GPS Protocol (GARMIN 40)

OBSERVATIONS OF THE GARMIN-GARMIN PROTOCOL

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author: william.soley@sun.com, werme@zk3.dec.com
URL: http://playground.sun.com/pub/soley/garmin.txt
(this work has nothing to do with Sun Micro-
systems) (nor Digital Equipment Corp.)

This is a description of the GARMIN-GARMIN protocol as spoken by the Garmin GPS-75 GPS receiver and the Garmin PCX5 MS-DOS software. The information here has been determined by observing the communication between the two units while sending "chosen plaintext". This spec is at best, incomplete, and at worst, incorrect. Lots of assumptions were made based on the observed behavior of the protocol. It is also unknown how much of this protocol is common to other Garmin products. But, unless Garmin decides to be cooperative, this is about the best we can do. Use it at your own risk!

All references to GPS-75 behavior came from William Soley. A major update to this was made in July, 1996 by Eric Werme, studying the behavior of his GPS-45. There is much in common between the protocols used by the two models, but there are differences. Much of Werme's study focused on protocol commands not used by PCX5, all of which are subject to change, even between revisions of firmware within a model! If you must rely on some part of the protocol, it should be part that is used by Garmin's PCX5 software.

Layer 1

Data is standard Async.

9600 bits per second.
8 data bits.
no parity.
1 stop bit.

Layer 2

The data stream consists of frames each having the following format:

DataLinkEscape (0x10)

RecordType (one byte) $$
Length (one byte) ** $$
DataField ("length" bytes) ** $$
CheckSum (one byte) **
DataLinkEscape (0x10)
EndTransmission (0x03)

** - fields indicated by "**" are subject to escape. Any occurrence of a DataLinkEscape
character (0x10) in these fields is preceded by another DataLinkEscape (0x10) resulting in a pair. Escape bytes added in this way are not counted in the record length (i.e. bytes are counted before the escapes are added).

$$ - the bytes comprising fields indicated by "$$" are summed and thelow-order 8 bits are
then negated (2's complement) to form the CheckSum. Any added DataLinkEscapes are not included in the sum.

Software processing this protocol layer on input can discard the initial DataLinkEscape, the checksum and later bytes, and compress the doubleDataLinkEscapes into one. The remaining bytes constitute Layer 3 protocol frames.

Layer 3

When a non-ACK/NAK or asynchronous frame is received an ACK or NAK is sent depending on the checksum validity of the received frame. ACK/NAK frames are the same format as a regular frame:

RecordType = 0x06 (ACK) or 0x15 (NAK)
Length = 2
DataField = RecordType of record being acknowledged, 0x00

When a non-ACK/NAK frame is sent, the sender waits for an ACK/NAK. Ifa NAK is received,
or if no ACK is received after about 1 second, the sender retransmits the frame.

Power Up

When the GPS-75 is powered on, it transmits an 0x5A character.
When the GPS-45 is powered on, it transmits 0xFE and 0X5A characters.

Holding the button while pressing to turn the unit onwill erase the unit's memory and result in the messages:

Stored Data Lost
Searching the Sky
Holding the button while pressing to turn the unit on will put the unit in TEST mode. The GPS-75 a will display a series of concentric rectangles will be displayed and animated to give the illusion of passing through a tunnel. Pressing will toggle between the tunnel display and a display showing:

Testing ...
Sgnl Amplitude 2168
TCX0 Drift -19.978

While in TEST mode, a continuous stream of RecordType=0x00, 0x01,and 0x0d messages
will be sent to the serial port.Also, while in TEST mode the "<" and ">" may be used to adjust display contrast, but the adjustment does not appear to be saved.

The GPS-45 behaves somewhat differently. The status screen is the first to be displayed and includes a keypad test feature. In addition to the box display is an all black display. The GPS will send a stream of RecordTypes 0x00, 0x27, 0x28.

Data Presentation

Numeric data within the Garmin protocol is in binary, and several formats are used. Those are described here. Skimming this section now will make it easier to understand the protocol's commands.

short integer
- length = 2 bytes, in order of increasing significance.
Negative numbers are expressed as 2's complement.

Examples:
00 00 = 0x0 = 0
01 00 = 0x1 = 1
10 00 = 0x10 = 16
00 01 = 0x100 = 256
00 10 = 0x1000 = 4096
ff ff = 0xffff = -1
f0 ff = 0xfff0 = -16

long integer
- length = 4 bytes, in order of increasing significance.
Negative numbers are expressed as 2's complement.

Examples:
00 00 00 00 = 0x0 = 0
01 00 00 00 = 0x1 = 1
00 01 00 00 = 0x100 = 256
00 00 01 00 = 0x10000 = 65536
00 00 00 01 = 0x1000000 = 16777216
ff ff ff ff = 0xffffffff = -1
f0 ff ff ff = 0xfffffff0 = -16

float
- length = 4 bytes, IEEE single precision floating
point. Least significant byte first.

This format consists of:
1 bit - sign
8 bits - exponent, excess 127
23 bits - mantissa, implied high-order 1

double
- length = 8 bytes, IEEE double precision floating
point. Least significant byte first.

This format consists of:
1 bit - sign
11 bits - exponent, excess 1023
52 bits - mantissa, implied high-order 1

ASCII string
- series of ASCII bytes, usually padded with blanks.

Example:
47 50 53 20 37 35 20 20 32 2e 32 31 20 = "GPS 75 2.21"

date/time
- length = 4 bytes, long unsigned integer encoded as
86400 + number of seconds since midnight, Jan 1 1990.
Note: unix_time = garmin_time + 631065600

Examples:
00 00 00 00 = 0x0 = undefined

80 51 01 00 = 0x15180 = Jan 1 1990 00:00:00
7d f0 ef 2d = 0x2deff07d = Jun 4 1994 03:09:49

long lat/lon
- length = 4 bytes, long signed integer encoded as
11930464.7111111111 * lat/lon in degrees, or
683565275.576431632 * lat/lon in radians.
The former factor as a ratio is 2**30/90.
As a C expression, it is ((1L << 30) / 90.0).
All values are in map datum WGS 84.

Examples:
00 00 00 00 = 0x0 = 0.0 deg
61 0b b6 00 = 0xb60b61 = 1.0 deg
00 00 00 40 = 0x40000000 = 90.0 deg
00 00 00 c0 = 0xc0000000 = -90.0 deg
00 00 00 80 = 0x80000000 = -180.0 deg

double lat/lon
- length = 8 bytes, IEEE double precision floating point
encoded as lat/lon in radians. All values are in map
datum WGS 84.

Examples:
00 00 00 00 00 00 00 00 = 0.0 rad
00 00 00 00 00 00 f0 3f = 1.0 rad
00 00 00 00 00 00 f8 3f = 1.5 rad
00 00 00 00 00 00 00 40 = 2.0 rad
00 00 00 00 00 00 08 40 = 3.0 rad
00 00 00 00 00 00 f0 bf = -1.0 rad
00 00 00 00 00 00 00 c0 = -2.0 rad