Wave Fundamentals and Modulation Demonstration Board

Purpose: The purpose of this board is to give the instructor a ready instructional resource to support lesson presentations in wave fundamentals and modulation. The board would be used in conjunction with a projection capable oscilloscope and an external audio amplifier during platform instruction of the concepts.

During the wave fundamentals lesson, the board produced audio waveform frequency and amplitude are manipulated to reinforce the relationship between frequency, wavelength, and pitch and to reinforce the independence of amplitude and frequency. The audio is fed into the external amplifier to provide audio presentation while the waveform is visually displayed on the oscilloscope.

During the modulation lesson, a simulated carrier wave is modulated by the audio wave using amplitude modulation. The input and output waveforms are displayed by the oscilloscope so that comparisons can be made as the waveforms are manipulated. The audio wave’s frequency and amplitude are manipulated to show the effects of varying modulation percentages and over modulation.

During the demodulation lesson, the modulated carrier is fed into a demodulator circuit. The input modulated waveform, original audio waveform, demodulator output, and filtered output waveforms are displayed sequentially on the oscilloscope to allow the instructor to walk the students through the demodulation process.

Circuit Diagram: This the circuit diagram of the board:
Circuit Board: This is what the board looks like:

Lesson examples:

**Wave Fundamentals:** The instructor would begin the lessons by presentation the vocabulary of waveforms so that students will be able to understand the subsequent lessons on modulation where that vocabulary is used. The instructor would connect the oscilloscope to TP1 to display the audio waveform and connect a computer speaker amplifier to J1 to provide sufficient audio levels to be heard by the students. The projected display would look like this:
The instructor would use this screen to illustrate the vocabulary used to describe a waveform (crest, trough, wavelength, frequency, period, amplitude). Then the frequency is changed through the range by adjusting R6. The frequency range is between approximately 2 and 3 Kilo Hertz. During this portion of the demonstration, the instructor would emphasize the relationship between frequency and pitch. Next, the instructor would emphasize the inverse relationship between frequency and wavelength. Finally, the instructor would vary the amplitude of the wave using R8. During this portion of the demonstration, the instructor would emphasize the relationship between amplitude and loudness (strength) of the wave while pointing out the independence of amplitude and frequency.

**Modulation:** The instructor would begin the modulation demonstration by providing some background material on the concept of modulation. The board and oscilloscope would be set up by connecting one channel of the scope to TP1 and the other channel to TP2. The scope display would be as depicted below. The red trace simulated a radio frequency carrier wave; the blue trace represents the audio to be imbedded on the carrier wave during modulation.

![Modulation Diagram](image-url)

Next, one channel of the scope is moved from the carrier on TP2 to the demodulator output on TP5. The demodulator output is display in this example in blue. The instructor uses this waveform to illustrate the concept of amplitude modulation...the amplitude of the carrier wave is varied in step with the amplitude of the audio wave being imprinted on the carrier.
The concept of amplitude modulation is further reinforced by varying the amplitude of the audio wave using the R8 control. The following panels show approximate levels of 50%, 25%, and 0% modulation:
The instructor can next demonstrate the concept of over modulation by increasing the audio wave amplitude beyond the 100% modulation level. Varying amounts of distortion become evident as the modulation level goes beyond 100%.

Here the student can see the amplitude of the audio wave increase and at beyond a certain point (100% modulation), the carrier waveform becomes distorted (flat topping) and no longer faithfully follows the audio waveform.

Demodulation: The instructor would begin the demodulation demonstration by providing some background material on the concept of demodulation. The demodulation demonstration is set up by configuring the board for 100% modulation and connecting one channel of the scope to the audio waveform at TP1 and the other channel the output of the demodulator at TP6. TP6 is connected to a simple diode rectifier that is used to demodulate the AM waveform. The display will look like this:
The instructor can use this display to illustrate that the carrier waveform has been modified by the demodulator (the AC component has been eliminated and a DC wave is the result). The instructor can also point out that there are still some remnants of the carrier wave still present that corrupts the desired audio waveform.

The board is next configured with one scope channel connected to the filter output at TP7. The display would look like this:

![Display Image]

Using this display the instructor would point out that filter has removed virtually all of the remnants of the carrier that remained after demodulation and that the audio output is a fair duplication of the original audio waveform. This is a good opportunity for the instructor to point out that the modulation/demodulation process is not perfect and that there is always going to be some distortion of the audio waveform during the process due to the imperfections of electronic circuitry.