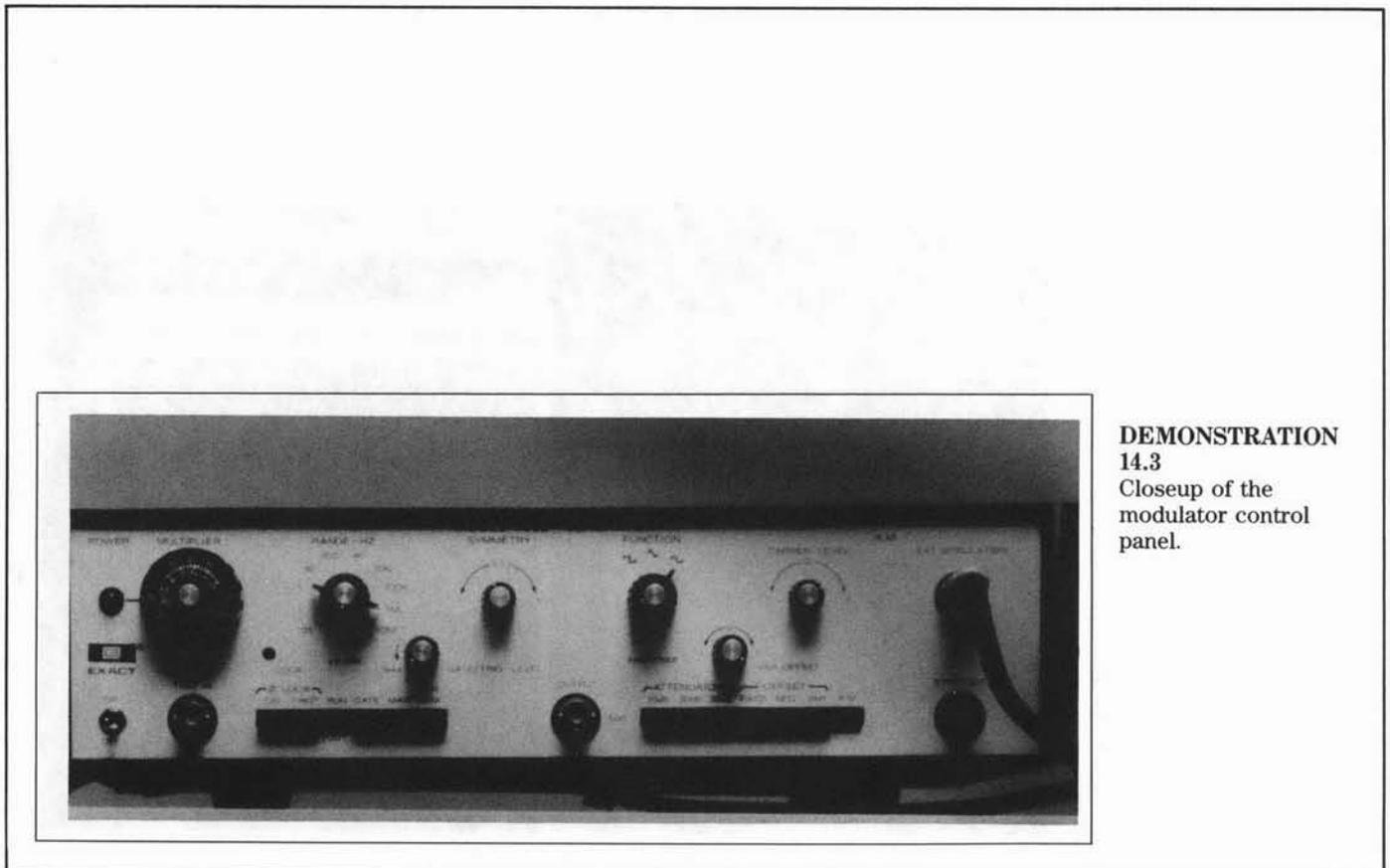
**14.2**

Illustration of waveforms associated with sinusoidal amplitude modulation.





**TRANSPARENCY 14.3**  
Block diagram of modulating system used in the demonstration.

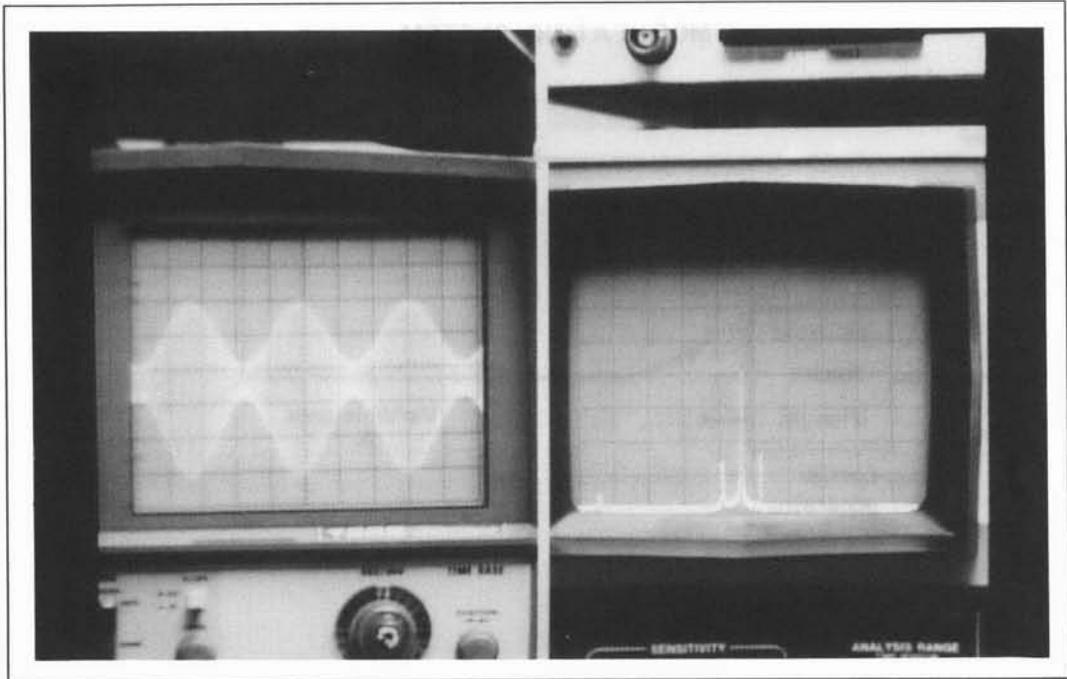


**DEMONSTRATION 14.3**  
Closeup of the modulator control panel.

**DEMONSTRATION**

14.4

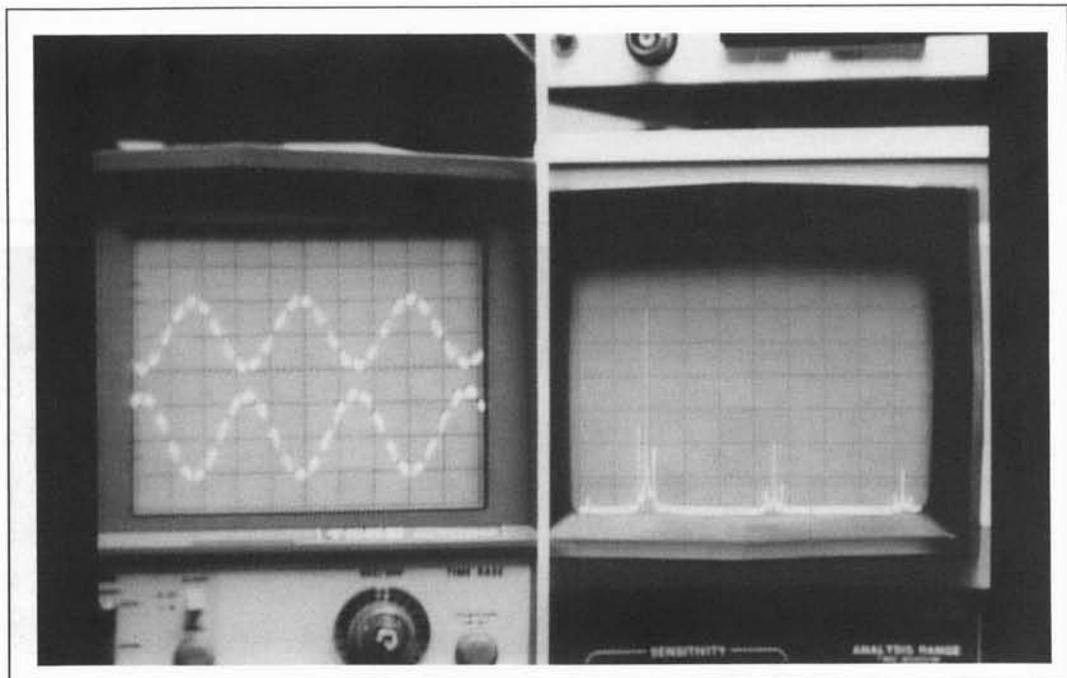
Sinusoidal amplitude modulation with a sinusoidal carrier displayed in the time domain (left) and frequency domain (right).

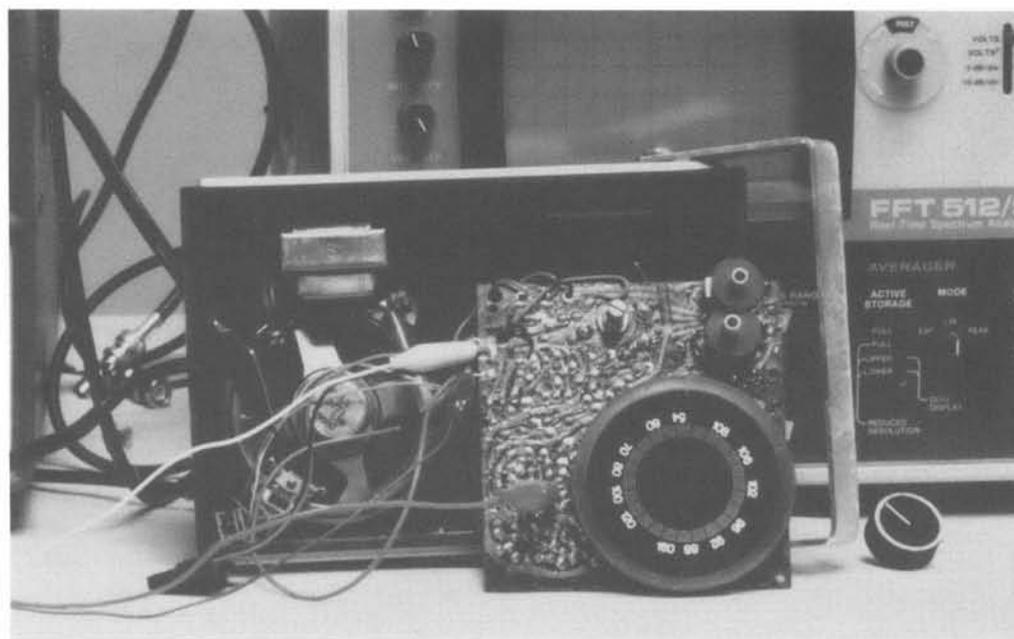


**DEMONSTRATION**

14.5

Sinusoidal amplitude modulation with a square-wave carrier displayed in the time domain (left) and frequency domain (right).





**DEMONSTRATION**  
**14.6**  
AM radio receiver.

MIT OpenCourseWare  
<http://ocw.mit.edu>

**Resource: Signals and Systems**  
Professor Alan V. Oppenheim

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