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COMMAND LINKS

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COMMAND LINKS

The equipment used to send command signals to a vehicle actually performs the function of a communications link. Since a carrier must be altered by various means before it can transmit intelligence, one should be acquainted with the types and functions of modulation.

A. Modulation

Modulation is a process of impressing intelligence upon a carrier by altering the carrier's amplitude, frequency, or phase, in accordance with the variations of the signal being transmitted. When some characteristic of the carrier is caused to vary as a function of the instantaneous value of the modulating signal, the receiver can detect the variations and translate it into an intelligible form. Modulation methods can be broadly classified into five general categories:

1. Amplitude modulation
2. Frequency modulation
3. Phase modulation
4. Pulse modulation
5. Doppler principle

1. Amplitude Modulation

Amplitude modulation (AM) is the process by which the magnitude of a carrier wave is varied according to the modulation wave envelope as shown in Figure 1.

2. Frequency Modulation

Frequency modulation (FM) is the process which impresses the signal on the carrier by varying the frequency of the carrier in accordance with the frequency of the signal as shown in Figure 2.

3. Phase Modulation

Phase modulation is a slight modification of frequency modulation and is accomplished by passing the radio frequency and audio frequency signals through various phase-finding networks which tend to change the phase of the AC radio frequency carrier voltage. This means that the phase of the cycle shifts with respect to each preceding cycle and that the last cycle is ahead or behind its normal phase as shown in Figure 3.

t_1 - NORMAL PERIOD

t_2 - LONG PERIOD - PEAK OCCURS LATER DUE TO PHASE SHIFT

t_3 - SHORT PERIOD - PEAK OCCURS EARLIER DUE TO PHASE SHIFT

FIGURE 3

4. Pulse Modulation

Pulse modulation samples the intelligence to be transmitted during brief, periodic intervals and uses these samples to modulate the carrier. There are several types of pulse modulation which are shown in Figure 4 and listed as follows:

- a. Pulse Amplitude Modulation (PAM)
- b. Pulse Width Modulation (PWM)
- c. Pulse Displacement Modulation (PDM)
- d. Pulse Frequency Modulation (PFM)
- e. Pulse Count Modulation (PCM)

FIGURE 4

5. Doppler Principle

The Doppler effect produces a frequency-shift modulation external to the transmitting equipment as contrasted to previously discussed modulation which was accomplished internally. The Doppler principle involves the apparent change in the frequency of electromagnetic waves observed while the source and target are in motion relative to each other.

Figure 5 is an illustration of the Doppler effect.

FIGURE 5

A. Antennas

An antenna is an electronic device that is used either for radiating electromagnetic energy into space or for collecting electromagnetic energy from space. Fortunately, separate antennas seldom are required for transmitting and receiving radio energy assuming, of course, that the frequency is the same. This property of interchangeability of the same antenna is known as antenna reciprocity.

Usually, the most important characteristic of a radar antenna is its directional property or directivity. Directivity means that an antenna radiates more energy in one direction than in another. In some operations, some antennas are required to send all energy in one direction and in other systems it is desirable for the energy to be radiated equally well in all directions from the source.

C. Propagation into Space

Any part of the electromagnetic field set up by an antenna travels away from the antenna in a straight line. If there is nothing between the emitting antenna and receiving antenna, the radiated energy will travel directly to the receiving antenna. At a height of some 60 miles above the earth, there is a heavily ionized layer of atmosphere called the ionosphere. Generally, medium and high frequency waves are reflected easily, whereas ultra high and super high frequencies are more likely to be lost through penetration of the ionosphere. (See Figure 6).

D. Vehicle Transponder

In previous sections we have shown how a command message is generated, modulated, and propagated through space. Now, we will look at what occurs when the message reaches the vehicle. The message enters the vehicle at the command antenna, fed into the transponder receiver, demodulated and converted into proper form and then fed to the decoder where the following units are extracted:

1. Checks message address
2. Triggers and pulses from message
3. Digit content or command
4. Checks for missing digits
5. Checks for double digits

Assume a command message of the following nature to be transmitted:

1110101 11

			t.s. 1	2		3		4						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				0				0						

UNDELAY MESSAGE

BLOCKING OSCILL.

10 μ S

20 μ S

AND

BLOCKING OSCILL.

1st GATE

DIFF.

2nd GATE AMP

BLOCKING OSCILL.

CAPTURE FALL

OR II

AND IV

OR I

200 μ S DELAY

BLOCKING OSCILL.

STOP PULSE

AND V

UNDELAY / 10 μ S DELAY

BLOCKING OSCILL.

AND VII

AND VI

20 μ S DELAY (also B.O)

AND 4

AND 7

AND 5

Stopper

EXTRACTS 2'S

DOUBLE DIGIT

CHECK

12 3 4 5 6 7 8 9 10 11 12 13 14 15 17

Undelay message

10 μ s delay

20 μ s delay (1)

AND output

First Gate

Differentiator output

Second Gate

Gated Amplifier

OR I

OR II

20 μ s delay (also B.O)

AND 4

AND 7

AND 5

Stopper

8.5 μ S

TRIGGERS OUT

E. Multiplexer

Data returning from a Space Vehicle is fed from the antenna, to a receiver, through a data processing system and finally to a multiplexer. The multiplexer accepts parallel information and converts it into serial form with a definite timing between each output. The multiplexer consists of diode tree and shift registers as shown in Figure 8.

FIGURE 8

F. Binary Exercise

The block diagram below (Figure 9) describes a typical Tactical Air Control and Navigation System (T.A.C.N.). The object is to acquire an aircraft at extreme range and determine its approach to the airport. The computer determines Speed, Altitude, Glide Angle, and Bearing (S.A.G.B.). Figure 10 shows a Data Flow Block Diagram of the binary components.

SHIFT REGISTER - 1

BINARY SECTION
FIGURE 10

This section concludes the notes on a command guidance system using binary information. The next section will deal with telemetry components and systems that are in use today.