GPS Packet Structure

The Lassen iQ GPS Receiver uses a proprietary communicates via serial communication. The serial stream of data from the receiver is broken into bytes that form packets of varying length, which can be decoded into a command with data. The receiver uses a proprietary packet structure, which was developed by the manufacturer, called Trimble Standard Interface Protocol (TSIP). According to the datasheet, the packet structure is as follows:

"TSIP packet structure is the same for both commands and reports. The packet format is:

<DLE> <id> <data string bytes> <DLE> <ETX>

Where:
• <DLE> is the byte 0x10
• <ETX> is the byte 0x03
• <id> is a packet identifier byte, which can have any value excepting <ETX> and <DLE>.

The bytes in the data string can have any value. To prevent confusion with the frame sequences <DLE> <ID> and <DLE> <ETX>, every <DLE> byte in the data string is preceded by an extra <DLE> byte ('stuffing'). These extra <DLE> bytes must be added ('stuffed') before sending a packet and removed after receiving the packet. Notice that a simple <DLE> <ETX> sequence does not necessarily signify the end of the packet, as these can be bytes in the middle of a data string. The end of a packet is <ETX> preceded by an odd number of <DLE> bytes.

Multiple-byte numbers (integer, float, and double) follow the ANSI/IEEE Std. 754 IEEE Standard for binary Floating-Point Arithmetic. They are sent most-significant byte first. This may involve switching the order of the bytes as they are normally stored in Intel based machines.

Specifically:
• UINT8 = Byte: An 8 bit unsigned integer.
• UINT16 = Word: A 16 bit unsigned integer.
• INT16 = Integer: A 16 bit integer.
• INT32 = Long: A 32 bit integer.
• UINT32 = ULong: A 32 bit unsigned integer.
• Single - Float, or 4 byte REAL has a precision of 24 significant bits, roughly 6.5 digits.
• Double - 8 byte REAL has a precision of 52 significant bits. It is a little better than 15 digits" (Lassen 87).

The following pages reference packets which were recorded during a capture of all output from the GPS receiver in the early morning of July 12, 2005. Due to the amount of data recorded, only the excerpts are presented here. Please contact the author for a digital copy of the complete data capture.

Report Packet 0x41 - GPS Time

From the data stream, we will examine the following packet:
10 41 48 44 23 1D 05 33 41 50 00 00 10 03

- GPS Time of Week – Bytes 0 – 3 – This is given as the number of seconds (SINGLE) from 12:00:00 am on Sunday. If this were to be negative, it would denote the time is not yet known.

From the packet, bits 0:3, 0x48 44 23 1D, is 0100 1000 0100 0100 0010 0011 0001 1101 in binary. This equals 2^(1001 0000 – 0111 1111) * 1.100 0100 0010 0011 0001 1101, which rounded is 1100 0100 0010 0011 00 or 200,844.

- Extended GPS Week Number – Bytes 4 – 5 – This is the number of weeks (INT16) since January 6, 1980.

From the packet, bits 4:5, 0x05 33, equals 1,331 decimal. Given there are 1331 weeks and two days between the recording date and January, 6 1980, this result is as expected.

- GPS UTC Offset – Bytes 6 – 9 – This is the offset in seconds (SINGLE) to calculate

From the packet, bits 6:9, 0x41 50 00 00, is

Report Packet 0x4A – GPS Position Fix (20 Byte Format)

10 4A 3F 04 5F 0E BF B8 09 A9 42 58 69 D0 C7 EF BF 4A 48 44 21 C0 10 03

The following map was generated from entering the GPS coordinates derived from the data stream, converted to degrees, at Jeff Boulter's website. As you can see this exactly pinpoints my apartment in Windmeadows.

- Latitude – Bytes 0:3 – This is the latitude radians (SINGLE) of the current GPS coordinate, with positive for north latitude and negative for south latitude.

Hex: 3F 04 5F 0E
Binary (float): 0011 1111 0000 0100 0101 1111 0000 1110
Sign = 0, Exp = 0111 1110, Mantissa = 1.000 0100 0101 1111 0000 1110
= (Sign ? (-1) : (1)) * 2^(Exp - 127) * Mantissa
= Mantissa with binary point shifted left 1 place
= 0.1000 0100 0101 1111 0000 1110
= ~0.517075 radians north latitude.

- Longitude – Bytes 4:7 – This is the longitude radians (SINGLE) of the current GPS coordinate, with positive for east longitude and negative for west longitude.

Hex: BF B8 09 A9
Binary (float): 1011 1111 1011 1000 0000 1001 1010 1001
Sign = 1, Exp = 0111 1111, Mantissa = 1.011 1000 0000 1001 1010 1001
= (Sign ? (-1) : (1)) * 2^(Exp - 127) * Mantissa
= Sign bit denotes negative
= Mantissa with binary point shifted 0 places
= 1.011 1000 0000 1001 1010 1001
= ~1.437795 radians west longitude.

Report Packet 0x56 - Velocity Fix, East-North-Up (ENU)

10 56 00 00 00 00 00 00 00 00 00 00 00 00 43 2D 91 53 48 44 23 00 10 03

- East velocity is bytes 0:3 and of type SINGLE. It is in meters / second and positive for east and negative for west.

Since the receiver could not be in motion at the time of testing this value is zero.

- North velocity is bytes 4:7 and of type SINGLE. It is in meters / second and positive for north and negative for south.

Since the receiver could not be in motion at the time of testing this value is zero.

- Up velocity is bytes 8:11 and of type SINGLE. It is in meters / second and positive for up and negative for down.

Since the receiver could not be in motion at the time of testing this value is zero.

- Clock Bias Rate is bytes 12:15 and of type SINGLE. It is in meters per second.

Hex: 43 2D 91 53
Binary (float): 0100 0011 0010 1101 1001 0001 0101 0011
Sign = 0, Exp = 1000 0110, Mantissa = 1.010 1101 1001 0001 0101 0011
= (Sign ? (-1) : (1)) * 2^(Exp - 127) * Mantissa
= Mantissa with binary point shifted right 7 places
= 1010 1101.1001 0001 0101 0011
= ~173 decimal seconds difference.

- Time of Fix is bytes 16:19 and of type SINGLE. It is in GPS seconds and is the time of the fix that produced the data packed occurred.

Hex : 48 44 23 00
Binary (float): 0100 1000 0100 0100 0010 0011 0000 0000
Sign = 0, Exp = 1001 0000, Mantissa = 1.100 0100 0010 0011 0000 0000
= (Sign ? (-1) : (1)) * 2^(Exp - 127) * Mantissa
= Mantissa with binary point shifted right 17 places
= 1100 0100 0010 0011 00.00 0000
= 200,844 decimal seconds from midnight Sunday of the week, or about 7:45 am.

Calculating Distance

Once I had written a program to output the GPS coordinates to the LCD of Mr. 2-Bots, I performed an experiment to ascertain how much change in the coordinate corresponded to a given distance of movement.

	Lat	Lon
Left 12’	3F04 5F35	BFB8 0992
Center	3F04 5F3E	BFB8 09A0
Right 12’	3F04 5F3C	BFB8 09A4

Latitude:	0 0111 1110	Sign = 0	Exponent = 126
Longitude:	1 0111 1111	Sign = 1	Exponent = 127

= (Sign ? (-1) : (1)) * 2^(Exp - 127) * Mantissa

Center – Left:	sqrt((9>>1)^2 + 14^2) = ~15
Center – Right:	sqrt((2>>1)^2 + 4^2) = ~5

Works Cited

- Lassen iQ GPS Receiver System Designer Reference Manual. February 2005. Trimble Navigation Limited. 15 July 2005. <http://www.sparkfun.com/datasheets/GPS/Lassen%20iQ_Reference%20Manual.pdf>.
- GPS Coordinate Converter. 2005. Jeff Boulter. 15 July 2005. <http://boulter.com/gps/>