CHAPTER 6

LINK-4A

INTRODUCTION

The Link-4A system is a fully automatic, high-speed data transmission system used for aircraft control. The system provides controlling information to the aircraft, using radio transmission between the controlling ship and the controlled aircraft. The Carrier Aircraft Inertial Navigation System (CAINS) is also a part of the Link-4A system. The CAINS system is used to load alignment and way-point data into the aircraft on the flight deck or the hangar deck.

After completing this chapter, you should be able to:

- **Describe the functions of the Link-4A system.**
- **Describe the operating modes of the Link-4A data terminal set.**
- **Describe the types of messages used by the Link-4A system.**
- **Describe the functional operation of the Link-4A data terminal**
- **Describe the test messages used in the Link-4A system.**

LINK-4A SYSTEM OVERVIEW

The two major components of the Link-4A system are the Link-4A CDS system and the CAINS system. Both systems use serial time-division multiplexing to transmit control and reply messages over a frequency-shift keyed (FSK) UHF radio communications channel. The CAINS system can also transmit data via hard-wired stations on the flight deck or hangar deck.

LINK-4A CDS SYSTEM

The Link-4A CDS system is used to provide one-way or two-way communications between the controlling station and up to 100 controlled aircraft. The controlling station transmits to the aircraft control messages containing vectoring information, commands, and data pertaining to the target or destination of the aircraft. The aircraft transmits reply messages containing information concerning its heading, altitude, airspeed, and tactical readiness. The aircraft control messages are developed by the CDS computer using radar-derived target data, reply data from the aircraft, and other tactical data.

A typical shipboard Link-4A system configuration is shown in figure 6-1. It consists of the CDS computer, a data terminal set, a communications switchboard, and a UHF radio transceiver.

The CDS computer outputs parallel digital data to the Link-4A data terminal set. Currently, the data terminal set most shipboard installations use is a type of the AN/SSW-1 (U). It will be designated as the AN/SSW-lA/B/C/D/E(U). The data terminal set converts the computer data into a serial time-division multiplexed pulse train that is transferred to the radio transceiver through the communications switchboard. The communications switchboard connects the selected UHF transceiver to the data terminal set. The radio transceiver converts the pulse train into FSK variations in the carrier signal frequency.

After the aircraft receives the transmitted data, it may respond by transmitting data to the controlling

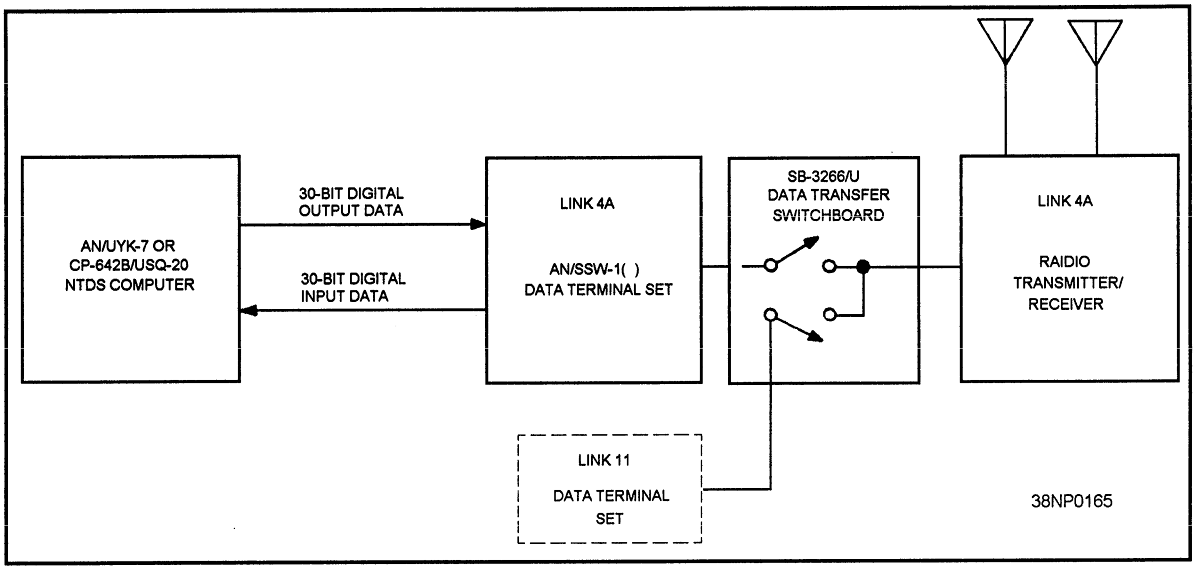

Figure 6-1.—The shipboard Link-4A CDS system.

station. This is the reception cycle. The receiver removes the carrier frequency and forms the serial data pulse train. The pulse train is sent to the data terminal set via the switchboard. The data terminal set converts the serial pulse trains into parallel data and sends the data to the CDS computer.

In a typical aircraft carrier system, the four distinct modes of operation in the Link-4A system are intercept vectoring, air traffic control, automatic carrier landing system, and precision course direction.

Intercept Vectoring

Intercept vectoring enables the controlling ship to guide an aircraft to an intercept point. The two types of data sent to the aircraft during intercept vectoring are command data and situation data. Command data provides direct steering and control information, whereas situation data provides the aircraft with an overall picture of the tactical situation with respect to its target.

This data is used to guide the aircraft within striking range of its target at optimum position and altitude for an attack. The messages also contain instructions to the pilot, such as target identity, break engagement, and return to base.

Air Traffic Control

In the air traffic control mode, Link-4A is used to control the aircraft in the carrier's traffic pattern. The control station transmits data to the aircraft to maintain safe flight patterns and assigns priority for landing approach. As each aircraft enters the landing pattern, it is transferred to the automatic carrier landing system for final approach and landing.

Automatic Carrier Landing System

The automatic carrier landing system selects aircraft in the order of priority from the pattern and enters them into the final approach. During the final approach, a precision radar tracks the aircraft. Correct information pertaining to the approach is transmitted to the aircraft's autopilot. When conditions are unfavorable for a landing, the wave-off control is initiated and the aircraft is guided through a short pattern and the landing approach is repeated.

Precision Course Direction

The precision course direction mode is used in the remote guidance of bomber and reconnaissance aircraft, and drones. The guidance messages contain pitch, bank, heading, altitude, and airspeed commands to permit very precise control of the aircraft's flight path.

CARRIER AIRCRAFT INERTIAL NAVIGATIONAL SYSTEM (CAINS)

The CAINS system is used to load alignment and way-point data into aircraft on the flight deck or the hanger deck. Aircraft alignment data consists of longitude, latitude, and ship's velocity data from the ship's inertial navigation system. Way-point data is a set of predetermined geographical points loaded into the aircraft's navigation computer. Way points provide the aircraft with destination or target information.

When the CAINS system is used, data can be loaded into the aircraft by either a hard-wired system or RF radio transmission. The hard-wired insertion of data is accomplished when the aircraft is connected to a deck edge outlet box (DEOB). The pulse amplifiers of the AN/SSW-1D/E can provide outputs for up to 40 of these DEOBs. After the initial data is loaded, the aircraft is disconnected from the DEOB, but it continues to receive alignment data until the launch. Then the aircraft system reverts to its original tactical condition.

LINK-4A MESSAGE FORMATS

The following are the three types of messages used in the Link-4A system: **control messages, reply messages,** and **test messages.** These messages use two basic formats. Control messages are transmitted from the controlling ship to the aircraft. Reply messages are transmitted from the aircraft to the control station.

The timing for Link-4A communications is determined from the duration of the transmit and receive cycles. The standard CDS control messages are 14 msec in duration, while the receive cycle for reply messages is 18 msec in duration. The CAINS system does not use reply messages; therefore, a 2 msec receive cycle is substituted to allow time for the Link-4A data terminal set to initialize the next message. Thus we have the following two timing cycles: 14/18 (control message 14 msec/receive cycle 18 msec) and 14/2 (control message 14 msec/receive cycle 2 msec).

CONTROL MESSAGE FORMAT

Control messages are assembled and transmitted during the 14-msec **transmit frame.** Figure 6-2 shows the standard structure of a Link-4A control message. During the transmit frame, the transmit key signal and the control message pulse train are sent to the radio set transmitter. The transmit frame is divided into seventy 200 µsec time slots that contain the **sync preamble,** the **data bits,** and the **transmitter un-key** signal.

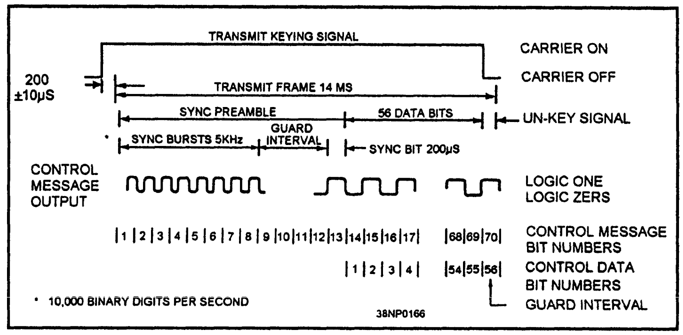

Figure 6-2.—The Link-4A control message format.

Sync Preamble

The sync preamble is made up of the first 13 time slots of the control message. The first eight time slots each contain one cycle of a square wave, consisting of 100 µsec in the "0" state and 100 µsec in the "1" state. These eight time slots are known as the sync burst. Following the sync burst are four time slots in the "0" state, called the guard interval. The guard interval indicates the changeover to the 200-µsec data signals. Time slot 13 is the start bit and is always a "1."

Data Bits

The Link-4A message data is contained in the 56 time slots (slots 14 through 69) that follow the sync preamble. Each time slot contains one data bit. The first 13 bits of this data is a binary number that indicates the address of the particular aircraft. Only the aircraft with this preassigned address will recognize the message and act on the message data. Following the address is a five-digit label that designates the type of data contained in the message. The labels correspond to the modes of operation. The last digit designates whether the message is an A or B type. In most modes, both an A and a B type of message are required to transmit all the necessary data to the aircraft. The remaining data bit time slots contain the various control commands.

Transmitter Un-key Signal

The last time slot (slot 70) is a 200-μsec period allotted for transmitter turn-off time and does not contain any data.

REPLY MESSAGE FORMAT

Reply messages are received during the 18-msec receive cycle. The reply message contains a total of 56 time slots and occupies a period of 11.2 msec. This 11.2-msec reply must be received during the 18-msec receive cycle. This allows for a maximum of 4.8 msec for transmission delay.

The reply message consists of a sync preamble, 42-data bit time slots, and a guard interval, as shown in figure 6-3. The sync preamble is identical to the control message sync preamble. The information in the 42-data time slots is divided into groups of digits that identify the source and type of message, and the message data. The last time slot is the guard interval and it allows for transmitter turn-off time.

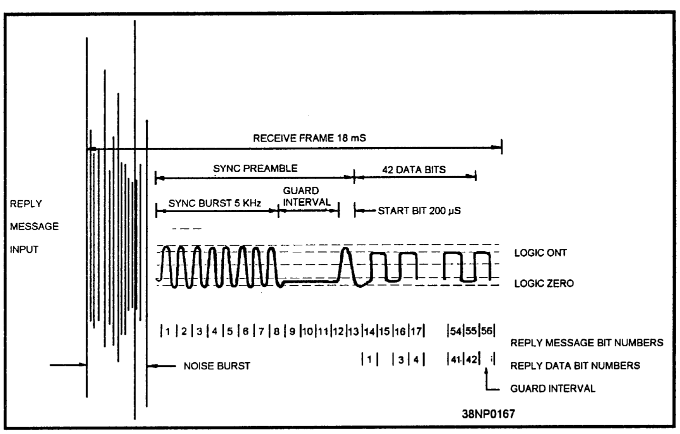

Figure 6-3.—The Link-4A reply message format.

TEST MESSAGES

During Link-4A operations the controlling station sends test messages at periodic intervals to the data terminal set for testing the message processing and display circuitry of the aircraft being controlled. The test messages also check the data terminal set and its interfaces. The two types of test messages are **universal test message** (UTM) and **monitor control and reply messages** (MCM/MRM).

Universal Test Messages

Universal test messages (UTMs) are Link-4A control messages that are always addressed to a particular universal address and contain fixed, specific information in each data field. The UTMs provide the controlled aircraft with a means to verify proper operation of the link.

Monitor Control and Reply Messages

Monitor control messages (MCMs) are Link-4A control messages that are sent to the data terminal set from the CDS computer to initiate internal testing of the data terminal set. After the data terminal set completes its self-check, the MCM is transmitted with the universal address. Depending on the equipment configuration of the aircraft, the MCM will either be rejected or processed as a UTM.

The monitor reply message (MRM) is sent to the CDS computer upon the successful processing of the MCM. The MRM is effectively a return of the MCM data content which indicates that the internal and interface tests were successful.

THE LINK-4A SYSTEM COMPONENTS

The Link-4A system consists of the CDS computer, a data terminal set, a communications switchboard, and a UHF radio set.

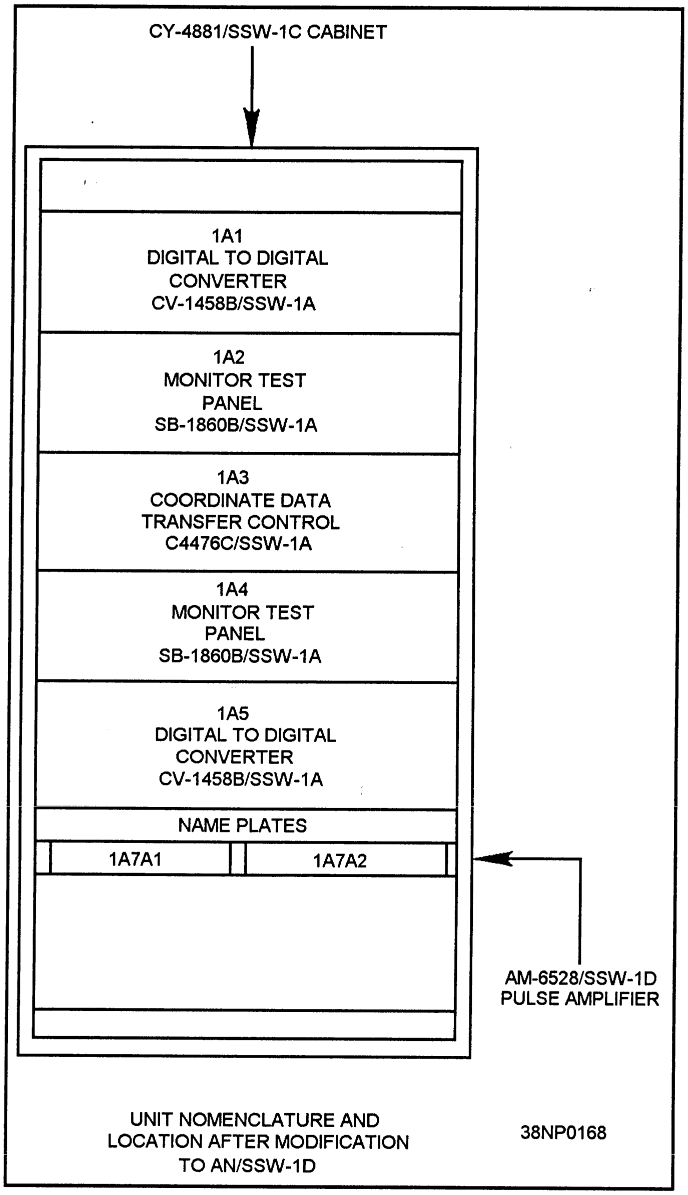

Figure 6-4.—The AN/SSW-1D/E data terminal set.

DATA TERMINAL SET AN/SSW-1D/E

The Link-4A data terminal set is the AN/SSW-lD/E. The data terminal set performs the following functions:

- Provides overall Link-4A system timing
- Converts parallel data from the CDS computer into serial data for transmission to controlled aircraft
- Converts serial data received from controlled aircraft into parallel data for input to the CDS computer.

The current five versions of the AN/SSW-1 used in shipboard Link-4A systems are the AN/SSW-1A, 1B, 1C, 1D, and 1E. The AN/SSW-1A, 1B, and 1C are operationally and functionally identical, as are the AN/SSW-1D and 1E. The major difference between the two groupings of versions is the single-channel capability of the AN/SSW-1A/B/C and the dual-channel capability of the AN/SSW-1D/E. Each of the dual channels is capable of the link operations of the single channel AN/SSW-1. The dual-channel AN/SSW-1D/E is also capable of transmitting CAINS data. For purposes of this lesson, we use the AN/SSW-1D/E.

The AN/SSW-1D/E shown in figure 6-4, consists of the following eight major subassemblies: one **coordinate data transfer control,** two **digital-to-digital converters,** two **monitor test panels,** two

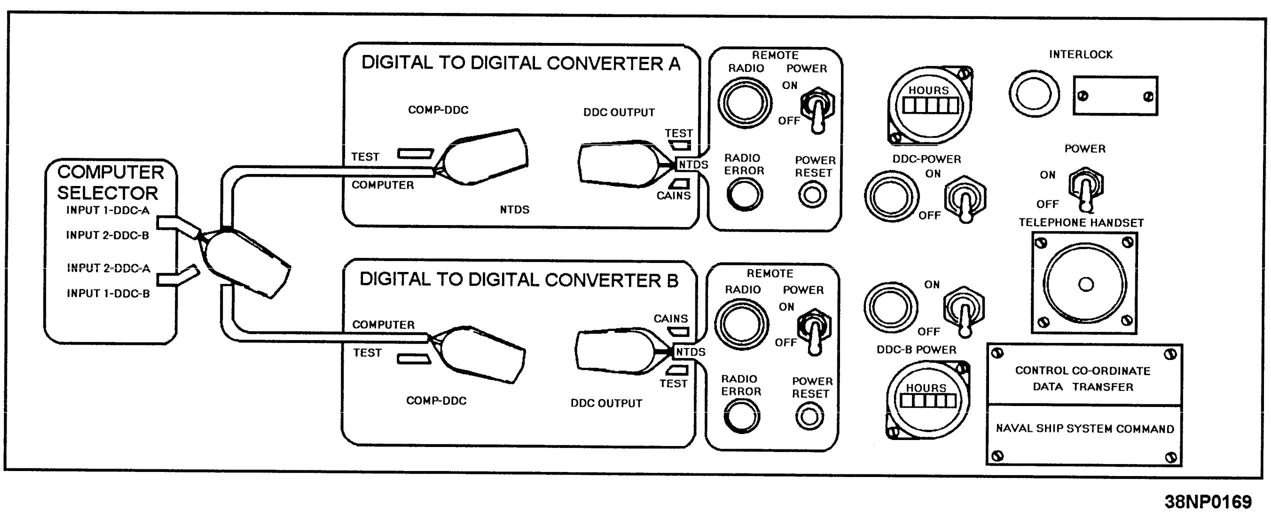

Figure 6-5.—The coordinate data transfer control assembly (AN/SSW-1D/E).

pulse amplifier assemblies, and a power supply assembly. There are two independent equipment groups in the AN/SSW-1D/E. Each group is capable of simultaneous operations with separate and dedicated computer input-output channels and dedicated UHF radio sets.

Coordinate Data Transfer Control

The coordinate data transfer control assembly enables the connection of each of the digital-to-digital converters (DDC) to one of two different computers. The control panel for the coordinate data transfer control assembly is shown in figure 6-5. The COMPUTER SELECT provides switching, such that DDC A is connected to computer 1 and DDC B is connected to computer 2 or vice versa. Either of the two DDCs maybe connected to its monitor test panel for off-line testing. The DDC output options are the CDS (old NTDS) radio set, the CAINS system, or the test mode.

Digital-to-Digital Converter

The digital-to-digital converter assembly provides system timing, converts parallel data from the CDS computer into serial data for transmission by the UHF radio set, and converts serial data received from the radio set into parallel data for input to the CDS computer. The DDC is the heart of the data terminal set.

Monitor Test Panel

The monitor test panel provides the technician with a means to monitor Link-4A operations and off-line testing capabilities. There is one monitor test panel for each DDC.

Pulse Amplifier

The pulse amplifiers provide level and signal conversion functions to allow the AN/SSW-1D/E data terminal set to drive the serial output for the UHF radio set and the deck edge outlet boxes for CAINS.

COMMUNICATIONS SWITCHBOARD

The communications switchboard interconnects the AN/SSW-1 to the UHF radio sets. The communications switchboard is similar to the Link-11 switchboard described in chapter 4 of this manual.

LINK MONITOR SYSTEM (LMS-4)

The LMS-4 provides stand-alone Link-4A monitor and readiness check capabilities, and its operation is similar to the LMS-11 covered in the previous chapter. The monitor function listens passively to the Link-4A communications between the control station and the controlled aircraft. Signal analysis and test message validity are performed on the data. The readiness check function tests the readiness of the control station to conduct live two-way Link-4A operations. Control messages transmitted by the control station are monitored and the LMS-4 generates the reply messages required to maintain two-way communications.