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TELEMETRY TIMING ANALYSIS FOR IMAGE RECONSTRUCTION OF KOMPSAT SPACECRAFT

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ABSTRACT

The KOMPSAT (KOrea Multi-Purpose SATellite) has two optical imaging instruments called EOC (Electro-Optical Camera) and OSMI (Ocean Scanning Multispectral Imager). The image data of these instruments are transmitted to ground station and restored correctly after post-processing with the telemetry data transferred from KOMPSAT spacecraft.
The major timing information of the KOMPSAT is OBT (On-Board Time) which is formatted by the on-board computer of the spacecraft, based on 1Hz sync. pulse coming from the GPS receiver involved. The OBT is transmitted to ground station with the house-keeping telemetry data of the spacecraft while it is distributed to the instruments via 1553B data bus for synchronization during imaging and formatting. The timing information contained in the spacecraft telemetry data would have direct relation to the image data of the instruments, which should be well explained to get a more accurate image.
This paper addresses the timing analysis of the KOMPSAT spacecraft and instruments, including the gyro data timing analysis for the correct restoration of the EOC and OSMI image data at ground station.

1. INTRODUCTION

Unlike other spacecraft, there are three processors involved in KOMPSAT for the on-board processing. It is imperative that very sophisticated timing scheme would be implemented for the three processors and other 1553B subscribers. Furthermore, KOMPSAT has three different payloads that should operate synchronously, which makes the scheme more complicated.

It is also necessary to evaluate an optimum method for analyzing the timing relations of some mission critical telemetry such as gyro data. Since the capturing and transmitting of gyro data would be done by different processors, their timing latency including the transmission delay occurred in the 1553B bus could be a point of concern.

2. THE SYNCHRONIZATION SCHEME

KOMPSAT uses a GPS receiver to provide very accurate time and position information and utilizes the 1 Hz clock coming from the GPS receiver to synchronize all 1553B BUS subscribers

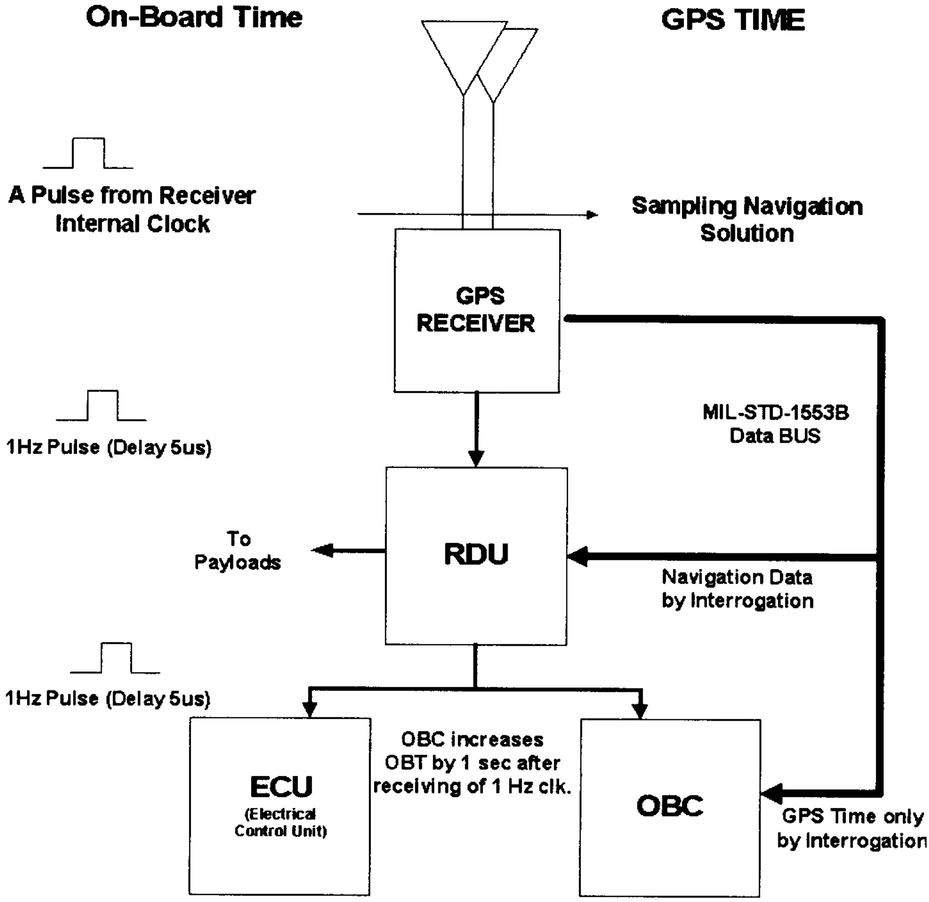

Figure 1. The Timing Synchronization Concept of KOMPSAT.

including three processors and payloads. The GPS position data will be internally processed by RDU (Remote Drive Unit) and downlinked via S-band telemetry in ECI (Earth Centered Inertial) and ECEF (Earth Centered Earth Fixed) formats while the GPS time information will be transmitted to OBC (On-Board Computer) and RDU and then sent to MCE (Mission Control Element) without any processing (Lee 1998). The time format provided by the GPS receiver is selectable among GPS time and UTC (Universal Time Coordinated) time by means of UTC time correction control (Motorola 1994) and the latter will be involved in the normal operation of KOMPSAT. The accuracy of the GPS position data would be 100 meters (1) and 2 μ sec accuracy would be considered for the time information when Selective Availability (SA) code is turned ON (Schauer 1997). The GPS receiver samples navigation solution including position and time information at the rising edge of the 1Hz clock so that the 1Hz clock is synchronized to the sampling time of the GPS receiver. OBC receives the 1Hz clock and increases OBT formatted weeks and quarter seconds, at its rising edge.

The maximum error of the 1Hz clock is ± 2 μ sec in two cycles and this error could cause the drift of the GPS sampling time. That means OBT could not have synchronism with GPS UTC time,

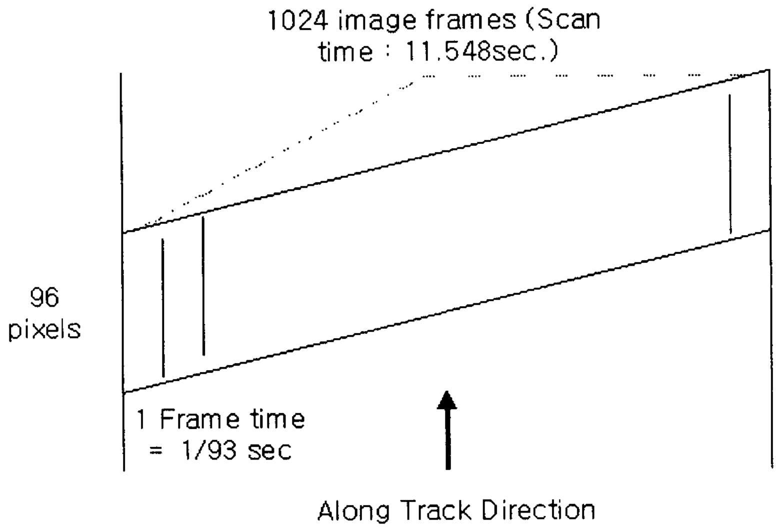

Figure 2. OSMI imaging concept and Frame error evaluation.

and sometimes the difference between them may be larger than the length of one second. Ground station should track the time difference for a precise image reconstruction and OBT adjustment is occasionally required by means of uplink commanding when the difference is too big (Kim 1998).

The 1Hz clock pulse is sent to the payloads by the RDU electronics. There is 1μ sec internal delay in the GPS receiver and 5sec delays at maximum would be occurred in RDU mainly due to the internal circuit delay of RDU DPLL (Digital Phase Lock Loop) (Lee 1998). Those delays could be assumed consistent during the operational lifetime of KOMPSAT. The RDU 1Hz clock output also has up to ± 2 μ sec uncertainty with respect to the 1Hz clock of the GPS receiver, which is independent of the drift of the 1Hz clock output.

The utilization of the 1Hz clock and OBT in each payload is as follows:

2.1 SPS and OSMI

When SPS (Space Physics Sensor) and OSMI receive OBT from OBC via 1553B Bus, they are going to store it at one of their registers without processing. At the rising edge of the 1Hz clock, the stored OBT then begins to be used for the time tagging of the observed data and this scheme makes the telemetry data contain the time information that is exactly 750msec behind with respect to the OBT downlinked by OBC at same minor frame. To correct it in ground process, it is necessary to add three quarter-seconds to the time information of the telemetry data. There will be a slight difference between the frame sync of OSMI image data and the 1Hz clock since an asynchronous timing is involved in OSMI, which could hardly be compensated because of no information provided.

2. 2 EOC

The timing process of EOC is almost identical to that of OSMI and adding 750msec to the time information is also required in EOC image data during ground processing. For EOC image data, the frame sync difference from the 1Hz clock, which is caused by the asynchronous timing of EOC,

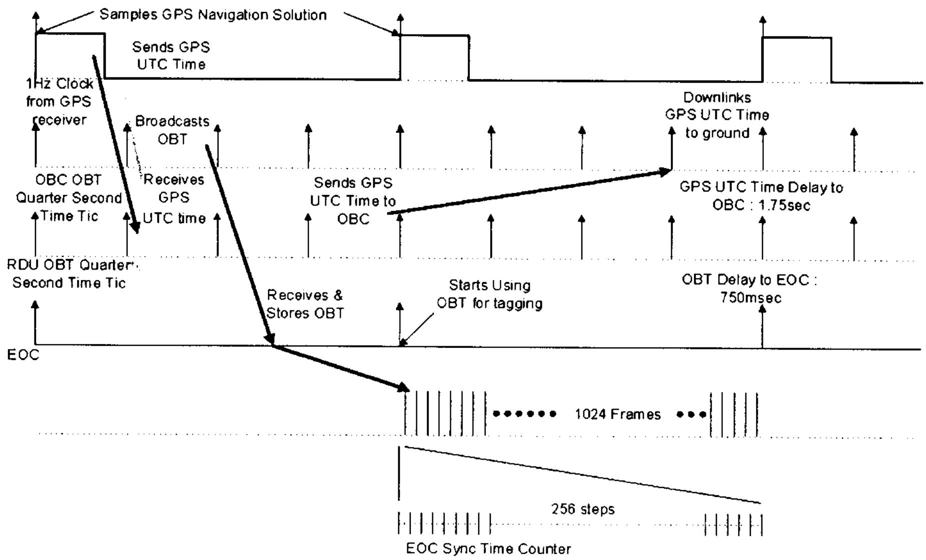

Figure 3. GPS UTC Downlink and EOC Time-tagging.

may be very slight, but critical. In order to compensate for it, EOC image has the information of sync time counter indicating the frame sync difference in respect to the 1Hz clock, which counts the difference by dividing the frame counter into 256 steps (Whitley 1997). Since the frame counter has 1024Hz of clock rate, the resolution of the sync time counter could be derived into 3.8 μ sec (1/1024/256sec) as shown in Figure 3. The sync time counter will be included in every frame of EOC image and the OBT is also inserted in every frame of the image data as remaining constant between the 1Hz-clock pulses.

3. DOWNLINK AND IMAGE RESTORATION

The OBT is broadcast to each of the payloads as well as PDTS (Payload Data Transmission System) once per second over the 1553B data bus. The EOC and OSMI use it for the time tagging of their image data as stated above, at each second in the telemetry format. PDTS performs no alteration of their image data before or during transmission to ground station, and only uses OBT for telemetry refresh (Wolf 1997).

In ground station, it is highly necessary to compensate the time differences of the payload data to restore the image or science information correctly. For example, the timing compensation procedure of EOC image data could be as follows:

1. Upon receiving of EOC image data, the time information tagged in every frame would be increased by 3 quarter-seconds.
2. Ground station knows the current time difference between OBT and the GPS UTC time downlinked and then compensates it.
3. The time information is incremented uniformly within a step of 1/1024 second and then applied to each corresponding image data frame.

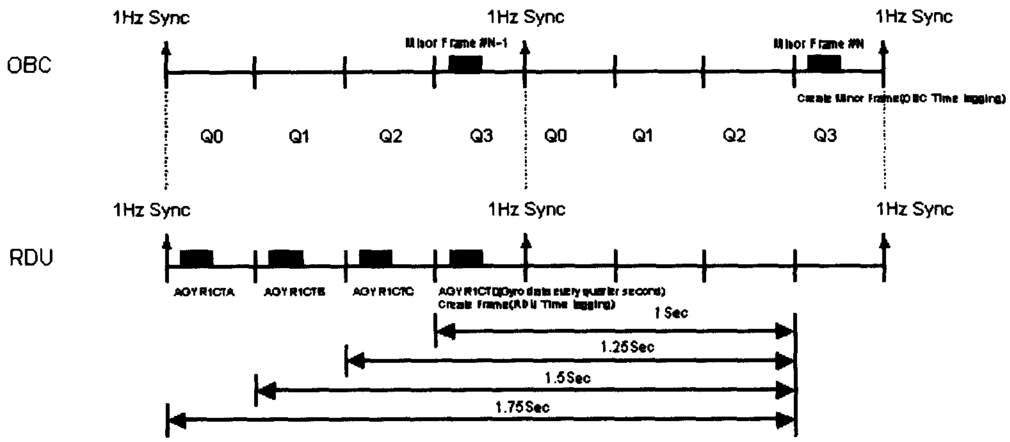

Figure 4. Timing diagram of gyro pulse counter data.

4. The information of the sync time counter included in every frame is applied to the time information by adding or subtracting.

It is important to track the current difference between OBT and the GPS UTC time for a precise image reconstruction. OBT is downlinked in every minor frame and the GPS UTC time is transmitted to ground in every 16 seconds with a transmission delay of one second. It is required to know that the GPS UTC time received must be compared with the OBT downlinked a second ago. The OBT time compared in this process must be subtracted by 3 quarter-seconds (750msec) in this case, since the OBT included in the corresponding minor frame of telemetry has been sampled during the forth quarter-second period of the minor frame. The UTC information is provided to ground station up to 10-9 second order, but it is reliable only when it comes within the 10 μ sec order information (Schauer 1997).

4. GYRO DATA TIMING

The counter data of the gyro pulses are sampled in every quarter-second after receiving the 1 Hz clock. This counter data would be included in the state-of-health data of RDU as well as the quarter-second time tag. RDU generates its SOH data at the third quarter-second (Q3) with keeping the synch- ronism and sends the data to OBC through the 1553B bus right after formatting (Kim 1998). As mentioned earlier, OBC downlinks the data to ground in the next Q3 period with being included in OBC SOH data.

There is 1.75 seconds difference between the sampling time of the pulses counter and the minor frame time which indicates the moment of downlink as shown in Figure 4. It is necessary to compensate the time difference for acquisition of the real sampling time of the counter. In the same manner, it is needed to subtract 1.5, 1.25 and 1.0 second from the counter to get the real sampling time of each gyro data, respectively.

5. CONCLUSION

In this paper, the processing methods of several time information for more accurate data restoration were demonstrated as well as the time synchronization scheme. Even though there are several contributors of delays and time differences due to the different processing methods involved, they could be compensated satisfactorily by ground processing. A synchronization method over several subscribers including a GPS receiver was also presented, which could be applied to other spacecrafts, particularly it is very effective when a number of equipments are involved in synchronism.

REFERENCES

Kim, Y. H. 1998, KOMPSAT.98.BUS.001
Lee, J. H. L. 1998, KOMPSAT.98.BUS.002A
Motorola, 1994, VICEROY GPS Receiver S/W ICD, 99-P30205Y-XB, 36
Schauer, G. 1997, GPS Receiver Specification, 12
Whitley, R. 1997, 97.M111.RHW-015
Wolf, R. S. 1997, KOMPSAT.97.410.024