IMPLEMENTATION OF REAL TIME TELEMETRY & PLAY-BACK DATA IN A SINGLE DATA STREAM

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Abstract: ***The satellite need to be communicated, commanded and tracked. This job is done by the telemetry system which receives the signal from the ground station and also transmits back for the station. This combined system enables data to be sent continuously to track and moniter the health parameters of the satellites. It also helps us to send commands to carry out various tasks like switching the transponders in and out of service and switching redudant units etc.***

The telemetry data of which 256 bytes or 2048 bits per frame will be generated at 4 kHz. Each frame takes 512ms duration at 4kbps. The input data stream which is coming at 4kbps and at the duration of 512ms is at fed to the logic block. If the input data stream is transferred at 32 kbps instead of 4kbps the remaining bandwidth of 28kbps can be utilized to transfer other data. This involves a delay of 512ms in the transmission because an entire frame will be stored before shifting at 32kbps.

Telemetry data is divided into frames and each frame consists of 256bytes of information. In case of small satellites only one data stream is available. In order to download both normal and PB data, increase the data rate to 32kbps and then multiplex normal and PB data.

Index terms: ***Satellite is communicated, commanded and tracked, implementation of single data stream, real time and playback, increasing the data rate to 32kbps, multiplexing.***

I. INTRODUCTION

The low earth orbit satellite which is below distance of 600-800km from earth transmits receives the radio frequency signal from antenna (ground) to satellite. The signal which is transmitted is called as telecommand and which sends certain command to the satellite and the receiver signal is called as telemetry signal which receives the information regarding the health of the satellite.

The low earth orbit satellites which revolves from pole to pole orbit and there will be certain time the satellite is visible to the ground station and during this the real time telemetry data is available to the ground station. During the nonvisible period the HK data is stored in the spacecraft and is transmitted from spacecraft when it is visible at the higher data rate called playback (PB) data.

Therefore two data streams transferred one is real time in the duration 512ms at 4kbps and the stored data in the duration 128ms at 16kbps. In the particular satellite which needs only one data stream which needs to send both the normal and playback data then the process of multiplexing is done. This is done at 32kbps. In order to convert normal and PB data, normal data rate is up-converted to 32kbps from 4kbps by storing one entire frame. This involves the delay of one frame duration.

IMPLEMENTATION OF REAL TIME TELEMETRY AND PB DATA

SATELLITES:

A satellite is defined as a secondary object revolving about a primary object. Man-made satellites are called artificial satellites which are put in the orbit to serve a desired purpose. Communication satellites are weather forecast satellites are placed in the circuit orbit at the height of 36,000 km period. This orbit is called geosynchronous orbit. If the plane of the orbit is in equatorial plane of the earth is called geostationary orbit. The orbit of special important is the sun synchronous polar orbit in which the plane of the orbit shifts about one degree per day. Since the earth revolves around the sun at the rate of about 1 degree per day. A satellite in sun synchronous orbit would cross the equator always at

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a fixed local solar time. Each observation satellites are put in this orbit called polar orbit which is around 600-800km above earth surface.

Fig. 1 IRS Satellite

Fig. 2 Antenna

TELEMETRY, TRACKING COMMAND AND COMMUNICATION MODE:

The satellite also need to be communicated, commanded and tracked. This job is done by the telemetry system which receives the signal from the ground station and also transmits back for the station. This combined system enables data to be sent continuously to track and moniter the health parameters of the satellites. It also helps us to send commands to carry out various tasks like switching the transponders in and out of service and switching redudant units etc.

Telemetry data is divided into frames and each frame consists of 256bytes of information. In case of small satellites only one data stream is available. In order to download both normal and PB data, increase the data rate to 32kbps and then multiplex normal and PB data.

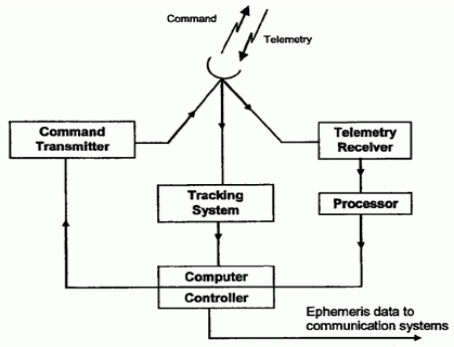


Fig. 3 Command Transmitter & Telemetry receiver

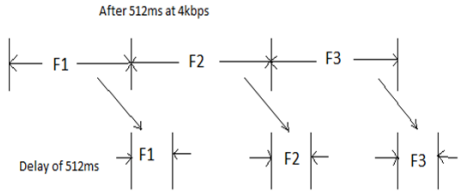
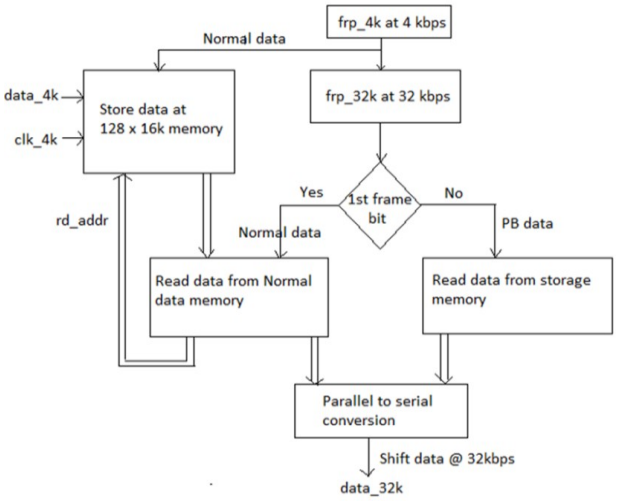


Fig. 4 Delay during Transmission.

The telemetry data of which 256 bytes or 2048 bits per frame will be generated at 4 kHz. Each frame takes 512ms duration at 4kbps. The input data stream which is coming at 4kbps and at the duration of 512ms is at fed to the logic block. If the input data stream is transferred at 32 kbps instead of 4kbps the remaining bandwidth of 28kbps can be utilized to transfer other data. Consider data frames of time 512ms each and clock cycle of 250µs. This involves a delay of 512ms in the transmission because an entire frame will be stored before shifting at 32kbps.

FLOW CHART:



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Step 1*. The frame pulse frp_4k at 4pkbs is divided into eight frame place pulses i.e, frp_32k clock at 32kbps.*

Step 2. *At the first bit of frp_32k the normal data from 128x16k memory will be read.*

Step 3. *The reading takes place at faster rate i.e, at 32kbps and 128 blocks of memory can be filled at 64ms and rest of the frp_4k frame will be filled with playback-data.*

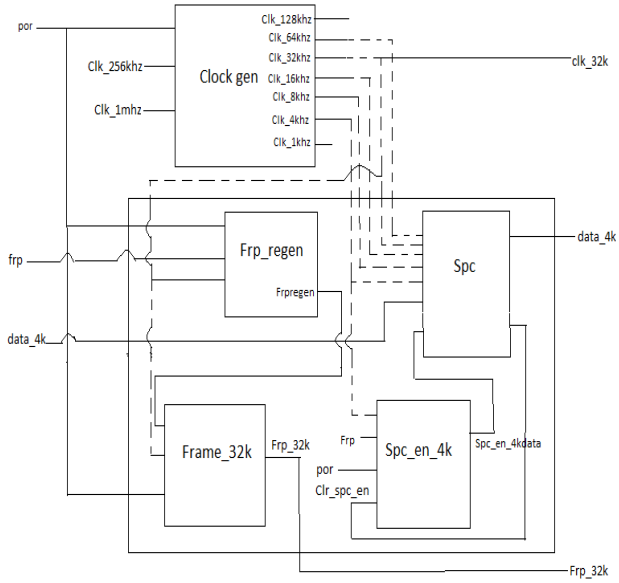
Step 4. *Two memory block i.e, one for normal data and playback data is used and during first frame bit the 32kbps serial data is filled with normal data until the time 64ms and rest of the 448ms is filled with playback-data*

Step 5. *After completion of first frame then the memory address will be updated with new bytes of data.*

Step 6. *The parallel data with both normal and playback data is converted to serial at 32kbps to form a single data stream.*

II. BLOCK DIAGRAM

A. Top module



Real time telemetry and PB data in single data stream:

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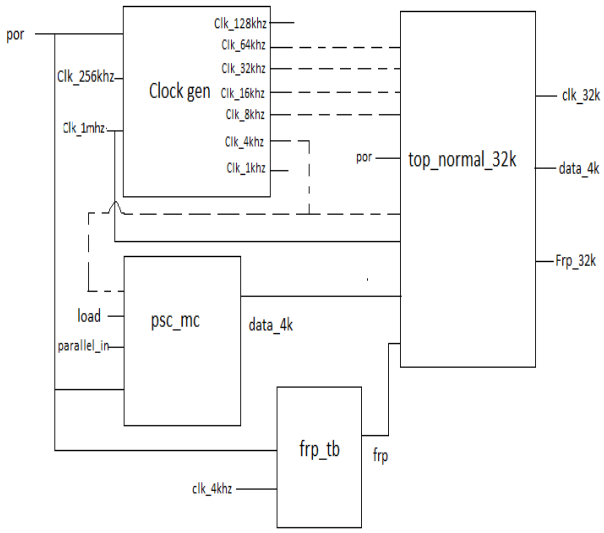
B.Test bench module



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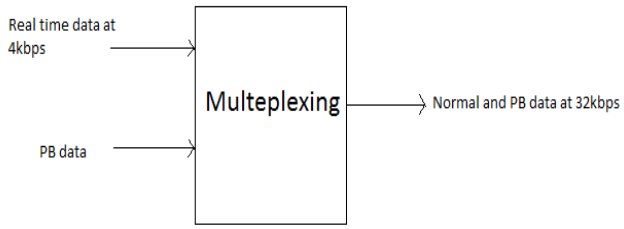

Fig. 5 Multiplexing

Each frame takes 512ms duration at 4kbps. The telemetry data of 256 bytes or 2048 bits per frame is portioned into into 2 bytes or 16 bits in one

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block and forms a total of 128 memory blocks. The two memory block for both normal and PB data is used. The telemetry signal of normal data at 4kbps of 16 bits is read to memory from series to parallel converter (SPC) and its written to parallel to series converter (SPC). It consumes $1/8^{th}$ time to store normal data but there involves a delay of 512ms in the transmission because an entire frame will be stored before shifting at 32kbps. The telemetry signal of playback data at 32kbps of 16bits is read to playback memory block from SPC and its stored at PSC of 16 bits. The remaining $7/8^{th}$ time i.e 448ms in each frame is used to store playback data.

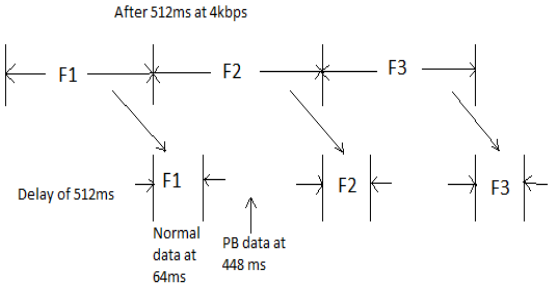

Fig.6 Real time TM & PM data in single data stream.

III. SIMULATION RESULTS

1.Module : clk_gen

Theory:

In this module, when por='1', then counters 'counter_master[7:0]' & 'counter_slave[7:0]' are low. When por='0' both counters 'counter_master[7:0]' &'counter_slave[7:0]' increments with respect to 256khz clock.

clk_128khz = counter_master(0);
clk_64khz = counter_master(1);
clk_32khz = counter_master(2);
clk_16khz = counter_master(3);
clk_8khz = counter_master(4);
clk_4khz = counter_master(5);
clk_1khz = counter_master(7);

2.Module: frp_tb

Theory:

In this module, when por='1', then frp='0'. When por='0', then the output frame pulse 'frp' will be high after every 512 ms with respect to rising edge of 4 khz clock. This can be done using counter 'cnt[7:0]'.

3.Module : frp_regen

Theory:

In this module, when por='1', then the regenerated frame pulse 'frpregen' will be low. When por='1', the counter 'cnt[5:0]' increments during the rising edge of 'frp' with respect to 32 khz clock. When the counter reaches the value "111000" then 'frpregen' becomes high. Module : Frp_32k

4.Module : Frp_32k

Theory:

In this module, when por='1', then the output frame pulse 'frp_32k' will be low.

When 'frpregen' (regenerated frame pulse of 512 ms) is high, then 'frp_32k' is high. During falling edge of 'frpregen', the 8 bit counters 'counter_master[7:0]' & 'counter_slave[7:0]' increments with respect to 32 khz clock, and when both the counters reaches the value "11111111", the output frame pulse 'frp_32k' will be high. So, there will be eight output frame pulses 'frp_32k' each of length 64 ms within the regenerated input frame pulse 'framegen' of length 512 ms.

5.Module : Spc_en_4k

Theory:

When por = '1', then spc_en_4kdata will be low.

In other case, during falling of 'frp' and frp'event & when frp_clr = '0', then frp_en = '1'. During falling edge of clk_4khz and when frp_en = '1', output spc 4k enable data 'spc_en_4kdata' will be high.

6.Module : psc_tb

Theory:

When por ='1', then counters reg_m[2047:0] & reg_s[2047:0] are '0'.

In other case, during falling edge of 32 khz clock 'clk' and clk'event, if 'load' is high then 'parallel_in' is fed to reg_m. Else when load is low then, reg_s(1 to 2047) & '0' is

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fed to reg_m. So output serial data 'serial' is reg_m(0) i.e, 0^{th} bit of reg_m.

7.Module : Spc

Thoery:

The 16_bit input serial data is converted to parallel data with respect to 4 khz clock and the counter is used for counting 16 clock cycles and the serial to parallel conversion takes place after every 16 bits. The parallel_out data from serial-to-parallel converter is written to the memory block and after completion of first memory location i.e, after 4 ms it goes to the second memory location. Therefore the total of 128 memory location is written at each frame of 512 ms.

The address from each memory location is read with respect to faster clock i.e, at 32khz. The period of each clock is 31.25 us and the total of 128 block can be read at time 64ms at 32 kbps. The read_address at the faster rate is converted from parallel to serial data and the output is obtained at 32 kbps and extra 28 kbps is used for playback data.

IV. TESTBENCH WAVEFORMS

1.Module : clk_gen

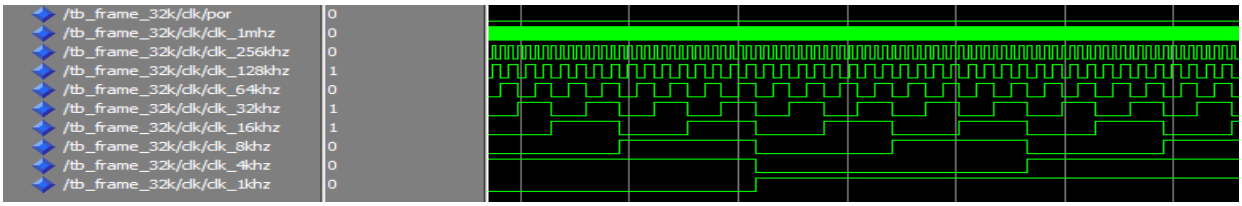

Fig.6 Testbench waveform for clk_gen module

2.Module: frp_tb

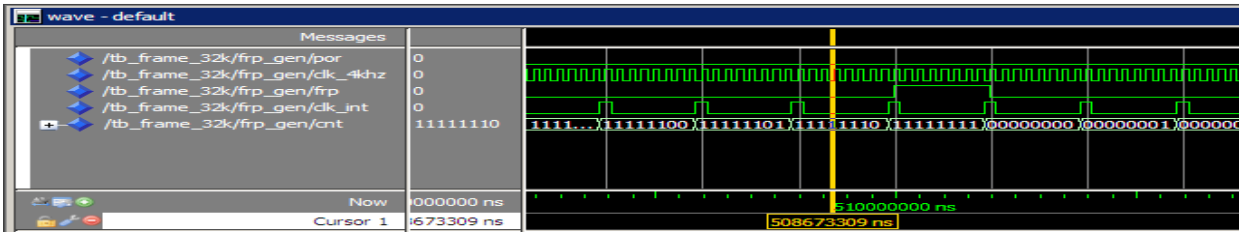

Fig.7 Testbench waveform for frp_tb module

3.Module : frp_regen

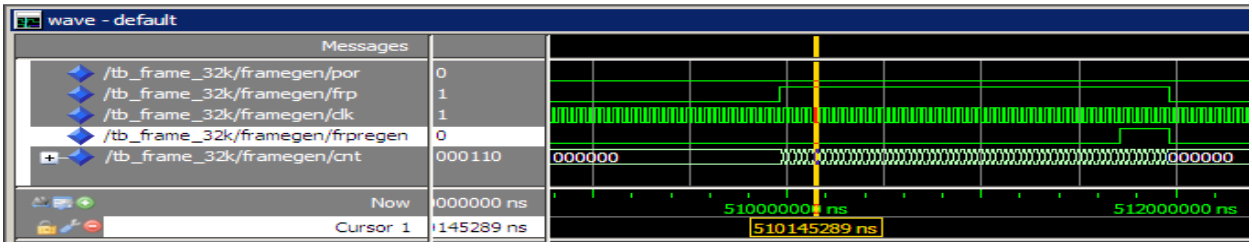

Fig.8 Testbench waveform for frp_regen module

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4.Module : Frp_32k

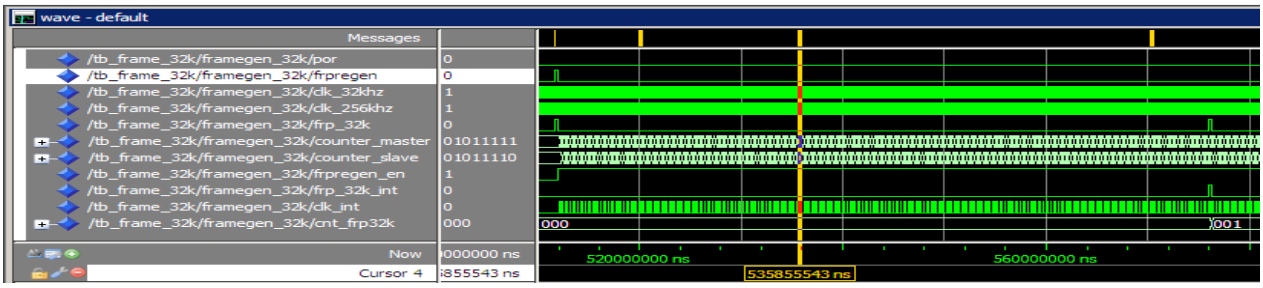

Fig.9 Testbench waveform for frp_32k module

5.Module : Spc_en_4k

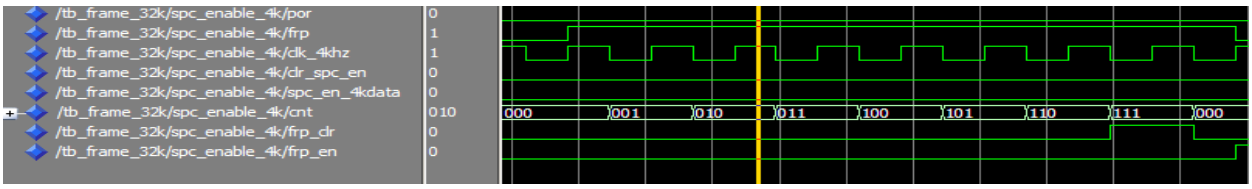

Fig.10 Testbench waveform for spc_en_4k module

6.Module : psc_tb

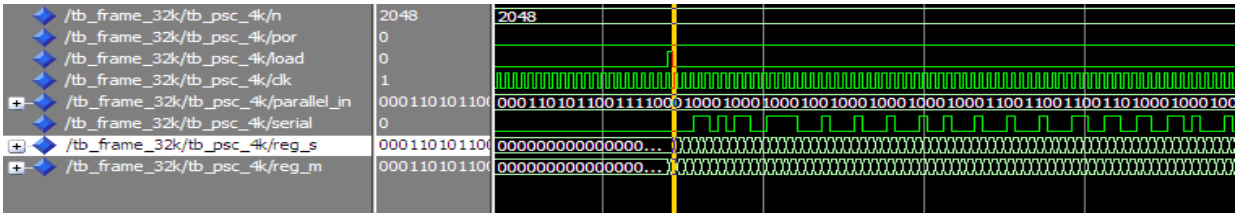

Fig.11 Testbench waveform for psc_tb module

7.Module : Spc

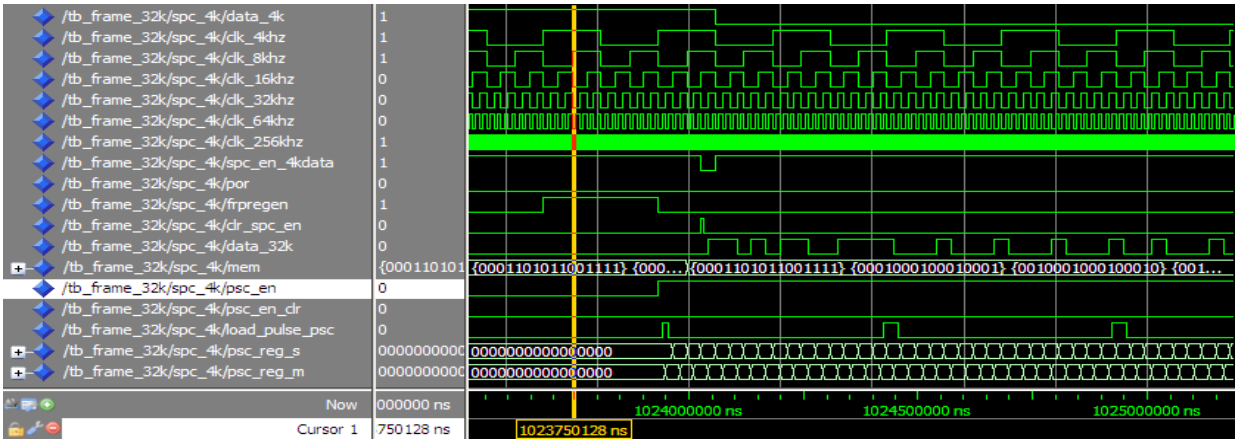

Fig.12 Testbench waveform for spc module

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CONCLUSION

1. In low earth orbit satellites the health of the satellite is determined even when the satellite is not visible to the ground station.

2. Both Normal telemetry and Playback telemetry data is sent in single data stream.

3. Stored playback data is sent in same single data stream when communication takes place with earth antenna.

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