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DESIGN AND FUNCTIONAL TEST OF ON-BOARD FLIGHT ANALOG VIDEO SYSTEM

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ABSTRACT

This paper describes design, implementation and functional test of on-board flight analog video system. Video system is the part of the telemetry system as a means of providing flight vehicle's image data. Adopting analog video transmission technique, we could design and test the system in a short time and implement the prototype model with simpler circuits. As results of the functional test, we have made the verification and validation of two cameras' switching in time, and frequency modulation and demodulation of NTSC color signals successfully.

Keywords: rocket, analog video telemetry, on-board camera, video transmitter, NTSC, pre-emphasis, de-emphasis

1. INTRODUCTION

Gathering rocket performance data has always been an important part of the launch process. Acceleration, audio, shock, temperature, and vibration transducers have successfully been used to capture vehicle performance data during flight. While these transducers often provide adequate information, there are occasions when "a picture is worth a thousand words." Strategically mounted cameras can capture important launch events before and during the launch. Prior to launch, these cameras could serve a variety of pre-launch checkout needs including inspection and verification. During the launch, these same cameras can be used to provide visual monitoring of the flight critical events.

We have designed and tested analog video system functionally that is composed of two cameras, video control unit (VCU), video transmitter and antennas. Without any digital data processing, we could develop this video system simply and easily. Video control unit needs to select one video signal between two cameras according to the flight key events including 1st/2nd stage separation, 2nd stage engine ignition, satellite separation and so on. Video transmitter shall modulate NTSC (National Television System Committee) color video signals to S-band frequency after pre-emphasis circuit (McMahon 1992, Thorn 1973). In this paper, we provide the design description and functional test results with various block diagrams and pictures of the NTSC on-board analog video system (Grob 1984).

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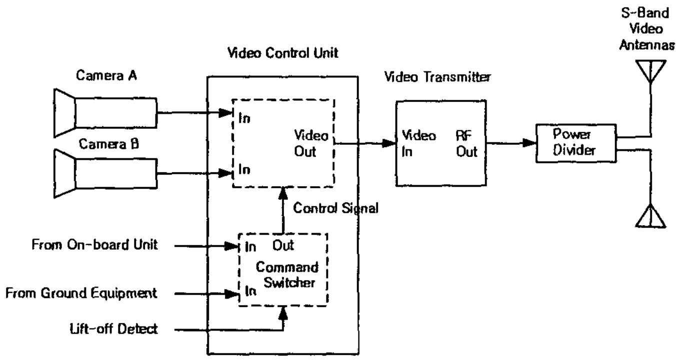


Figure 1. Configuration of on-board analog video system.

Table 1. Auto sequence timing for video selection.

Flight time(second)	Selection	Key events
0 ~220	Downward A video	1st stage engine ignition, lift-off
220~ 228	Upward B video	payload fairing jettison
228 ~520	Downward A video	1st stage engine cutoff, 1st/2nd stage separation, 2nd stage engine ignition/cutoff
520 ~600	Upward B video	2nd stage/satellite separation, CCAM begin/end

2. DESIGN OF ON-BOARD ANALOG VIDEO SYSTEM

On-board analog video system has sub-units with two cameras, video control unit, video transmitter and S-band power divider and antennas as shown in Figure 1. Two cameras shall be low profile products and placed on the outer wall of the upper stage. One gets the pictures of the upward direction, and the other does the images of downward direction. Only one image signal between two cameras would be selected by video control unit and sent to video transmitter according to event sequence timing conditions because we design the video system with analog transmission method. Table 1 shows switching times and selected images under the key events of the flight mission analysis.

As the major component of this system, video transmitter modulates the video camera signal from video control unit into S-band analog FM (Frequency Modulation) with AC coupling mode and then amplifies the modulated signal. In particular, pre-emphasis circuit is built in to enhance signal to noise ratio (SNR) of color video signal before modulation processing (Taylor 1982). Lastly, RF signal from video transmitter is splitted and distributed by power divider and radiated through antennas to the ground station.

3. FUNCTIONAL TEST OF ON-BOARD ANALOG VIDEO SYSTEM

For functional test of the video system, we have used two cameras, model XC-999 made in Sony company. While video control unit implemented on the bread board, the signal generator board for video control unit was also designed and implemented with FPGA (Field Programmable Gate Array) and ULN2803A darlington arrays according to signal interfaces as shown in Figure 1.

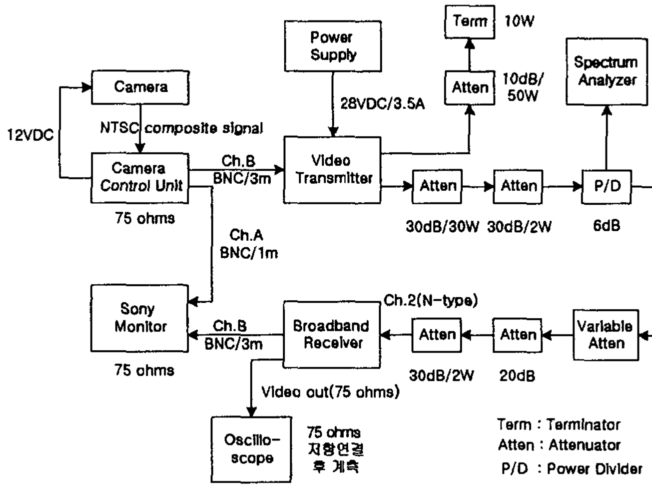
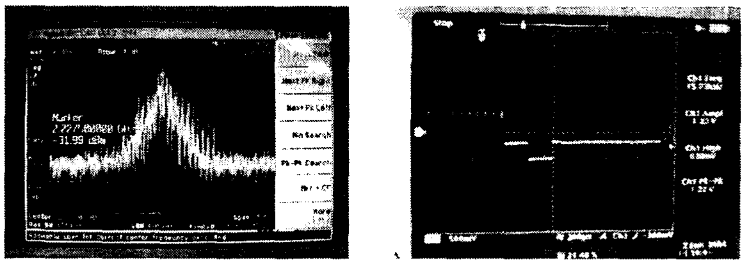
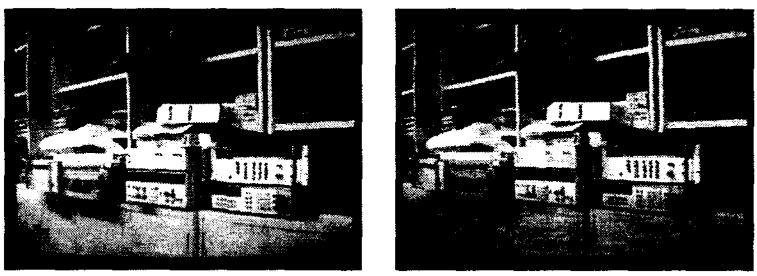


Figure 2. Test configuration of prototype video transmitter.



(a) Spectrum of composite signal (b) Vertical blanking signal

Figure 3. Spectrum and vertical signal after FM modulation.



(a) Original picture (b) Reconstructed picture@-84dBm

Figure 4. Comparison of pictures' quality according to RF receiving power.

We have validated that video control unit operated in time by auto sequence switching of Table 1.

Figure 2 shows the test configuration of prototype video transmitter. The key objectives for this test are to: 1) check the FM modulation status into S-band frequency without any distortion of

NTSC video signal, especially vertical blanking signal with DC constituent, 2) find out the value of the intermediate frequency bandwidth (IFBW) for the best reconstructed picture at the receiver, 3) compare the original and reconstructed pictures, and discover the minimum input sensitivity of the receiver through the best IFBW.

As shown in Figure 3, we have acquired the RF spectrum with predicted center frequency, following FM modulation and validated the successful modulation without any distortion of NTSC video signal including the vertical blanking signal (McMahon 1992, Grob 1984). As setting and testing the various values of the receiver's IFBW, the best bandwidth was come out 13MHz. Because de-emphasis circuit is included in the broadband receiver, we could monitor the output of the receiver directly. Finally, the original and reconstructed pictures have been compared to RF receiving power, as shown in Figure 4. This test could be executed by setting various attenuation values between video transmitter and broadband receiver. Up to -80dBm, we couldn't distinguish between the original and reconstructed images. From –81 dBm to –91 dBm, we have recognized that receiving pictures' quality got worse and at last, any images wouldn't be displayed on the monitor at –92 dBm, the minimum input sensitivity for the implemented analog video transmission system.

4. CONCLUSIONS

On-board analog video system has been designed, implemented in prototype model and tested functionally. Due to analog video transmission, the system needs to select one video signal between two cameras according to the flight key events and perform pre-emphasis processing and FM modulation with NTSC video signal. Through the functional test, we have verified and validated that the video switching was operated in time with designed sequences, and FM modulation and demodulation were executed in success. Lastly, we have compared the pictures' quality between the original and reconstructed images according to RF receiving power.

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