CONDITIONING AND RECOVERY OF AIRCRAFT POSITION SIGNALS THROUGH AN EXISTING DATA LINK

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Summary A Signal Data Converter system records aircraft present position and altitude data on film and also displays this data in a ground shelter, allowing for real time surveillance by a ground observer. This is accomplished by adapting a unique digital data transmission system to an existing infrared video data link.

Introduction The Signal Data Converter system described herein allows for real time surveillance by a ground based observer. The system records aircraft present position and altitude data on film and displays this data in a ground shelter. This is accomplished by adapting a unique digital data transmission system to an existing infrared video data link, By means of this new system the aircraft's present position and altitude are recorded, telemetered and displayed on the ground. Thus target coordinates can be immediately acted upon or the filmed data can be analyzed some time later by intelligence personnel.

This paper will concentrate on the designs that were necessary in converting the analog input signals into digital form and setting up a time codification and sequence to allow the use of the existing telemetry link. The only available transmission time was to be restricted to every other blanking pulse interval. After signal conditioning in both form and format the information is fed to the existing telemetry transmitter.

The signal recovery circuitry will also be described in detail. This signal recovery is achieved without any additional timing commands since the system is self-synchronizing. The ground based equipment reconverts the transmitted information into the analog form necessary for decimal display.

Signal Data Converter System, (see figure 1) The Signal Data Converter system receives north-south (N-S) and east-west (E-W) present position input signals from the navigational computer, and an altitude input signal from the radar altimeter. These input signals represent the distance of the aircraft from some known point (in kilometers) in both the N-S and E-W directions, and the altitude of the aircraft in feet. These signals drive N-S, E-W, and altitude counters in the airborne camera, and are converted to serial-digital form for telemetry to the ground. On the ground, this data is converted back to parallel-analog form, and is used to drive N-S, E-W, and altitude counters in both the ground camera and in the display panel.

Airborne Signal Data Converter (see figure 2)

(1) N-S & E-W Present Position Indicator - The N-S and E-W Present Position indicator receives input signals from two 2speed synchro control transmitters (CX's) in the navigational computer. The N-S and E-W signals are fed to 2-speed synchro transformers (CT's). The two CT outputs are then fed to a cross-over network. When the servo is far away from null, the output from the coarse CT is fed to the servo amplifier. When the servo approaches null, the cross-over network switches from the coarse CT to the fine CT. The output from the fine CT is then applied to the servo amplifier until the servo reaches null. The output from the servo amplifiers is fed to servo motors, which in turn drive the N-S and the E-W counters. These counters display the present position of the aircraft in kilometers.

(2) N-S and E-W Digitizers - The present position signals from the navigational computer are also fed to the N-S and E-W Digitizers. These digitizers contain analog servos similar to those in the N-S & E-W Present Position Indicator, except that the servo motors drive digital encoders instead of counters. These encoders are rotary devices which convert an analog (shaft position) input into a digital output. The encoder generates a 13-bit binary work which represents the shaft position of the encoder in digital form.

(3) Altitude Converter - The CX signal from the altimeter is non-linear with respect to altitude. Before it can be used, it must first be linearized by the Altitude Converter. The non-linear altitude CX signal from the altimeter is fed to an analog servo in the Altitude Converter. This analog servo drives a function potentiometer. The electrical output from the wiper of this function pot is non-linear with respect to the rotation of its shaft. The function of the output is the inverse of the function of the altitude signal. Thus, when the non-linear altitude signal drives the function pot, its output is linear with respect to altitude.

(4) Altitude Digitizer - The output from the function pot in the Altitude Converter is fed back-to-back to a function pot in the Altitude Digitizer, which in turn produces an error signal if the two pots are in different positions. This error signal is fed to an analog servo which drives both a digital encoder and a CX, The digital encoder is the same as those in the N-S and E-W Digitizers.

(5) Altitude Indicator - The altitude CX signal from the Altitude Digitizer drives an analog servo in the Altitude Indicator. The servo positions the altitude counter, which displays the altitude of the aircraft in feet.

(6) Servo Scanner and Transmitter (Logic Circuitry) (see figure 3) - The airborne logic circuitry scans the three 13-bit words from the N-S, E-W, and altitude digital encoders and converts them from the parallel-bit, serial-word form to the serial-bit, serial-word form for telemetering to the ground. This is done as follows: The airborne logic circuitry (figure 3) receives external 5-microsecond data timing (T) pulses every 5.5 milliseconds. (Figure 4 illustrates all the pulses referred to in this discussion.) The data timing pulse is fed to a one-shot multivibrator. The 25-microsecond command pulse from this one-shot multivibrator synchronizes to the data timing pulse, resulting in a system-start pulseo The system-start pulse has the same period as the command pulse, but is synchronized to the internal 50-KC oscillator instead of the external data timing pulse, The system-start pulse qualifies the count-by-14 network. This sends 14 C_o pulses to the output gates for every command pulse. The first C_o pulse is a clock pulse to the output gates, the second qualifies the 20 data bit from the parallel to serial register, the third pulse is again a clock pulse, the fourth pulse qualifies the 2^1 data bit, and so forth. This sequence continues until 7 clock pulses and 7 data bits are transmitted, This comprises the first half of a binary word. The next data timing pulse starts the same sequence for transmission of the remaining 6 bits of the 13-bit binary word. Besides triggering a command pulse, the external data timing pulse drives a count-by-7 network and a scan counter. The count-by-7 network's first two one-shot multivibrators produce one 200microsecond pulse and one I-millisecond pulse for every 7 data timing pulses. The 200-microsecond frame-start pulse signifies the beginning of each frame of data. The 1-millisecond blanking pulse prevents any clock or data pulses from being transmitted along with the frame-start pulse. The data timing pulses are fed to a count-by-2 network in the scan counter. The scan counter receives these output (X) pulses from this network and makes 4 counts in sequence. This count of 4 comprises one frame of output. The output of the scan counter drives a scan matrix, which selects the proper encoder to be read. The scanning sequence is continuous and takes the following format:

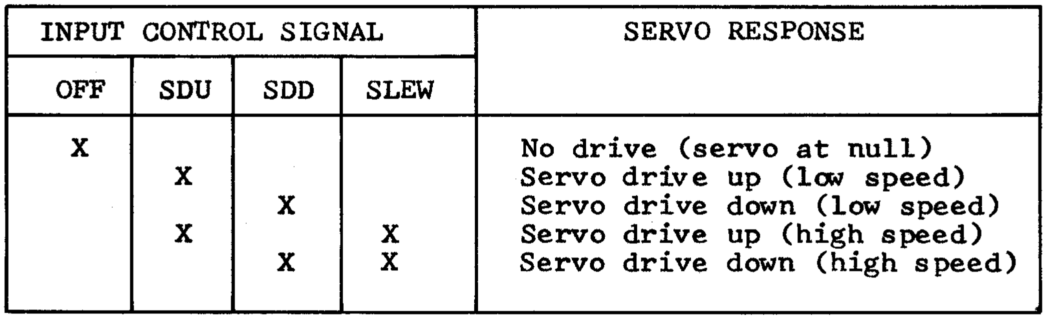
W Pulse	Y Pulse	Transmit
0	0	Frame-start pulse
0	1	N-S data
1	0	E-W data
1	1	Altitude data

When an encoder is read, a positive voltage is applied to the common brush for the scanning period of 11 milliseconds. During the scanning period, all brush outputs are fed to the brush selection logic, which performs V-scan selection and generates a 13-bit nonambiguous binary word. The binary word is fed to the parallel to serial register, and then to the output gate. The airborne logic circuitry is continuous in operation, and synchronizes to the external data timing pulses in 30 microseconds or less.

Ground Signal Data Converter (see figure 5)

(1) Servo Selection and Controller (Logic Circuitry) (see figure 6) - The function of the logic circuitry in the Servo Selection and Controller is to compare the N-S, E-W and Altitude input data telemetered from the airborne encoders with the feedback data from the ground encoders and drive the bang-bang servos until the input and feedback data are the same. This is done as follows: The serial input data telemetered from the Airborne Signal Data Converter is fed to a data sensor and to a pulse width detector. The data sensor separates the clock pulses from the data pulses. The pulse width detector gives one output pulse for every input 200-microsecond frame-start pulse. This output pulse resets the count-by-14 network, the word counter, and the time sharing network after each frame of data. The time sharing network receives input clock pulses from the data sensor, and pulses from the 50KC multivibrator. The time sharing network allows the count-by14 network to count 14 input clock pulses from the data sensor, and then 14 pulses from the 50KC multivibrator. Every output pulse from the count-by-14 network signifies one word of data. The clock pulses from the time sharing network are fed to a one-shot multivibrator, which in turn shifts the serial input data from the data sensor into the input register. This converts the input data from serial-bit form to parallel-bit form. (See figure 7 for sequence of operations.) At the same time that the input data is shifted into the input register, the decoding matrix scans the proper feedback encoder. When all 13 bits of input data are shifted into the input register, the output from the feedback encoder is fed to the brush selection network, and then to the feedback register. Since the data from the feedback encoders is in parallel-bit form, it does not require shifting to be fed into the register. After the feedback data is in the feedback register, the time sharing network sends 14 50KC pulses to a one-shot multivibrator which in turn shifts both the input data and the feedback data into the serial adder. The serial adder finds the difference between the input and feedback data by adding the complement of the feedback data to the input data. The difference is then fed back into the input register. Thus, as the input data is leaving the input register, the difference is delayed slightly and fed right in behind. When all the difference data is in the input register, it is then fed to the servo drive network. The servo drive network decides which way the servo has to be driven, and whether it should be driven at normal speed or slew speed. The output from the servo drive network is fed to the servo control networks, which specify which servo is to be driven. The AC control signal from the servo control network is fed to the bang-bang servo, which drives the servo to null. When the servo reaches null, the input and feedback data are the same, and no control signal is fed to the servo. The input data is sampled every 38.5 milliseconds, and the entire sequence is repeated.

(2) N-S, E-W, and Altitude Digital to Analog Servos - These servos are commonly called “bang-bang” servos. This is due to the fact that the input AC control signal to these servos is either on or off. When the control signal is on, it is at either one of two levels. The servo, when it is running, can either run in one direction (servo drive up), or the other (servo drive down), at either speed. When the servo is sufficiently far away from null, it is driven at high speed. When it approaches null, control is switched to low speed. The following table shows the various inputs and the corresponding servo response.



INPUT CONTROL SIGNAL				SERVO RESPONSE
OFF	SDU	SDD	SLEW	
X				No drive (servo at null)
	X			Servo drive up (low speed)
		X		Servo drive down (low speed)
	X		X	Servo drive up (high speed)
		X	X	Servo drive down (high speed)

Except for the type of input, these “bang-bang” servos work the same way as an ordinary analog servo. Each bang-bang servo drives an encoder and a 2-speed CX. The encoders work the same as those in the Airborne Signal Data Converter. The 2speed CX provides analog signals to drive the analog servos in the N-S and E-W Present Position Indicators, and in the Altitude Indicators,

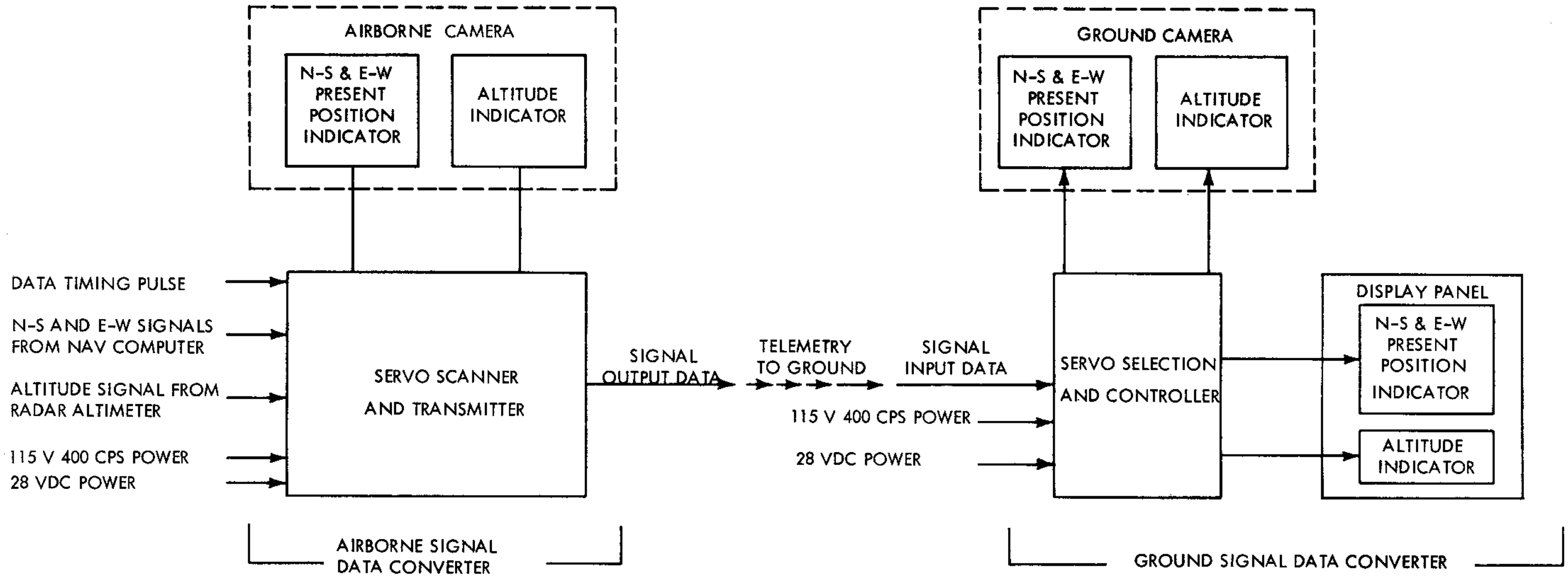


Figure 1 - Block Diagram of Signal Data Converter System

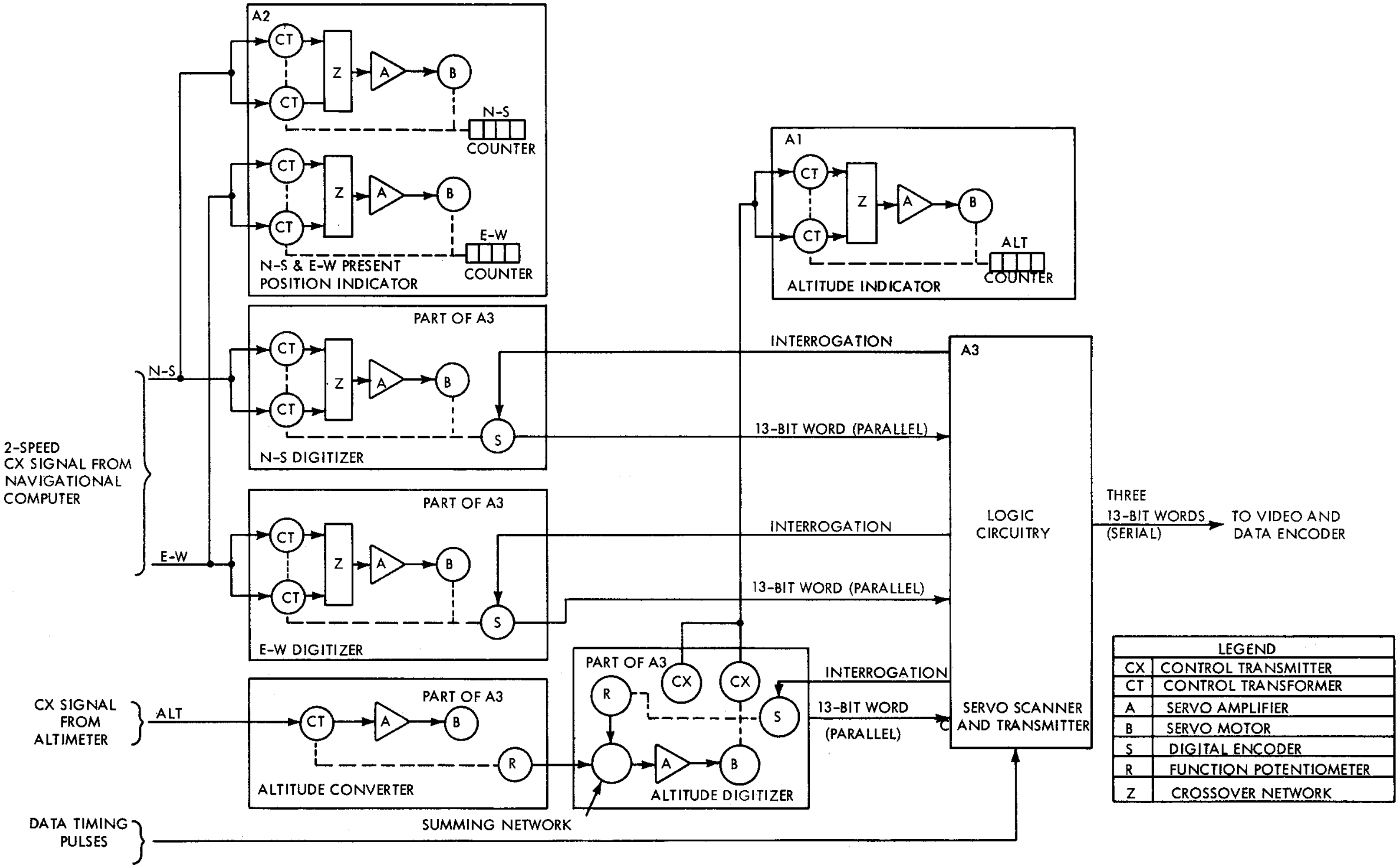


Figure 2 - Block Diagram of Airborne Signal Data Converter

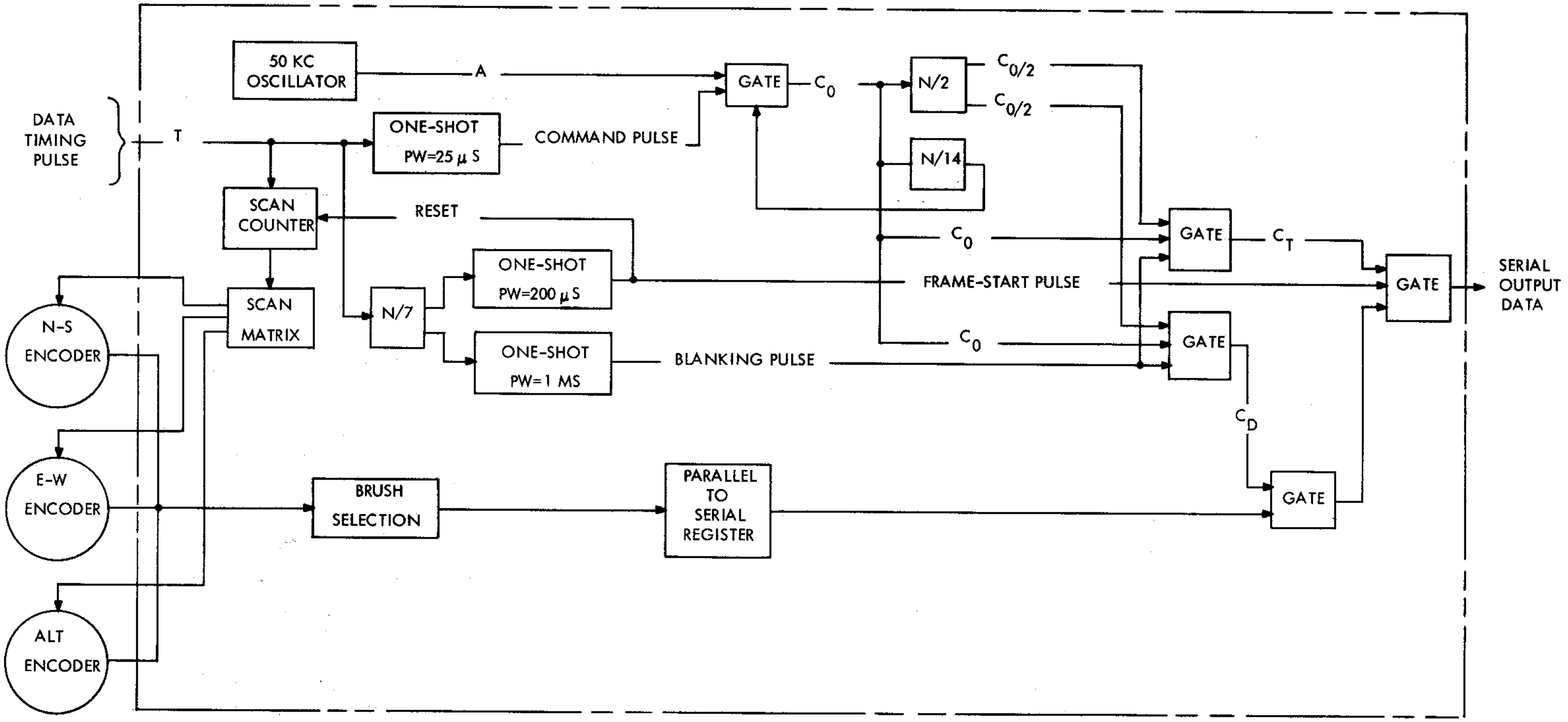


Figure 3 - Airborne Logic Circuitry

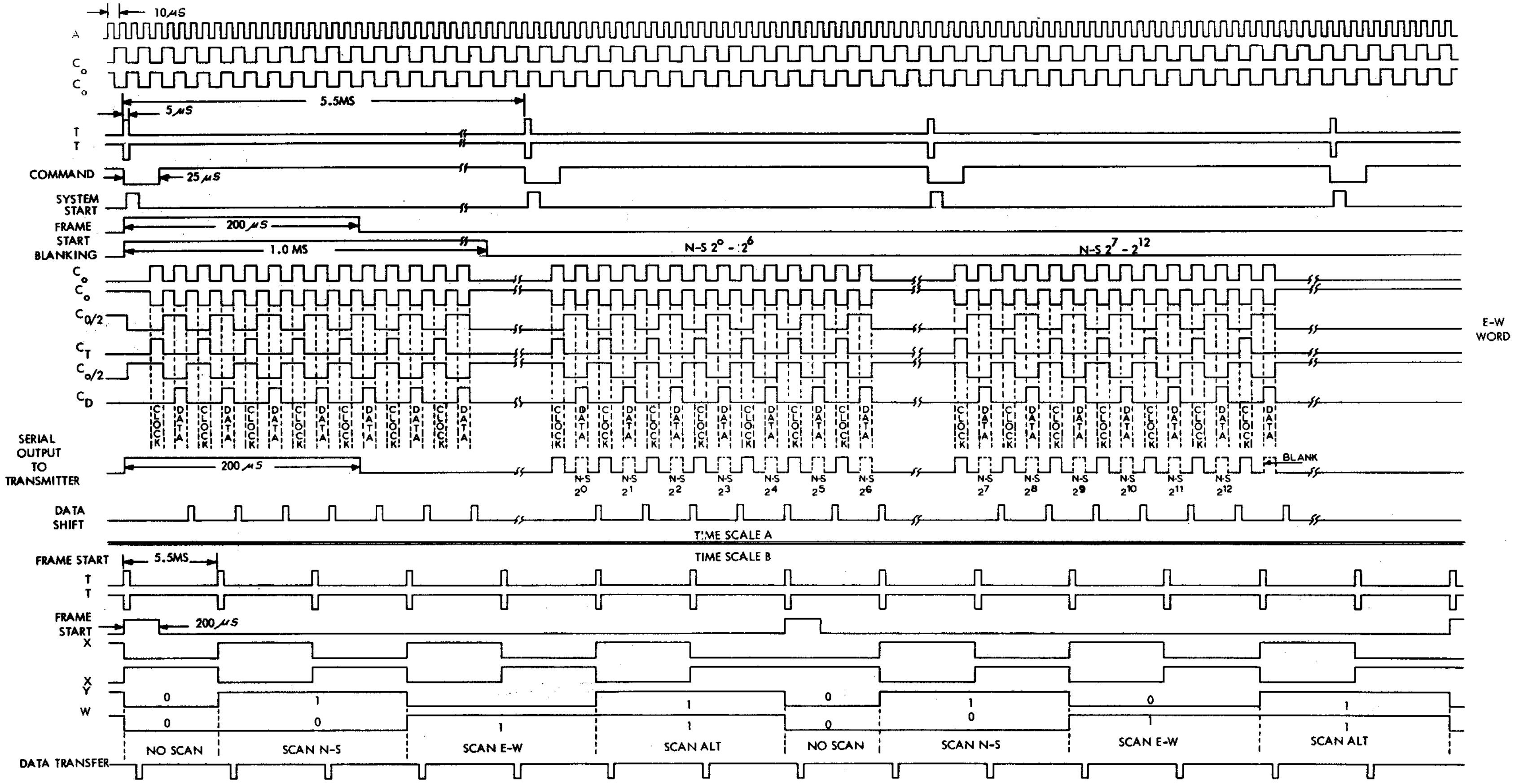


Figure 4 - Timing Diagram of Airborne System

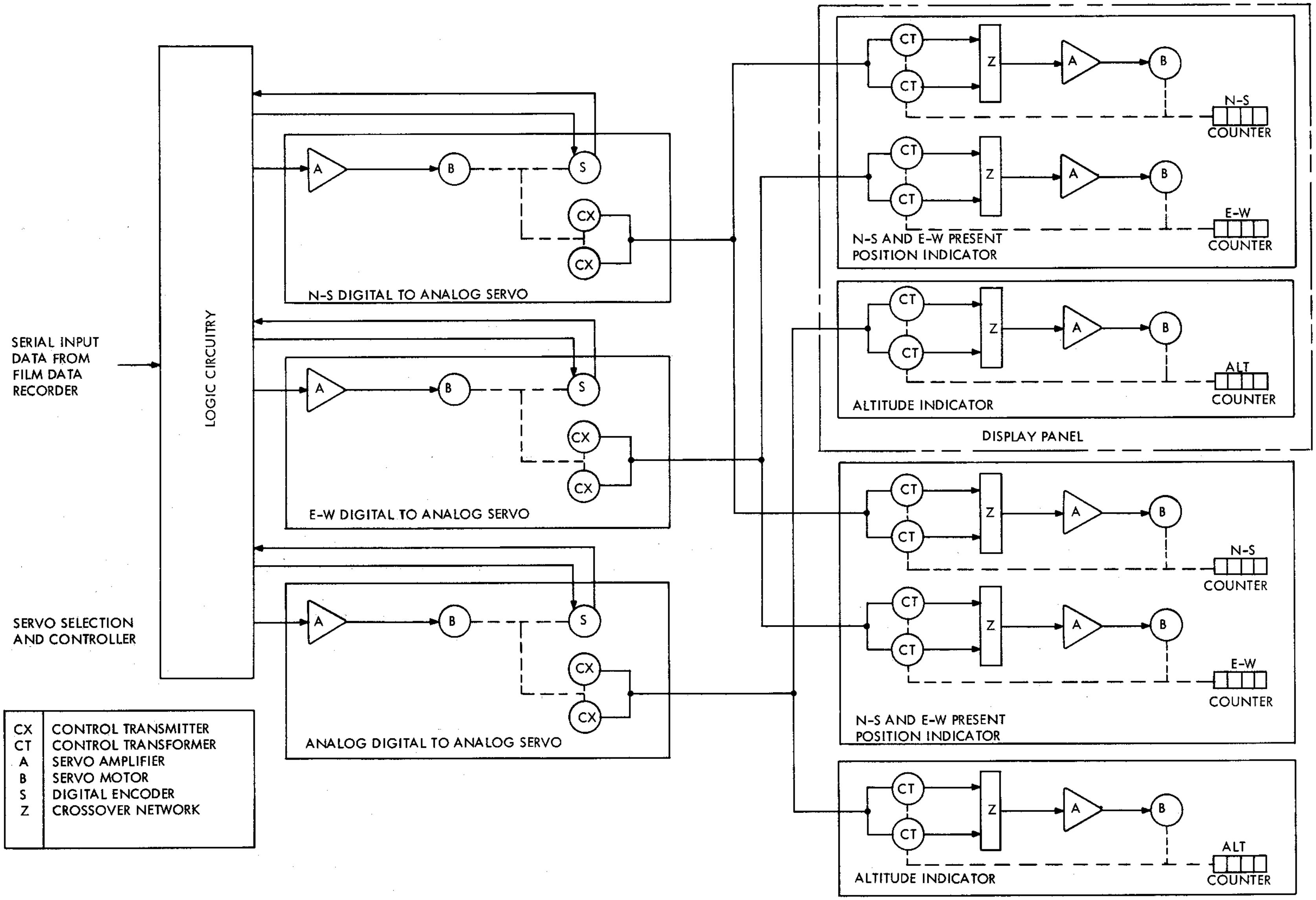


Figure 5 - Block Diagram of Ground Signal Data Converter

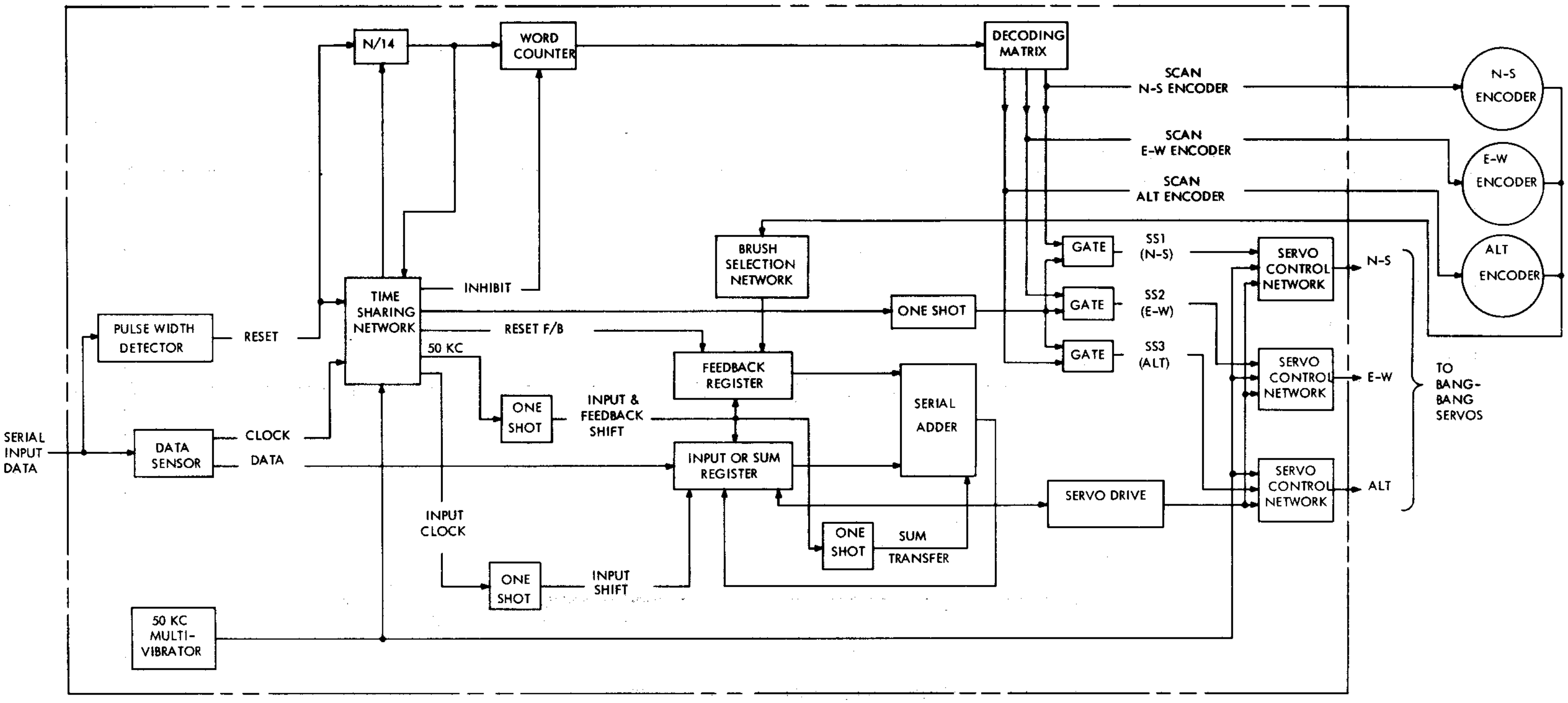


Figure 6 - Ground Logic Circuitry

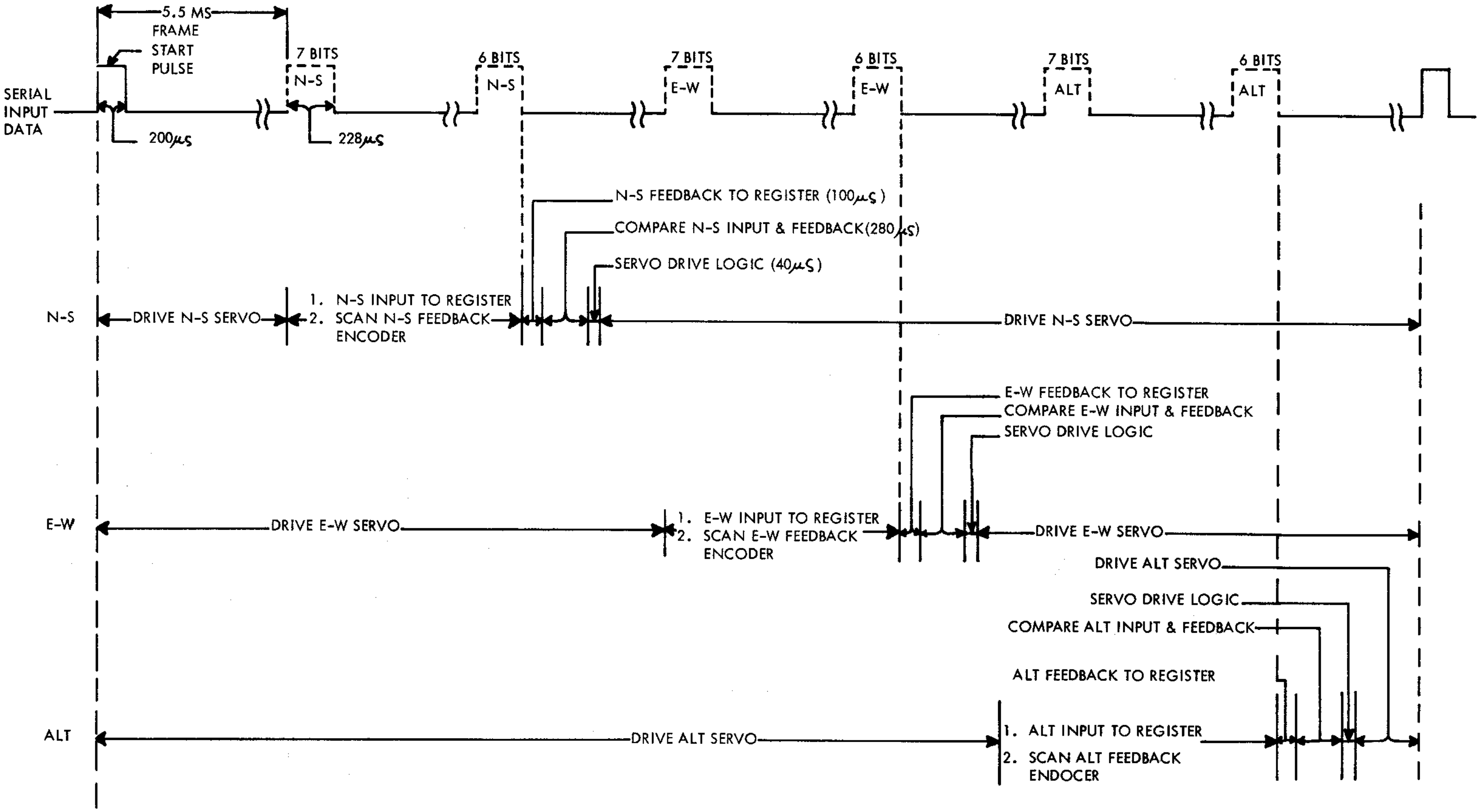


Figure 7 - Sequence of Operations, Ground System