Appendix A: GPS-04 Receiver

To locate the moving target in 3D, a satellite based positioning using GPS model GPS-04 trainer has been used. The block diagram of the GPS-04 receiver kit is shown in Fig.A1.

![Fig.A1 Block diagram of GPS-04 Receiver](image)

It consists of GPS 25LP sensor board, antenna, low noise amplifier code modulator, correlator bank, embedded microcontroller and power conditioner. This receiver uses twelve correlators in parallel after down conversion and track up to twelve visible satellites. To locate the target in 3D, it requires only four active satellites. Hence, the proposed system used only four strongest received signal satellites to accurately locate the target [127]. The embedded micro-controller is used to implement functions such as synchronization, fetching
the navigation messages, and calculating position information. It stores data through the use of NMEA message, using various kinds of windows [128].

**SNR plot window**

![SNR plot Window](image)

**Fig. A2 SNR plot Window**

The Signal To Noise Ratio(SNR) plot window displays the signal strength levels from several satellites. It uses the GPGSV NMEA message to extract the signal to noise ratio, which is specified as a number from 0-99 dB. Depending on the number of satellites in view, the number of SNR bars will vary. At the top of each SNR bar, the raw SNR value is displayed. Full scale is considered any SNR value of 60 dB. At the bottom of each bar shows the satellite ID or Psuedo Random Number.

The SNR bar will change its colour depending on whether the satellite is used in the navigation solution returned by the GPGSA NMEA message. If a satellite is not used in the position fix solution, the signal quality bar will be in gray and if the satellite used in the solution, the quality bar will be blue.
**SKY plot window**

The sky plot window looks like as shown in Fig.A3. Study of satellite azimuth and elevation angles are found, using sky plot window. It uses GPGSV NMEA command to extract azimuth and elevation for each satellite that is in view. Each satellite is identified by Psuedo Random Number (PRN) with letters ‘A’ and ‘E’ denoting its position in terms of azimuth and elevation angles respectively.

![sky plot Window](image)

**Fig. A3 sky plot Window**

The colour of the text for each satellite indicates how the satellite is used in the position solution. When the text is in red, the satellite is used in the solution and it in gray, the satellite is not put to use in the solution.
**NAVIGATION window**

The navigation window will look like as shown in Fig. A4. It is used to study and observe land navigation. The navigation window displays the three position elements:

- Latitude
- Longitude
- Altitude

These values will update each time the GPS receiver sends the GPGGA NMEA message.
The survey plot window looks like as shown above. It is used to study and observe the position of the object on graphical platform. Similar to the navigation window, the survey window displays latitude, longitude and altitude. These three elements of position are displayed as text in navigation window, however, while they are displayed graphically in the survey window. The window also displays five of the Dilution of Precision Factors. The survey window is one of the more interesting windows displaying data graphically.

The survey window is split into three frames. The first, at the top, is the survey frame. Here, a plot of past position history is displayed graphically and is known as paths. Paths can be saved to disk and viewed later. The frame directory below the survey frame is the Altitude frame. This frame simply plots the altitude. To the right of Altitude frame is the Position Statistics frame. This frame displays position average and Dilution of Precision. It has the ability to average position and altitude displaying the data. It uses a method of standard running average (sum of data/number of samples). These averages are both displayed graphically in the survey frame and text in the statistics frame.
The standard deviation shows how much the position is moving around. Graphically, the standard deviation is displayed in the survey frame. Position calculations are made using triangulation. Signals from three satellites are required in order to obtain two-dimensional position and time information. Signals from four satellites are required for three-dimensional position information. The receiver, based on signal transmission delays, makes measurements of the distance between the user and the satellites. These distances are called pseudo-ranges and can be written as \( R_i = c \times T_i \).