# OBSERVATIONS OF THE GARMIN-GARMIN PROTOCOL

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(this work has nothing to do with Sun Microsystems)

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!

## 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 occurance of a DataLinkEscape character (0x10) in these fields is preceeded 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 sumed and the low-order 8 bits are then negated (2's compliment) to form the CheckSum. Any added DataLinkEscapes are not included in the sum.

## Layer 3

---

When a non-ACK/NAK 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. If a 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.

Holding the <CLR> button while pressing <PWR> to turn the unit on will erase the units memory and result in the messages:

Stored Data Lost
Searching the Sky

Holding the <ENT> button while pressing <PWR> to turn the unit on will put the unit in TEST mode. A series of concentric rectangles will be displayed and animated to give the illusion of passing through a tunnel. Pressing <ENT> 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.

## Data Presentation

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

## Record Types and Formats

The following table describes the observed RecordTypes.

---

RecordType = 0x00
Length = 4
Description:
Sent asynchronously while in TEST mode or when enabled by the RecordType=0x1C command, with mask 0x01.

---

RecordType = 0x01 SignalAmplitude
Length = 4
DataField =
2 bytes - unsigned short - Signal Amplitude
2 bytes - ? 00 fe
Description:
Sent every 4 seconds while in TEST mode or when enabled by the RecordType=0x1C command, with mask 0x01. The exact meaning of the last 2 bytes is unknown.

---

RecordType = 0x06 ACK
Length = 2
DataField =
1 byte - copy of RecordType from record being ACK'd
1 byte - always zero
Description:
The recipient is expected to retransmit the last record if an ACK is not received within about 1 second. ACK is not sent in response to ACK or NAK.

---

RecordType = 0x09 Unknown
Length = 2
DataField =
2 bytes - ? 02 00
Description:
Sent in response to 1c command.

---

RecordType = 0x0a Request
Length = 2
DataField =
2 bytes - unsigned short - operation code
01 00 = 0x1 = download almanac (RecordType 1f)
02 00 = 0x2 = query position (RecordType 11)
03 00 = 0x3 = download proximity waypoints (RecType 13)
04 00 = 0x4 = download route (RecordType 1d and 1e)
05 00 = 0x5 = query UTC clock time (RecordType 0e)
06 00 = 0x6 = download tracks (RecordType 22)
07 00 = 0x7 = download waypoints (RecordType 23)
08 00 = 0x8 = power off
0b 00 = 0xb = set Tone=MSG+KEY then power off (beeps)
Description:
This record is sent to request the recipient to download the specified data records. For requests 1,3,4,6, and 7, the recipient should respond with RecordType=0x1B (Begin-Transfer), followed by some number of data records, followed by RecordType=0x0C (EndTransfer). For requests 2 and 5, the recipient should respond with a single data record. The 2nd DataField byte appears to be ignored.

```
-----------------------------------------------------------------
RecordType = 0x0c       EndTransfer
Length = 2
DataField =
        2 bytes - unsigned short - type of transfer being ended
                01 00 = 0x1     = almanac
                03 00 = 0x3     = proximity waypoints
                04 00 = 0x4     = routes
                06 00 = 0x6     = tracks
                07 00 = 0x7     = waypoints
Description:
        This record is sent following the last data record of
        an upload or download to denote the end of the transfer.
-----------------------------------------------------------------
RecordType = 0x0d       Event
Length = 4
DataField =
        2 bytes - EventType
                0c 00   keyboard event (TEST mode only)
        2 bytes - as follows:
            if EventType = 0c 00 (keyboard) then one of:
                01 00   <PWR/STAT> down
                02 00   <PWR/STAT> down + 1 sec
                03 00   <PWR/STAT> down + 2 sec
                04 00   <AUTO/STO>
                05 00   <GOTO/MOB>
                08 00   <NAV>
                09 00   <RTE>
                0a 00   <PWR/STAT> released
                0b 00   <WPT>
                0c 00   <0>
                0d 00   <ABC/1>
                0e 00   <DEF/2>
                0f 00   <GHI/3>
                10 00   <JKL/4>
                11 00   <MNO/5>
                12 00   <PQR/6>
                13 00   <STU/7>
                14 00   <VWX/8>
                15 00   <YZ-/9>
                16 00   <CLR>
                17 00   <ENT>
                18 00   <"<">
                1a 00   <">">
Description:
        Sent asynchronously while in TEST mode or when enabled
        by the RecordType=0x1C command, with mask 0x02.  There
        are other possible values of EventType but I haven't
        figured them out, yet.
-----------------------------------------------------------------
RecordType = 0x0e       ClockData
Length = 8
DataField =
        1 byte  - month (1=Jan, 2=Feb, etc.)
        1 byte  - day of month
        2 bytes - unsigned short - year
        1 byte  - hour
```

```
        1 byte  - unknown (always zero)
        1 byte  - minute
        1 byte  - second
Description:
        This record is sent in response to a RecordType=0x0a
        (Request) DataField=0x5 (ClockTime) request.  It contains
        the UTC clock time.
-------------------------------------------------------------
RecordType = 0x11       PositionData
Length = 0x10
DataField =
        8 bytes - IEEE double - double latitude
        8 bytes - IEEE double - double longitude
Description:
        This record is sent in response to a RecordType=0x0a
        (Request) DataField=0x2 (Position) request.  It contains
        the current double precision floating point 2D position
        in radians.
-------------------------------------------------------------
RecordType = 0x13       ProximityData
Length = 0x3A
DataField =
        6 bytes - ASCII waypoint name - blank padded
        4 bytes - long latitute
        4 bytes - long longitude
        4 bytes - date/time created
        40 bytes - ASCII comment - blank padded
        4 bytes - IEEE float - alarm radius in meters
Description:
        This record is used when uploading or downloading
        proximity waypoints.  A RecordType=0x1B (BeginTransfer)
        is sent specifying the number of waypoints, followed by
        the specified number of ProximityData records, followed
        by a RecordType=0x0C (EndTransfer) record.
-------------------------------------------------------------
RecordType = 0x15       NAK
Length = 2
DataField =
        1 byte  - copy of RecordType from record being NAK'd
        1 byte  - always zero
Description:
        The recipient is expected to retransmit the last record
        immediately when it receives an NAK.  NAK is not sent in
        response to ACK or NAK.
-------------------------------------------------------------
RecordType = 0x1A       SatelliteStatus
Length = 0x38
DataField =
        8 instances of ...
        1 byte  - satellite ID number - 1
        1 byte  - elevation, degrees
        2 bytes - signal quality
        1 byte  - 1 if being tracked, else 0
        1 byte  - status bits
        1 byte  - ? 00
Description:
        Sent every 6 seconds when enabled by the RecordType=0x1C
```

```
        command, with mask 0x80.
-----------------------------------------------------------------
RecordType = 0x1B       BeginTransfer
Length = 2
DataField =
        2 bytes - unsigned short - number of data records to follow
Description:
        This record is sent before the first data record of an
        upload or download to denote the beginning of transfer.
-----------------------------------------------------------------
RecordType = 0x1C       EnableAsyncEvents
Length = 2
DataFeild =
        2 bytes - unsigned short - enable bit mask, logical-or ...
                00 00 = 0x0     = disable all (no bits set)
                01 00 = 0x1     = enables RecordType=00,01,02
                02 00 = 0x2     = enables RecordType=0d
                04 00 = 0x4     = enables RecordType=14
                08 00 = 0x8     = enables RecordType=16
                10 00 = 0x10    = enables RecordType=17
                20 00 = 0x20    = enables RecordType=07,12,19
                40 00 = 0x40    = enables RecordType=07,12
                80 00 = 0x80    = enables RecordType=1a
                ff ff = 0xffff  = enables all (all bits set)
Description:
        GPS responds to this request with RecordType=0x20 then
        0x09.  If no DataField is present, appears to have same
        effect as a mask of 0xffff.  This command enables
        asynchronous reporting of the selected events.  Not much
        is known about this command because it is not used by the
        PCX5 software so the record contents is mostly unknown.
        WARNING: AsyncEvents appear to stay enabled accross power
        cycles and can confuse host software if it is not expecting
        to receive them.
-----------------------------------------------------------------
RecordType = 0x1D       RouteData
Length = 0x15
DataFeild =
        1 bytes - route number
        20 bytes - comment - blank padded
Description:
        This record is used when uploading or downloading routes.
        A RecordType=0x1B (BeginTransfer) is sent specifying the
        number of records, followed by RecordType=0x1D (RouteData)
        RecordType=0x1E (RouteWaypointData) records, then a
        RecordType=0x0C (EndTransfer) record.
-----------------------------------------------------------------
RecordType = 0x1E       RouteWaypointData
Length = 0x3A
DataField =
        6 bytes - ASCII waypoint name - blank padded
        4 bytes - long latitute
        4 bytes - long longitude
        4 bytes - date/time created
        40 bytes - ASCII comment - blank padded
Description:
        This record is used when uploading or downloading routes.
```

```
        A RecordType=0x1B (BeginTransfer) is sent specifying the
        number of records, followed by RecordType=0x1D (RouteData)
        RecordType=0x1E (RouteWaypointData) records, then a
        RecordType=0x0C (EndTransfer) record.
-------------------------------------------------------------
RecordType = 0x1F       AlmanacData
Length = 0x2A
DataField =
        2 bytes - unsigned short - week (or 0xffff if poor health)
        4 bytes - IEEE float - Time of Applicability(s)
        4 bytes - IEEE float - Af0(s)
        4 bytes - IEEE float - Af1(s/s)
        4 bytes - IEEE float - Eccentricity
        4 bytes - IEEE float - SQRT(A) (m^1/2)
        4 bytes - IEEE float - Mean Anom(rad)
        4 bytes - IEEE float - Argument of Perigee(rad)
        4 bytes - IEEE float - Right Ascen at TOA(rad)
        4 bytes - IEEE float - Rate of Right Ascen(r/s)
        4 bytes - IEEE float - Orbital Inclination(rad)
Description:
        This record is used when uploading or downloading almanac
        data.  A RecordType=0x1B (BeginTransfer) is sent specifying
        the number of satalites, followed by the specified number
        of AlmanacData records, followed by a RecordType=0x0C
        (EndTransfer) record.
-------------------------------------------------------------
RecordType = 0x20       SoftwareVersionData
Length = 7
DataFeild =
        7 bytes - ASCIZ string - software version (e.g. " 2.21 ")
Description:
        GPS sends this in response to RecordType=0x1C.
-------------------------------------------------------------
RecordType = 0x22       TrackData
Length = 0xD
DataField =
        4 bytes - long latitute
        4 bytes - long longitude
        4 bytes - date/time recorded
        1 byte - 01 if first record in session, else 00
Description:
        This record is used when uploading or downloading track.
        A RecordType=0x1B (BeginTransfer) is sent specifying the
        number of track data records, followed by the specified
        number of TrackData records, followed by a RecordType=0x0C
        (EndTransfer) record.
-------------------------------------------------------------
RecordType = 0x23       WaypointData
Length = 0x3A
DataField =
        6 bytes - ASCII waypoint name - blank padded
        4 bytes - long latitute
        4 bytes - long longitude
        4 bytes - date/time created
        40 bytes - ASCII comment - blank padded
Description:
        This record is used when uploading or downloading way-
```

points. A RecordType=0x1B (BeginTransfer) is sent specifying the number of waypoints, followed by the specified number of Waypoint records, followed by a RecordType=0x0C (EndTransfer) record.

---

RecordType = 0xFE IdentificationReq
Length = 0
DataField =
Description:
The recipient, presumably a GPS, is expected to transmit its Identification and Software Version as RecordType=0xFF (IdentificationData). GPS-75 appears to ignore the DataField if one is supplied, but the PCX-5 software always transmits a DataField of one byte always containing 0x20.

---

RecordType = 0xFF IdentificationData
Length = 0x12
DataField =
2 bytes - unknown - 17 00
2 bytes - unsigned short - SoftwareVersion * 100
(e.g. dd 00 = version 2.21)
14 bytes - ASCIZ Identification string
Description:
This record is sent in response to RecordType=0xFE (IdentificationReq).

---

Example: Identification Request

```
-> 10 fe 00 02 10 03
<- 10 06 02 fe 00 fa 10 03
<- 10 ff 12 17 00 dd 00 47 50 53 20 37 35 20 20 32 2e 32 31 20 00 62 10 03
-> 10 06 02 ff 00 f9 10 03
```

The first message, 10 fe ... is a command to the GPS to identify itself. The second message, 10 06 ... is the GPS acknowledging the command. The third message, 10 ff ... is the GPS sending the response containing its identification (the asciz string "GPS 75 2.21" begins in the 4th byte of DataField). The fourth message, 10 06 ... is the acknowledgment to the GPS of the response message.

The GPS-75 appears to ignore the DataField of the 0xFE command, however, the PCX5 software appears to always send a DataField of 0x20. (The example above is shown with a null DataField.)