Communication Systems II - Laboratory

Experiment 2

Pulse Time Modulation

Objective

1. To Examine the PWM modulator operation and signal waveforms.
2. To describe how the PPM signal is generated from the PWM signal and analyzing signal waveforms.
3. To examine how the PWM and PPM receivers work.
4. To examine the operation of the blocks which make up the demodulators and the modulated signal waveforms.

Apparatus

1. T20A boards of the ElettronicaVeneta (EV) training kit.
2. DC power supply.
3. Oscilloscope.
4. Connecting wires.

Theory

The sample values of a message can modulate the time parameters of a pulse train, namely the pulse width or its position. The corresponding processes are designated as pulse duration modulation (PDM) and pulse-position modulation (PPM) and are illustrated in Figure 1. PDM is also referred to as pulse width modulation (PWM). Note that the pulse width or pulse position varies in direct proportion to the sample values of $x(t)$.

Figure 2 shows the block diagram and waveforms of a system that combines the sampling and modulation operations for either PDM or PPM. The system employs a comparator and a sawtooth-wave generator with period (T_S). The output of the comparator is zero except when the message waveform $x(t)$ exceeds the sawtooth wave, in which case the output is a positive constant A. Hence, as seen in the figure, the comparator produces a PDM signal with trailing-edge modulation of the pulse duration. (Reversing the sawtooth results in leading-edge modulation while replacing the sawtooth with a triangular wave results in modulation on both edges.) Position modulation is obtained by applying the PDM signal to a monostable pulse generator that triggers on trailing edges at its input and produces short output pulses of fixed duration.

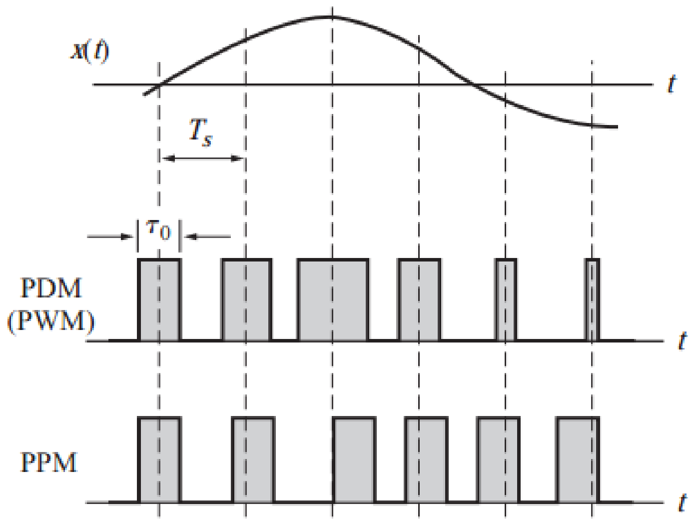

Figure 1: Types of pulse-time modulation.

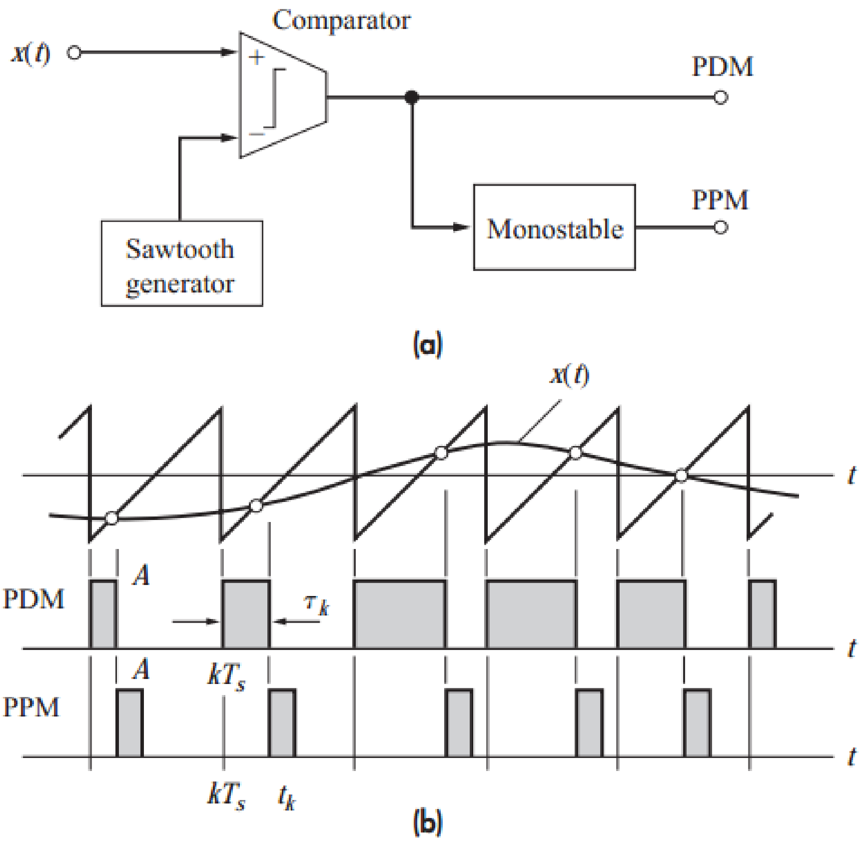

Figure 2: Generation of PDM or PPM: (a) block diagram; (b) waveforms.

Careful examination of Figure 2-b reveals that the modulated duration or position depends on the message value at the time location t_k of the pulse edge, rather than the apparent sample time kT_s. Thus, the sample values are nonuniformly spaced. Inserting a sample-and-hold circuit at the input of the system gives uniform sampling if desired, but there's little difference between uniform and nonuniform sampling in the practical case of small amounts of time modulation such that $t_k - kT_s \ll T_s$.

In order to demodulate a PTM signal, first consider the following approximate expression of a PDM signal:

$$x_{\text{PDM}}(t) \approx Af_s\tau_o[1 + \mu x(t)] + \sum_{n=1}^{\infty} \frac{2A}{\pi n} \sin n\phi(t) \cos n\omega_s t \qquad (3.1)$$

where $\phi(t) = \pi f_s \tau_o[1 + \mu x(t)]$ and μ controls the amount of duration modulation. Apparently, the modulated signal contains the message $x(t)$ plus a DC component and phase-modulated waves at the harmonics of f_s. The phase modulation has negligible overlap in the message band when $\tau_0 \ll T_s$, so $x(t)$ can be recovered by lowpass filtering with a DC block. This approach of demodulation is known as direct demodulation. PPM demodulation, on the other hand, is performed by converting the PPM signal into a PWM one, with subsequent lowpass filtering.

Procedure

Part I: Pulse Width and Pulse Position Modulation (PWM & PPM)

A) Pulse Width Modulation (PWM)

1. Use the Function Generator block of the T20A board to generate 1 kHz sinusoidal modulating signal (message) of 0.5 V_{pp}. Display and sketch the generated message signal.
2. Use the SAWTOOTH GENERATOR block of the T20A board to generate 8 kHz sawtooth signal. Display and sketch the generated signal.
3. Use the Timing block of the T20A board to generate 8 kHz pulse train signal. Display and sketch the sampling pulses.
4. Use the message, sawtooth signal and the sampling pulses generated above to generate PWM signal. Display and sketch the generated signal.
5. Synchronize the oscilloscope with sampled signal and with sawtooth waveform to verify:
   - The trailing edge of the pulses corresponds to the sampling pulses.
   - The leading edge corresponds to the duration of the PWM pulses.

B) Pulse Position Modulation (PPM)

1. Repeat steps (1 – 4) above.
2. Use the PPM Modulator block to generate a PPM signal. Display and sketch the generated signal.

3. Synchronize the oscilloscope with PWM and with PPM signal to verify that the PPM signal is made up by a train of pulses which correspond to the leading edges of PWM pulses with fixed duration and varied positions.
4. Vary the amplitude of the modulating analog signal to write down notes.

Part II: Pulse Width and Pulse Position Demodulation

A) PWM Demodulation

1. Generate a PWM signal, pre-setting the module as in Part I-A. Use the 3.4 kHz filter block to filter the PWM signal. Display and sketch the reconstructed signal.
2. Cascade-connect the 5kHz low-pass filter with the 3.4 kHz one in order to increase the overall filter selectivity. Display and sketch the reconstructed signal.

B) PPM Demodulation

- **Direct Demodulation**
  1. Generate a PPM signal, pre-setting the module as in Part I-B. Use the 3.4 kHz filter block to filter the PPM signal. Display and sketch the reconstructed signal.
  2. Cascade-connect the 5kHz low-pass filter with the 3.4 kHz one in order to increase the overall filter selectivity. Display and sketch the reconstructed signal.
- **PPM Conversion Demodulator**
  1. Generate a PPM signal, pre-setting the module as in Part I-B. Use the amplifier and limiter blocks to respectively amplify and limit the PPM signal. Display and sketch these signals.
  2. Examine the output signal from the pulse regenerator and phase adjust blocks then use the PPM/PWM convertor to convert PPM into PWM signal. Display and sketch the converted signal.
  3. Use low-pass filtering to reconstruct the message signal. Adjust the phase of the regenerated sampling pulse train till you get a best match of the message waveform at the filter's output and sketch it.

Discussion

1. Describe a system to demodulate PWM and PPM signals.
2. What are the reasons that make us lump PWM and PPM together under one heading?
3. Design a circuit to convert PPM to PWM Using D flip-flop.

Prepared by:
Dr. Lubab A. Salman (Communications Lab. Supervisor)
Hajer S. Muhammed Ridha (Communications Lab. Assistant)
Yaseen A. Mohammed (Communications Lab. Instructor)

References

[1] Carlson, A. B. and P. B Crilly, *Communication Systems – An Introduction to Signals and Noise in Electrical Communications*, The McGraw-Hill Companies, Inc., New York, Fifth Edition, 2010.

[2] *EV-T10A and EV-T10B Training Kit Manuals*, Elettronica Veneta & Inel Spa, Treviso, Italy