Frame Description for Sweden 2006 Flight

Data frames are emitted once per second using an RS-232 serial protocol. The port parameters are 19.2K baud, 8 bits, no parity, and one stop bit. The data connector at the instrument end is a DE9S type (9 pin sub-miniature D, female), with a data signal present on pin 2 and a signal ground on pin 5. Since this is compatible with a standard PC COM port, ground station development and testing are made simpler.

Data frames are 256 bytes long, taking about 133 ms to transmit. The format of the data frame is shown in Table 1. All fields have bytes ordered with most significant byte first. Note that some fields in the frame have different meanings depending on the value of the frame counter.

offset	length	name	description
0	2	SYNC	sync word 0xEB90
2	4	FC	frame counter
6	4	GPS	data varies with frame counter; $\texttt{FC} \equiv 0 \pmod 4$ means altitude in mm; $\texttt{FC} \equiv 1 \pmod 4$ means GPS time in ms of day; $\texttt{FC} \equiv 2 \pmod 4$ means latitude in 2^{-31} semi-circle, $\texttt{FC} \equiv 3 \pmod 4$ means longitude in 2^{-31} semi-circle
10	2	LL	low level rate counter (counts per second)
12	2	PD	peak detect rate counter (counts per second)
14	2	HL	high level rate counter (counts per second)
16	30	PHOT	20 packed 12bit photometer samples (counts per 50ms)
46	120	LC	20 sets of 4 light curve samples (counts per 50ms); LC1 and LC2 are two-byte fields, LC3 and LC4 are one-byte fields
166	78	SPEC	52 12bit wide spectrum channels consisting of 1/4 the entire spectrum; 1st quarter when $\texttt{FC} \equiv 0 \pmod 4$, etc.
244	2	IRQ	interrupt counter from peak detect board
246	6	MAG	magnetometer data; for FC even: (B_x, B_y, B_z) in units of 10 nT; for FC odd: (pitch, roll, 0xEEEE) with angles in units of 0.1°
252	2	PPS	number of milliseconds into the frame when the GPS pulse per second arrived
254	2	CHK	a checksum, the unsigned sum of the 127 preceding two-byte fields of this frame

Table 1 Frame contents

The various x-ray products are calculated at different times so that care must be taken in comparing them. For instance, the rate counters and IRQ counter in frame $4n$ should be directly comparable with one another and refer to x-rays acquired in the 1-second interval ending several milliseconds prior to the transmission of frame $4n$. The values of PD and IRQ should be the same, and $\texttt{PD}+\texttt{HL} = \texttt{LL}$ should be satisfied. In a given frame,

$$\sum_{i=1}^{4}\sum_{j=1}^{20} \texttt{LC}_{ij} \leq \texttt{PD}$$

since the light curves omit the highest energies. In contrast, the 208 channel x-ray spectra are acquired during one interval and then dribbled out later. To compare spectrum totals with rate counters, realize that the spectrum output in frames $4n$ to $4n+3$ was accumulated during times in which frames $4n-4$ to $4n-1$ were being transmitted, and the corresponding PD data for those times are found in frames with frame counter running through values $4n-3$ to $4n$:

$$\sum_{i=4n-3}^{4n} \texttt{PD}_i = \sum_{i=4n}^{4n+3}\sum_{j=1}^{52} \texttt{SPEC}_{ij}.$$

The telemetry and DPU are clocked by a crystal which produces a divided down tick every millisecond. Every 1000 ticks (approximately 1 second), the DPU ends a data accumulation interval, builds a telemetry frame, and then sends that frame out as telemetry data. Since the accumulate/emit cycle is about 1 second long, the GPS unit should always produce a single pulse per second within this interval. This causes an interrupt at which the DPU saves the count in its millisecond counter for future timing use. This value appears in the telemetry frame as `PPS`. As an example, suppose frame $4n$ contains a value `0x0100` is `PPS`. This means that data in frame $4n$ began accumulating at 256 ms before and ended 744 ms past the UTC second time.

We also want to identify the time of day associated with a specific UTC second mark. Every second, between 100 and 500 ms after `PPS`, the GPS devices transmits a packet containing a time stamp and position data to the DPU. The transmit time is about 270 ms, after which the data is extracted and available for insertion into a TM frame. The `GPS` field contains data from the most recently acquired GPS packet. When a frame with `FC` of the form $4n + 1$ is output, it contains the most recent time stamp in the form of GPS milliseconds of week. GPS time is 14 s ahead of UTC as of March 2006. Some care is needed in clock synchronization.

> **Example** Suppose `PPS` = 800 when `FC` = 401. This means that the UTC second boundary occurred 800 ms into the accumulation period for frame 401. The associated GPS time stamp would be processed between 370 ms and 770 ms after the `PPS` interrupt, much too late to be included in frame 401. Therefore, frame 401 contains a time stamp associated with the `PPS` interrupt from the previous frame, 400.