The Zodiac Chipset Message Protocol

The Zodiac Global Positioning System (GPS) chipset communicates with a host system through messages sent over an RS-232 serial data link. There are two basic message structures available: Conexant binary and National Marine Electronics Association (NMEA)-0183. This Application Note provides detailed information on using the binary format, which contains the capability to implement very simple or rigid protocols.

The binary data format uses a consistent message structure with a flexible Flag Word included. Through use of the Flag Word, the Original Equipment Manufacturer (OEM) is able to implement several levels of command/response protocol.

Basic Conexant Binary Message Structure

There are two parts to a binary message: the header and an optional data area. Each part has a checksum appended to it. All messages are made up of a sequence of 16-bit words that are transmitted over the RS-232 data link with the least significant byte first (sometimes referred to as a "little-endian" system). The general message format is shown in Figure 1. The header of each message follows a standard format also shown in Figure 1.

The Message Header

The message header is composed of four words: the synchronization, message ID, message length, and flag words.

Synchronization Word. This word (81FFh, ASCII Start of Header [SOH] followed by DEL) is intended to provide a constant pattern that may be searched for to synchronize the listener with the message sender. Since the bytes are sent with the least significant byte first, a listener can ignore all bytes until an FFh value is observed followed by an 81h, then begin to record bytes and interpret the message. Should data exist containing the FFh pattern, the pattern is detected either by the next byte not being 81h, or when a checksum fails later. If that happens, the FFh and any other non-FFh bytes that are received should be discarded until another FFh is found.

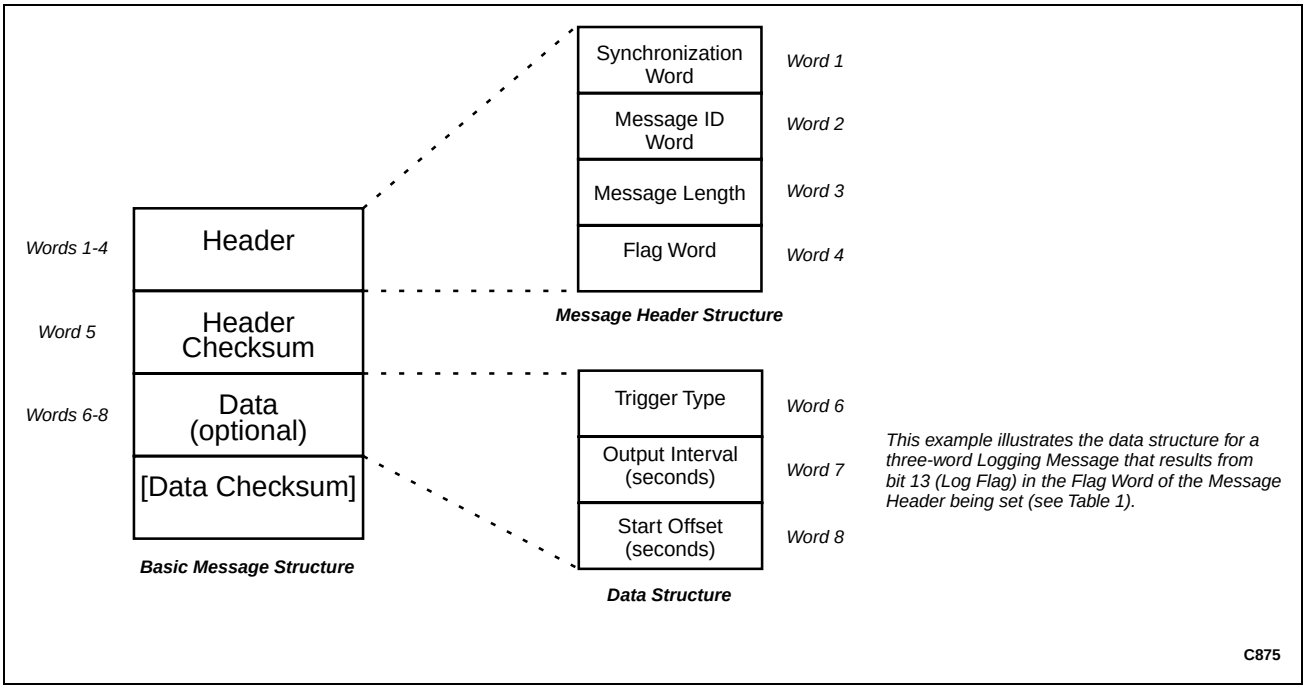

Figure 1. Zodiac Binary Message Structure

Message ID. This word contains an integer value indicating the type of message (refer to the Zodiac GPS Receiver Family Designer's Guide for a list of current message IDs). Messages may be grouped by ID into output messages (IDs in the 1000 to 1199 range) and input messages (IDs in the 1200 to 1399 range). Input messages always originate with the OEM, but the receiver may send a message with the same ID back to the OEM to acknowledge or negatively acknowledge the input message, itself. Output messages may originate in either the chipset (when the receiver outputs data or status) or from the OEM equipment (when the OEM equipment sets the output characteristics).

Data Length. This word indicates how many data words follow the header. If the length is 0, the message is called a "header-only" message and there will not be a data checksum. If the length is greater than 0, that number of data words follows the header checksum; a data checksum follows the last data word in this case.

Flag Word. This word consists of 16 bits interpreted individually as flags.

The Message Header Checksum

The checksums sent after the header and after the data area are calculated in the same way. The method is to sum all bits in the portion of the message, then negate the result. All math is performed using 16-bit signed integers with carries, or overflows, ignored. The following example illustrates how a checksum is calculated:

Message:	81FFh	Synchronization Word
	0E38h	Message 1000
	0000h	No data words
	8503h	Disconnect, request NAK (ID 03)
Sum:	153Ah	Ignore the carry
Checksum:	EAC6h	2's complement of the sum

Note: if the sum is 8000h or 0000h, the 2's complements are also 8000h and 0000h, respectively, which is acceptable.

To verify a checksum, simply add all words including the checksum:

Message:	81FFh	
	0E38h	
	0000h	
	8503h	
Checksum:	EAC6h	
Sum:	0000h	Ignore the carry

Messages with proper checksums that are received correctly always add up to zero.

Flag Word Structure and Bit Usage

The Flag Word, word 4 of the message header, is interpreted as 16 discrete bits as shown in Table 1.

The Flag Word bits can be described as four functional groups: logging bits, the query bit, ACK/NAK bits, and User ID bits. When an output message (message ID in the range of 1000-1199) originates in the receiver, the Flag Word is set to 0000. Output messages originating in the OEM equipment use the flag bits to set up the receiver's output characteristics. In response to output messages originating in the OEM equipment, the receiver responds with header-only output messages with appropriately set flag bits.

Table 1. Flag Word Bits

Bit	Name	Function	Bit Group
15 (MSB)	D	Disconnect Flag	Logging
14	C	Connect Flag	Logging
13	L	Log Flag	Logging
12	0	Not Used – Set to 0	
11	Q	Query Flag	Query
10	R	Request Flag	ACK/NAK
9	A	ACK Flag	ACK/NAK
8	N	NAK Flag	ACK/NAK
7-6	00	Not Used – Set to 00	
5-0 (LSB)	*xx xxxx*	User Identification	User ID

Logging Bits

Together, bits 15 to 13 provide a means of setting up message logging. The OEM uses the D bit (Disconnect Flag) to disconnect, or turn off, the output of a message. Normally, the receiver sends a 1000 message (Geodetic Position Status Output) every second. Sending a 1000 message from the OEM to the receiver with the D bit set causes this output to stop.

The C bit (Connect Flag) is used to tell the receiver that this message type should be connected for output. If only the C bit is set, the receiver begins to output the specific message according to the already established logging parameters.

For example, output message 1007 (Channel Measurement Message) is not normally output by the receiver. If the OEM wants to receive this message, a 1007 message is sent with the C bit set. Upon receipt, the receiver begins to output the message every one second (default output rate).

Note that if both the C and D bits are set in a message sent to the receiver, the receiver ignores the message.

The L bit (Log Flag) is used by the OEM equipment to control the output rates of messages. When the L bit is set, the OEM equipment includes three data words and a data checksum in the message. The data structure of this logging message is shown in Figure 1.

Note that the C or D flag can be combined with the L flag so that the OEM can connect or disconnect a message and adjust its logging parameters in one message.

Query Bit

The Q bit (Query Flag) is used for a special case of querying the receiver. When a message with the Q bit set is received, the receiver generates a one-time output message with the current or most recent data. Query messages may be sent at any time; they often return the same data as was last sent by a message currently connected and being output. The query message can be used to replace messages that have become corrupted during transmission or to get infrequently needed data.

ACK/NAK Bits

Bits 10 to 8 are used to implement the ACK/NAK protocol. Only the OEM initiates this protocol, never the receiver (all receiver output messages containing actual data or status do not have ACK/NAK bits set).

There are three ACK/NAK bits: R, A, and N. The R bit is used to request an acknowledgment to a message. When an R bit is set, either the A or N bit must also be set to designate what type of response is requested. When both the A bit and R bit are set, the receiver is asked to send an acknowledgment (ACK)when the message is received correctly. When both the N bit and R bit are set, the receiver is asked to send a negative acknowledgment (NAK) whenever the message is received with an error in either header or data. If all messages from the OEM to the receiver are to be acknowledged, all three bits should be set.

When a message with the R bit set is received, the receiver verifies the message. If everything is correct and the A bit was set, the receiver generates an ACK message with the R bit turned off and the A bit set. The receiver sends an NAK message any time it receives a message with the R and N bits set and the message is bad. A bad message means it has failed either checksum, or there is something invalid about the contents, such as an unknown message number, an illegal parameter, or similar problem.

When the receiver creates an ACK or NAK message, the only flag bits it sets are the A or N bit (as appropriate) and the six user ID bits. The C, D, and L bits are always cleared by the receiver.

Note that in the current software, the receiver never initiates a protocol exchange by sending a message with the R bit set.

User ID Bits

The final set of bits to consider are the six Least Significant Bits (LSBs) of the Flag Word. These bits can be used by the OEM when an ACK/NAK protocol is started and are meant for the OEM to identify individual messages of multiple sets.

For example, if Message 1351 (Raw DGPS RTCM SC-104 Data) is being used by the OEM to send RTCM correction data to the receiver, there would typically be a stream of these messages to send. The OEM could number each message sequentially from 0 to 63, repeating the sequence, and then request an NAK. Then, if the receiver were to report a message was received in error, the OEM would know which message to resend.

Logging Message Data Structure

In the data structure example presented in this Application Note (the three-word Logging Message resulting from the L bit [bit 13] being set in the Flag Word of the Message Header), word 6 is the Trigger Type. This word tells the receiver when to send a message. When this word is set to 0, the message is to be output on time (i.e., output it periodically based on time parameters defined in the next two words). When this word is set to 1, the message is to

be output whenever the data in the message is updated in the receiver.

As long as the receiver is active, it is either tracking satellites or searching for them on channels. If the OEM is interested in monitoring the receiver's status, Message 1002 (Channel Summary), for example, can be requested to be output every second. The OEM can then see the progress from searching to locking onto satellites to using resulting data in a navigation solution.

In contrast, Message 1003 (Visible Satellites), for example, reports on visible satellites. The receiver only computes which satellites are visible periodically (usually every few minutes or when a new almanac is found for a satellite). Rather than having this message output based on the clock time, have it output whenever the receiver updates the information. That way, the OEM can see new values whenever the receiver calculates them.

When the trigger type is set to "time" (word 6 set to 0), the remaining two data words specify when to start sending the message and how often to continue sending it. Word 7, "Output Interval," specifies the number of seconds between messages. The valid range is 0 to 65535. If the value is 0, the message is sent only once, the same as if the receiver is responding to a query message. For all other values, the receiver sends the message at that rate. Word 8, "Start Offset," indicates when to send the first message. The valid range for this value is 0 to 60, with values 0 and 60 having special meaning. A start offset of 0 means to send the first message immediately. A start offset of 60 means to send the first message at the start of the next minute. All other values specify the number of seconds after the start of the minute to send the first message.

For example, if the start offset is 10, the first message is sent at 10 seconds after the start of the minute. If this message is sent at 5 seconds after the start of the current minute, the first output message is sent by the receiver at 10 seconds after the start of the current minute (i.e., 5 seconds after the message is sent). If this message is sent at 15 seconds after the start of the current minute, the first message appears 10 seconds after the start of the next minute, or 55 seconds after the logging message is sent.

Message Protocol Example

To illustrate the message protocol, a fully documented messaging sequence is shown in Table 2. In this sequence, the OEM system wants to receive Message 1009 (ECEF Position Status Output Message) every 10 seconds, beginning at the start of the next minute. Also, the receiver needs to acknowledge the logging parameters and connect message (Message 1009 with the C bit set.). For illustration purposes, assume that the logging request and one of the data output messages are received in error.

Table 2. Sample Message Logging Sequence (1 of 2)

Action	Response			
	Word	Data Sent by OEM	Data Sent by Receiver	Comment
A. The OEM requests Message 1009 to be logged every 10 seconds starting at the start of the next minute. Message should be ACKed or NAKed as appropriate.	1	81FFh		Synchronization word.
	2	1009		Message 1009.
	3	3		Three data words follow.
	4	2701h		L, R, A, N bits set. The OEM sets this as message number 1.
	5	[checksum]		For words 1 to 4.
	6	0		Trigger on time.
	7	10		Send every 10 seconds.
	8	60		Start sending at the start of the next minute.
	9	[checksum]		For words 6 to 8.
B. The receiver did not receive the message correctly. Send an NAK.	1		81FFh	Synchronization word.
	2		1009	Message 1009.
	3		0	No data words follow.
	4		0101h	N bit set, OEM message number 1.
	5		[checksum]	For words 1 to 4.
C. The OEM re-sends the message exactly as before (Note that the OEM could advance the message number if desired)	1	81FFh		Synchronization word.
	2	1009		Message 1009 (re-sending).
	3	3		Three data words to follow.
	4	2701h		L, R, A, N bits set. OEM message Number 1 is repeated.
	5	[checksum]		For words 1 to 4.
	6	0		Trigger on time.
	7	10		Send every 10 seconds.
	8	60		Start sending at the start of the next minute.
	9	[checksum]		For words 6 to 8.
D. The receiver receives the message correctly, verifies that all data fields are within valid ranges, and sends an ACK message.	1		81FFh	Synchronization word.
	2		1009	Message 1009.
	3		0	No data words follow.
	4		0201h	A bit set. Echo OEM message Number 1.
	5		[checksum]	For words 1 to 4.
E. The OEM commands the receiver to connect Message 1009 and to ACK or NAK the connection.	1	81FFh		Synchronization word.
	2	1009		Message 1009.
	3	0		No data words follow.
	4	4702h		C, R, A, N bits set. OEM message Number 2.
	5	[checksum]		For words 1 to 4.
F. The receiver validates the message, finds it correct, and sends an ACK.	1		81FFh	Synchronization word.
	2		1009	Message 1009.
	3		0	No data words follow.
	4		0202h	A bit set. Message Number 2.
	5		[checksum]	For words 1 to 4.

Table 2. Sample Message Logging Sequence (2 of 2)

Action	Response			
	Word	Sent by OEM	Sent by Receiver	Comment
G. The receiver sends the first data output. This occurs at the start of the next minute.	1		81FFh	Synchronization word.
	2		1009	Message 1009.
	3		16	Sixteen data words follow.
	4		0	Always set to 0 for data output messages.
	5		[checksum]	For words 1 to 4.
	6-21		[ECEF data]	Refer to the description of Message 1009 in the Zodiac GPS Receiver Designer's Guide
	22		[checksum]	For words 6 to 21.
H. The OEM receives the above data message but fails the checksum. The OEM sends a query message to have the data re-sent.	1	81FFh		Synchronization word.
	2	1009		Message 1009.
	3	0		No data words follow.
	4	0803h		Q bit set, OEM message number 3. No ACK/NAK protocol is requested
	5	[checksum]		For words 1 to 4.
I. The receiver re-sends the data. Note that the OEM message number is not copied into the message. That data is only sent as part of an ACK or NAK message.	1		81FFh	Synchronization word.
	2		1009	Message 1009.
	3		16	Sixteen data words follow.
	4		0	Always set to 0 for data output messages.
	5		[checksum]	For words 1 to 4.
	6-21		[ECEF data]	Refer to the description of Message 1009 in the Zodiac GPS Receiver Designer's Guide
	22		[checksum]	For words 6 to 21.