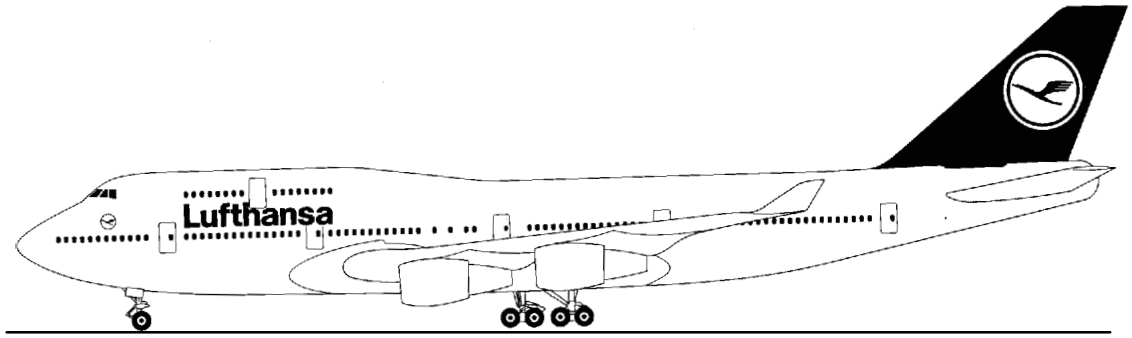
Lufthansa Technical Training

Training Manual B 747-400



ATA 34-33
RADIO ALTITUDE

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ATA 34-33 RADIO ALTITUDE

RADIO ALTIMETER SYSTEM - INTRODUCTION

The Radio Altimeter (RA) System measures the distance from the airplane to the terrain and supplies a display of altitude in the flight compartment.

The system operates from 0 to 2500 feet and is used primarily during the approach and landing phases of the flight.

The frequency of operation is 4300 MHz.

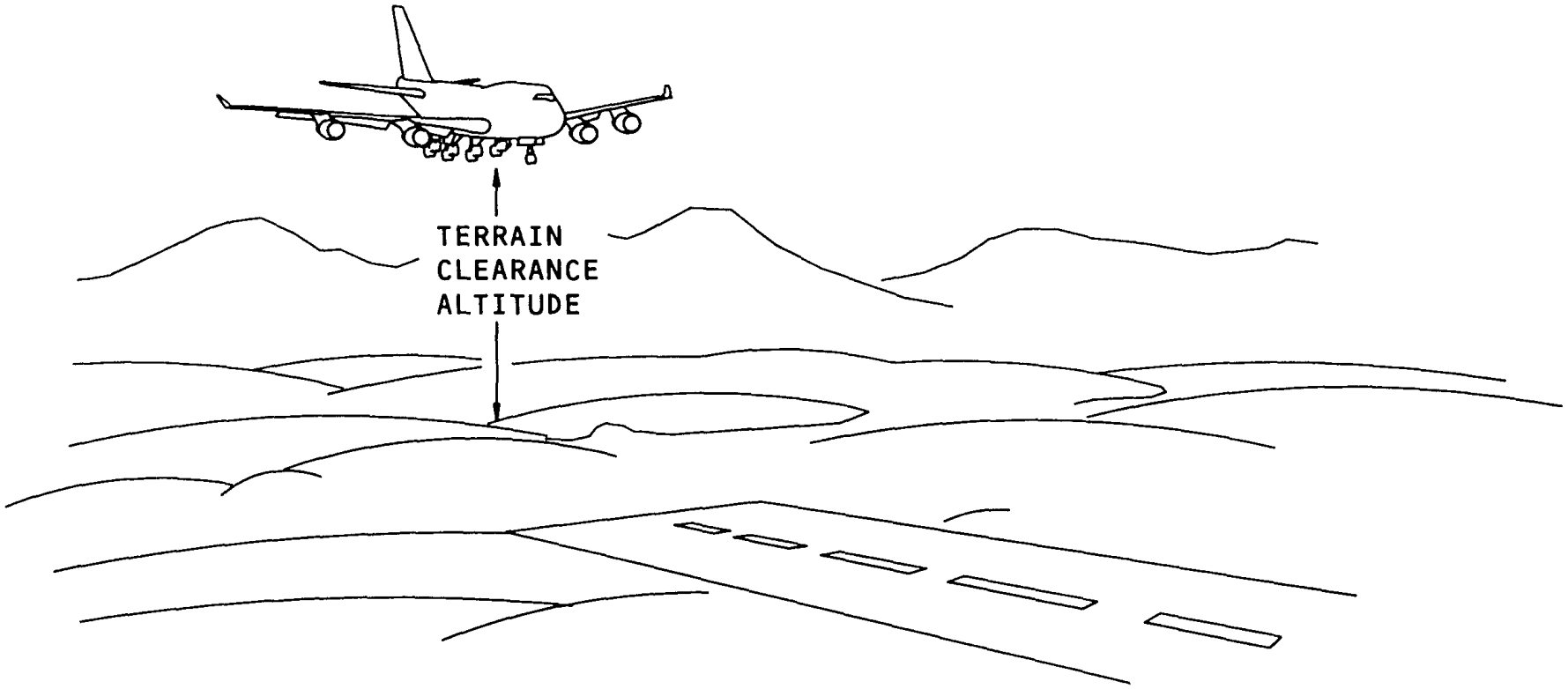

Figure 1 RADIO ALTIMETER SYSTEM - INTRODUCTION

RADIO ALTIMETER SYSTEM

The RA system supplies accurate measurement of absolute altitude (height above the terrain) from 2500 feet to touchdown. The system is used primarily during the approach, landing and takeoff phases of flight.

Three RA systems are installed. They each consist of:

- One Radio Altimeter Receiver/ Transmitter (RA R/T)
- One RA transmit antenna
- One RA receive antenna

Radio altitude data routes on digital data buses to these LRUs:

- Flight control computer (FCC)
- Modularized avionics and warning electronics assembly (MAWEA) (left and right RA R/Ts only)
- Ground proximity warning computer (GPWC) (left RA R/T only)
- EFIS/EICAS interface units (EIUs)
- Data management unit (DMU)
- TCAS computer (traffic alert and collision avoidance system) (left and right RA R/T's only)

Fault summary data goes to the central maintenance computers (CMCs) through the EIUs.

The primary flight display (PFD) supplies a visual display of radio altitude.

The EICAS display supplies a visual display of RA system status.

The air/ground discrete inhibits RA test in flight.

The CMC sends:

- A digital test discrete to start a ground test.
- A signal to the RA R/T's fault memory to establish flight legs.

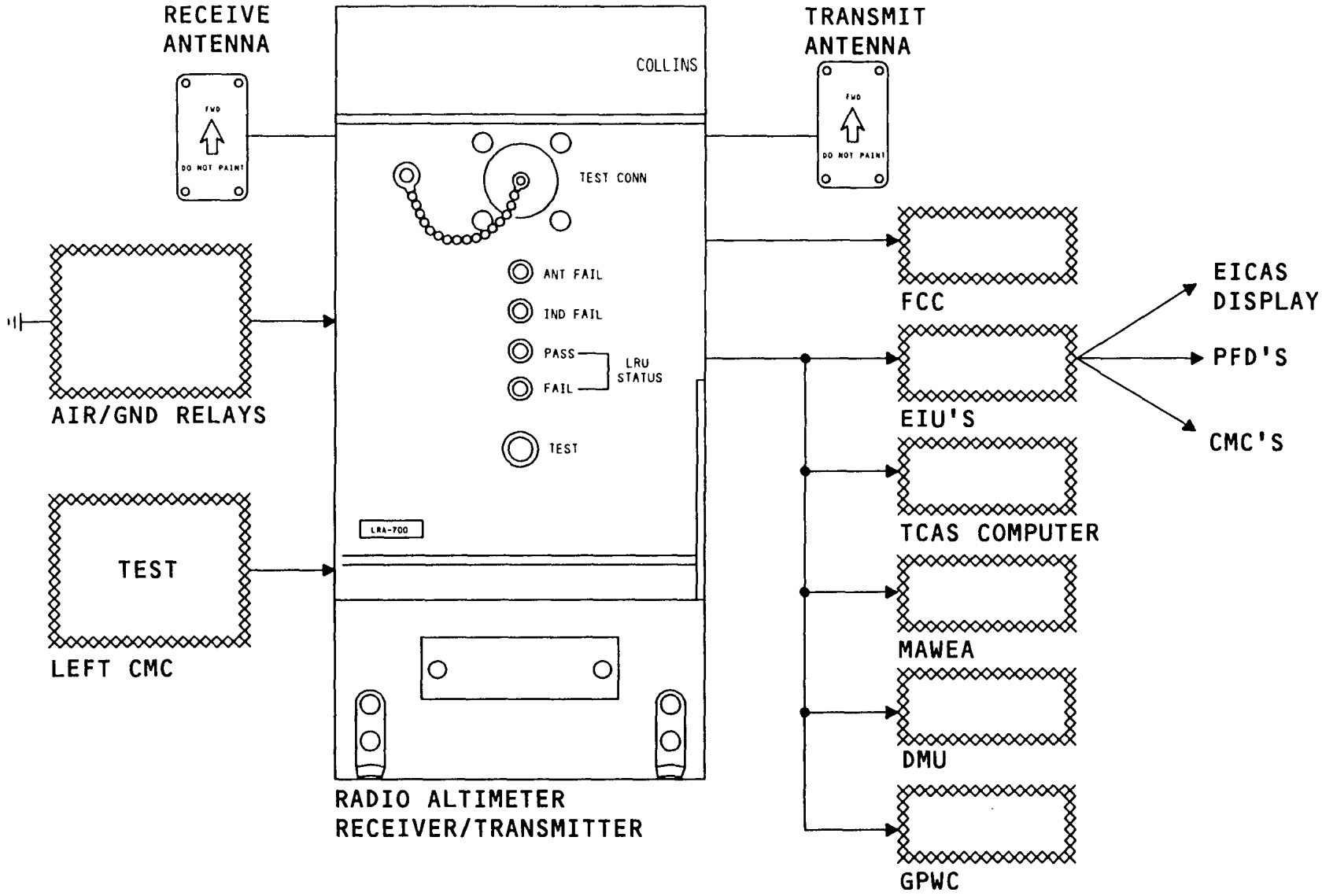

Figure 2 RADIO ALTIMETER SYSTEM

RADIO ALTIMETER SYSTEM

The RA system supplies accurate measurement of absolute altitude (height above the terrain) from 2500 feet to touchdown. The system is used primarily during the approach, landing and takeoff phases of flight.

Three RA systems are installed. They each consist of:

- One Radio Altimeter Receiver/ Transmitter (RA R/T)
- One RA transmit antenna
- One RA receive antenna

The RA sends data on digital data buses to these LRUs:

- Flight control computer (FCC)
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- Ground proximity warning computer (GPWC)
- EFIS/EICAS interface units (EIUs)
- Data management unit (DMU)
- TCAS computer (traffic alert and collision avoidance system)

Fault summary data goes to the central maintenance computers (CMCs) through the EIUs.

The CMC sends a digital test discrete to start a ground test.

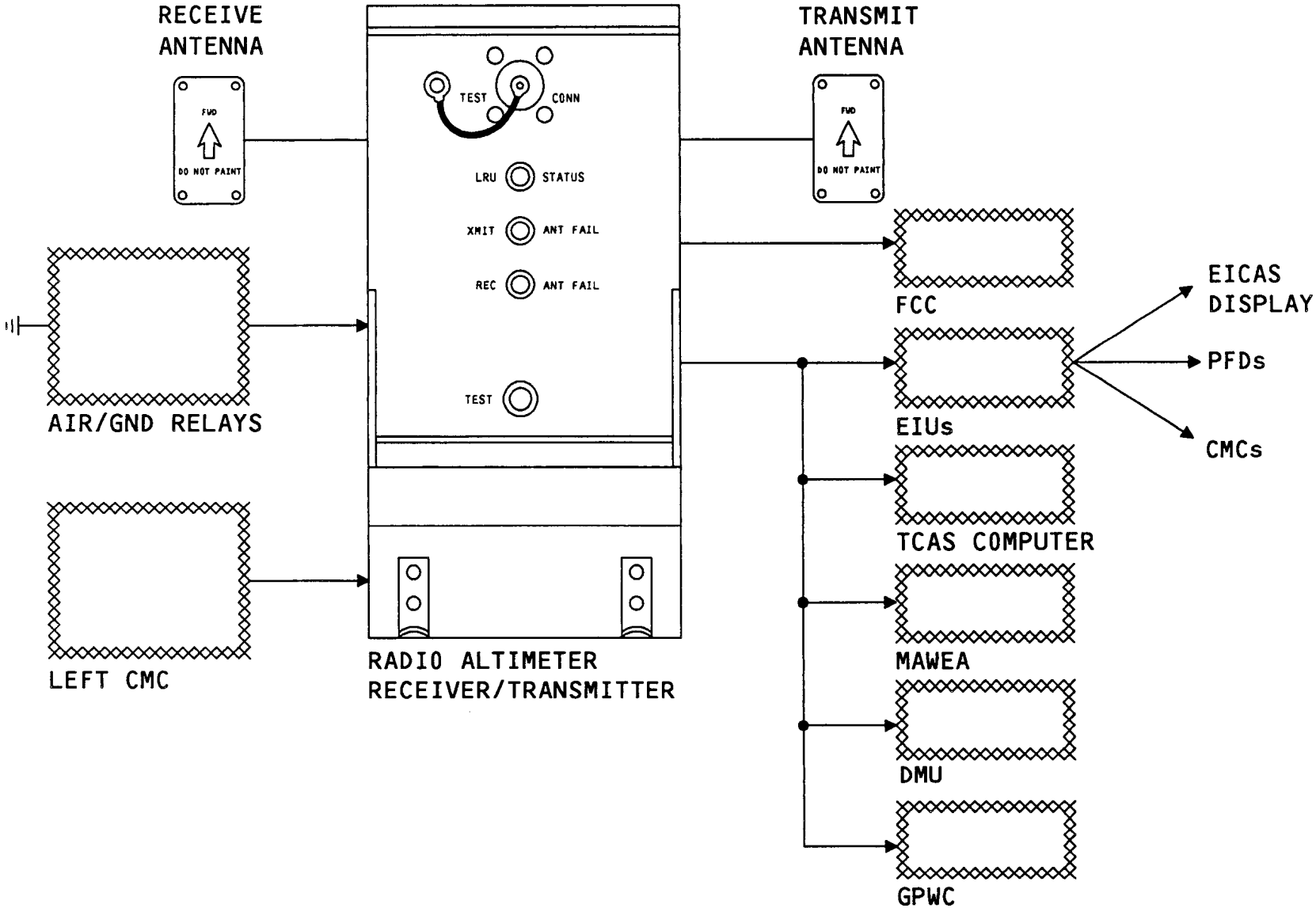


Figure 3 RADIO ALTIMETER SYSTEM

COMPONENT LOCATION - 1

The RA system components in the center equipment center are the:

- Left RA R/T
- Center RA R/T
- Right RA R/T

The RA system components on the bottom of the fuselage are the:

- Left RA receive antenna
- Center RA receive antenna
- Right RA receive antenna
- Left RA transmit antenna
- Center RA transmit antenna
- Right RA transmit antenna

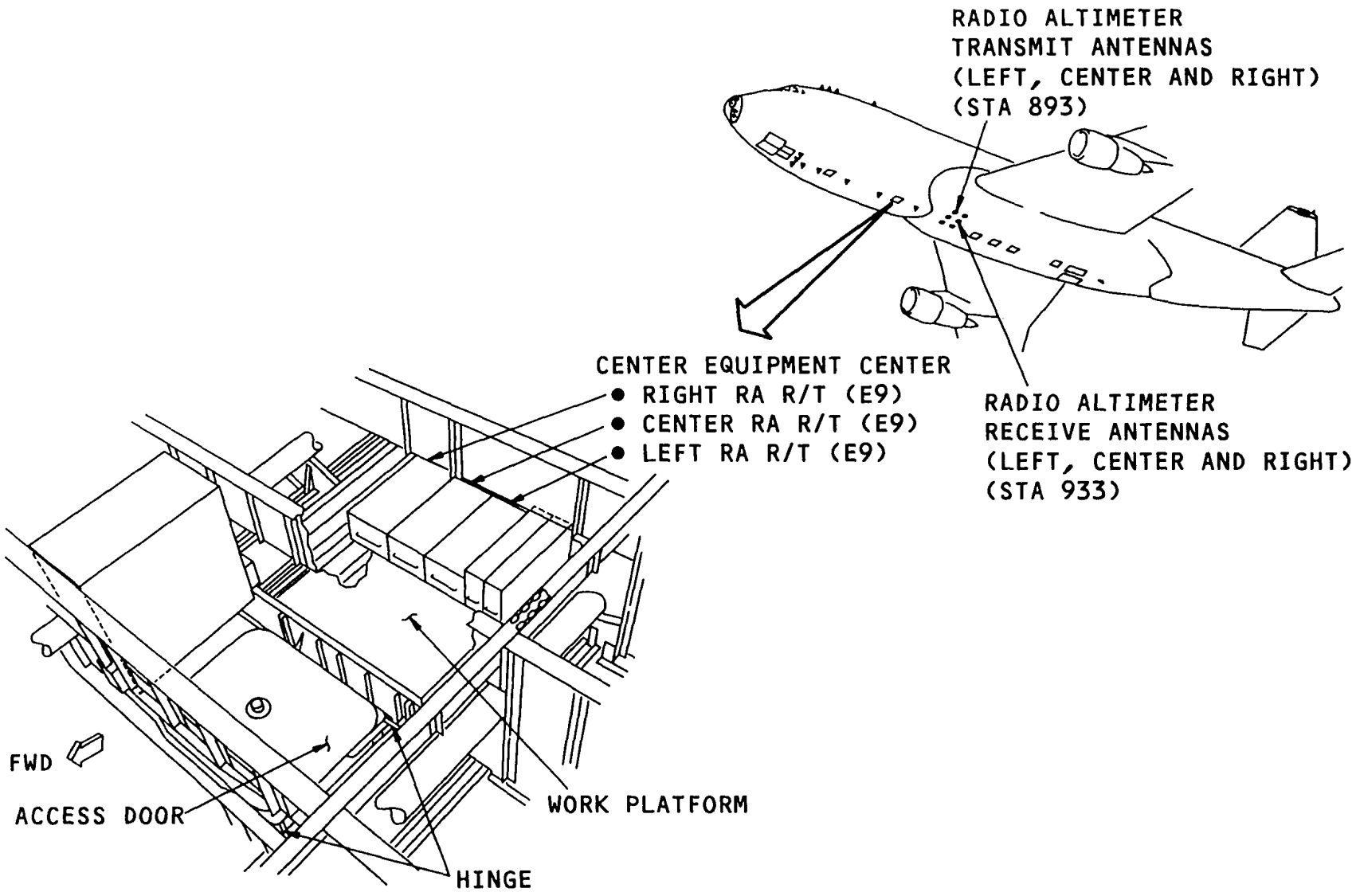


Figure 4 COMPONENT LOCATION - 1

COMPONENT LOCATION - 2

The RA system components and interfacing components located in the flight deck are the:

- Primary flight displays
- Left and right EFIS control panels
- Left and right control display units (CDU's)
- Left RA circuit breaker
- Right RA circuit breaker
- Center RA circuit breaker

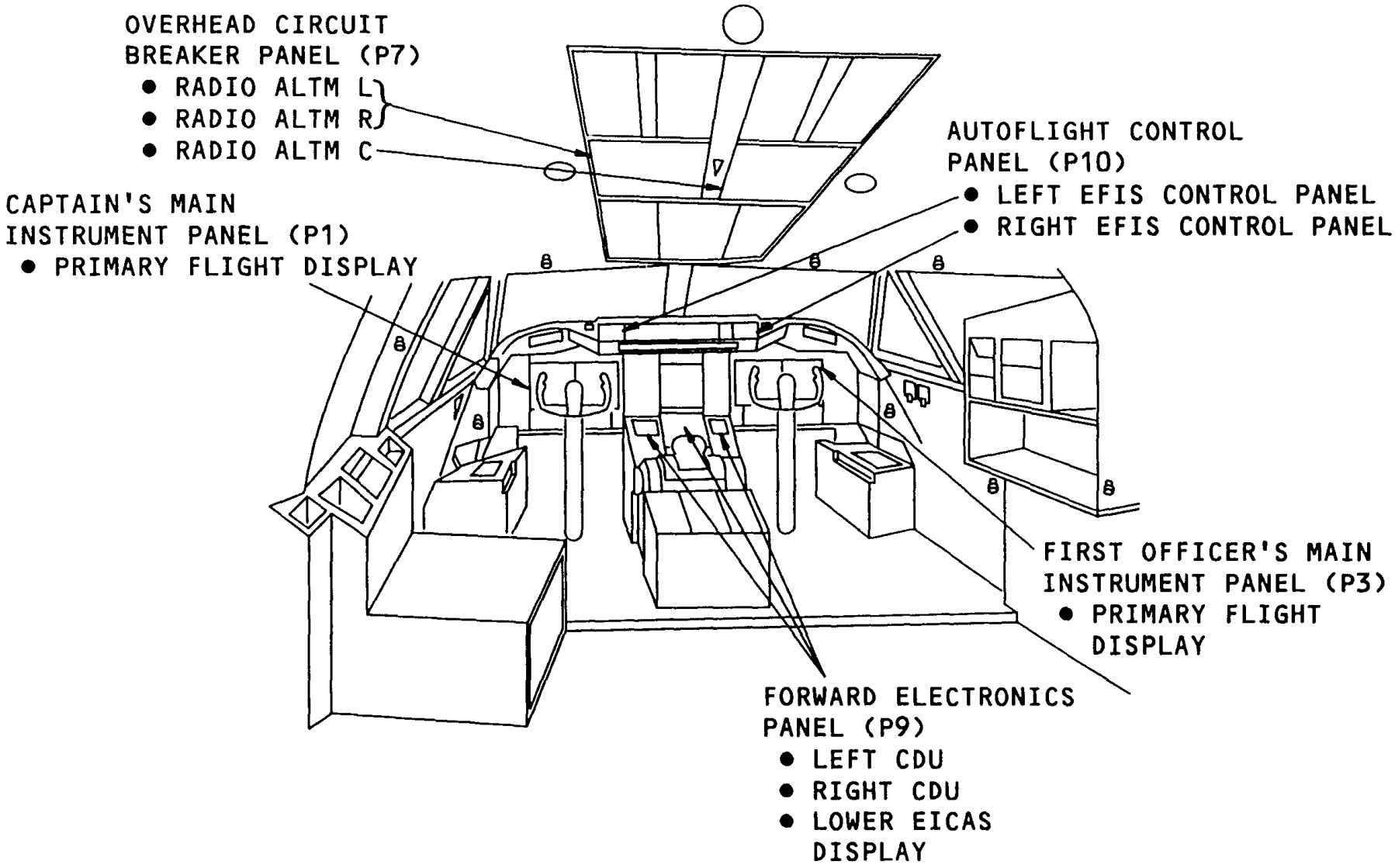


Figure 5 COMPONENT LOCATION - 2

Figure 6

POWER AND ANTENNA INPUTS

Power

The RA R/T's are powered by:

- 115v ac bus 3 (left RA R/T)
- 115v ac bus 2 (right RA R/T)
- 115v ac bus 1 (center RA R/T)

Antenna Interfaces

The transmit antennas send RF signals toward the terrain. The receive antennas send reflected RF signals into the receiver circuits of the RA R/Ts.

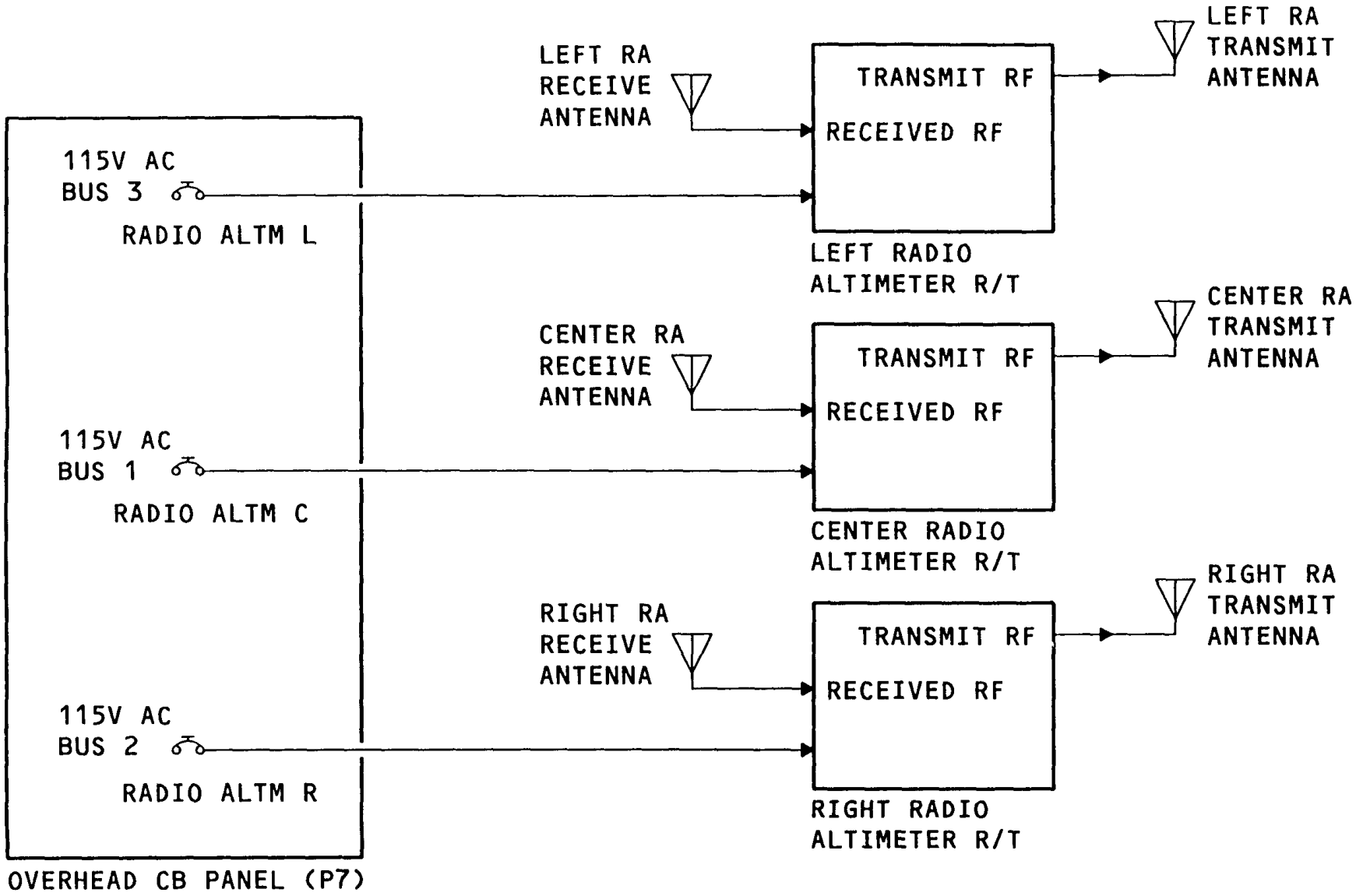


Figure 7 POWER AND ANTENNA INPUTS

DISCRETE INPUTS

Test Inhibit

The test inhibit input from the FCC to the RA R/T supplies a functional test inhibit signal. This prevents the RA manual test in an automatic approach.

Air/Ground Discrete

All faults detected within the RA R/T are stored in a nonvolatile fault memory. The faults are stored by flight segments. Each flight leg is started when the airplane becomes airborne as detected by the air/ground relay.

Input Program Pins

The continuous data program pins are jumpered to assure a continuous data output to the FCC, regardless of the validity of the sign/status matrix (SSM).

The aircraft installation delay (AID) program pins are jumpered for an AID of 57 feet. This calibrates the system so

that the altitude display is zero at touchdown. It compensates for the length of the antenna cables plus fuselage to ground distance including flare angle.

The system select program pin input sets the system modulation rate and system identification. The modulation for the left system is set at 105 Hz, the center system at 95 Hz and the right system at 100 Hz.

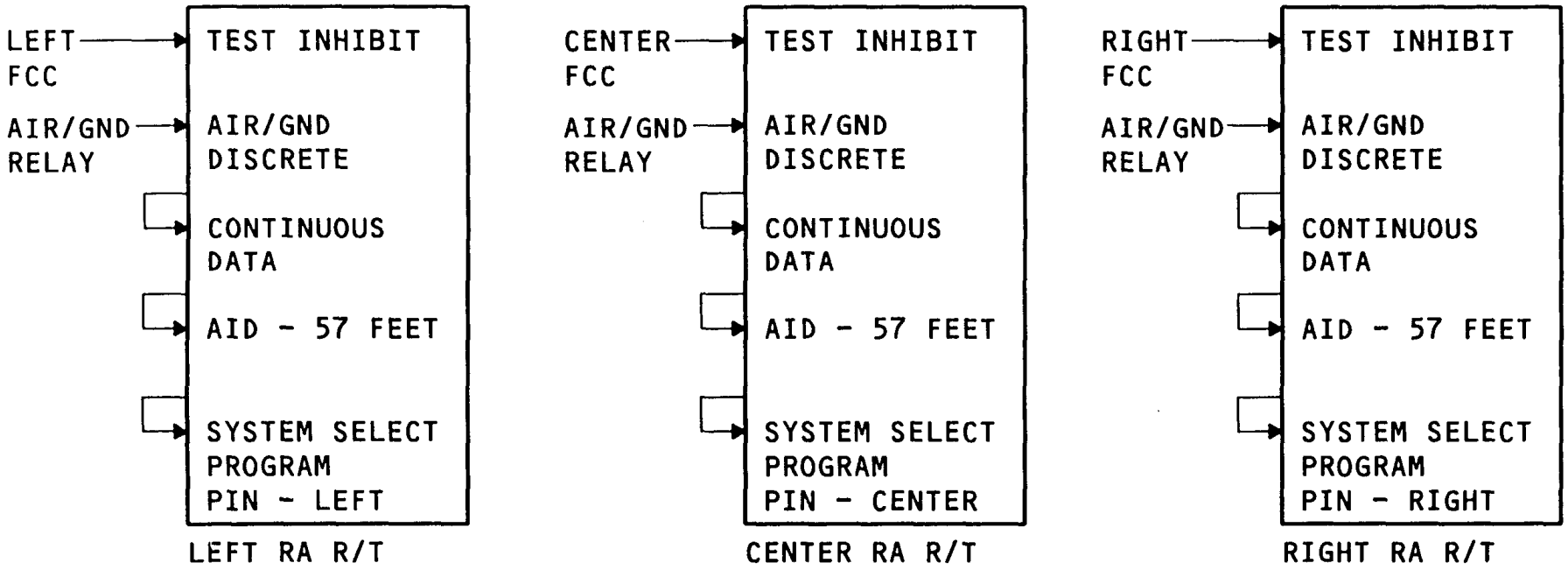


Figure 8 DISCRETE INPUTS

DECISION HEIGHT INPUTS

Decision Height (DH) goes to the on side CDU. The CDU monitors the data for presence and validity. If a failure of the EFIS control is detected, the CDU is used to select DH. The center CDU cannot act as a backup EFIS control panel. RA is sent to the EIU's to determine DH and to the Ground Proximity Warning System.

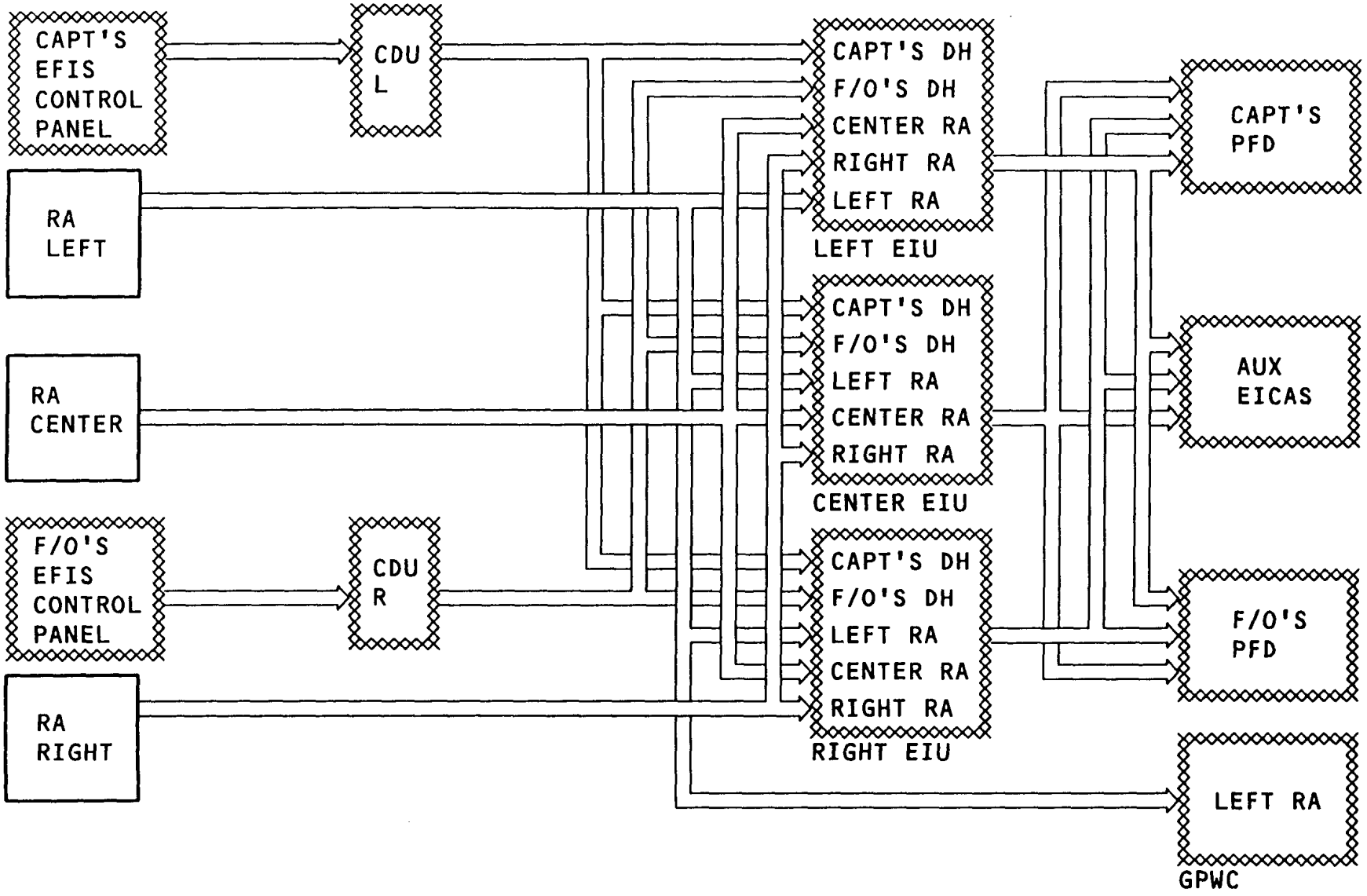


Figure 9 DECISION HEIGHT INPUTS

CMC INPUT

Any of the three CDUs may be used to request fault information and start a test of the RA systems through the CMCS.

Normally, the left CMC sends a digital test discrete to start a test. If the left CMC fails, a relay in the left CMC energizes. The CMC data goes from the right CMC to the RA R/Ts.

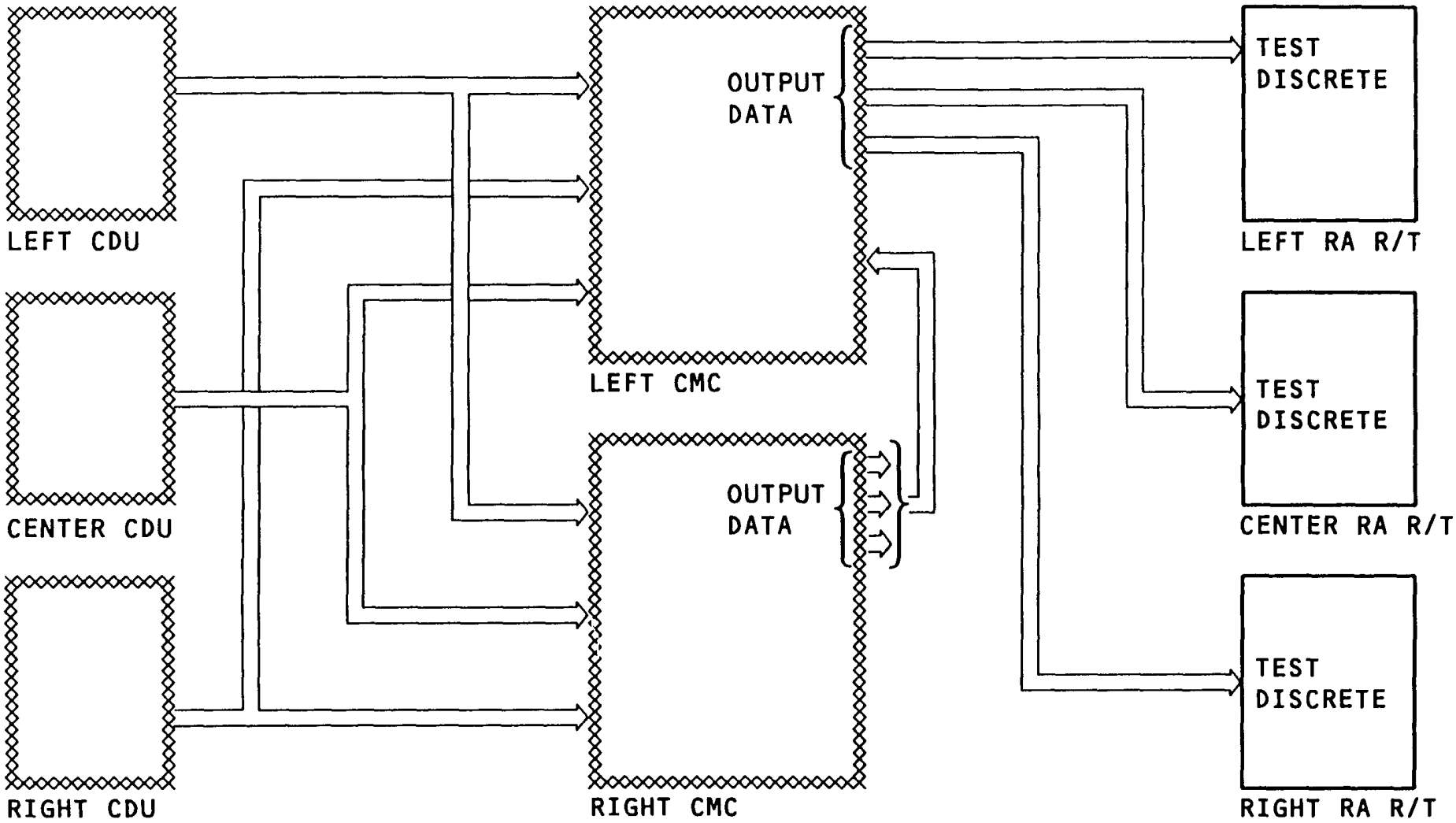


Figure 10 CMC INPUT

DATA BUS OUTPUTS

General

The RA systems supply data to the:

- Left, center, and right EFIS/EICAS interface units (EIUs)
- Left, center, and right flight control computers (FCCs)
- Ground proximity warning computer (GPWC)
- Modularized avionics and warning electronics assembly (MAWEA)
- Data management unit (DMU)
- TCAS computer (traffic alert and collision avoidance system)

Altitude Data

Computed radio altitude from three RA systems goes to each of the three EIUs. The EIUs multiplex this information with inputs from other airplane systems and supplies an output to the captain's and first officer's PFD. Each EIU supplies an output to each PFD.

Altitude data from the left, right and center RA systems goes to the:

- FCCs for approach logic
- DMU for system trend analysis

Altitude data from the left RA system goes to the GPWC for ground proximity alert and warning logic.

Altitude data from the left and right RA systems goes to the master monitor cards in the MAWEA for warning logic, and to the TCAS computer to set sensitivity levels and for intruder advisory calculations.

Fault Summary Data

Fault summary words from each radio altimeter system also go to each EIU. The EIUs send the data to:

- The central maintenance computers (CMCS)
- The auxiliary EICAS display

The CMCs store the fault summary word in nonvolatile memory. Upon request from any control display unit (CDU) the left CMC sends the fault summary data to the CDU for display.

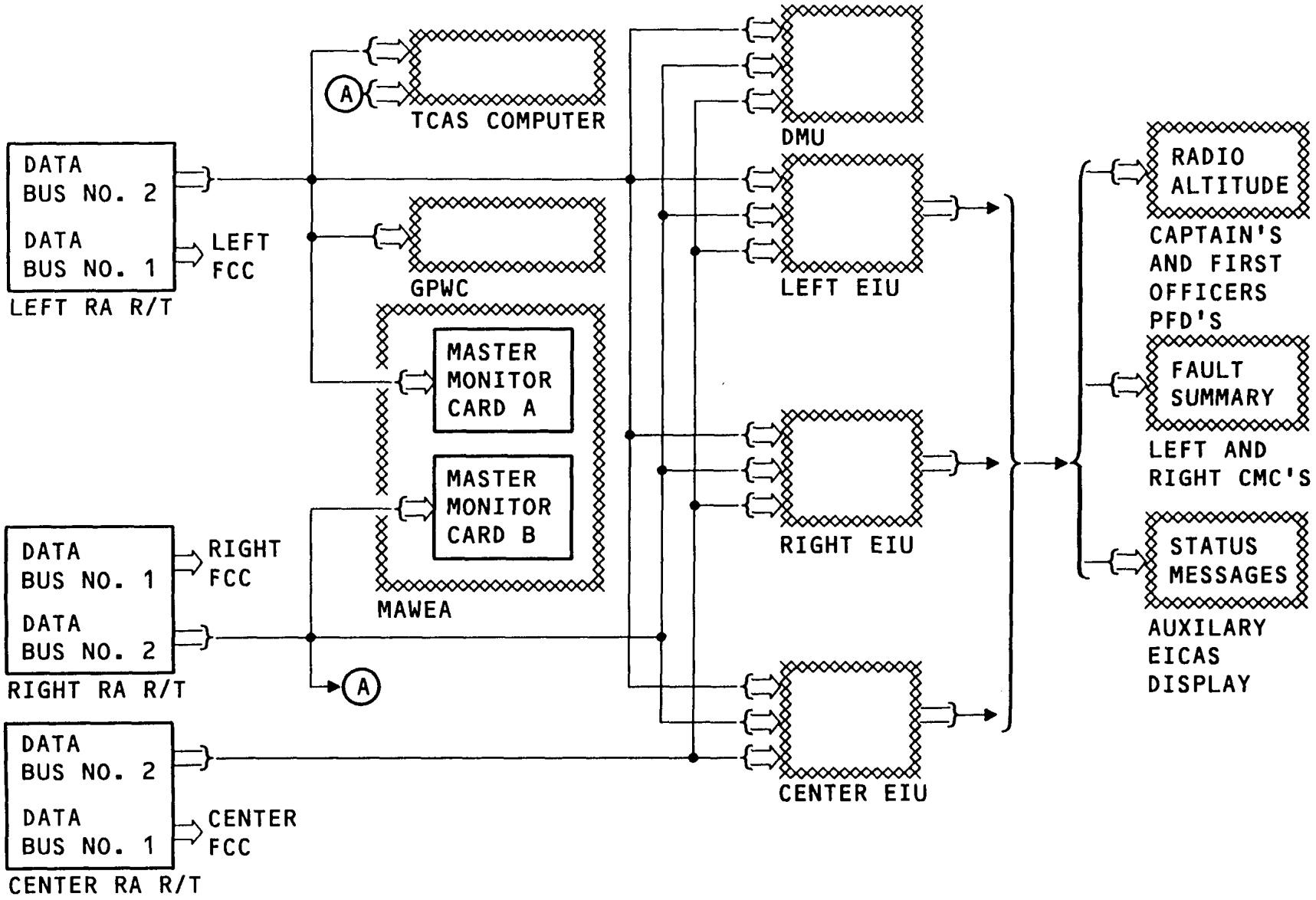


Figure 11 DATA BUS OUTPUTS

RA RECEIVER/TRANSMITTER

Purpose

The radio altimeter (RA) receiver/transmitter (R/T) sends computed data to the aircraft systems requiring radio altitude.

Characteristics

- Frequency = 4,300 MHz +/- 50 MHz
- Transmit power = 500 mw nominal
- - Operating range = -20 to 2500 feet
- - Forced air cooling is required

Operation

Four LED status indicators are on the front panel:

CAUTION: STATIC SENSITIVE. DO NOT HANDLE BEFORE READING PROCEDURE FOR HANDLING ELECTROSTATIC DISCHARGE SENSITIVE DEVICES (REF 20-41-02/201). CONTAINS DEVICES THAT CAN BE DAMAGED BY STATIC DISCHARGE.

- A red LED labeled LRU STATUS FAIL indicates a receiver/transmitter fault
- A green LED labeled LRU STATUS PASS indicates valid receiver/transmitter operation
- A red LED labeled ANT FAIL indicates an antenna fault
- A red LED labeled IND is inoperative

A TEST pushbutton is supplied to start a self-test.

The RA R/T has a non-volatile memory for storing fault information from the last sixty-three flights. It can store up to thirteen faults per flight.

A test connector on the front panel serves to connect test equipment for ramp tests and radio altitude simulation.

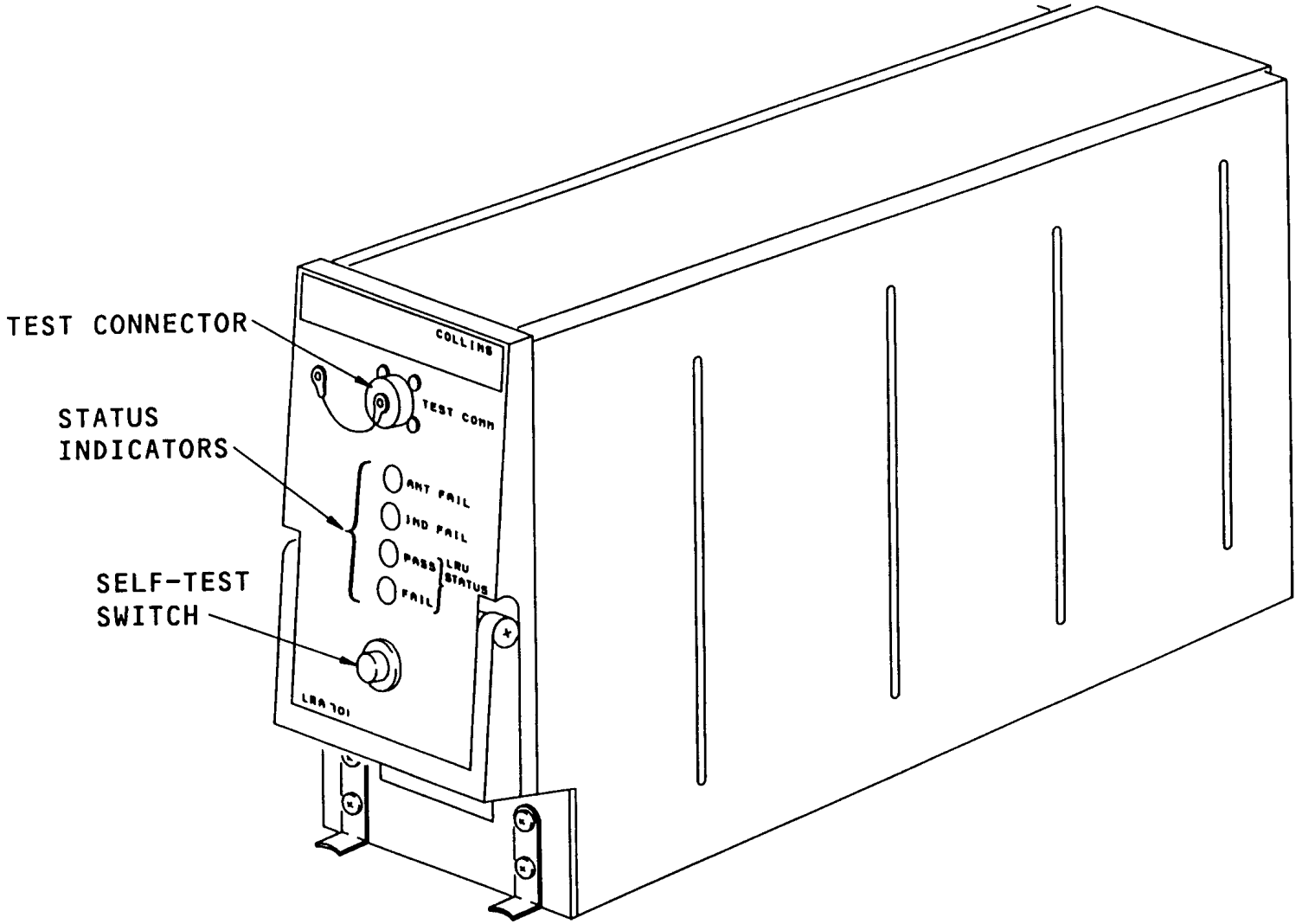


Figure 12 RA RECEIVER/TRANSMITTER

RA RECEIVER/TRANSMITTER

Purpose

The radio altimeter (RA) receiver/transmitter (R/T) sends computed data to the aircraft systems requiring radio altitude.

Characteristics

- Frequency = 4,300 MHz +/- 50 MHz
- Transmit power 600 mw nominal
- Operating range
- 20 to 5,000 feet
- Forced air cooling is required

Operation

Three LED status indicators are on the front panel:

- A green/red LED labeled LRU STATUS shows the R/T status.
- A red LED labeled XMIT ANT FAIL shows a transmit antenna fault
- A red LED labeled REC ANT FAIL shows a receive antenna fault.

A TEST pushbutton is supplied to start a self-test.

The RA R/T has a non-volatile memory for storing fault information from the last sixty-three flights. It can store up to thirteen faults per flight.

A test connector on the front panel serves to connect test equipment for ramp tests and radio altitude simulation.

CAUTION: STATIC SENSITIVE. DO NOT HANDLE BEFORE READING PROCEDURE FOR HANDLING ELECTROSTATIC DISCHARGE SENSITIVE DEVICES (REF 20-41-02/201). CONTAINS DEVICES THAT CAN BE DAMAGED BY STATIC DISCHARGE.

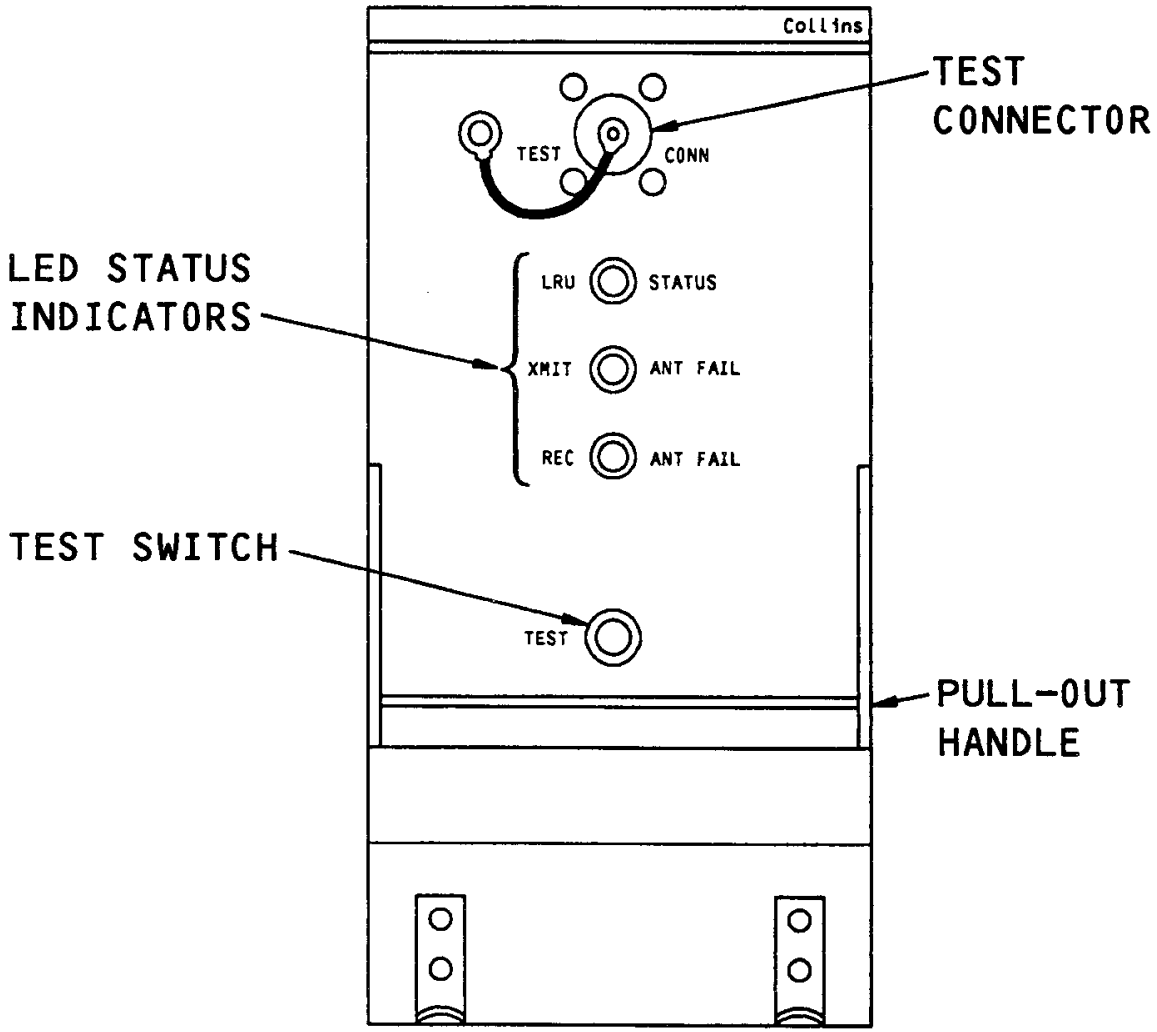


Figure 13 RA RECEIVER/TRANSMITTER (COLLINS 900)

RA - ANTENNA

Purpose

The RA system uses six (6) separate antennas that operate in the 4200 to 4400 MHz frequency range. Each RA R/T has a dedicated transmit and receive antenna. The transmit and receive antennas are identical and interchangeable.

Antenna Removal/Installation

The antennas are attached to the bottom of the fuselage with four screws. There is an O-ring seal in a groove around the electrical connector mounting to ensure moisture protection. The radiation side of the antenna has red markings ”FWD” and ”DO NOT PAINT”. Do not paint the radiation surface or the backplate of the antenna.

CAUTION: WHEN REMOVING THE ANTENNA EXTRA FORCE MAY BE REQUIRED TO BREAK THE AERODYNAMIC FILLET SEAL. TO PREVENT DAMAGE TO THE AIRPLANE AERODYNAMIC FAIRING PANEL OR ELECTRICAL CABLE AT ANTENNA BASE, CAREFULLY PRY AROUND THE ANTENNA WITH SEALANT REMOVAL TOOL UNTIL SEAL IS COMPLETELY BROKEN.

NOTE: WHEN INSTALLING THE ANTENNA, BE CERTAIN FAYING SURFACE IS CLEAN. INADEQUATE RF GROUNDING WILL CAUSE IMPROPER SYSTEM OPERATION.

NOTE: THE TRANSMIT ANTENNA COAX IS A CRITICAL LENGTH OF 90”+ .25”. THE RECEIVE ANTENNA COAX IS A CRITICAL LENGTH OF 121.32”+ .25”.

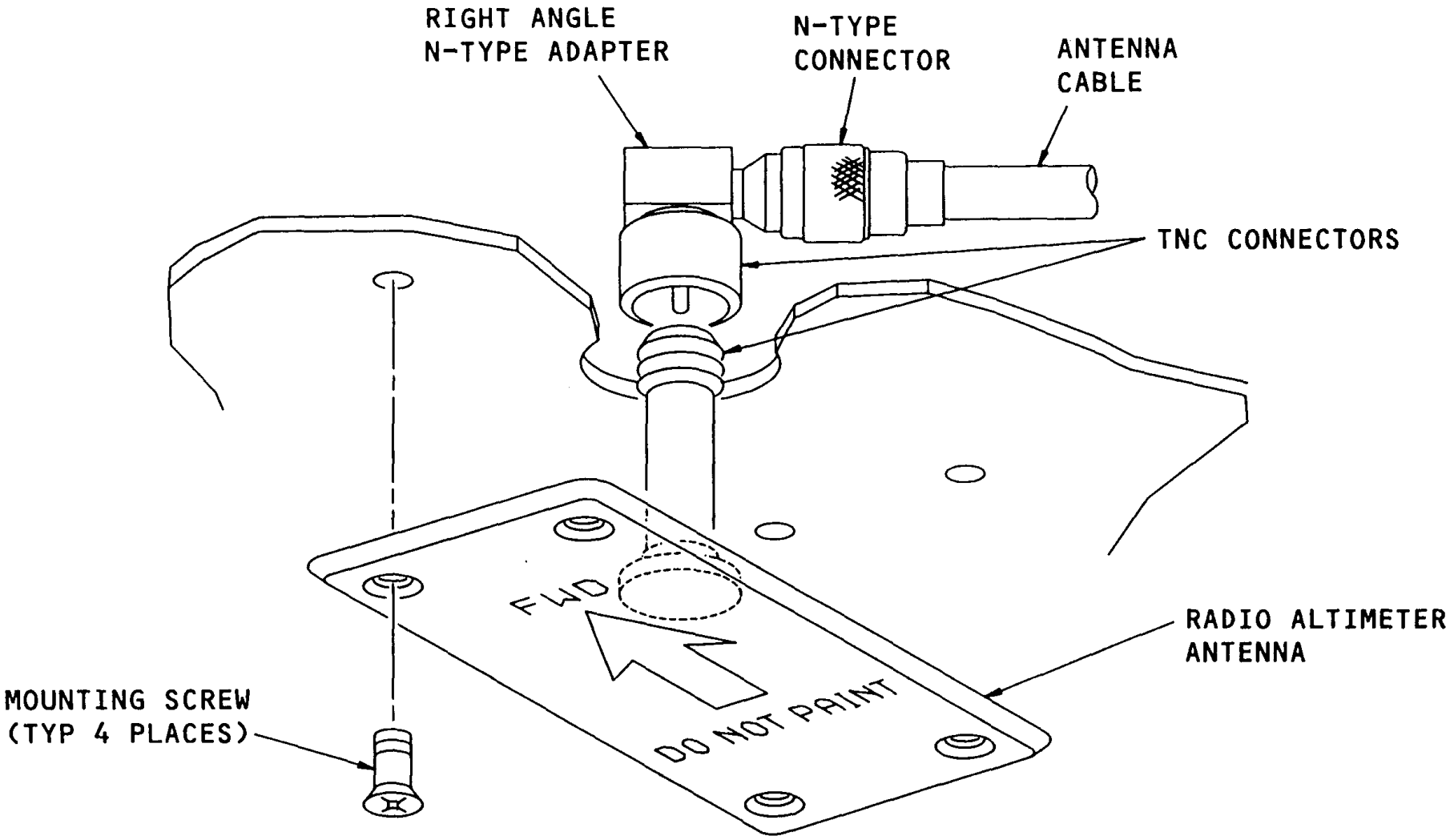


Figure 14 RA - ANTENNA

SYSTEM SELECTION / PRIORITY

Purpose

The EIU source select switches allow the flight crew to set either the left, center or right EIU input to their respective PFDs. The PFDs decide which radio altimeter system data is shown.

Operation

Each EIU receives radio altitude data from all three RA systems. The PFD considers these conditions in deciding which radio altitude data to use:

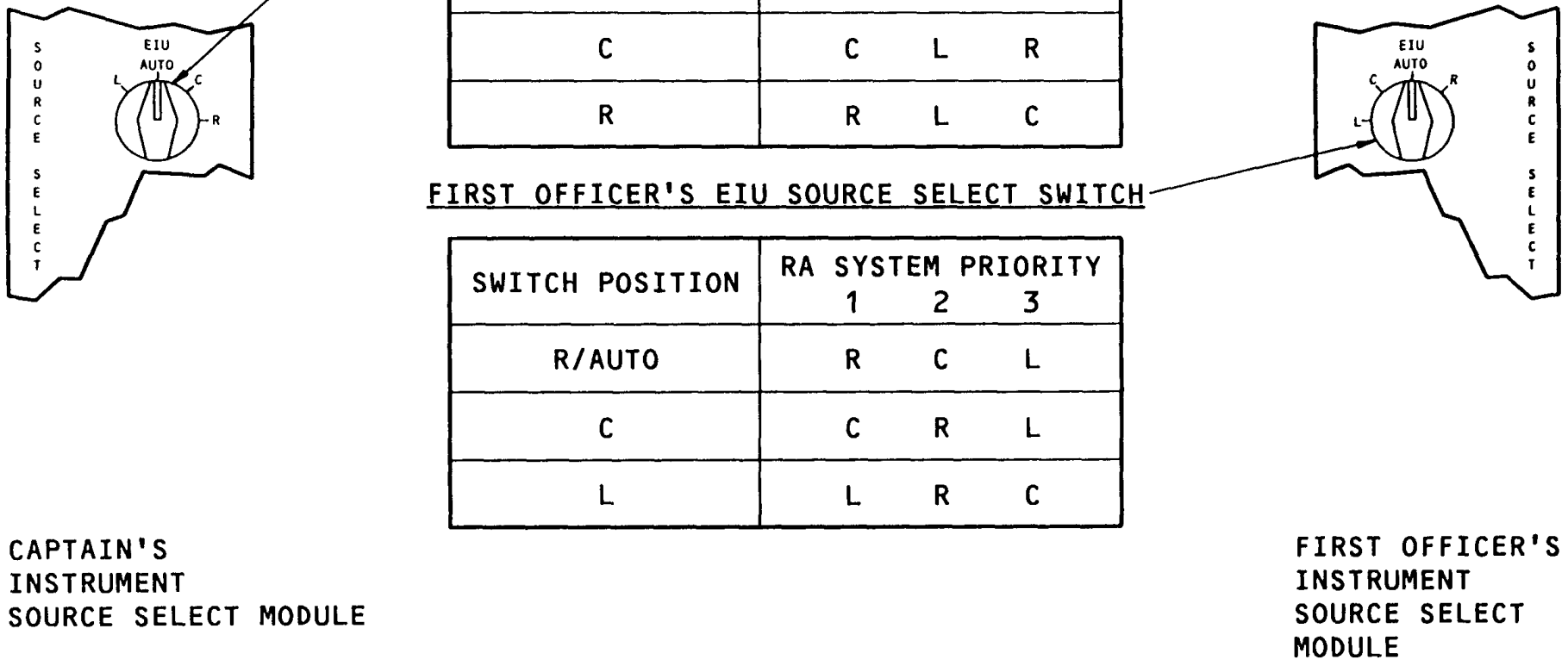
- EIU source select switch position
- Priority programming
- RA system status

The EIU source select switch position decides which EIU input to process. Each EIU input to the PFD contains altitude information from the left, center, and right RAs.

Priority programming decides which of the three radio altitude data signals (all within each EIU input into the PFD) is shown.

RA system status is monitored by the PFD. If the displayed RA system fails, data from the next highest priority RA system will be shown.

Priority for each EIU source selection is shown.



SWITCH POSITION	RA SYSTEM PRIORITY 1	2	3
L/AUTO	L	C	R
C	C	L	R
R	R	L	C

SWITCH POSITION	RA SYSTEM PRIORITY 1	2	3
R/AUTO	R	C	L
C	C	R	L
L	L	R	C

Figure 15 SYSTEM SELECTION / PRIORITY

EFIS CONTROLS AND PRIMARY FLIGHT DISPLAYS

EFIS Control Panel

The EFIS control panel sets decision height (DH) and resets a DH alert. DH is shown on the captain's and first officer's PFDs. The left EFIS control panel controls the captain's PFD, the right EFIS control panel controls the first officer's PFD.

operation

The DH-MDA set control consists of:

- A two-position rotary switch
- A 24-detent position 360 degree rotary switch
- A RST pushbutton switch.

The two-position rotary switch supplies:

- Decision height (DH)
- Minimum descent altitude (MDA)

With DH selected, the 24-detent position 360 degree rotary switch

adjusts the DH between -1 foot and +999 feet.

The RST (reset) switch allows manual reset of the DH alert.

The MDA function is not related to radio altimeter system operation.

PFD

The PFD shows radio altitude and decision height for use primarily during approach and landing.

Radio Altitude Display

Radio altitude shows digitally for altitudes between -20 and 2500 feet. The display updates in:

- 2 foot increments from -20 to 100 feet
- 10 foot increments from 100 to 500 feet
- 20 foot increments from 500 to 2500 feet

Above 2500 feet the display is blank.

Decision Height Display

Decision height shows below and right of the attitude display. It includes the letters DH and the set value. If the DH set is less than zero feet, or greater than 999 feet, the display is blank.

Decision Height Alert

As the airplane descends through the set decision height value:

- The radio altitude readout changes from white to yellow.
- The green decision height display changes to large yellow letters DH.
- During the first three seconds the letters DH blink.

To reset a DH alert:

- Push the RST switch on the EFIS control panel.
- Climb to a height 75 feet above the set decision height.
- Automatic reset at touchdown.

Reset causes the DH readout to return to normal and the RA readout to white.

Rising Runway Display

- Shows on approach under 1000 ft.
- Starts to rise at 200 ft.

Invalid Data

Invalid RA data:

- Shows by a yellow RA flag
- Occurs when the RA R/T detects a failure in the RA system

Invalid EFIS control panel DH data:

- Shows by a yellow DH flag when the radio altitude is less than or equal to 2500 feet.
- Shows by a blank display when the radio altitude is more than 2500 feet.
- Occurs when the EFIS control panel has an internal failure or a dead bus. This is sensed by the activity monitor in the CDU.

When RA data and DH data are both invalid, the yellow RA and DH flags show.

No Computed Data (NCD)

RA NCD:

- Shows a blank RA display
- Occurs when the transmitted signals return is too weak for normal operation

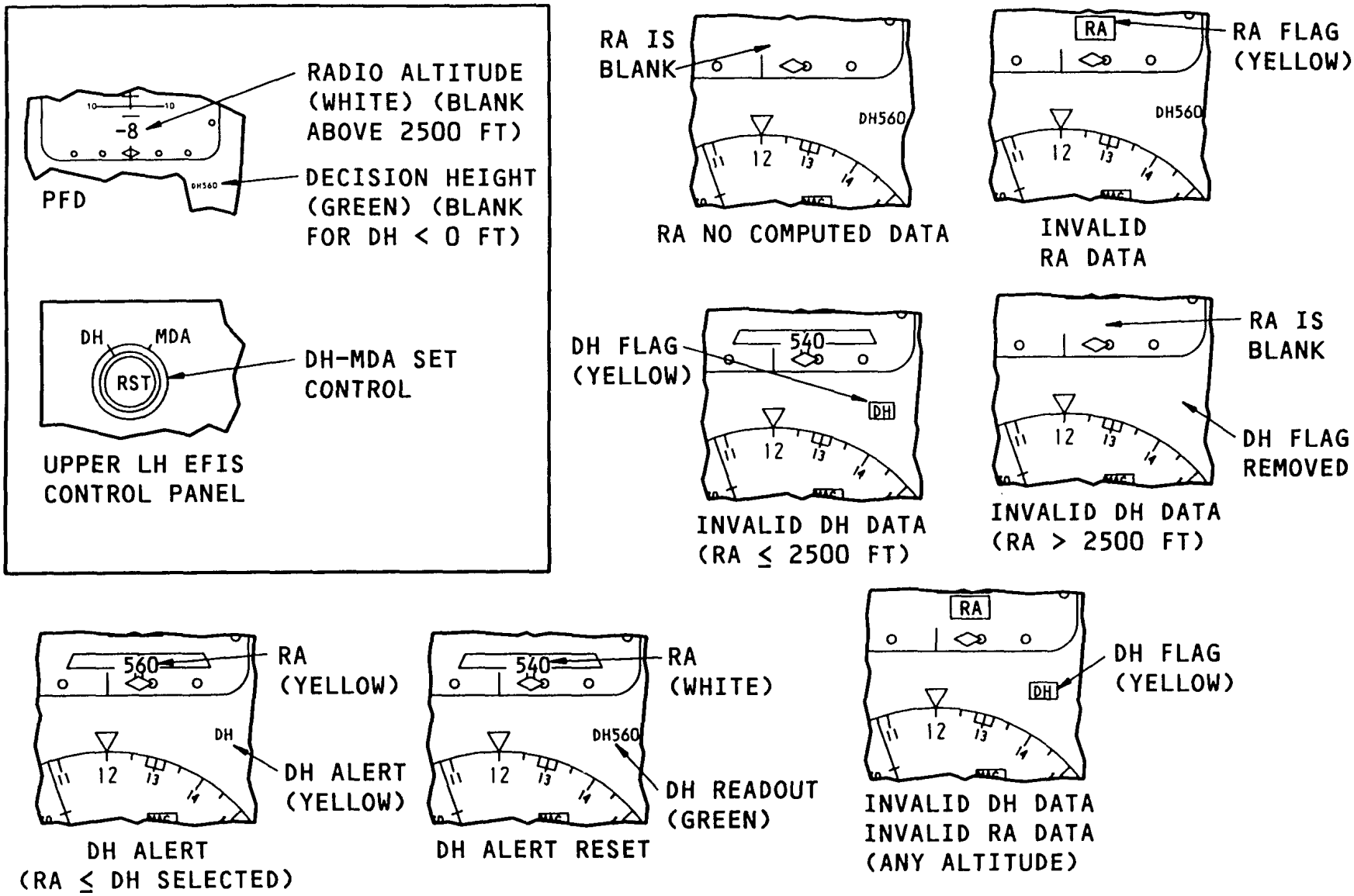


Figure 16 EFIS CONTROLS AND PRIMARY FLIGHT DISPLAYS

CONTROL DISPLAY UNIT - EFIS CONTROL

Purpose

When an EFIS control panel fails, the EFIS control page on the CDU is used to enter decision height information. It is also used to reset decision height alerts. The EFIS control page is accessed from the CDU main menu page.

Operation

After an EFIS control panel failure, the EFIS control page shows the last decision height value received from the EFIS control panel. The DH may be changed by keyboard entry on the CDU. Valid entries are 0 to 999 feet.

The line select key next to DH reset allows manual reset of a DH alert. DH reset from a CDU is possible only after the failure of the onside EFIS control panel.

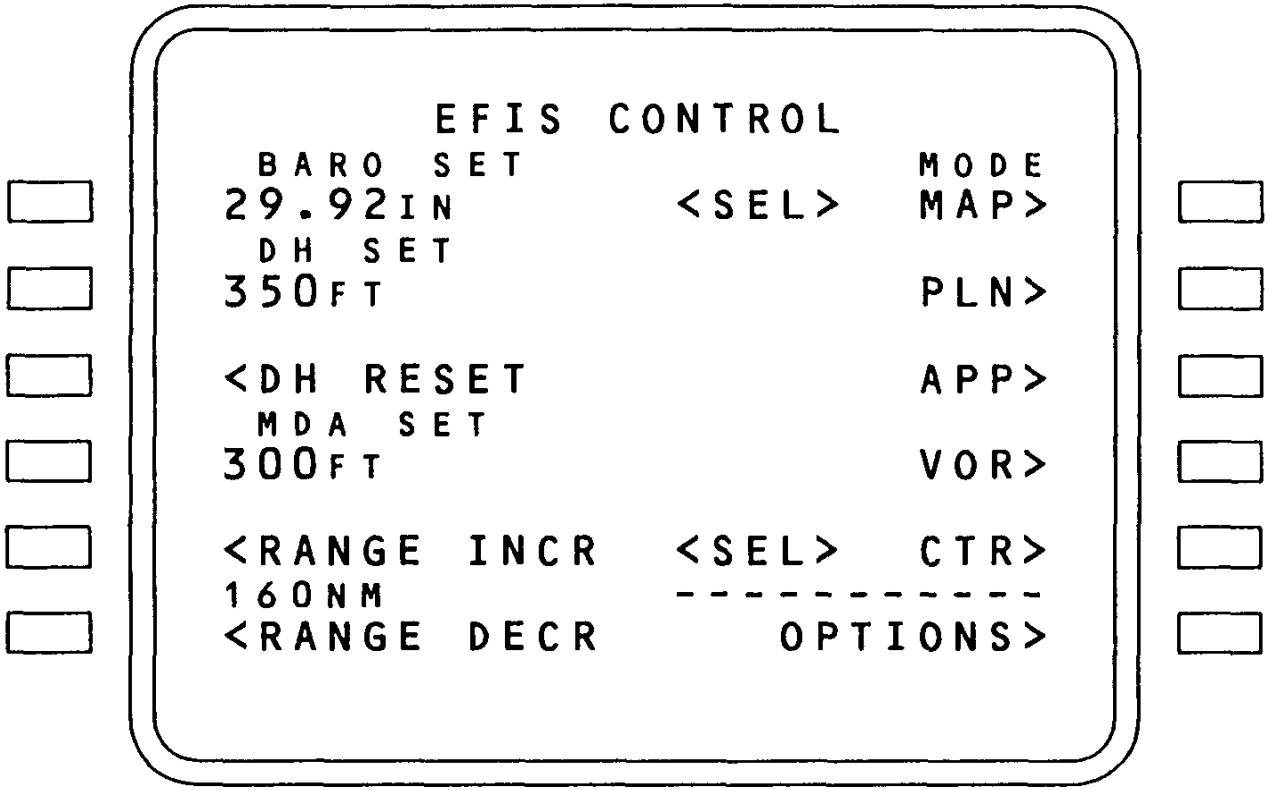


Figure 17 CONTROL DISPLAY UNIT - EFIS CONTROL

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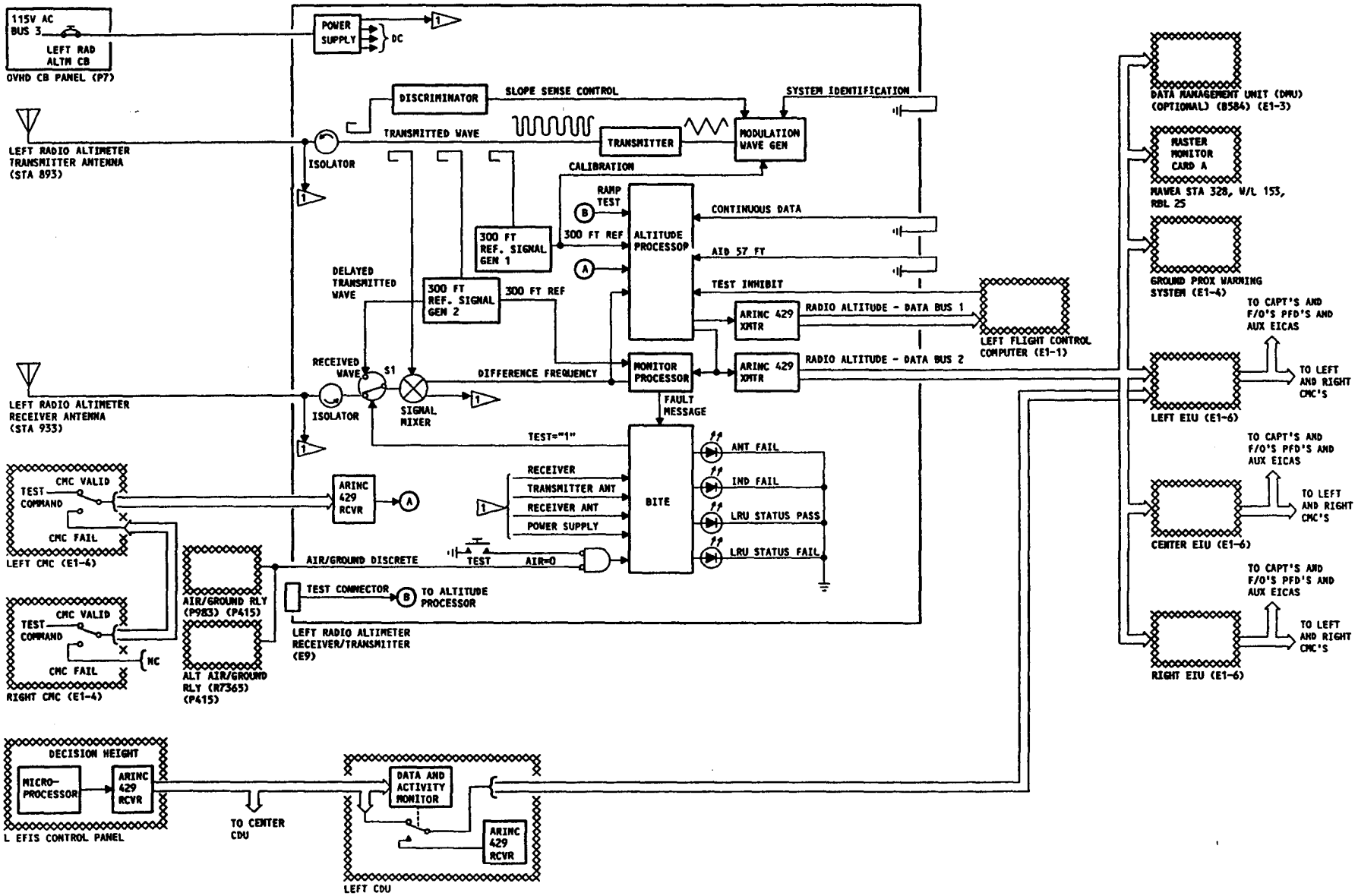

Figure 18 RA – SCHEMATIC DIAGRAM (C700)

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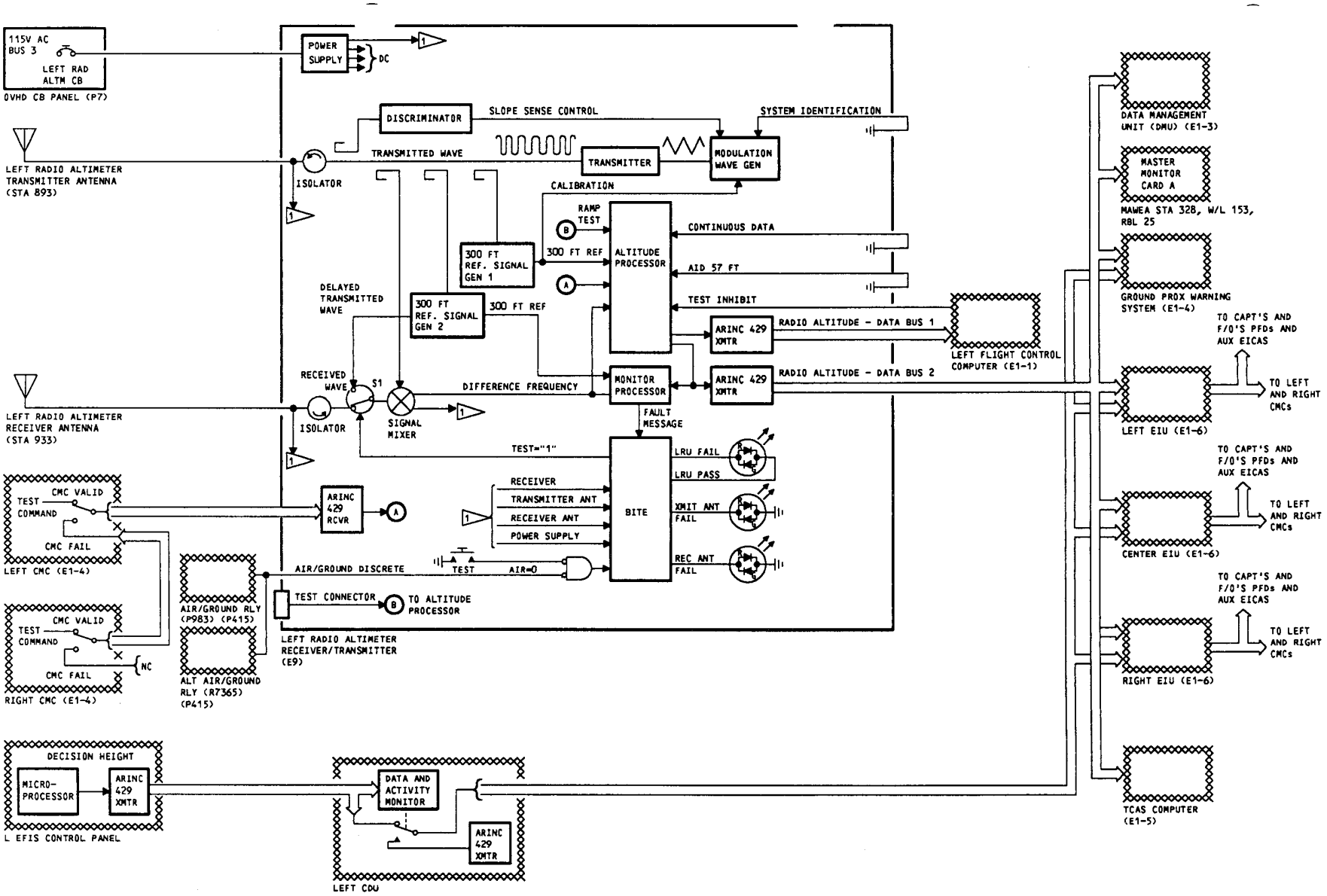

Figure 19 RA – SCHEMATIC DIAGRAM (C900)

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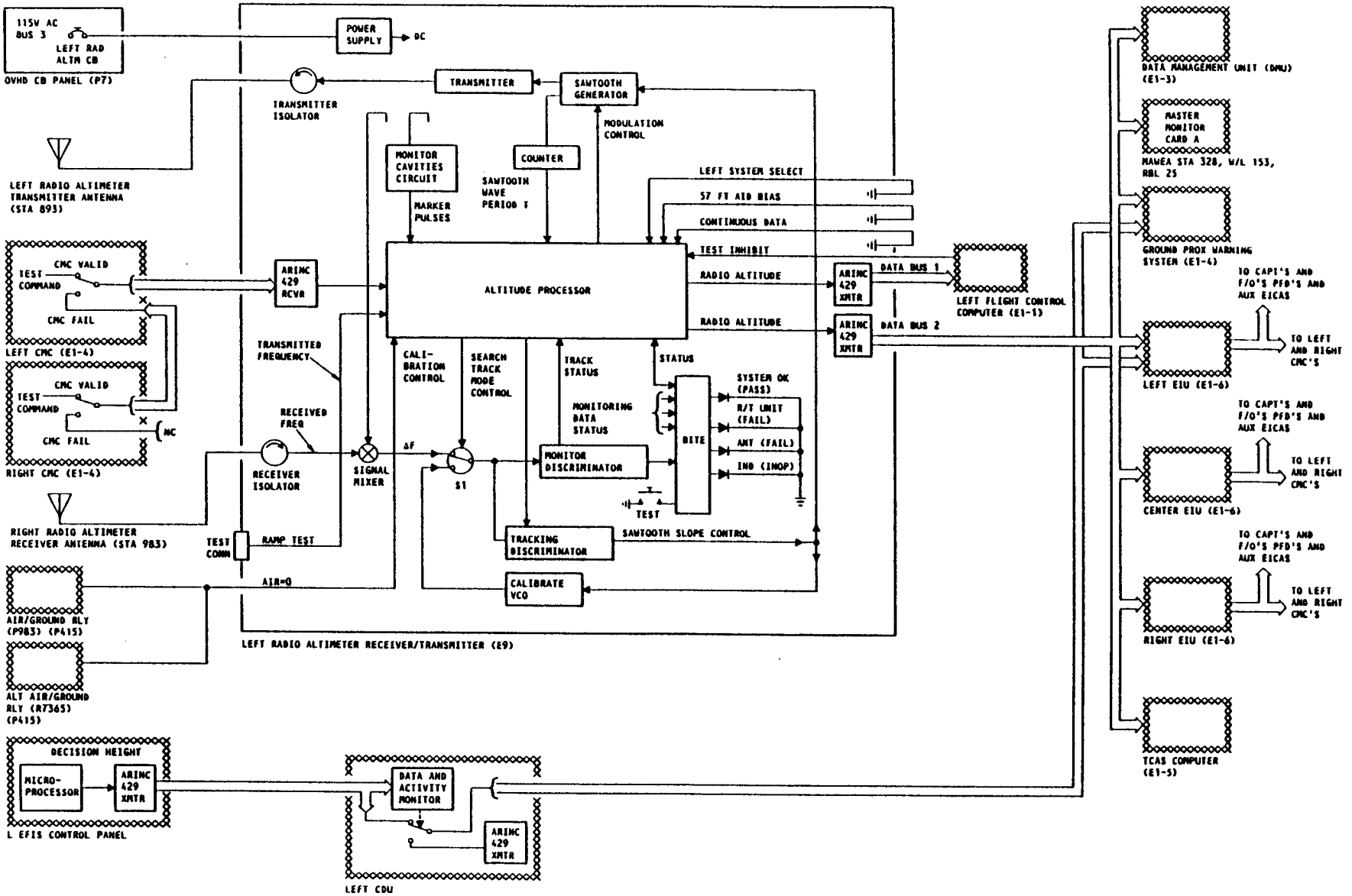


Figure 20 RA – SCHEMATIC DIAGRAM (B)

RF PROCESSING

Transmit and Receive

The RA receiver/transmitter transmits a FM/CW signal through the transmit antenna. This signal consists of a CW carrier sweeping linearly from 4,250 to 4,350 MHz 100 times a second.

The signal is transmitted, reflected from the terrain, and picked up by the receive antenna. The transmit and receive signals are mixed in the receiver to develop a difference frequency. The difference frequency is proportional to the signal travel time to the terrain and back. This difference is converted to altitude data in the altitude processor and output on two ARINC 429 data buses. These buses supply radio altitude and status (valid, invalid, test and no computed data) information to:

- The left FCC
- The GPWC
- The left, center and right EIUs
- Master monitor card A of the MAWEA
- The data management unit (DMU)
- The WAS computer

Input Program Ping

The continuous data program pin is jumpered to assure non-interrupted data output, regardless of validity.

The aircraft installation delay (AID) program pin is jumpered for 57 feet. This calibrates the system so that the altitude readout is zero at touchdown. It compensates for the length of the antenna cables plus fuselage to ground distance including flare angle.

The system select program pin input sets the system modulation rate and system identification. The modulation for the left RA system is set at 105 Hz, the center RA system at 95 Hz and the right RA system at 100 Hz.

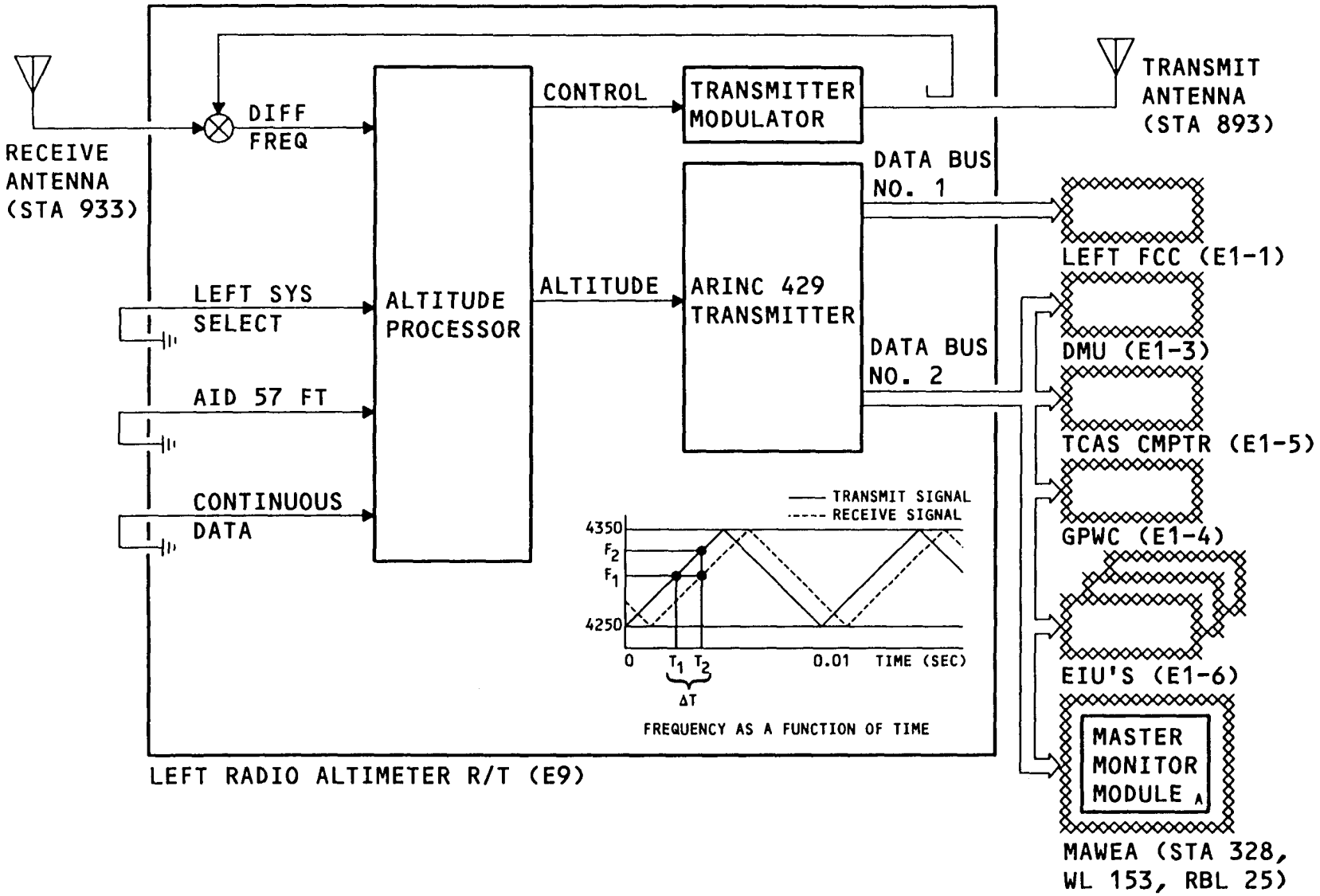


Figure 21 RF PROCESSING

RA MONITORING / TESTING

BITE Module

The BITE module monitors the circuits in the RA receiver/transmitter for faults. These faults are grouped by flights. Faults are stored in the RA R/T and are read out in the shop through the automatic test equipment (ATE) connector. The CMCs define a flight for the R/T's internal flight fault memory.

Test

An RA system self-test starts from the TEST switch on the front of the RA R/T. The results of a self-test show on the LED indicators on the RA R/T.

A ground test starts on a control display unit (CDU). When the ground test is started, a test command from the CMC goes to the RA R/T to start the test.

The results of a ground test are sent to the CMCs through the EIUs for display on the CDU. Status information is continuously sent from the RA R/T to the CMCs through the EIUs. This is for fault monitoring of the RA system.

A test inhibit discrete goes from the left FCC to the left RA R/T during an automatic landing.

A discrete from the air/ground relay prevents self-test during flight and is an alternate source of defining flight legs.

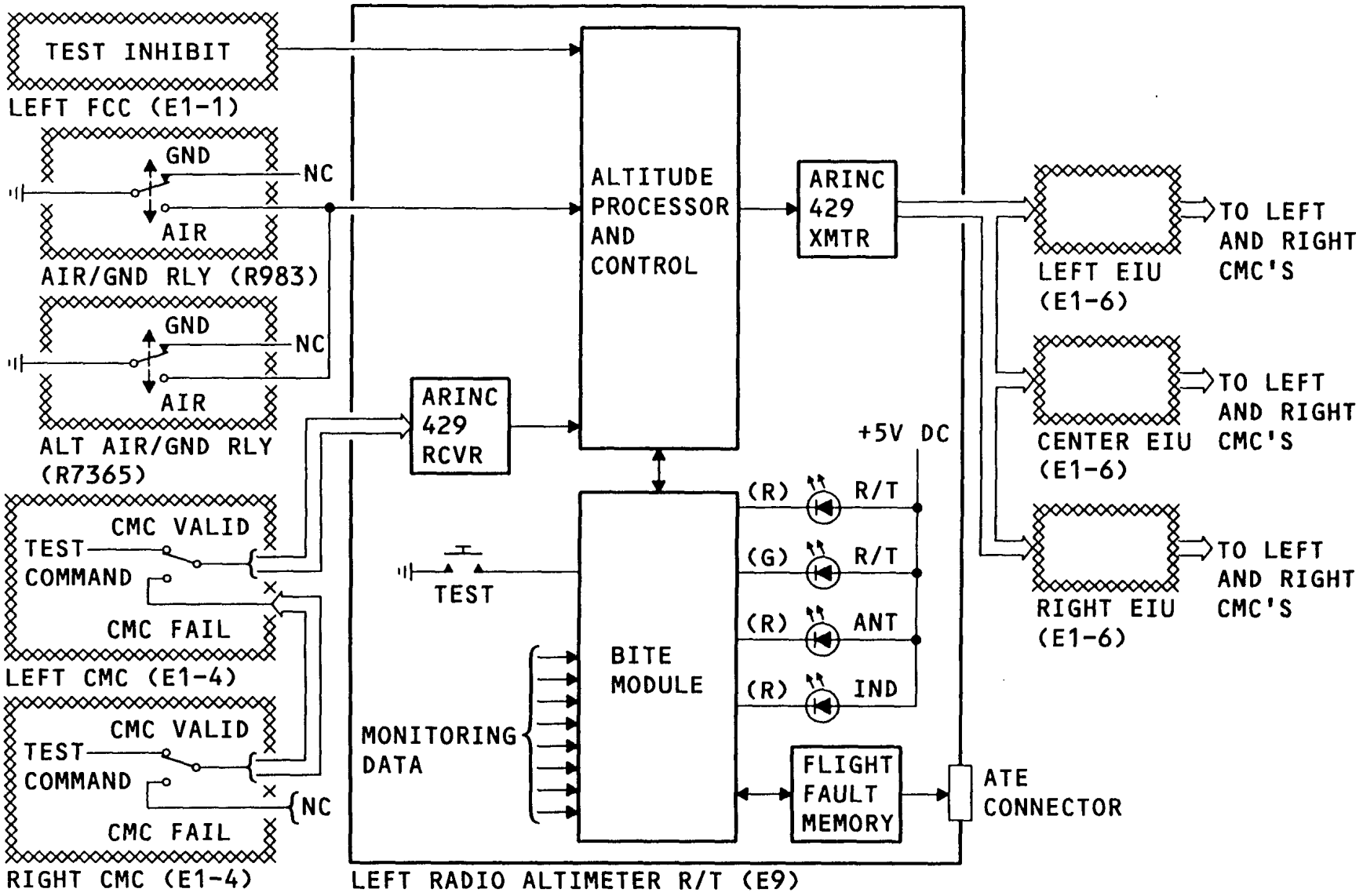


Figure 22 RA - MONITORING / TESTING

DECISION HEIGHT (DH)

DH is selected on the left EFIS control panel. The output of the ARINC 429 Transmitter (XMTR) is sent to the left CDU and to the center CDU. The center CDU cannot act as a backup EFIS control panel. In the left CDU, the digital data is sensed in the Data and Activity Monitor. If a failure is detected, the 429 XMTR in the CDU is enabled and DH can be selected on the onside CDU. The output then goes to the PFD's and AUX EICAS through the left EIU.

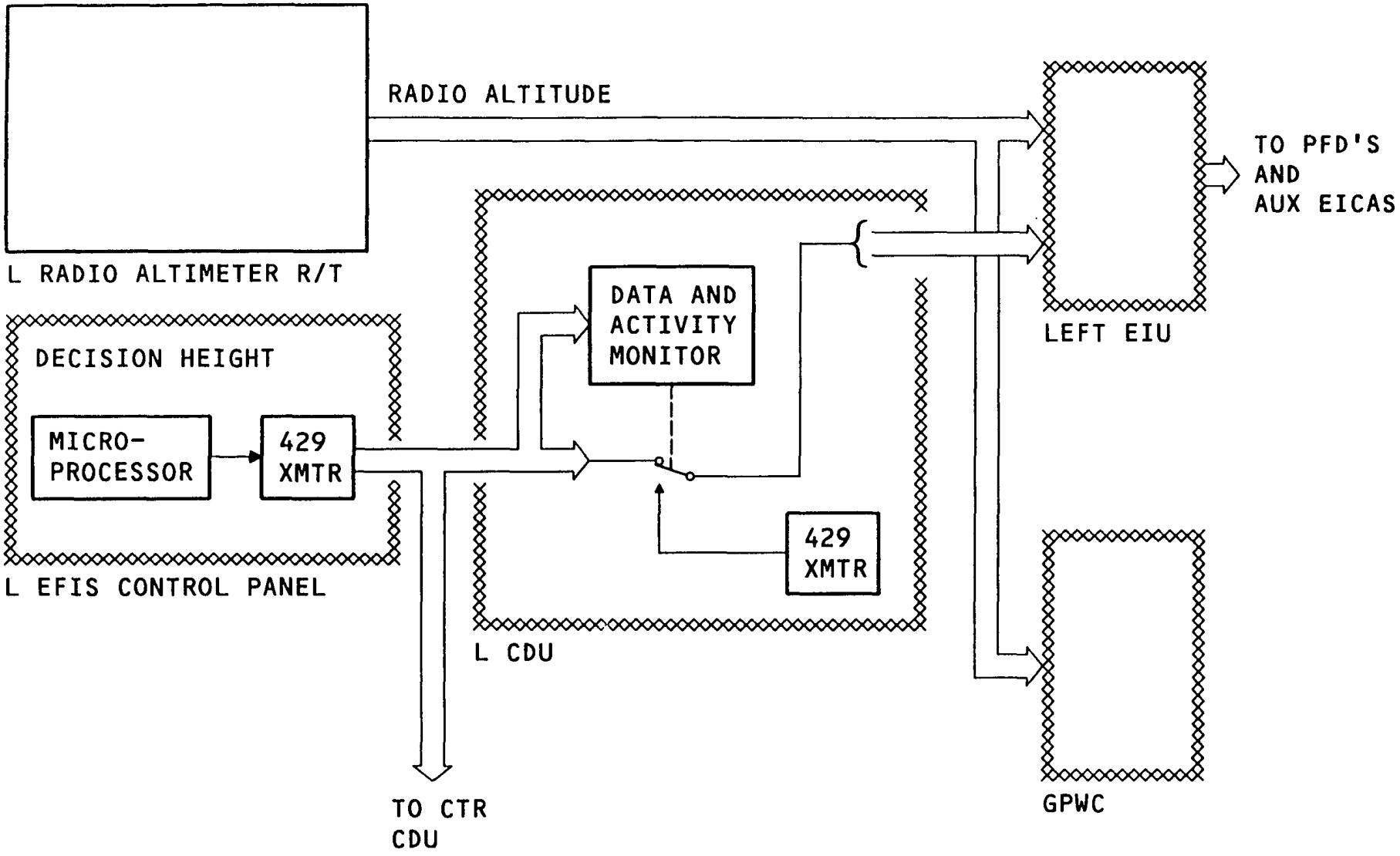


Figure 23 DECISION HEIGHT (DH)

SELF - TEST

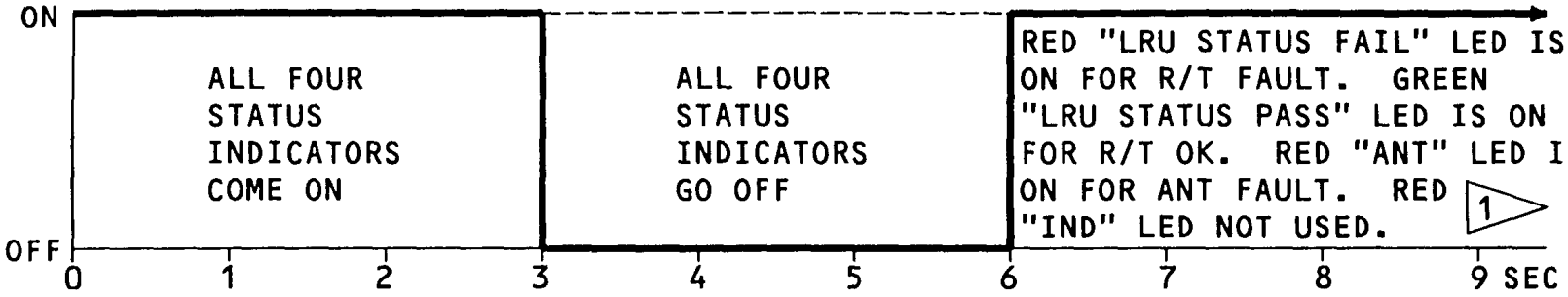
Operation

To start a self test of the RA system push the TEST switch on the RA R/T front panel. With the TEST switch pushed and held, the front panel LEDs come on for three seconds to show that they are operative. The lights then go off for three seconds. After this period, the appropriate LEDs come on to show either a normal (green) or fault (red) condition. The LEDs remain on until the test switch is released.

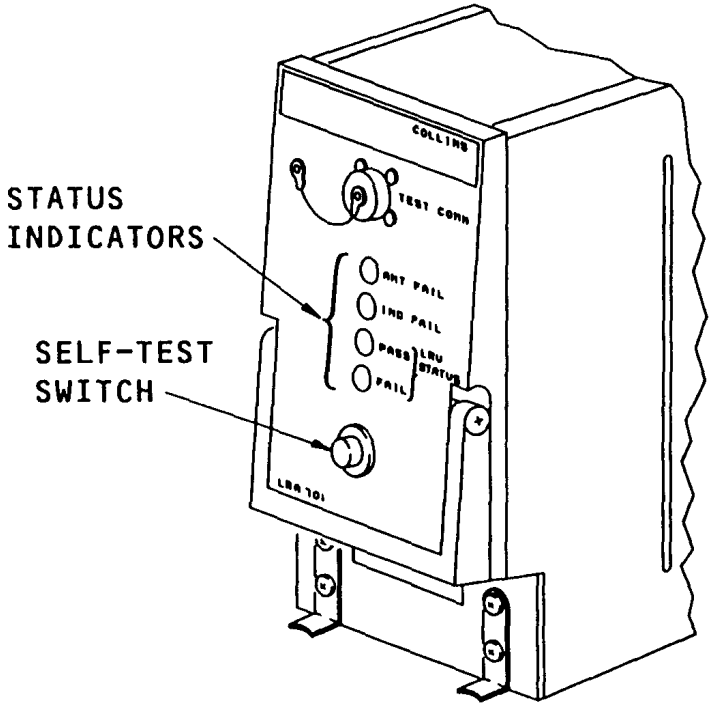
During the self-test a radio altitude of 40 +2 feet shows on the PFD. The test value shows as long as the TEST switch is pushed.

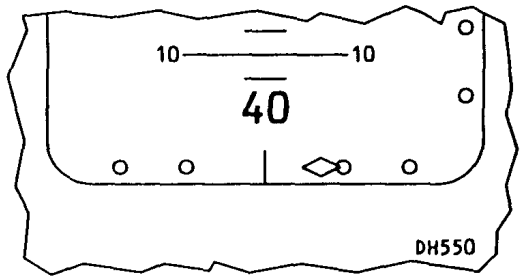
Test Inhibit

The self-test function is prevented by a test inhibit discrete. The discrete is received from the flight control computer during a normal automatic landing.



RADIO ALTIMETER R/T STATUS INDICATORS





PFD - RADIO ALTITUDE OF 40 FEET SHOWN WHILE TEST SWITCH IS PUSHED

1 THE LED OR LED'S REMAIN ON UNTIL THE SWITCH IS RELEASED

Figure 24 SELF - TEST

GROUND TESTS

Ground Test

Ground tests of the radio altimeter systems are selected on the CDU. The ground test systems page on the CDU identifies the ATA chapters which have ground test capabilities. Push the line select key next to 34 NAVIGATION to show the GROUND TESTS page.

To start a test of one of the radio altimeter systems push the line select key next to that system. A test precondition screen shows. This screen shows the expected test response for a RA test. To start the test, push the line select key next to START TEST>.

Ground Test Results

The word PASS on the same line as the system tested shows the system passed the ground test. Failure of the ground test is shown by the word FAIL next to the system selected for ground test. Pressing the line select key next to FAIL causes the GROUND TEST MESSAGE page to be shown. The selected page gives more specific information about the test failure.

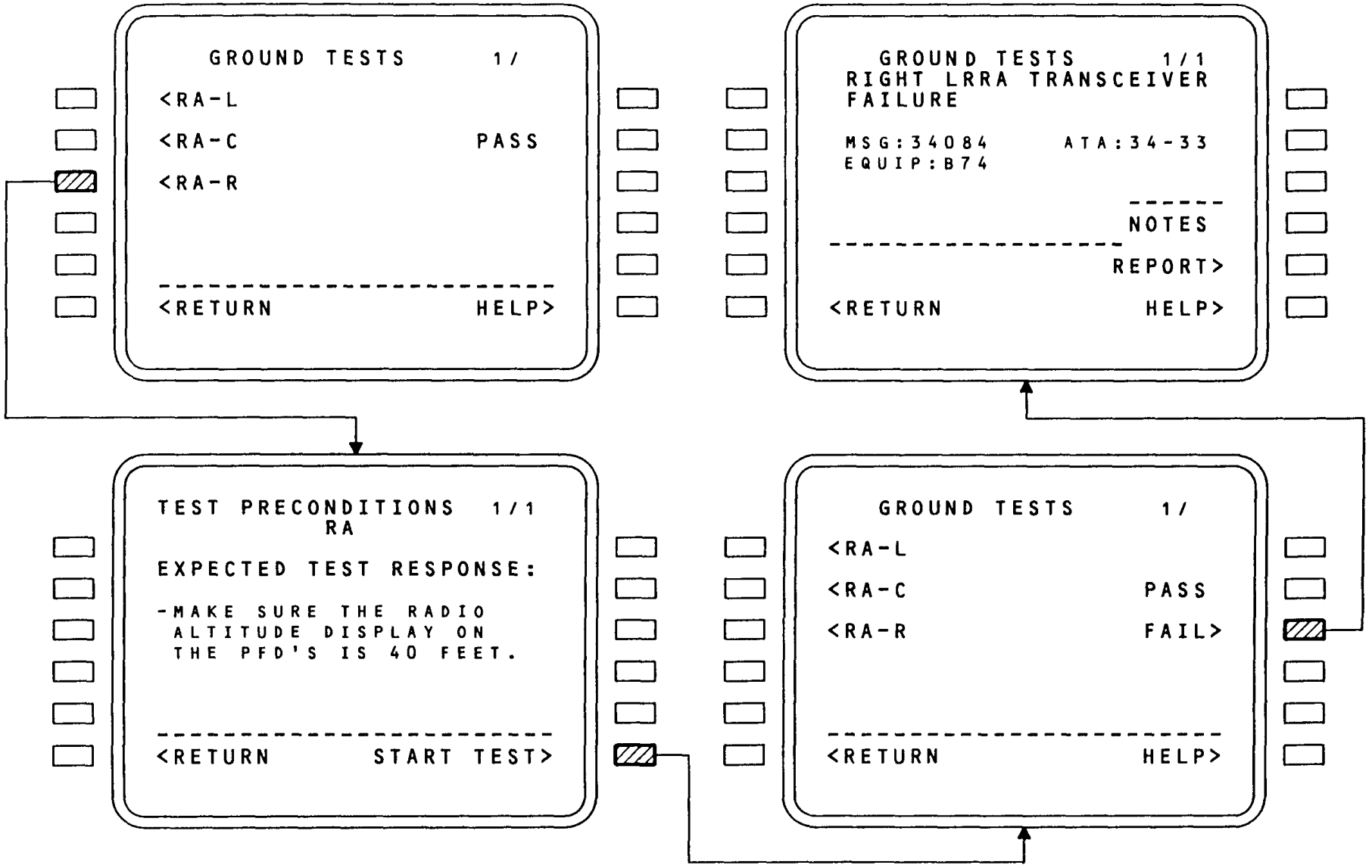


Figure 25 GROUND TESTS

FLIGHT DECK EFFECTS AND CMC MESSAGES

Flight Deck Effects

A failure of the left, right and center radio altitude transceivers causes the RA flag to show on the primary flight display.

When both the captain and first officer are on the same source of RA data because of EIU switch selections or RA transceiver failures, the advisory message >SNGL SOURCE RA shows on the main EICAS display.

A failure of the left, center or right RA transceiver causes the status message to show.

CMC Messages

The different types of CMC messages for the RA system are:

- RA-X FAIL OR CMC - RA-X BUS FAIL (ARINC 429 CMC to RA transceiver bus failure)
- EIU-X FAIL OR RA-X - EIU-X BUS FAIL (ARINC 429 RA transceiver to EIU bus failure)

RA-X NO TEST RESPONSE (The RA transceiver failed to respond to a CMC ground test)

RA-X TRANSCEIVER FAIL (RA transceiver failure)

RA-X TRANSMIT ANTENNA FAIL (RA transmit antenna failure)

RA-X RECEIVE ANTENNA FAIL (RA receive antenna failure)

RA-X FAIL (NO BUS OUTPUTS) (both ARINC 429 outputs from the RA transceiver have failed)

RA-X FAIL OR RA-X TRANSMITTER-B OUTPUT BUS FAIL (the transceivers 02 output bus (transmitter-B) has failed)

NOTE: X = L (LEFT), C (CENTER) OR R (RIGHT)

FLIGHT DECK EFFECT	TYPE	DESCRIPTION
RA	EFIS (PFD) FLAG	L, C AND R RA FAILURE
>SNGL SOURCE RA	ADVISORY MESSAGE	CAPT AND F/O ON SAME RA
RADIO ALT X 1	STATUS MESSAGE	L, C OR R RA FAILURE

CMC MESSAGES

RA-X FAIL OR CMC ~ RA-X BUS FAIL
EIU-X FAIL OR RA-X ~ EIU-X BUS FAIL
RA-X NO TEST RESPONSE
RA-X TRANSCEIVER FAIL 1
RA-X TRANSMIT ANTENNA FAIL
RA-X RECEIVE ANTENNA FAIL
RA-X FAIL (NO BUS OUTPUTS)
RA-X FAIL OR RA-X TRANSMITTER-B OUTPUT BUS FAIL

1 X = L (LEFT), C (CENTER) OR R (RIGHT)

Figure 26 FLIGHT DECK EFFECTS AND CMC MESSAGES

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TABLE OF FIGURES