GOES-9 Raw Data Acquisition & Image Extraction

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Abstract: The Geostationary Operational Environmental Satellite (GOES) 9, which is currently located at 155°E geostationary orbits, has transmitted earth observation data acquired by imager to CDA at NOAA. After the acquisition on ground, observation data are corrected on ground and re-transmitted to GOES-9 for the dissemination to users. In this paper, the procedure and result from raw data acquisition and pre-processing for earth observation imagery retrieval from GOES-9 Raw data acquired in Korea at May 2005 are introduced.
Keywords: GOES-9, Imager, Raw Data Acquisition, Pre-Processing, Earth Observation Imagery Retrieval

1. Introduction

The Communication, Oceanic and Meteorological Satellite (COMS) has been developed since 2003 to be launched at 2008. The COMS is the first Korean satellite for meteorological and oceanic missions in the geostationary orbit.

In addition to the payload for oceanic application, GOCI (Geostationary Ocean Color Imager), MI (Meteorological Imager) will be installed to the COMS. The objective of MI is to observe and monitor the earth environment according to the mission schedule. The MI has a heritage from ITT imager. So, it is expected that the most characteristics of MI, to be attached to COMS, will be similar to those of currently operatinal GOES imager. And the MI raw data protocol and format from MI to COMS bus system may also be the same as that of GOES. So, it is expected that the acquisition and pre-processing experience for the current GOES-9 raw data will be helpful to the ground segment development.

So, KARI has tried to acquire GOES-9 raw data directly from GOES-9 spacecraft and acquired them at May 2005. And earth imagery from GOES-9 imager was retrieved on ground. In this paper, the result of the acquisition and pre-processing for the GOES-9 raw data and earth imagery retrieval from them is addressed.

2. GOES-9 Raw Data Acquisition

1) Transmitting Format

Fig. 1 illustrates the PN coding and NRZ-S process of GOES-9 imager data before UQPSK modulation consisted of I channel linked Sounder data, 40 kbps and Q channel linked imager data, 2.6028 Mbps.

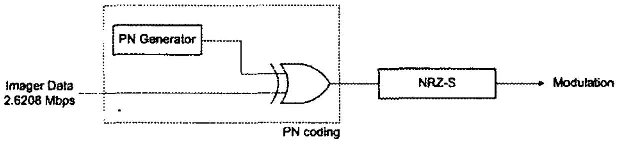

Fig. 1 PN and NRZ-S Coding

The XOR operation of GOES-9 imager data and PN generator output is the point of PN coding. PN generator has specific 15 bits and the imager data has nulls of 15 bits which are located in front of one frame, 480 bits. After coding for one frame, the generator is resetting to specific 15 bit, so the frame of PN coded output is 480 bit with a kind of synchronization code, 15 bit. The detailed structure of PN generator is described in Fig. 2.

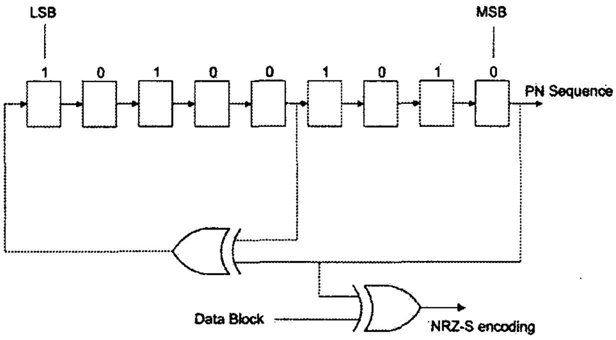

Fig. 2 Structure of PN Generator

The seed value, "010100101" is shifted to left and the first bit space is filled with the XOR of 5th bit and 9th bit. The XOR of 9th bit, PN, and imager data is moved on to NRZ-S encoding. In the receiving system in ground segment, the original imager data can be obtained by the XOR of prepared PN sequence and input data. Fig. 3 illustrates the prepared PN sequence of ground segment, which is equal to that of spacecraft in hexadecimal code.

```
52 BC BB 81  CE 93 D7 51  21 9C 2F 6C  D0 EF 0F
F8 3D F1 73  20 94 ED 1E  7C D8 A9 1C  6D 5C 4C
44 02 11 84  E5 58 6F 4D  C8 A1 5A 7E  C9 2D F9
35 33 01 8C  A3 4B FA 2C  75 96 78 FB  A0 D6 DD
```

Fig. 3 PN Sequence in Hexadecimal Code

2) Raw Data Receiving

To receive the GOES-9 raw data in a condition of 10^{-6} BER (Bit Error Rate), the figure of merit, needs to be over 22.66 dB/K which matches to the 13M antenna receiving system in SRMO (Satellite Radio Monitoring Center). The SRMO is government agency located at ICheon in Gyeonggi Province. Fig. 4 illustrates the receiving block diagram consisted of antenna and receiver.

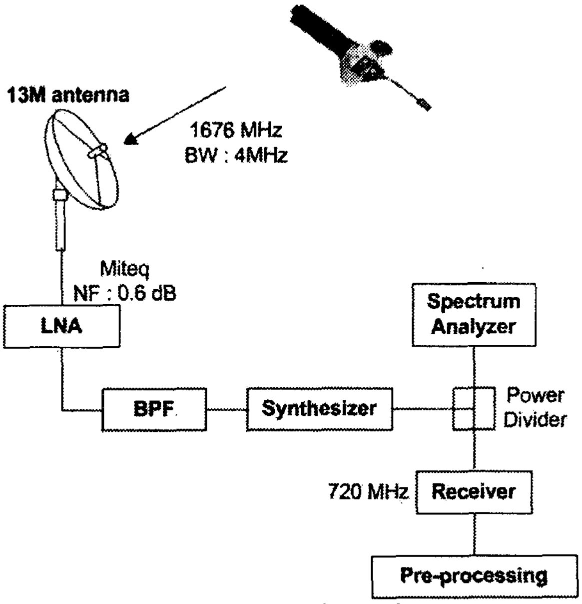

Fig. 4 Receiving Block Diagram

At first, GOES-9 raw data is received at 13M antenna and amplified through LNA (Low Noise Amplifier) and BPF (Band Pass Filter). Through synthesizer, its frequency is converted to 720 MHz and separated into two ones. The one is transmitted to spectrum analyzer for signal monitoring and the other is transmitted to the receiver for demodulation and decoding. The pre-processing consists of frame synchronization, PN decoding and archiving. Fig. 5 describes the flow of data and configuration of equipments.

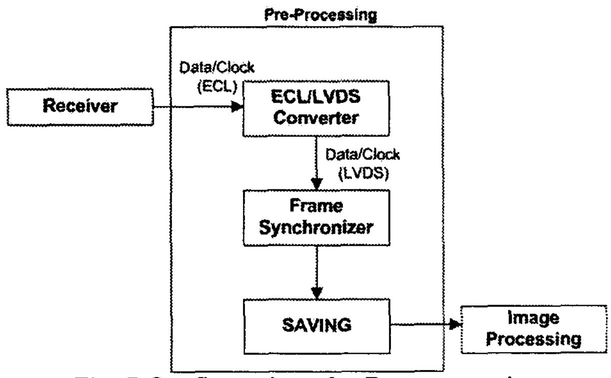

Fig. 5 Configurations for Pre-processing

The demodulated and decoded data is transmitted to ECL/LVDS converter and the LVDS data/clock moves on to frame synchronizer. For the frame synchronization, the specified code needs to be defined at frame synchronizer. As mentioned at previous sentence, we can say this code is "52B" which is 12 bits as described in Fig. 3. Figure 6 shows an example of pre-processing with synchronized data except PN decoding (a) and PN decoded data, namely original data (b).

```
 0: 52 BD 3B FD  EA 95 55 61  5D BC 27 6D  2F E8 C9 85
16: 7D F1 F3 3F  92 AF 1E 00  C2 A1 1D A2  43 89 3B 82
32: 11 FC FB 5E  ED 5D BC BC  5D BF 16 36  30 4A F3 01
48: E0 BE 4D 38  3C 11 8A 7F  BA 4F C0 DD
```

(a) Frame synchronized data except PN decoding

```
 0: 00 01 80 7C  24 06 82 30  7C 20 08 01  FF 07 C6 7D
16: 40 00 80 1F  06 42 00 7C  1A 08 01 CF  1F C5 7F 80
32: 00 78 1E 06  82 10 74 1D  07 C1 DF 1B  C9 7F C0 00
48: 6C 1D 06 C2  10 64 1C 07  41 EF 16 00
```

(b) Original data

Fig. 6 Pre-processing Sample

3. GOES-9 Earth Imagery Retrieval

1) Wideband Data Block Structure

The wideband data is a set of several "block" data, which has the size of 480bits. Conceptually, wideband data consists of two type data, which are active scan format data and scan reversal format data.

The active scan format data contains radiometric data which are produced from the observation of the earth, space and blackbody. Fig. 7 shows the structure of the active scan format data.

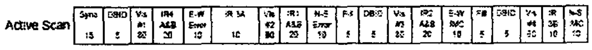

Fig. 7 The Structure of Active Scan Format Data

Meanwhile, the scan reversal format data contains auxiliary data which consist of header, trailer, space look, telemetry and electronic calibration data. These data include information for the SOH (State Of Health), operational information and calibration and so on. Fig. 8 shows the structure of the scan reversal format data.

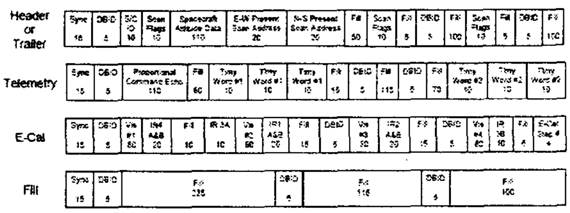

Fig. 8 Scan Reversal Format

2) Scan Mechanism of ITT Imager

Fig. 9 shows the way that earth observation with the scan mirror of the ITT imager which is installed at 2-axis gimbals system and moves for scanning the earth in E-W or W-E direction. The three additional active scan format data after EOL (End-Of-Line) describe the sampling delays in the visible & IR channel data. In the interval between trailer and header, scan mirror turnaround in N-S direction and settling are done. At the same time, several auxiliary information including SOH, telemetry and so on will be formatted to scan reversal format data and transmitted to the ground station. So, the line scanning direction is reversed after turnaround.

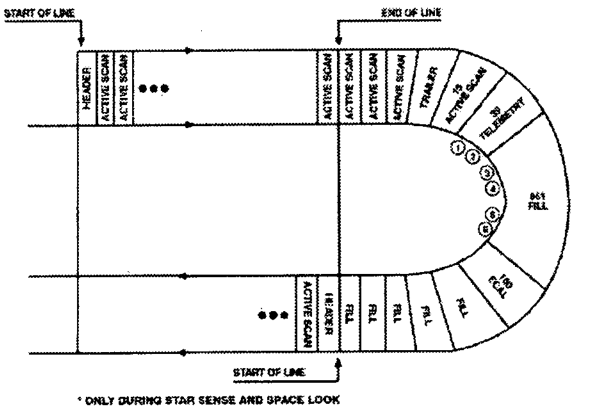

Fig 9. Scan Mechanism

Because additional 3 active scan format data, which are acquired before the trailer, are for the sampling delay of ITT imager, the number of the actual observation data between header and trailer is n-2 if the number of active scan format data between header and trailer. Table 1 shows the visible and IR channel data validity in active scan format data between header and trailer. Finally, the width is about to 4*(n-2) for visible channel image and n-2 for 4 IR channel images.

Table 1. Validity of active scan format data in a line

	Block 0	Block 1	Block 2	...	Block n-2	Block n-1	Block n
VIS	For delay	actual	actual	actual	actual	actual	For delay
IR	For delay	For delay	actual	actual	actual	actual	actual

GOES-9 raw image of full disk, northern hemisphere and pacific area were extracted during the test. Table 2 shows the dimension of each image in pixel unit.

Table 2. Dimensions of GOES-9 raw images

	No. of active scan format data between header and trailer	Width of the image line	
		VIS	IR
Full Disk	5209	20836	5209
Northern Hemisphere	5209	20836	5209
Pacific	2751	11004	2751

3) Considering Scan Direction of ITT Imager

According to Fig. 9, GOES-9 raw images have been retrieved considering scanning direction by referring header information.

4) GOES-9 Raw Image Extraction and Retrieval

Table 3 shows the dimension of GOES-9 raw images extracted and retrieved from GOES-9 raw data.

Table 3. GOES-9 raw images dimension

	Full Disk image		Northern Hemisphere image		Pacific image	
	Width	Height	Width	Height	Width	Height
VIS	20,836	10,832	20,836	6,264	11,004	5,800
IR	5,209	2,708	5,209	1,566	2,751	1,450

Below images are final results for the image extraction from GOES-9 raw data.

(1) Full Disk images

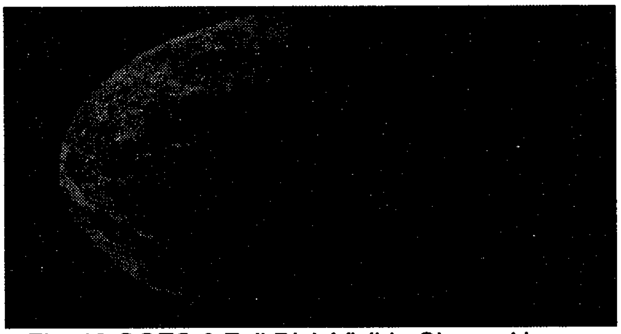

Fig. 10 GOES-9 Full Disk Visible Channel image

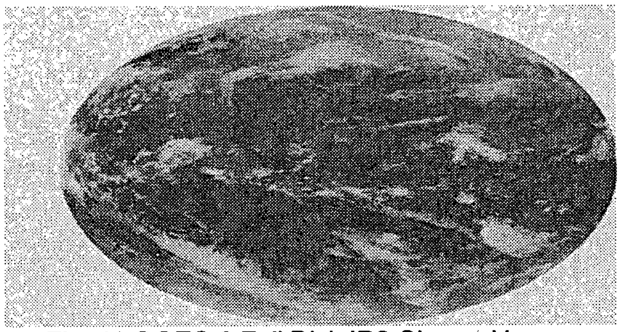

Fig. 11 GOES-9 Full Disk IR2 Channel image

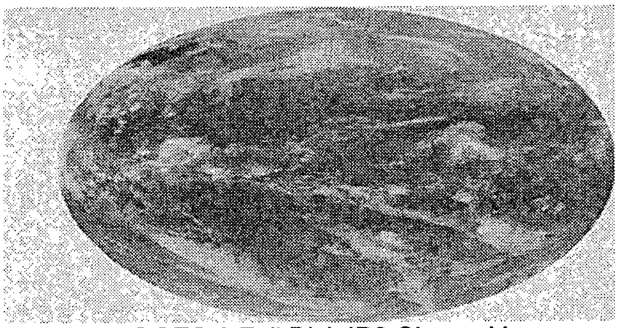

Fig. 12 GOES-9 Full Disk IR3 Channel image

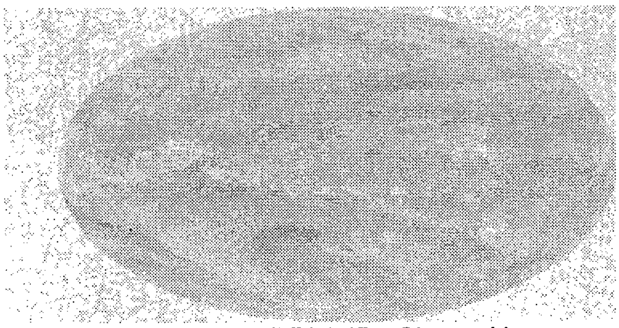

Fig. 13 GOES-9 Full Disk IR4 Channel image

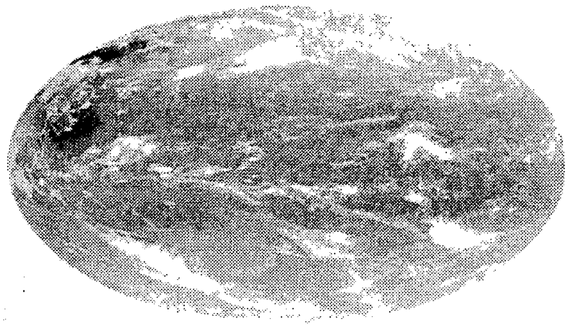

Fig. 14 GOES-9 Full Disk IR5 Channel image

(2) Northern Hemisphere images

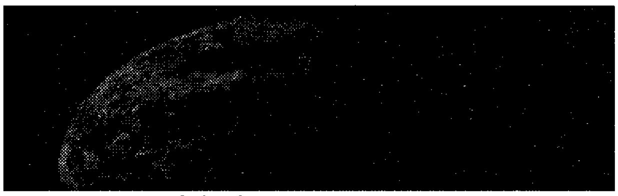

Fig. 15 GOES-9 Northern Hemisphere Visible Channel image

Fig. 16 GOES-9 Northern Hemisphere IR2 Channel image

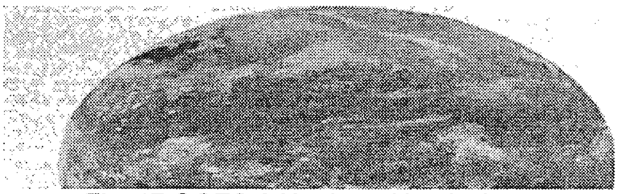

Fig. 17 GOES-9 Northern Hemisphere IR3 Channel image

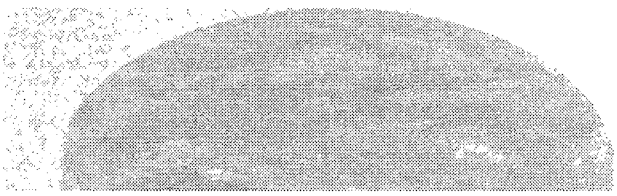

Fig. 18 GOES-9 Northern Hemisphere IR4 Channel image

Fig. 19 GOES-9 Northern Hemisphere IR5 Channel image

(3) Pacific images

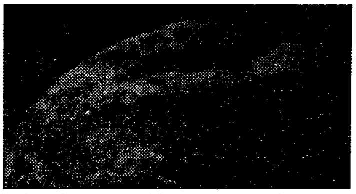

Fig. 20 GOES-9 Pacific Visible Channel image

Fig. 21 GOES-9 Pacific IR2 Channel image

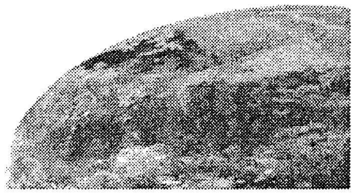

Fig. 22 GOES-9 Pacific IR3 Channel image

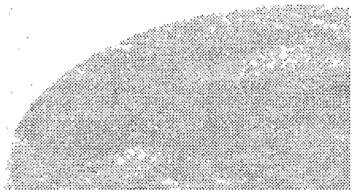

Fig. 23 GOES-9 Pacific IR4 Channel image

Fig. 24 GOES-9 Pacific IR5 Channel image

5. Conclusion

In this paper, the result of the acquisition, pre-processing and image extraction for the GOES-9 raw data is addressed.

It is expected that detailed algorithms and techniques applied to this paper will be helpful to develop COMS raw data acquisition and processing functions on ground station.

References

[1] ITT Imager Operational Reference Manual, 2003, ITT Industries Aerospace/Communications Division